

Principles of Specialty Nursing

Under the Auspices of the *European Specialist Nurses Organisations (ESNO)*

Series Editor: Ber Oomen

Afra Masià-Plana

Anastasia Liossatou *Editors*

Principles of Nursing in Kidney Care

Under the Auspices of EDTNA/ERCA and
EKPF



Springer

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Under the Auspices of the European Specialist
Nurses Organisations (ESNO)

Series Editor

Ber Oomen, Executive Director,
European Specialist Nurses Organisation,
Arnhem, The Netherlands

The role of the specialist nurse in Europe is still not clearly defined. Despite the fact that there have been formal training programs – e.g. for nurse anaesthetists, operating room nurses, intensive care and mental health nurses – for years now, the practices, status, duration and content of training can vary greatly from country to country. Some other specialist roles, e.g. for Diabetes, Dialysis, Urology and Oncology, have successfully been established in Europe with the help of professional transnational collaborations.

Moreover, advances in medical technologies and more sophisticated treatment will not only require specialist nurses in order to ensure quality and safety of care, but will also call upon them to assume new roles in their professional field to compensate for physician shortages. Most of the available literature on specialty nursing practice currently comes from the USA, Canada, and Australia, and accordingly reflects evidence-based nursing in these countries.

Therefore, there is a need to establish European evidence-based practice on the basis of different clinical experiences. This series, which encompasses textbooks for each specialty, shapes evidence-based practice in Europe, while also integrating lessons learned from other continents. Moreover, it contributes to clarifying the status of the specialist nurse as an advanced practice nurse.

Each volume is dedicated to a specialty such as Mental health and Pyschiatry, firstly published, Oncology, Gastroenterology/Endoscopy, Anesthesia, Kidney Care, Critical Care etc. and for most of them, textbooks are supported by ESNO member societies.

Afra Masià-Plana • Anastasia Liossatu
Editors

Principles of Nursing in Kidney Care

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and EKPF



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Foreword

Dear Readers, dear Colleagues,

I take great pleasure in welcoming you to the new book **Principles of Nursing in Kidney Care**, born from the collaboration between the EDTNA/ERCA (European Dialysis Transplant Nurse Association/European Renal Care Association) and ESNO (European Specialist Nurse Organization).

The increasing prevalence of chronic kidney disease and the rising demand for renal replacement therapy have made the role of renal nurses more important than ever. Renal nursing requires a combination of specialized knowledge, skills, and compassion for people who are suffering from kidney disease.

The aim of this publication is to give value once more to the EDTNA/ERCA mission “achieving the best level of education, standards and research for all renal care professionals caring and supporting their patients and families around the world.”

This book describes all the aspects of nursing interventions toward people with kidney disease, both acute and chronic, in adults and children. It includes some contributions from experienced renal nurses and other healthcare professionals such as dietitians, psychologists, and nephrologists, who all have extensive knowledge in the field of renal care. They have shared their expertise to provide practical insights, case studies, and examples to help nurses develop the skills and knowledge needed to provide the highest quality of care. The book also includes some insights from people with kidney disease, as the research and knowledge in kidney care are always multidisciplinary and inclusive.

I hope that this book will serve as a valuable resource for nurses who work in renal care, and that it will help to improve the care provided to people affected by kidney disease. I would like to thank all the contributors for their hard work in creating this book, and we hope that it will be of benefit to nurses worldwide.

Sincerely,

EDTNA/ERCA President
Hergiswil, Switzerland

Ilaria de Barbieri,

Preface

My motivation for this book lies at the intersection of my passion for the nursing profession and my interest in the dynamic processes involved in the specialties of the kidney. I am proud of this profession, in which nurses have developed a wide range of proficiencies, including management, leadership, care, decision making, and technical skills. During the time of editing and writing this book, I have learned much. Collaborating with experts around the world has bolstered my knowledge and encouraged me to develop a wider understanding of kidney nursing.

The purpose of this book is to provide updated content relating to renal care in nursing, so that future nurses and multidisciplinary health professionals may develop their understanding of kidney care for people suffering from kidney failure. This book also operates as a good foundation for nurses who wish to refresh their knowledge in kidney care. Each chapter is written by experts in their specific field, and data has been provided using the latest evidence available.

The book examines new areas arising in the field of nursing in kidney care. These new areas include sexual health, considered another pillar of health and quality of life, and patient partnership in management and decision making, which is proven to have excellent outcomes not only for the health system but also for the design of new standards. We always wanted to put the person/patient in the center of care and not only to focus on the disease but also on the person who suffers it as well as their families.

My hope is that this book encourages both kidney nurses and all multidisciplinary health care teams that care for people suffering from kidney failure to adopt a holistic perspective when providing care. This will support an approach that considers the complexity of each case, and armed with the latest evidence, can achieve good outcomes for individuals, their families, and the health care system.

Girona, Spain

Afra Masià-Plana

Acknowledgments

The edition of this book has given us great strength in believing once again in the crucial work that nursing professionals are capable of, especially in the kidney field. It has been a valuable journey where we have not only learned but also enjoyed during the process of creating and revising this book.

We would like to express our appreciation and thank all the authors of this publication for their time, effort, and knowledge in writing their chapters. Also, we would like to recognize the assistance of Mrs. Susan Rogers, EDTNA/ERCA English language proof-reader, who has supported the linguistic checks for this book.

We are grateful to Springer Nature's editorial team for giving us the opportunity to be part of this international project. All their unconditional support throughout the process has been impeccable, so a big "thank you" goes to Mrs. Nathalie Lhorset-Poulain and all the editorial team.

Furthermore, we would like to give special gratitude to the ESNO society for supporting and encouraging us to build this project, especially to Mr. Ber Omer, ESNO Executive Director.

This book would not have been possible without the support from the EDTNA/ERCA Executive Committee. EDTNA/ERCA, as a leading international association in nephrology, has been a key element in advancing kidney nursing science and knowledge for renal nurses and other healthcare professionals. Moreover, this book is endorsed by the European Kidney Patients Federation (EKPF), and we would like to give a big thank you to the president Mr. Daniel Gallego, who has supported and encouraged this project.

Finally, we would like to acknowledge with gratitude the support and love of colleagues and family. We are very lucky to be surrounded by amazing people. Thank you all.

Afra Masià-Plana
Anastasia Liossatou

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Currently she is a Scientific Board Member of EDTNA/ERCA, full time lecturer at the faculty of nursing in University of Girona, Spain.



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EDTNA/ERCA conferences. Currently, Anastasia is undertaking her PhD at the Department of Nursing, The University of Peloponnese, Tripoli Greece.



Introduction to Kidney Functions and Pathophysiology

Debbie Fortnum

Learning Objectives

- To review the key anatomical structures of the kidney
- To identify the main functions of each section of the nephron
- To understand the excretory and homeostasis processes of the kidney tubules
- To explain the exogenous functions of the kidney
- To link pathophysiology with understanding symptoms of kidney dysfunction

1 Introduction

Kidney and nephron functions are complex. This chapter examines the basic aspects of renal physiology and pathophysiological processes that underpin renal disease. The reader should then be able to understand the impact of a disease on kidney functions and the subsequent symptoms that are generated. With this approach the reader will be able to determine the specific care that is required.

2 Basic Anatomy of the Kidney

The kidneys lie behind the peritoneum, adjacent to either side of the vertebral column, and are paired organs. A healthy kidney is approximately 11 cm long, weighing about 150 g. The renal artery and vein (left and right) provide the blood supply to the kidneys. Each kidney has an outer cortex and inner medullary region (Fig. 1). Approximately one million nephrons are found in each kidney. The filtering and re-absorptive part of the nephrons sit in the cortex region and the concentrating and

D. Fortnum (✉)
EDTNA/ERCA Brand Ambassador, Perth, Australia

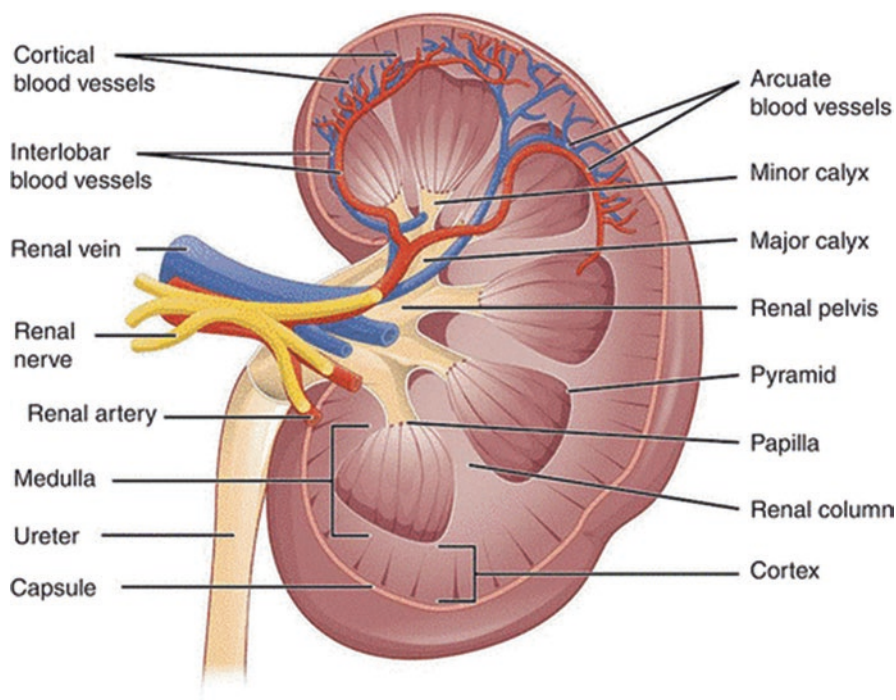


Fig. 1 Anatomy of the kidney. (Reproduced with permission from Springer Nature. Buffi et al. [1])

diluting components mainly sit in the medullary region (Fig. 2). The urine then drains via the collecting ducts into the pelvis of the kidney, via the ureter and into the bladder [3, 4].

3 Nephron Structure and Functions

The nephron is the functional unit of the kidney, of which 85% are cortical nephrons and 15% are juxtamedullary nephrons. The nephrons are supported by the cortex and medullary interstitial cells which also supports the peritubular capillaries [3–5]. The structure of the nephron is related to its complex functions and contains five components which each performs a distinct process (Table 1).

4 Blood Supply

The renal artery and vein (left and right) deliver blood to the arcuate arteries. The arteries then feed arterioles which deliver blood to the Bowmans capsule. There is a tiny knot of capillaries in each Bowmans capsule. The arteriole delivering blood is known as the afferent arteriole and leaving the capsule is the efferent arteriole.

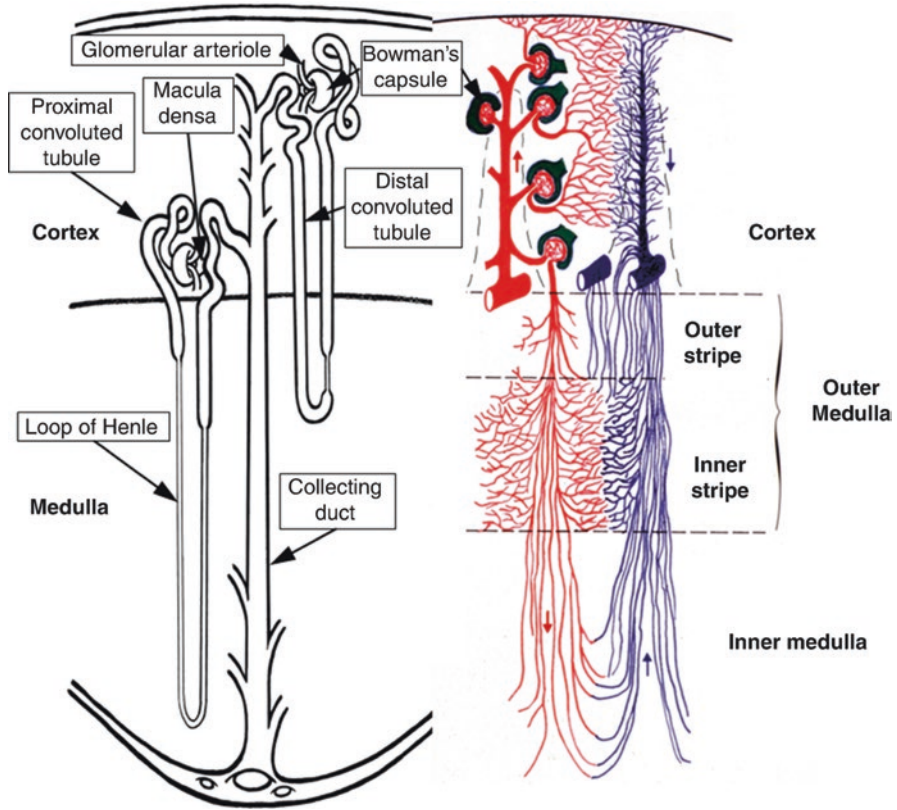


Fig. 2 Anatomy of a nephron. (Reproduced with permission from Springer Nature. Rayner et al. [2])

Within the kidney are peritubular capillaries surrounding each section of the nephron and reabsorbing or secreting electrolytes depending on concentration gradient levels and the active pumps which are controlled by hormonal messengers. The specific capillary surrounding the loop of Henle is known as the vasa recta. The final stage of the capillary network are the venous capillaries returning filtered and cleaned blood to the renal vein to enter the systemic circulation [5].

5 Fluid Regulation

Kidneys can vary the volume of urine excretion per day from as little as 300 mls up to 23 L, depending on the fluid input and insensible output of the body, which is influenced by other external conditions. The average urine output is 1.5 L in 24 h. The concentration of urine is measured in units of osmolality (mOsmol/kg water). The average range of urine osmolality in people with normal kidneys is between 300 and 500 mOsmol/kg water. Serum osmolality is usually tightly maintained at

Table 1 Description and function of each part of the nephron [5]

Functional part	Description	Function
Bowman's capsule (in cortex or medulla)	Capsule that surrounds the glomerulus (knot of capillaries). Blood enters via afferent arteriole and leaves via efferent arteriole	Filtration of blood. Low molecular weight solutes filter through endothelial cells into Bowman's space from glomerulus ^a Filtration rate dependent on concentration gradient between afferent and efferent arteriole. 180 L filtrate per day at 125 ml/min
Proximal convoluted tubule (in cortex or medulla)	First section; pars convoluta (about 14 mm). Epithelial cells are full of mitochondria and have brush border. Blood supply is from peritubular capillaries	High level of reabsorption of water and electrolytes into capillaries (85%). Active transport and diffusion (by mitochondria). Water moves by osmosis
Loop of Henle (in medulla)	Descending and ascending thin limb (shorter in cortical nephrons). Thin permeable cells. Vasa recta provides blood supply	Descending loop filtrate concentrated by passive osmosis of water. Ascending loop impermeable to water but pumps out more chloride and sodium ions to keep osmolality high in interstitium
Distal convoluted tubule (in cortex)	Thick ascending limb, pars convoluta (1 mm long) and connecting distal tubule. Epithelial cells with less mitochondria	Active fine tuning of urine and correcting of electrolytes. Feedback from hormones regulates these functions. That is, aldosterone regulates potassium and sodium. Parathyroid hormone regulates calcium and phosphate
Collecting duct (medulla)	Final part of nephron from connecting distal tubule to the ureter	Collects urine, site of action to further retain water (presence of antidiuretic hormone) and transfers urine to pelvis then into the ureter

^aThe healthy glomerular basement membrane barrier is highly restrictive to larger molecular weight proteins including albumin but when damaged it becomes leaky leading to proteinuria [6]

290 mOsmol/kg (+/-5mosm/kg) [5]. A number of mechanisms control fluid balance including:

- The Loop of Henle facilitates urine volume variance with its complex counter-current concentration mechanism. This is facilitated by the ability of the ascending limb to pump sodium chloride into the interstitium while being impermeable to water. This increased medullary tissue osmolality allows additional water to be reabsorbed into the vasa recta capillaries, via the interstitium, from the water permeable descending limb of the loop of Henle.
- In response to dehydration the posterior pituitary gland releases antidiuretic peptide (ADH) (also known as vasopressin) which increases collecting tube permeability, thereby increasing body water reabsorption. Urine can concentrate up to 1200 mosm/kg if required.
- The distal tubule macula densa contact point with the glomerulus triggers the renin-angiotensin aldosterone system (RAAS) to retain fluid and increase blood pressure (as above).
- Thirst mechanism (osmoreceptors in the hypothalamus) is stimulated when serum osmolality increases by 2–3%. Dehydration or excess sodium intake can trigger thirst [7].

- Atrial natriuretic peptide is released from stretch receptors in cardiac atrial cells to inhibit aldosterone, renin and ADH release, thereby increasing urine output. Without ADH urine can have an osmolality as low as 50 mOsmol/kg [3, 5].

Urine specific gravity is a measure that defines the ratio of the density of urine compared to the density of water. Dark urine that is concentrated, specific gravity >1.030 , indicates extreme dehydration. Urine, specific gravity <1.010 , that is pale indicates that someone is well or over hydrated (or possibly drinking alcohol which suppresses ADH) [8].

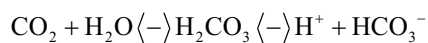
Kidney disease reduces fluid regulation capacity, leading to vascular and cellular fluid overload manifesting as hypertension, edema and ultimately pulmonary edema. It also reduces the inability to concentrate urine output during episodes of dehydration. The action of some diuretics to treat fluid retention also interferes with the capacity of the kidneys to regulate potassium, another example of the complexity of kidney functions [4, 5].

6 Acid Base Balance

Bicarbonate buffering is an essential kidney function to maintain the body pH (acid levels) between 7.38 and 7.42. Metabolism within cells continuously generates carbon dioxide (CO_2) which dissolves in plasma to produce carbonic acid (H_2CO_3). Excretion options for the acid component are:

- as CO_2 via the lungs,
- or eliminating the hydrogen (H^+) ions via the kidneys during bicarbonate regeneration from the carbonic acid [4].

This equation demonstrates the constant movement of these ions as required [4].



The glomerulus filters all bicarbonate but usually reabsorbs 90% in the proximal tubule (a complex chemical process within the tubular wall that regenerates bicarbonate) with the fine-tuning completed in the distal tubule. Biofeedback mechanisms drive this process based on the pH of the body [3].

During acidosis either the kidneys or lungs have to increase their output. For example:

- In metabolic acidosis (kidney failure) the carbonic acid (H_2CO_3) can be broken down back to carbon dioxide (CO_2) and water (H_2O), (move equation to the left), with additional carbon dioxide being blown off by the lungs.
- In respiratory acidosis the kidneys increase their net loss of hydrogen (move equation to the right) by utilizing ammonia as a buffer and creating an acidic urine [3, 4].

Another option to rebalance acidosis is that hydrogen ions may also be exchanged with potassium. This has the risk of causing hyperkalemia when the body is trying to correct metabolic acidosis, or conversely metabolic alkalosis when the body is trying to manage hyperkalemia [3, 4].

These compensatory solutions have limitations if underlying pathophysiological issues are not corrected. Specifically in kidney disease, the failure of these usual acid base balance systems leads to metabolic acidosis with a low bicarbonate (compensated—pH normal—or uncompensated pH high) [3–5]. If trying to diagnose acid base abnormalities the analysis of urine pH, blood pCO₂ and pO₂, pH, and HCO₃ will assist to diagnose the original cause [5].

7 Blood Pressure Regulation (Renin–Angiotensin Aldosterone System—RAAS)

Blood pressure regulation has many components. The actual blood pressure at any given time is dependent on the volume of blood the heart pumps with each beat, the rate of the heart and the resistance of the peripheral vasculature to the blood that is being circulated (formula 1).

Formula 1: Blood Pressure [5].

$$\text{Blood pressure} = \text{cardiac output (stroke volume and heart rate)} \\ \times \text{total peripheral resistance (TPR)}$$

Kidneys play an important role in maintaining blood pressure. This is known as the renin–angiotensin aldosterone system (RAAS). It starts with a feedback mechanism through the juxtaglomerular (JG) apparatus. The JG apparatus consists of the macula densa cells in the distal tubule which are in direct contact with the renin releasing cells. A decreased blood volume causes the glomerular filtration rate to decrease, with a simultaneous reduction in distal tubule chloride. The JG apparatus detects the fall in chloride and stimulates the macula densa cells to signal the renin releasing cells to release renin. Renin then triggers the renin–angiotensin system (Fig. 3) and the final product angiotensin II causes peripheral vasoconstriction quickly increasing TPR; one component of blood pressure maintenance [3].

To provide a permanent solution the extracellular volume must be increased to facilitate improved cardiac stroke volume. Aldosterone is stimulated by angiotensin II and activates the renal tubules to retain sodium which they do by increasing excretion of potassium (Fig. 3). As discussed previously sodium retention increases water retention [3, 4].

In the short term the RAAS system restores supply of blood to the kidney by improving blood pressure. However, in the long term the overstimulation of RAAS is part of the hypertensive nephropathy never ending cycle. The hypertension itself also leads to nephrosclerosis, further damaging the renal arterioles and glomerular

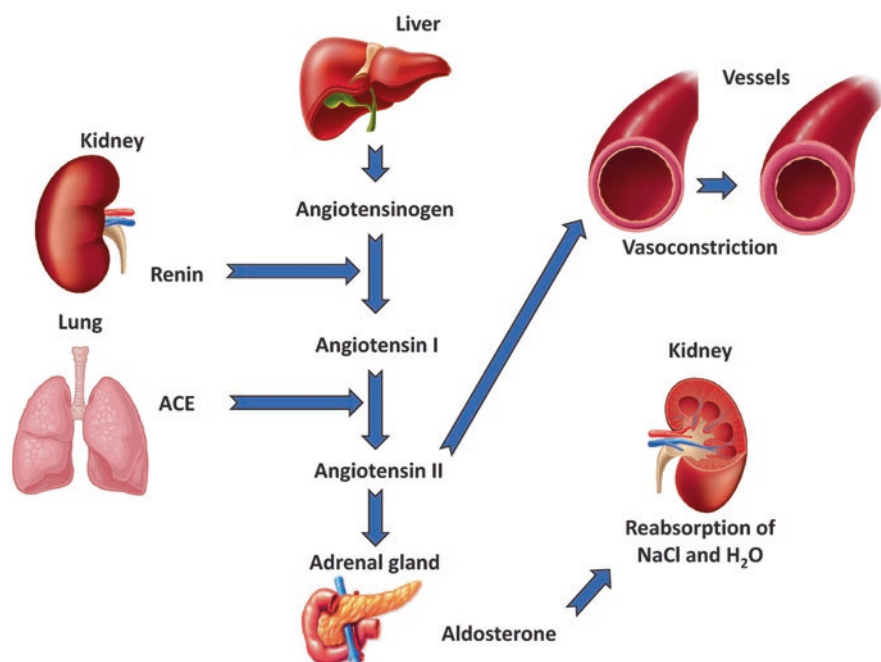


Fig. 3 Renin–angiotensin–aldosterone system. (Reproduced with permission from Springer Nature. Ghanem and Megahed [9])

blood supply. Furthermore, renal artery stenosis also occurs in up to 25% of individuals due to the hypertension induced atherosclerosis and hyaline arteriolar sclerosis further worsening hypertension [3, 4].

In late-stage kidney failure the mechanisms to regulate blood pressure, fluid balance and acid base balance become less effective with excess sodium (hypernatremia), potassium (hyperkalemia) and hydrogen (acidosis) often occurring simultaneously regardless of the cause of the kidney disease. Hypertensive retinopathy and left ventricular hypertrophy are other impacts [4, 5].

8 Calcium Phosphate Regulation

Calcium is 50% albumin bound and 50% ionized in plasma (hence corrected calcium levels that are adjusted based on albumin levels) [3]. Phosphate is an important buffer in blood and has an inverse relationship with calcium. Both calcium and phosphate are the main mineral constituents of bone. Kidney plays a crucial role in regulation of calcium and phosphate:

- The distal tubule excretes excess phosphate and balances calcium.
- In the presence of high serum levels of phosphate, or low serum levels of calcium, parathyroid hormone (PTH) is stimulated acting on the distal tubule to reabsorb calcium or excrete phosphate as required.
- When serum calcium is low the PTH that circulates also stimulates the kidney to activate vitamin D to 1, 25 dihydroxycholecalciferol. This enhances gut absorption of calcium.
- Unfortunately PTH also releases calcium from bones leading to weakened bones if levels are abnormal in the long term, such as with kidney disease.
- If serum calcium is high calcitonin is released from the thyroid gland to facilitate the redeposition of calcium into the bone.
- Long term hyperphosphatemia leads to hyperparathyroidism [3–5].

The failure of appropriate kidney regulation of calcium and phosphate coupled with a lack of vitamin D and over secretion of PTH leads to metabolic bone disease. Many other factors including the duration of the abnormally high phosphate levels and normal aging hormonal changes also influence the type of bone disease [4].

9 Excretion of Waste Products

The kidneys excrete a huge range of electrolytes, toxins and metabolites. Two of these, creatinine and urea are surrogate markers for kidney function. Urea is a by-product of protein metabolism, while creatinine is a by-product of muscle activity. Although the term uremic syndrome is used colloquially there are multiple waste products (known and unknown) that are responsible for many of the miscellaneous symptoms experienced by those with kidney disease. Other examples are uric acid and beta 2 microglobulin [4].

10 Regulation of Electrolytes

Another of the major functions that kidneys have is the regulation of electrolytes. The kidneys maintain a balance of electrolytes by shifting sodium levels as the body requires. When the level of electrolytes in the body is too low or too high, the resulting condition is called an electrolyte imbalance. Maintaining an electrolyte balance is a complex process in which includes various body feedback mechanisms and hormones dictating which electrolytes need to be retained or eliminated. Keeping balanced electrolyte levels is vital for the multiple functions of the body. People who suffer from kidney disease the regulation of electrolytes is altered immediately. For example magnesium often is with deficiency in people who suffer from kidney disease [4].

11 Erythropoietin Production

The hormone erythropoietin is a glycoprotein that signals the bone marrow to proliferate and differentiate erythrocyte precursors (erythrocyte stimulating agent—ESA). The peritubular cells and endothelial cells of the cortex are stimulated to produce ESA in the presence of hypoxia. Once kidneys are damaged this does not occur although the liver has a role to play in producing about 25% of the bodies ESA [3, 4].

The failure of the kidney to produce ESA is a key factor that leads to the anemia of kidney disease. If accompanied by iron deficiency, the result is iron deficiency anemia.

12 Drugs and the Kidney

The kidneys, often in partnership with the liver, excrete many drugs from the body. The glomerulus may or may not filter drugs and this usually depends on their binding level with proteins (protein bound drugs are not filtered but water-soluble drugs are). The kidneys also actively secrete some drugs and their metabolites in the tubules, with smaller molecules being eliminated more easily. Water-soluble drug reabsorption from the tubular lumen into the systemic circulation occurs passively with water reabsorption, and actively in the distal tubule where the process is facilitated by membrane drug transporters [3, 10].

During kidney failure these excretory functions decrease, leading to the risk of drug toxicity for renally excreted drugs (i.e., digoxin, metformin and gentamycin) or metabolites. Several drugs are also directly nephrotoxic to the tubules, i.e., non-steroidal anti-inflammatory drugs (NSAIDs), gentamycin, cyclosporin and contrast agents [5].

13 Kidney Pathophysiology and Links to Kidney Disease

It is important to acknowledge that the extensive range of causes of kidney disease all have different impacts on the kidney functions. For example:

- Chronic kidney disease (CKD) impacts the glomerular filtration rate (GFR) over an extended period of time compared to acute kidney injury (AKI) which presents over a few days.
- Diabetic nephropathy, affecting 20–40% of those with diabetes [11], is highly associated with stimulating the RAAS and causing hypertension. Its slow progression means that the impact on exogenous functions such as production of EPO (erythropoietin) which can develop anemia, and the activation of vitamin D which can develop metabolic bone disease, is high relative to the GFR, compared to other renal diseases.

- In polycystic kidney disease (5% of world kidney disease) [12], the cysts will fill the kidney replacing normal kidney tissue and reducing the number of nephrons. Anemia is rare and urine output volume is often normal, but pain and hematuria are common.
- Glomerulonephritis will directly damage nephrons causing glomerular inflammation and increased protein filtration commonly leading to a nephrotic syndrome with excess protein loss or a nephritic syndrome with hematuria.
- Acute kidney injury will impact immediately on the ability of the nephrons to regulate fluid and electrolyte balance but will have limited impact on complications related to exogenous functions.
- Infectious diseases and reflux nephropathy can lead to chronic pyelonephritis with the inflammation causing renal vascular damage and leading to hypertension [5].

Therefore, when reviewing a person with kidney disease it can be assumed that they could lose various aspects of the “normal functions” of the kidney at different points in their disease trajectory. These will manifest with extensive symptoms and signs. Review of any individual should consider:

- What pathophysiological structures are damaged by that underlying disease?
- What is the usual disease trajectory and timeline?
- How far are they down the trajectory—current staging of the kidney disease.
- Is the kidney damage likely to put them at risk of complications? (CKD causes more loss of non-glomerular functions than AKI).
- Systematic review of both signs and symptoms encompassing all body systems.

Careful history taking, a complete body system review and tests such as renal biopsy are important in understanding the damage and individualizing clinical care. Treatments can slow the progression of kidney damage and the earlier they are implemented increases the potential to delay the need for dialysis or the more common outcome of a cardiac related death. A good example is that in preventing AKI the simple measure of hourly urine output by nurses can be critical in identifying early kidney damage and facilitating rapid treatment, which then improves AKI outcomes significantly. A nurse who understands how kidneys function and the signs of early kidney damage can significantly reduce the risk to the patient [4].

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Management of Chronic Kidney Disease

José Jesús Broseta and Diana Rodríguez-Espinosa

Learning Objectives

- To define chronic kidney disease (CKD).
- To understand the epidemiological and healthcare implications of CKD.
- To identify patients at high risk of progression and cardiovascular morbidity.
- To name and diagnose main comorbidities associated with CKD.
- To mention the main treatment strategies and comprehend their pathophysiological mechanisms of action.

1 Introduction

Chronic kidney disease (CKD) is the common, progressive, and irreversible fate of a heterogeneous group of pathologies. Its prevalence, morbidity, and mortality are increasing, and therefore, health professionals from different areas need to comprehensively understand the entity's effects on patients and the tools we have in hand to reduce CKD progression and improve patient survival.

1.1 Chronic Kidney Disease Definition

According to the Kidney Disease Improving Global Outcomes (KDIGO) guidelines, CKD is defined as the presence of structural or functional abnormalities,

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estimated glomerular filtration rate (eGFR) less than 60 mL/min/1.73 m², albuminuria ≥30 mg/g, urinary or electrolyte abnormalities due to tubulopathies, present for more than 3 months [1].

1.2 Chronic Kidney Disease Classification

CKD is classified based on cause and estimated glomerular filtration rate (eGFR) and albuminuria categories (Fig. 1). Using this bidimensional classification allows us to identify peoples’ current renal state (i.e., eGFR) and their progression risk (i.e., albuminuria) [1]. This classification translates this risk of progression and events. Green is considered normal in the absence of other CKD criteria or low risk, yellow represents a moderately increased risk, orange is a high risk, and red is a very high risk. But it is also helpful to guide the frequency of monitoring: once a time when green or yellow, twice when orange, and equal or higher than 3 when red. And the referral decision-making: every patient classified in an albuminuria category A3 or an eGFR category G4 or G5 should be referred to a nephrologist.

CKD is defined as the common, progressive, and irreversible fate of a heterogeneous group of pathologies.

Prognosis of CKD by GFR and Albuminuria Categories: KDIGO 2012				Persistent albuminuria categories Description and range		
				A1	A2	A3
				Normal to mildly increased	Moderately increased	Severely increased
				<30 mg/g <3 mg/mmol	30-300 mg/g 3-30 mg/mmol	>300 mg/g >30 mg/mmol
GFR categories (mL/min/ 1.73 m ²) Description and range	G1	Normal or high	≥90			
	G2	Mildly decreased	60-89			
	G3a	Mildly to moderately decreased	45-59			
	G3b	Moderately to severely decreased	30-44			
	G4	Severely decreased	15-29			
	G5	Kidney failure	<15			

Green: low risk (if no other markers of kidney disease, no CKD); Yellow: moderately increased risk; Orange: high risk; Red, very high risk.

Fig. 1 Prognosis of CKD by GFR and albuminuria categories: KDIGO 2012. Levin A, Stevens PE, Bilous RW, Coresh J, de Francisco ALM, de Jong PE, et al. Kidney disease: Improving global outcomes (KDIGO) CKD work group. KDIGO 2012 clinical practice guideline for the evaluation and management of chronic kidney disease. Kidney International Supplements, 2013

1.3 Prevalence of Chronic Kidney Disease

Recent data from 11 European countries have estimated the prevalence of CKD among the general population to be around 10% [2], with its main etiologies being diabetic kidney disease (about 39%) and hypertensive nephropathy (about 26%) [3], which are also associated with obesity, sedentarism [4], and smoking habit [5]. In fact, the prevalence of CKD is higher with each cardiovascular risk factor aggregated, it further increases with age and is slightly more frequent in men [6]. In contrast, kidney-centered pathologies, such as primary glomerulopathies, autoimmune diseases, congenital urological anomalies, and genetic diseases, comprise the minority of causes for CKD [3].

1.4 Outcomes in Chronic Kidney Disease

Chronic kidney disease is not only a highly prevalent disease but it also represents the twelfth cause of mortality worldwide (although it is estimated to achieve the fifth position in 2040 and the first one by 2100), causes a high rate of hospitalizations, and is highly frequent associated with cardiovascular events. In fact, the leading mortality cause in CKD is cardiovascular disease, while heart failure decompensation is one of the most frequent diagnoses at admission among this population. Compared to cardiovascular, oncological, and pulmonary diseases that significantly reduced their mortality numbers, CKD mortality has remained stable for the past 20 years. The global burden of CKD is estimated to be 1.2 million deaths and 28 million life-years lost each year [7].

1.5 Costs in Chronic Kidney Disease

The combination of comorbidities in persons with CKD translates into high health-care costs, exponentially increasing as CKD progresses from one stage to the next until direct costs of about \$100,000/year when the patient is on maintenance dialysis, where readmission times shorten, hospital stays lengthen, and hyperkalemia emergency and clinic visits increase [8]. CKD is a significant public health issue as CKD, together with heart failure, represents one of the more expensive chronic diseases. Thus, early diagnosis and disease progression prevention are vital.

However, despite the wide availability of low-cost diagnostic tests, two out of three persons with CKD are not diagnosed, even in the disease's most advanced stages [9]. This is probably related to the insidious nature of the disease, a characteristic shared with hypertension and diabetes. Additionally, the underdiagnosis is associated with the fact that urine albumin excretion tests are not routinely ordered [10].

Fortunately, and despite the various etiologies behind CKD, which require specific management (e.g., immunosuppressive treatment in the case of

glomerulopathies), there is a set of common therapeutic strategies that slow disease progression and reduce cardiovascular and renal events regardless of the etiology that initiated it. In this chapter we will investigate the care and management of those with CKD.

2 Management

The control of hyperfiltration, classic cardiometabolic risk factors such as dyslipidemia, hypertension, smoking, obesity, sedentary lifestyle, or type 2 diabetes, as well as others such as hyperuricemia or metabolic acidosis, described more recently, both in a pharmacological and non-pharmacological approach, are the pillars of the management of non-dialysis-dependent persons with CKD.

Remember to treat:

- Lifestyle
- Hyperfiltration
- Diabetes
- Hypertension
- Dyslipidemia
- Metabolic acidosis

2.1 Hyperfiltration

Hyperfiltration consists of an increase in eGFR or filtration fraction through hemodynamic adaptations in the glomeruli. These occur physiologically in certain situations, such as in pregnancy or after consumption of a protein-rich meal, but also as an adaptive response to the loss of nephrons. In the latter case, this mechanism, maintained over the long term, eventually leads to glomerulosclerosis, proteinuria and, ultimately, the progression of CKD [11].

2.1.1 Renin–Angiotensin–Aldosterone System Inhibitors (RAASi)

Blockade of the RAAS is the cornerstone in the management of albuminuria. The KDIGO guidelines recommend initiation of an angiotensin-converting enzyme inhibitor (ACEi) or angiotensin II receptor antagonist (ARB) at the maximum tolerated doses in any patient with hypertension, diabetes with a urinary albumin/creatinine ratio (UACR) > 30 mg/g, or nondiabetic CKD with a UACR >300 mg/g [1]. In the American Association of Clinical Endocrinology's last guidelines, finerenone, a new mineralocorticoid receptor antagonist, has been pointed out as a treatment option for patients with CKD and type 2 diabetes in combination with an ACEi or ARB [12]. Persons with concomitant heart failure with reduced ejection fraction (HFrEF) should be treated with a mineralocorticoid receptor antagonist and

sacubitril/valsartan when tolerated [13]. Their main adverse events are hypotension and hyperkalemia, the most limiting factors to dose titration. But more infrequent ones, such as dry cough and angioedema, should also be identified.

Hyperkalemia

Considering the increased risk of hyperkalemia is crucial, and close monitoring of blood potassium at baseline is recommended, especially in double-blockade cases. High potassium levels interfere with the membrane potential, electrical impulse production, and propagation in myocytes and other muscle cells. Hence, severe hyperkalemia can induce deadly cardiac arrhythmias and flaccid paralysis [14]. Additionally, patients may also experience non-life-threatening side effects such as dizziness, palpitations, or leg weakness [15].

Given the increased risk, classically, physicians recommend patients with CKD adhere to a potassium-restricted diet, recent data show that dietary potassium sources that come from whole fruits (not juices) and vegetables rich in fiber are not associated with a risk of severe hyperkalemia, but on the contrary, are linked to a better nutritional status [16, 17]. Therefore, their strict restriction is not necessary. In refractory cases, potassium binders may be prescribed. Among the commercially available potassium binders are the classic sodium polystyrene sulfonate and calcium polystyrene sulfonate, which are characterized by bothersome side effects like constipation, diarrhea, vomiting, nausea, flatulence, indigestion, abdominal pain, and heartburn. Two more recent binders, patiromer and sodium zirconium cyclosilicate, are effective, safe, and better tolerated. The latter has a faster onset of action, making it useful in acute hyperkalemia cases [18, 19]

2.1.2 Sodium-Glucose Cotransporter-2 Inhibitors (SGLT2i)

The SGLT2i or glycosurics have appeared as a new therapeutic tool for treating type 2 diabetes and its comorbidities, with demonstrated cardiovascular and renal benefits. However, its therapeutic effects go beyond glycemic control, and, in fact, they have been shown to maintain this benefit in nondiabetic patients with CKD and heart failure [20–22]. In the context of CKD, these drugs proved to achieve a significant reduction in albuminuria and the risk of progression of CKD by 30–40%, delaying the entry into renal replacement therapy (Fig. 2).

Particular caution should be taken when this drug family is initiated in persons on concomitant diuretic treatment, in which volume status, blood pressure reduction, kidney function, electrolytes, and weight changes have to be checked at baseline and monitored at 2–3 weeks after initiation to avoid adverse events.

Regarding its potential adverse effects, the following should be considered:

- There is an increased risk of fungal genitourinary infections (especially in patients with very poor glycemic control) that only in a few cases would justify its suspension, assessing risk-benefit. In the event of such an infection, treatment would be a single dose of fluconazole 150 mg.

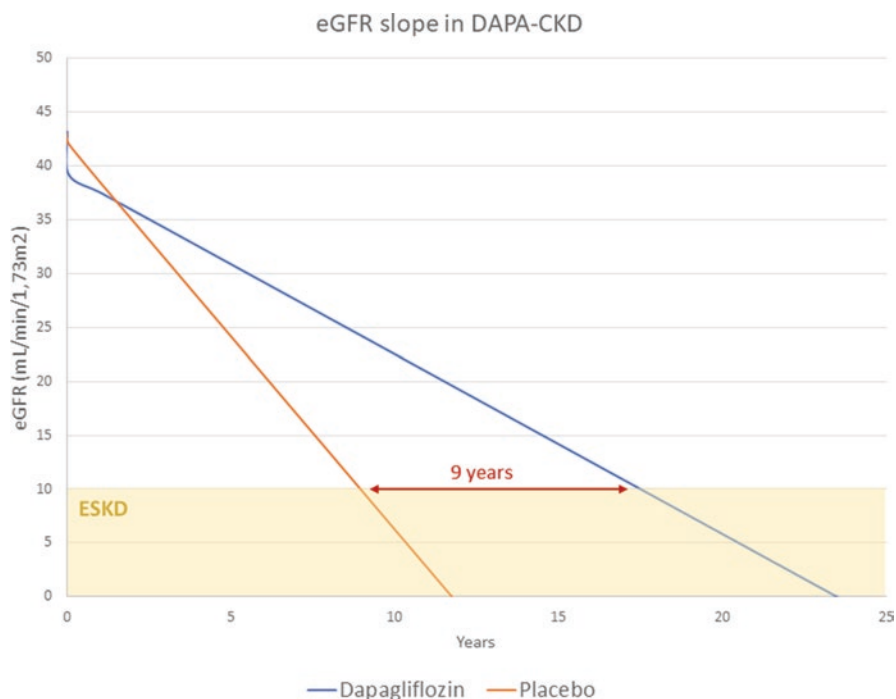


Fig. 2 Comparison of estimated glomerular filtration slope between those treated with placebo versus dapagliflozin and the consequent delay in entering in end-stage kidney disease of the latter. Self-construction with DAPA-CKD data

- Acute kidney injury can occur in patients taking several diuretics or in episodes of dehydration (common to RAASi). To avoid these, the patient should be instructed to temporarily discontinue the drug in diarrhea, vomiting, or hypotension episodes. However, a decline in eGFR by up to 30%, or greater when initiated in combination, is expected when SGLT2 and RAASi drug classes are initiated. Still, it must be considered a hyperfiltration correction rather than a kidney injury in the absence of dehydration. Indeed, the more significant the initial decline in the eGFR, the higher the kidney protection. In the case this increase persists for more than 4 weeks or is not correlated with a UACR reduction, it is necessary to reduce doses or stop treatment and evaluate other concomitant drugs and the patient's clinical situation (use of non-steroidal anti-inflammatory drugs (NSAIDs), excess diuretics, volume depletion), in addition to considering bilateral renal artery stenosis.
- Diabetic ketoacidosis, although infrequent, should be suspected in patients with intolerance to ingestion, vomiting, and ketonuria. Hyperglycemia is not necessary, as there is euglycemic ketoacidosis in these cases. It is associated with certain risk factors such as alcohol abuse or in patients whose insulin secretion deficit rather than insulin resistance predominates as the cause of diabetes.

2.2 Hypertension

2.2.1 Therapeutic Target

In patients with CKD, the blood pressure target has evolved toward stricter control as the guidelines have been updated, especially since the publication of the SPRINT study [23]. The 2021 blood pressure in CKD KDIGO guidelines, which are the most recent, recommend a target below 120/80 mmHg as long as it is well tolerated [24].

2.2.2 Blood Pressure Measurement

Patient preparation and a standardized blood pressure measurement technique are vital for the diagnosis and follow-up of hypertension. The following recommendations should be followed in order to have an excellent management of blood pressure [24].

Patients should:

1. Be seated in a chair, relaxed, with both feet on the floor and back supported, for at least 5 min. The patient's blood pressure (BP) should not be measured sitting or lying on a stretcher.
2. Not have smoked, exercised, or consumed caffeine at least 30 min before the measurement.
3. Have emptied their bladder.
4. Not talk during measurement or rest times.
5. Have BP measured in both arms and then use whichever arm gave the higher value. A difference of 15 mmHg or more between the two arms is associated with increased mortality risk.
6. Have the pressure cuff placed on the arm, at the level of the right atrium (approximately the midpoint of the sternum), with the cuff resting on a surface. In addition, it should be of adequate size.
7. Have their blood pressure estimated from the average of two or more readings on two or more occasions, separated by at least 1 min.
8. Have their study complemented with self-measurement of blood pressure (AMPA) at home or ambulatory blood pressure monitoring (ABPM) if a high blood pressure is measured at the medical visit. The latter is also useful for confirming the diagnosis of hypertension, identifying phenotypes of white coat hypertension, masked, diurnal or nocturnal pattern, etc., and is especially recommended in patients with CKD.

2.2.3 Treatment of Hypertension

Nonpharmacologic therapy should be the first step in the treatment and management of hypertension, especially among patients with CKD [24]:

- Daily sodium intake <2 g or < 5 g sodium chloride.
- Moderate-intensity exercise for 150 min per week (compatible with cardiovascular status and physical tolerance).

- Reduction of alcohol consumption and smoking cessation.
- Weight loss if overweight or obese.

The first-line treatment with antihypertensive drugs for persons with CKD should always be an ACEi/ARB at the highest tolerated dose, regardless of proteinuria or diabetes, to achieve a greater kidney protective effect [24]. Combination with another RAASi is contraindicated regardless of finerenone in diabetic kidney disease. As previously explained, creatinine and potassium should be monitored 2–3 weeks after treatment initiation to check for hyperkalemia. In the case of hyperkalemia, concurrent drugs must be reviewed, potassium intake has to be reduced, and the introduction of diuretics, sodium bicarbonate, or potassium binders must be considered. On its part, if the increase in creatinine is higher than 30%, other causes of acute kidney injury must be ruled out, volume repletion has to be reassessed, concomitant medications ought to be reviewed, and renal artery stenosis should be considered [25].

Double therapy should be considered when blood control is suboptimal or even at the start in persons with very high blood pressure. In that sense, the individualization of the treatment to the person's phenotype is the best option and should be addressed under these recommendations:

- In persons with coronary artery disease, a beta-blocker would be the chosen drug to add.
- In those with volume overload, a loop diuretic would be the best option.
- In those with heart failure with reduced ejection fraction, the combination of beta-blocker, SGLT2i, MRAs, and sacubitril/valsartan would be the best option, even at the lowest doses.
- Finally, in the rest of the situations, thiazide diuretics, preferably chlorthalidone, must be considered the preferred second-line treatment in hypertension management.
- Resistant hypertension is defined as persistent above-target blood pressure levels despite using maximum tolerated doses of three different drugs. In such cases, secondary hypertension must be ruled out. In the meantime, a combination of second-line drugs like dihydropyridine calcium antagonists, alpha-blockers, or vasodilators should be used.

Remember to target a BP below 120/80 mmHg as long as it is well tolerated.

2.3 Diabetes

Diabetes and prediabetic states with insulin resistance should be actively screened, prevented, and if diagnosed, properly treated to slow their progression.

2.3.1 Diagnosis of Diabetes

According to the latest American Diabetes Association guidelines, diabetes is diagnosed when at least two of the following criteria are met, either in single or different samples [26]:

- Basal plasma glucose after at least 8 h of fasting greater than or equal to 126 mg/dL.
- Glycated hemoglobin (HbA1c) $\geq 6.5\%$.
- Blood glucose value ≥ 200 mg/dL at 2 h after oral glucose tolerance test with 75 mg of glucose.

However, if there are classic symptoms or hyperglycemic decompensation, diabetes can also be diagnosed with any of these criteria or even with blood glucose ≥ 200 mg/dL, regardless of fasting [26].

The criteria defining prediabetes are [26]:

- Basal plasma glycemia after at least 8 h of fasting between 100 and 125 mg/dL.
- Glycated hemoglobin (HbA1c) between 5.7 and 6.4%.
- Blood glucose values between 140 and 199 mg/dL 2 h after the oral glucose tolerance test with 75 mg of glucose.

2.3.2 Therapeutic Target

In recent years there has been a change in the paradigm of diabetes management. From the point of view of glycemic control, semi-annual HbA1c monitoring is recommended. However, it can be measured quarterly when the patient is out of range, or therapeutic changes need to be evaluated. The HbA1c target should be individualized according to different factors, depending on which it will range from $<6.5\%$ to $<8\%$, being more permissive in persons with advanced CKD, established macrovascular complications, many comorbidities, and short life expectancy [27].

In addition, treatments that may produce hypoglycemia should rest as second-line options, but in those persons under these drugs, the propensity of the treatment to cause hypoglycemia, the awareness of the person to identify it, and the resources for its management should also be taken into account to determine an HbA1c goal.

It should be considered that the reliability of HbA1c for diabetes control declines as CKD progresses and that its value can be altered by metabolic acidosis, anemia, transfusions, iron repletion, and erythropoiesis-stimulating agents [27].

2.3.3 Lifestyle Recommendations for Chronic Kidney Disease Individuals and Family

CKD can be partially controlled with a few actions, one of them is to adapt the lifestyle in a way that kidney's life can be protected and prolonged. Some of the lifestyle recommendations for individuals and family members who suffer from CKD are as follows:

- Individualized diet according to other needs secondary to CKD but with a high content of vegetables, fruits, whole grains, fiber, legumes, vegetable proteins,

unsaturated fats, and nuts and less processed meats, refined carbohydrates, and sugary drinks.

- Protein intake of 0.8 g of protein per kg of weight per day.
- Daily sodium intake <2 g or <5 g of sodium chloride.
- Moderate-intensity exercise for 150 min per week (compatible with cardiovascular fitness and physical tolerance).
- Reduction of alcohol consumption and smoking cessation.
- Weight loss if overweight or obese.
- Patient education on diabetes.

2.3.4 Pharmacological Treatment of Diabetes

For the medical treatment of type 2 diabetes, and in accordance with the therapeutic objective of preventing cardiovascular and renal events, priority should be given to the two pharmacological groups that have demonstrated cardiorenal benefit: GLP-1 receptor agonists (GLP1a), specifically the human analogues (semaglutide, liraglutide, or dulaglutide)[28–31], and SGLT2 inhibitors [20–22].

Remember to target HbA1c individually, being stricter in young individuals and more permissive in persons with established macrovascular complications, many comorbidities, and short life expectancy

- A. In patients with an $\text{eGFR} \geq 30 \text{ mL/min/1.73m}^2$ it is recommended to directly initiate dual therapy with:
 - (a) Metformin
 - (i) The dose should be adjusted according to eGFR.
 - (ii) Suspension of treatment when eGFR falls below $30 \text{ mL/min/1.73 m}^2$.
 - (b) SGLT2 inhibitors
 - (i) They lose efficacy in glycemic control when eGFR falls, but they do maintain the cardioprotective and nephroprotective effects.
 - (ii) Due to lack of evidence, their initiation is not recommended with eGFR below $20 \text{ mL/min/1.73 m}^2$.
 - (iii) Once started, it can be maintained until starting dialysis, regardless of the current eGFR.
- B. In patients with $\text{eGFR} < 30 \text{ mL/min/1.73 m}^2$, or in those in whom metformin and iSGLT2 dual therapy is insufficient to achieve glycemic control, it is recommended to prescribe hypoglycemic drugs according to their comorbidities:
 - (a) In general, and especially in patients at high cardiovascular risk, it is recommended to associate GLP1a, especially in patients with a BMI $> 30 \text{ kg/m}^2$.
 - (b) In patients with steatohepatitis, the use of aGLP1 and thiazolidinediones is recommended.
 - (c) In patients who wish to avoid injectables, insulin should be avoided, and, in the case of wanting to initiate aGLP1, oral semaglutide should be chosen.

2.4 Dyslipidemia

CKD increases cardiovascular risk and changes the levels and composition of blood lipids due to uremia [32]. In its early stages, triglyceride levels are elevated, and high-density lipoprotein (HDL) cholesterol ones are reduced. Low-density lipoprotein (LDL) subclasses show a shift toward an excess of small dense LDL particles. There is also an increase in lipoprotein a [Lp(a)] that is inversely proportional to the fall in eGFR [33].

2.4.1 Pharmacological Treatment of Dyslipidemia

Hypercholesterolemia

High-potency statins plus ezetimibe are recommended to achieve the LDL cholesterol targets. If a patient is on statin therapy with or without ezetimibe and starts dialysis, it is recommended to maintain the treatment [34]. However, if the patient was not on it previously, it is not recommended to start it regardless of LDL cholesterol levels [35].

Other pharmacological options are the PCSK9 inhibitors (iPCSK9) which are indicated in cases of familial hypercholesterolemia, in patients with uncontrolled cholesterol despite a maximum tolerated dose of statins, and those who are intolerant to statins or in whom statins are contraindicated [36], and bempedoic acid, a novel therapeutic tool that can also be used in conjunction with statins and ezetimibe in patients who do not reach the target. However, its cardiovascular benefits have not yet been well proven [37].

Hypertriglyceridemia

In case of hypertriglyceridemia without risk of pancreatitis, dietary measures are recommended with the option of supplementing omega-3 fatty acids, which reduce triglyceridemia by 20–50% [38]. Gemfibrozil should not be added to statin therapy due to the great potential for interactions. Gemfibrozil inhibits statin metabolism through the glucuronidation pathway, leading to a marked increase in statin plasma concentrations. Since fenofibrate does not share the same pharmacokinetic pathways, the risk of myopathy is much lower with this combination therapy [39]. Furthermore, in cases where pharmacological treatment is insufficient, the alternative of lipoprotein apheresis exists as a safe and effective technique [40].

2.5 Obesity

An increased body mass index (overweight if $>25 \text{ kg/m}^2$ or obesity if $>30 \text{ kg/m}^2$) has been associated with impaired renal function, both indirectly through its association with the development of hypertension, diabetes, and arteriosclerosis and through direct mechanisms on glomerular hemodynamic, inflammation, and hormonal changes [41, 42].

Weight reduction has been associated with a decreased risk of developing CKD. The initial target is a weight loss of more than 5% in 6 months, which is necessary to reduce cardiovascular events [43, 44].

2.5.1 Management of Obesity

Obesity management improves symptoms and complications of comorbidities associated with it, which are also often independent factors of CKD progression. By losing weight, blood pressure, glycemia, sleep apnoea-hypopnea syndrome, or dyslipidemia become less difficult to control.

Remember that those people who are obese and reduce their weight of 5% in 6 months it also reduces cardiovascular events.

Lifestyle Recommendations in the Management of Obesity

The first approach recommended to patients who need to lose weight relies on the following measures:

- (a) Moderate-intensity exercise at least 150 min per week. Increase duration, intensity, and variety progressively as endurance and fitness improve.
- (b) Reduce caloric intake to 1200–1500 kcal/day or at least 30%.
- (c) Behavior modification techniques. Healthier eating, meal planning, limiting consumption of higher calorie foods and beverages, anxiety management techniques [45].

Pharmacological Treatment of Obesity

The Obesity Society [46], the Endocrine Society [47], and the American Association of Clinical Endocrinologists [48] recommend initiating it in patients with BMI > 30 kg/m² or > 27 kg/m² if comorbidities are associated. The treatment options are:

- GLP-1 receptor agonists are used in the management of diabetes and have proven safe in the treatment of weight loss in nondiabetics. They cause a loss of appetite by slowing gastric emptying, and some of them act at the level of the satiety center [49].
- Orlistat is an inhibitor of pancreatic lipase and, by this mechanism, of the absorption of 30% of the lipids ingested. It has adverse effects such as fecal urgency, flatulence, and oily stools [50].
- Bupropion-naltrexone is an adjuvant treatment that acts on the satiety center. It may cause an increase in blood pressure [51].

Surgical Treatment in Obesity

Bariatric surgery is indicated in obese patients with BMI ≥ 40 kg/m² or ≥ 35 kg/m² if associated with comorbidities. It has been shown to be associated with benefits in the risk of progression of CKD due to both the reduction in body weight and lower insulin resistance, better glycemic control, and lowers proteinuria [52].

2.6 Hyperuricemia

Hyperuricemia is clearly associated with hypertension, CKD, cardiovascular disease, and metabolic syndrome but has not been established as a causal factor in any of these disorders. There is only clear evidence to treat symptomatic hyperuricemia: gout or crystalluria, aiming for a target uric acid <6.7 mg/dL. And it is recommended to treat asymptomatic hyperuricemia on an individualized basis, especially when there are sustained or increasing high levels (> 8 mg/dL), by dietary modifications and withdrawal of drugs that may promote it (e.g., thiazides), when possible. When these measures fail, first-line treatment consists of a xanthine oxidase inhibitor, considering the potential risk of triggering a gouty attack with abrupt reductions in uricemia [53].

2.7 Acidosis

Metabolic acidosis has been related to increased mortality in patients with CKD both on dialysis and in previous stages, as well as to the risk of progression of CKD, so oral sodium bicarbonate is recommended to maintain serum bicarbonate of 23–29 mEq/L. These levels are usually achievable with doses of up to 3 grams daily (2–4 tablets or one teaspoon) [54].

2.8 Chronic Kidney Disease-Mineral Bone Disorder (CKD-MBD)

CKD-MBD integrates all the biochemical, skeletal, and extra-skeletal calcifications that result from mineral metabolism alterations in CKD. One or different combinations of them manifest mineral metabolism alterations in CKD [55].

The following abnormalities observed in calcium, phosphorus, and parathyroid hormone (PTH) appear in response to the loss of nephron mass: Klotho depletion, reduced phosphorus filtration, increased fibroblastic growth factor 23 (FGF-23), reduced 1, 25 (OH) vitamin D (calcitriol), increased PTH, and low serum calcium.

Serum calcium, phosphorus, and alkaline phosphatase should be determined with each visit in CKD stages 3–5 not on dialysis. PTH and vitamin D levels should be determined every 6 months or monthly if a treatment has been modified [56].

Patients with CKD are more likely to present a fatal cardiovascular event than to progress to end-stage kidney disease. The high mortality seen in this group of patients is closely related to atherosclerosis, mainly driven by uremic-toxin and altered calcium-phosphorus-driven vascular calcification as high phosphate and calcium can precipitate and deposit in soft tissues such as wall vessels. Clinically, this collection of abnormalities generates mineral bone density disorders that can be classified according to the following pathophysiological mechanisms: low bone turnover with abnormal mineralization (osteomalacia), low bone turnover with normal mineralization (adynamic bone disease), high bone turnover (osteitis fibrosa), low bone density (osteoporosis), and high bone density (osteopetrosis) [57]. One of

the most bothersome aspects of hyperphosphatemia management for patients is the use of phosphorus binders. Patient education on their importance and proper use is essential to CKD-MBD management [58]. Other treatments are 25-OH vitamin D, active analogues of vitamin D, and calcimimetics. Over the counter, calcium and aluminum-containing medications (such as antacids and nutritional supplements) should be avoided unless prescribed by the nephrologist [59].

The approach to each possible CKD-MBD alteration requires multiple approaches, as treating one deficiency may alter another component of calcium-phosphorus metabolism. Healthcare professionals' job is to modify medical treatment, nutritional approach, and patients' education to maintain homeostasis.

Patients with CKD are more likely to present a fatal cardiovascular event than to progress to end-stage kidney disease, partly due to calcium-phosphorus-driven vascular calcification as high phosphate and calcium can precipitate in wall vessels.

2.9 Anemia

Anemia is one of the most common and clinically relevant complications of CKD as it can severely alter patients' quality of life if left untreated. Anemia in CKD can appear from early stages; however, it usually occurs in stage 4 (or earlier in diabetic patients [stage 3b]) and worsens as CKD progresses; in dialysis patients, around 90% of patients present anemia [60].

2.9.1 Definition of Anemia

Anemia is defined as a blood hemoglobin concentration of <13 g/dl in adult males or < 12 g/dL in adult females [61]. The diagnosis of renal anemia is a diagnosis of exclusion. Other causes of anemia may be suspected if the severity of anemia is disproportionate to the stage of CKD; there is evidence of iron, folic acid, or vitamin B12 deficiency, pancytopenia, etc.

2.9.2 Recommended Periodicity for Hemoglobin Determinations

1. In patients without known anemia, hemoglobin levels should be measured when clinically indicated (development of symptoms: asthenia, dyspnoea, tachycardia, etc.) and
 - (a) At least once a year in persons with CKD G3.
 - (b) At least 2 times a year in persons with CKD G4-G5.
 - (c) At least every 3 months in patients in dialysis.
2. In patients with anemia and not treated with erythropoietin stimulating agents (ESA), hemoglobin levels should be measured when clinically indicated and
 - (a) At least every 3 months in persons with CKD stages G3-G5 not on dialysis (CKD-ND) or those on peritoneal dialysis (PD).
 - (b) Monthly in persons on hemodialysis (HD).

3. In patients with anemia and treated with ESA, hemoglobin levels should be measured when clinically indicated and
 - (a) Monthly in the correction phase.
 - (b) In the maintenance phase: in persons with non-dialysis dependent CKD, at least every 3 months; in those on HD monthly; and every 2 months in those on peritoneal dialysis.

2.9.3 Pharmacological Treatment of Anemia

The objectives of the treatment of anemia in CKD are to reduce transfusion requirements, improve patients' quality of life, reduce cardiovascular morbidity and mortality, and delay the progression of CKD.

Even though most patients with CKD anemia are due to iron deficiency and reduced erythropoietin production, an initial evaluation should include folic acid, vitamin B12, and thyroid stimulating hormone. Any deficiency found should be corrected before initiating treatment with an ESA.

Treatment of anemia of CKD includes [61]:

Remember that iron, folic acid, and vitamin B12 deficiencies should be corrected before initiating treatment with erythropoietin stimulating agents.

- Iron supplementation. Iron is essential hemoglobin synthesis, so it must be corrected before initiating an ESA to ensure optimization of erythropoiesis [62, 63]. Thus, iron administration is indicated in patients with CKD with anemia and iron deficiency. It should be noted that iron deficiency in patients with heart failure, regardless of the presence of anemia or not, is associated with decreased physical performance, worse health-related quality of life, and increased risk of mortality. Hence the European Society Cardiology guidelines recommend that all patients with heart failure should have their iron parameters determined and that treatment with intravenous iron carboxymaltose should be considered as a treatment option in symptomatic patients with heart failure, reduced ejection fraction, and iron deficiency [64]. Iron can be supplemented either by oral or intravenous formulations in accordance with patient tolerability to the former. Oral iron is associated with gastrointestinal side effects including nausea, flatulence, diarrhea or constipation, and black stools [65].
- Erythropoiesis-stimulating agents (ESA). Treatment with ESA should be considered when other causes of anemia have been excluded or corrected, and anemia persists despite iron replenishment [62]. Although a history of stroke, neoplasia, or previous ESA treatment are not absolute contraindications, the risk of disease recurrence or progression must be evaluated and discussed with patients [66].
- Hypoxia inducible factor (HIF) prolyl hydroxylase inhibitors. When oxygen levels are limited, HIF regulates biological processes that facilitate oxygen and iron transport to enhance cell survival, including genes involved in angiogenesis,

anaerobic glycolysis, fatty acid and mitochondrial metabolism, cell differentiation and motility, erythropoiesis, and iron metabolism. HIF-PHI inhibit the degradation of HIF subunits, independent of oxygen and iron levels, resulting in increased expression of HIF-regulated genes, such as EPO or the EPO receptor, and genes involved in iron uptake and transport. They can be used as an alternative to ESA in cases of ESA resistant anemia [67].

- Blood transfusions. Treatment of last resort when needed. In cases of severe ESA resistance or acute anemia, blood transfusions can be prescribed to correct CKD anemia and improve patient outcome. However, blood transfusion requirements are rare and other causes of chronic blood losses should be sought (e.g., colorectal cancer) [59].

3 Conclusions

CKD is a disease with a high economic, mortality, morbidity, and quality-of-life burden. Preventing CKD progression and cardiovascular events is vital to control this condition, so classic and emerging cardiovascular risk factors must be addressed. In that sense, a multimodal approach is needed to achieve excellent CKD management, requiring a combination of physicians, nurses, psychologists, physiotherapists, and dietitians.

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Oral Care for Adults with CKD

Tai Mooi Ho and Navdeep Kumar

Learning Objectives

- To raise awareness of the importance of oral care in the management of people with chronic kidney disease (CKD).
- To describe the oral manifestations associated with poor oral health in people with CKD.
- To understand the potential bidirectional relationship between oral health and CKD.
- To identify the key components of oral care assessment in people with CKD.
- To provide latest evidence-based oral care recommendations.

1 Introduction

Oral health is an important component of a person's general well-being and quality of life [1]. A healthy mouth allows the person to eat and speak without having difficulty/pain and to socialize without any psychosocial effects. This multidimensional aspect of oral health is captured in the universal definition developed by the FDI (*Fédération Dentaire Internationale*) World Dental Federation in September 2016 [2].

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Definition of Oral Health (FDI World Dental Federation)

Definition:

Oral health is multi-faceted and includes the ability to speak, smile, smell, taste, touch, chew, swallow, and convey a range of emotions through facial expressions with confidence and without pain, discomfort, and disease of the craniofacial complex (head, face, and oral cavity).

Further attributes of oral health:

- *It is a fundamental component of health and physical and mental well-being. It exists along a continuum influenced by the values and attitudes of people and communities.*
- *It reflects the physiological, social, and psychological attributes that are essential to the quality of life.*
- *It is influenced by the person's changing experiences, perceptions, expectations, and ability to adapt to circumstances.*

The main functions of the mouth are eating and speaking, both of which involve the lips, tongue, and teeth/dentures as well as adequate salivation. Adults normally have a maximum of 32 teeth. Saliva is also an important component of a healthy mouth and has several functions. It lubricates the mouth, thus facilitating speech and dietary intake, cleans the oral cavity by flushing food and debris, neutralizes acids, and helps to strengthen tooth surfaces. It contains a digestive enzyme (amylase), which acts on carbohydrate starches to help break them down into simple sugars. It also possesses antimicrobial properties [3].

A healthy mouth has the features as described in Fig. 1 [4].

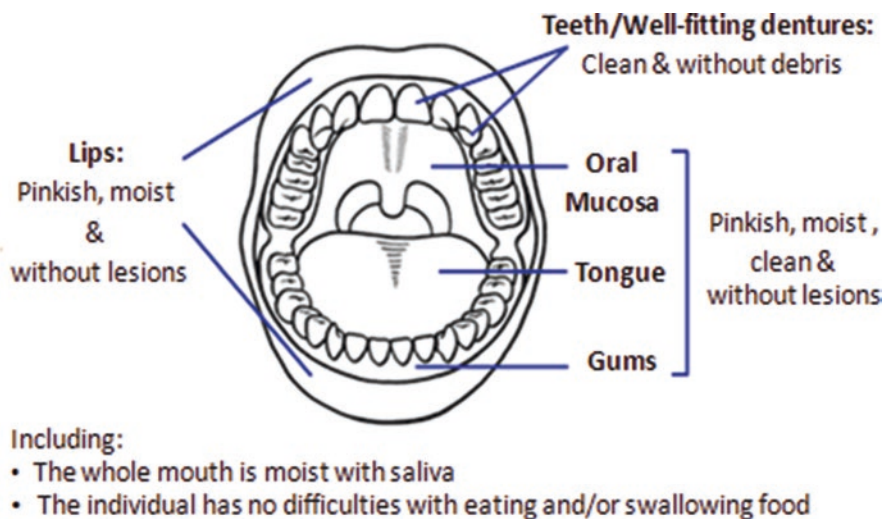


Fig. 1 Parts and description of a healthy mouth

2 Importance of Good Oral Hygiene

Maintaining good oral hygiene helps to prevent infections. Inadequate mouth care causes plaque build-up (sticky film of bacteria) on the teeth and can result in dental caries and periodontal disease (gum disease). If plaque build-up is not removed, it can harden to form calculus (yellow deposits attached to the teeth) which can worsen periodontal disease [5].

Poor oral health can significantly impact quality of life by disrupting physical, psychological, and/or social functioning due to difficulty with eating and/or speaking, insomnia, irritability, embarrassment, and low self-esteem [1, 6]. A tooth with dental decay and/or gum disease may be associated with pain, infection, and swelling, particularly when the decay involves the nerve of the tooth and there is a dental abscess. Furthermore, nutritional intake may also be compromised due to related dental pain, mobile teeth due to periodontal disease, and loss of teeth [7], causing problems with eating, drinking, and swallowing.

There is also an increasing body of evidence to support the association of poor oral hygiene/periodontal disease with non-communicable diseases [8], such as diabetes [9], cardiovascular disease (CVD) [10, 11], and chronic kidney disease (CKD) [12], among others.

3 Oral Health and CKD

Many authors have described the interaction between oral health and CKD [13–17]. According to Oyetola et al. [13], around 90% of people with CKD will have oral signs or symptoms, including bleeding gums, xerostomia (dry mouth), thrush, burning mouth, abnormal taste, and abnormal lip pigmentation. Ruospo et al. (2014) reported the results of their systemic review of oral findings described in 88 studies relating to 125 populations, involving a total of 11,340 adults on dialysis [18]:

- 57% had gum disease (periodontal disease)
- 50% had dry mouth
- 20% were edentulous
- 19% had oral pain
- 25% never brushed their teeth

Periodontal disease is highly prevalent and often more severe among people with CKD and may lead to tooth loss [14, 19, 20]. Signs of periodontal disease include [10]:

- Red or swollen gums (gingivitis)
- Bleeding from the gums, particularly during toothbrushing
- Bad taste
- Mobile teeth
- Increasing spaces between teeth
- Yellowish/brownish teeth due to dental calculus

Fisher et al. (2011) [15] suggested a bidirectional link between CKD and periodontal disease. This effect is postulated to be in part due to endovascular inflammation, which is a feature of both conditions, and mediated by diabetes duration and hypertension [21].

Periodontal disease has also been associated with many systemic consequences such as low serum albumin [22, 23], inflammation, infections, protein-energy wasting, atherosclerotic complications [24], and increased levels of markers of inflammation (e.g., C-reactive protein). It has been identified as a risk factor for the decline of kidney function and may be one of the aggravating factors increasing the risk for mortality [15–17, 25] and potentially contributing to higher cardiovascular risk [21, 23, 26]. Its association with cardiovascular morbidity and mortality has been described not only in people on hemodialysis (HD) [27] but also in those with CKD stages 3–5 [17].

Dry mouth, also known as xerostomia, is more common in people with CKD [28]. The dryness is caused by a lack of adequate saliva flow to mix with food particles during the process of mastication and is often accompanied by an abnormal taste and burning sensation. This can not only increase the risk of dental caries but also negatively impact on an individual's nutritional status and quality of life [6].

Epidemiological studies have identified that in addition to untreated oral infection being associated with systemic disease, it may also be the trigger for the spread of potentially pathogenic microorganisms such as candida, to other parts of the body, particularly in the immunocompromised transplant recipients [29].

4 Oral Manifestations of CKD

People with CKD are prone to develop a wide array of oral manifestations (Table 1) [14, 28, 30]. These can result in a significant impact on the person's quality of life. For example, a decreased salivary flow can result in several oral health problems such as discomfort, loss of oral tissue integrity, difficulty with chewing, swallowing foods and speaking, and an increased risk of dental caries and oral infections [3].

Further information is also available via the following link: <https://www.edtn-aerca.org/education/educational-session>.

Nurses have a fundamental role in ensuring that proper oral hygiene is provided to people under their care [31]. However, several authors have concluded that, in general, mouth care is given a low priority in clinical practice, despite displaying a positive attitude [32–35]. This has been reported to be due to a lack of adequate knowledge with regard to the importance of oral health and minimal clinical experience in the assessment of the oral cavity [34].

Table 1 Common oral manifestations in adults with CKD [14, 30]

Manifestations	Underlying cause in CKD
Xerostomia (dry mouth)	Restriction in fluid intake/dehydration Side effects of drug therapy Uremic involvement of salivary glands Mouth breathing
Metallic taste	Increased concentration of urea in the saliva transformed into ammonia and carbon dioxide by bacterial urease Metabolic disturbance Change in salivary flow/composition Low levels of zinc
Halitosis (bad breath)	Uremia—Ammonia release causing a “fishy/urine odor” Poor oral health/gum disease Contributed by underlying diabetic ketoacidosis Dietary factors
Gingival changes	
Gingival hyperplasia (enlargement)	Drug therapy such as cyclosporin (transplantation) and/or calcium channel blockers (hypertension)
Gingival bleeding	Platelet dysfunction and the effects of anticoagulants used (HD)
Pale gingivae	Anemia
Mucosal lesions	
For example, white patches and/or ulcerations	Drug therapy and/or uremia
Periodontitis	
Infectious inflammatory condition characterized by the damage of tooth support tissues due to the accumulation of bacterial dental plaque	Poor oral hygiene in the elderly Burden of common co-morbidities such as diabetes mellitus, multiple drugs regimen, and immune dysfunction
Oral infections	
Candidiasis (thrush)	Suppressed immune system among dialysis and transplant patients
Viral	
Dental anomalies	
Narrowing or calcification of the pulp chamber	Alterations in calcium and phosphorus metabolism
Loss of non-carious tooth tissue	Frequent nausea/vomiting or regurgitation induced by uremia and medication
Orofacial features	
Bones, teeth, and periodontium	Alterations in calcium and phosphorus metabolism

5 Oral Cavity Assessment

It is important to use an oral assessment guide to carry out a thorough screening of the patient’s mouth and establish a care plan tailored to patient’s individual needs. Assessment findings and all subsequent oral care provided should be recorded accordingly in the patient’s clinical notes. Nurses should provide oral hygiene care to admitted patients who are dependent and are unable to carry out the procedure on

Table 2 Oral cavity assessment [31]

Prior to the assessment: Explain procedure to patient and obtain verbal consent.		
Prepare equipment: A pen torch for better visibility, a clean wooden spatula.		
Wash hands, wear facemask, put on disposable apron and gloves.		
What to look out for:		
Patient's condition	Is the patient physically and mentally fit to perform daily oral care on his/her own?	
	Does the patient complain of: Pain? Difficulty with speaking? Difficulty with chewing/swallowing foods? Unpleasant taste?	
Oral cavity	Lips	Are they pink, smooth, and moist? Are they dried/cracked, with difficulty opening the mouth? Are they swollen/ulcerated?
	Tongue	Is it clean, pink, smooth, and moist? Is it dry, coated, fissured, and shiny? Does it look abnormal (white patches, very sore/ulcerated)?
	Teeth/ dentures	Are they clean (free of plaque and debris/food particles)? Any missing/broken/loose teeth? If dentures, are they well-fitted and comfortable? Any dental caries?
	Gums	Are they pink and moist? Are they swollen and red (inflamed)? Do they bleed during toothbrushing?
	Mucous membrane	This includes cheeks, palate, and under the tongue: Is it smooth, moist, and pink? Are there any lesions (ulceration and bleeding or white patches)? Is it reddened and coated?
	Saliva	Is it thin and watery? Is the mouth very dry with cracked tongue and lips? Does the mouth have an unpleasant smell?

their own. Ideally, every patient should have an oral assessment within 48 h of admission or at the first appointment with the kidney care team [31].

Prior to undertaking an oral assessment it is important to ensure that all the necessary equipment is available (Table 2). The renal nurse should then undertake a systematic assessment of the oral cavity and be aware of signs and symptoms that may indicate the presence of oral disease and/or manifestations of CKD (Table 2).

6 Toothbrushing

Toothbrushing after every meal should be part of a hygiene routine for patients who suffer CKD and a few aspects are very relevant in order to be effective and obtaining good outcomes from it. These are some tips to follow:

- Ensure that all patients have his/her own toothbrush. Toothbrushing is the best method for removing dental plaque, a thin coat of sticky colorless bacteria that forms on teeth through eating and drinking, particularly sugary foods and beverages. These bacteria absorb the sugar and convert it into acid which destroys tooth enamel, thus resulting in caries [31].
- Advocate for regular oral care with a toothbrush (small head with soft bristles) and a pea-sized amount of fluoridated toothpaste containing at least 1350 ppm fluoride. Higher fluoride (2800 or 5000 ppm) toothpaste can be prescribed for patients with dry mouth and/or sensitive teeth to erosion [31, 36].
- Toothbrushing should be undertaken at least twice a day—morning and night. Patients should not drink/eat for 30 min after brushing and not at all after brushing at night. The correct brushing method is to place the bristles of the toothbrush at a 45° angle to the gum line, gently move it in a circular motion, brushing the outer, inner and the chewing surfaces of all teeth, for 2 min in total [31].
- Advise patients to spit, not rinse the mouth during/after toothbrushing. This ensures that the beneficial effects of the fluoride in the toothpaste are optimized [31]. Patients should not brush their teeth immediately after an acidic meal/vomiting. Instead, they can be encouraged to rinse their mouth with water.
- Instruct patient to replace his/her toothbrush when the bristle becomes frayed, e.g., splaying of the outer tufts beyond the base of the toothbrush [37], as this is when the toothbrush is less efficient to remove dental plaque.
- Chlorhexidine 0.2% alcohol free mouthwash (used 30 min after toothbrushing) is the agent of choice to reduce dental plaque by inhibiting bacterial growth but frequent use tends to stain teeth [38, 39]. It may be advised for gum disease but should not be used if there is a reported allergy to this agent.

7 Denture Care

Those patients who have denture, should also follow a hygiene routine in order to avoid any infections or complications. The following indications can improve denture care:

- After each meal dentures should be cleaned thoroughly, using a small toothbrush/denture brush to remove debris and plaque.
- They should be removed every night and left overnight in water with a denture cleansing tablet. This measure has been proven to reduce the total bacterial count [40].
- For a hospitalized patient, dentures should be placed in a container with lid and marked clearly with the corresponding owner's full name.

8 Recommended Oral Care and Advice for Oral Health Problems

Table 3 describes examples of evidence-based recommendations that may be used for adults with CKD who are hospitalized (in a non-critical state, on dialysis sessions, or admitted as transplant recipients):

Table 3 Care and advice for oral health problems in different areas of the mouth according to their aspect and condition

Part of the mouth	Aspect and condition	Recommended care and advice
Lips	Pink, smooth, and moist	No special care needed but maintain usual oral hygiene.
	Dried/cracked, with difficulty opening the mouth	If painful, determine cause (e.g., ill-fitting dentures/ infection/other injuries) Use toothpaste without sodium lauryl sulfate (SLS) which causes less irritation [31] Keep mouth clean and take frequent sips of water. In case of fluid restriction, wet the mouth Apply a lubricant (e.g., olive oil, aloe vera gel, or rapeseed oil spray) to keep dry lips intact, thus preventing soreness from cracked lips. It also provides a natural barrier to infections [41]
	Swollen/ulcerated	Refer to medical staff
Tongue	Pinkish, moist, clean, and no lesions	No special care needed but maintain usual oral hygiene
	Dried and fissured	Same care as for dry mouth (see below)
	Abnormal appearance with white layer, ulcerated, and painful	Refer to medical staff
Teeth and gums	Teeth: Clean, not broken or loose/ well-fitting dentures Gums: Pinkish, moist, clean, and no lesions	Maintain oral hygiene as usual—toothbrushing morning and before bedtime
	Teeth: Dental plaque + cavities without pain Gums: Bleeding/swollen	Advocate regular toothbrushing morning and before bedtime and provide instruction on proper brushing technique. Chlorhexidine 0.2% alcohol free mouthwash may be used 30 min after toothbrushing (helps to reduce dental plaque by inhibiting bacterial growth, but frequent use tends to stain teeth [38, 39] it may be advised for gum disease Recommend professional dental cleaning to remove plaque
	Teeth: Severe pain with facial swelling	Refer to medical staff

Table 3 (continued)

Cheeks, palate and under the tongue	Clean and healthy looking	No special care needed but maintain usual oral hygiene
	Dry mouth, sticky secretions, food debris, ulcers <10 days	Dry and sore mouth: Clean the oral cavity. Remind the patient to keep his/her mouth clean and have frequent sips of water. If on fluid restriction, hydrate the mucosa with a sponge stick/moist soft toothbrush [31] Foam swabs/cleansers can be used but not as a routine substitute for a toothbrush because they do not effectively remove dental plaque [31, 42] Advise to chew sugar-free gum to stimulate salivary flow [31] Avoid sweet products/carbonated drinks/lemon juice as a measure to stimulate saliva. These products increase the possibility of dental caries and erosion [31] Do not recommend the use of lemon and glycerine swabs as they cause acidity/dental decay and dryness, respectively [43] Remember that medications can cause xerostomia [14]. Most people on dialysis have other common chronic conditions such as hypertension, diabetes, CVD, and mineral bone disease, all of which require long-term polypharmacy management Mouth ulcers: Advise patient to rinse mouth after meals besides maintaining standard oral hygiene Ask the medical staff about the use of topical analgesic and/or anti-inflammatory mouth sprays/mouthwashes with a numbing effect (e.g., benzydamine HCL 0.15%) [31]
	Dry mouth, sticky secretions, food debris, ulcers >10 days	Urgent referral to medical staff
Oral thrush (candidiasis) [30]	Oral thrush typically appears as white (sometimes red) patches on the palate, above the tongue or elsewhere in the mouth The white patches can usually be scraped off, turning into painful raw areas that can bleed	It is common in people who are immunocompromised (e.g., dialysis and transplant), those having dry mouth, taking antibiotics and/or steroids, and those not cleaning their dentures properly Encourage proper oral hygiene and healthy habits (refrain from smoking). Advise people who use dentures on how to clean their dentures (see “denture care”). In addition, chlorhexidine 0.2% alcohol free mouthwash can be used to clean and soak dentures in it for 15 min twice a day Manage/treat dry mouth, if present Advise people who use a corticosteroid inhaler to rinse the mouth with water after use Refer to medical staff for the prescription of antifungal treatment and to rule out any underlying causes

9 Dental Checkup

Some people may avoid going to the dentist because of dental anxiety and/or the cost of dental care/treatment. However, it is important that the nursing team educates patients and/or carers on the importance of oral hygiene and how to identify oral signs and symptoms that need to be treated by the dentist (Table 3).

It is recommended that all patients on dialysis, particularly those on the transplant list, should have regular dental follow-up. Hence, nurses should be advocates for these patients. Regular oral and dental care can help to reduce the oral disease burden, manage oral manifestations, and improve quality of life. In adults with CKD, it can also improve the transplant outcomes [44].

10 Case Studies

10.1 Case Study A

A 56-year-old male with stage 4 CKD attends his HD appointment complaining that his mouth feels very dry and uncomfortable.

A structured oral assessment is performed and it is noted that he has very dry, cracked lips, his tongue and soft tissues are also dry, there is a heavy build-up of plaque and calculus on the teeth, with several teeth that look like they have cavities, and others that are mobile.

1. Why would his dry mouth (xerostomia) be a concern?
 - It may be a sign of dehydration
 - It leads to increased plaque accumulation, which in turn can increase the risk of dental caries and periodontal disease
 - It also increases the risk of oral infections such as oral candidiasis
 - Soreness of the mouth/a burning sensation is often associated with it
 - It may lead to difficulty speaking, eating, and swallowing and ultimately contribute to malnutrition
 - It impacts negatively on quality of life
2. What advice would be given in relation to managing his dry mouth?
 - Increase fluid intake/take regular sips of water/suck on ice cubes (if appropriate in relation to fluid restriction)
 - Avoid salivary stimulants such as acid drinks (e.g., lemon/fruit drinks) and sweets
 - Instead to stimulate saliva flow suck on sugar-free sweets/use sugar-free chewing gum
 - Avoid alcohol, including alcohol-based mouthwashes, coffee (caffeine), and smoking as these can make a dry mouth worse
 - See the dentist/doctor regarding the potential use of saliva substitutes/stimulants

10.2 Case Study B

A 47-year-old female attends her clinic appointment and reports that her family complain about her bad breath, and this is significantly impacting negatively on her social interactions, confidence, and well-being.

On oral examination, it is noted that she has marked halitosis, despite brushing her teeth 3 times a day.

1. What could be causing this patient's halitosis?
 - Patients with CKD have high salivary urea levels
 - Decomposition of urea into ammonia increases halitosis
 - A dry mouth can also be associated with halitosis
 - Certain foods can be associated with halitosis, e.g., garlic, onions, cheese, and certain spices
 - The brushing technique may not be effective, particularly if the patient is experiencing fatigue in relation to her CKD
2. What advice would be given to the patient?
 - Discuss whether she needs any psychological support
 - Advise her to see the dentist to review how she is brushing her teeth and her diet

10.3 Case Study C

A 50-year-old female informs you that he has a metallic taste in his mouth which improves temporarily after a dialysis session.

1. Is there a correlation?
 - Dysgeusia (abnormal taste) is common in those with CKD
 - It has also been related to the urea content in the saliva and its subsequent breakdown to ammonia and carbon dioxide by bacterial urease
 - Temporary improvement after dialysis has been reported
 - Xerostomia may also contribute to altered taste perception
2. What would be a nursing concern regarding the impact of the metallic taste?
 - It may contribute to a poor nutritional intake (reduced intake and/or a switch to highly flavored/salty/acidic foods)
 - It may also have a negative impact on quality of life

10.4 Case Study D

When undertaking an oral assessment for a 45-year-old male who presents to the kidney clinic for the first time, it is noted that there are multiple mobile teeth, with several teeth already lost/missing.

1. What does the presence of mobile teeth usually mean?
 - The patient is likely to have advanced periodontal disease leading to a loss of bone support around the teeth and mobility
 - The patient's oral health and cleaning is likely to be poor
2. What are the risks associated with periodontal disease?
 - Pain
 - Infection
 - Loss of teeth
 - Reduced ability to eat efficiently
 - Negative impact on quality of life
 - Potential bidirectional relationship between CKD and periodontal disease
 - Periodontal disease is a contributing factor to increased morbidity and mortality in patients with CKD
3. What advice would be given to the patient?
 - Reinforce the importance of a healthy mouth
 - Review his toothbrushing habits
 - Give appropriate advice on how to adapt these
 - Advise him to see a dentist

11 Conclusions

Regardless of the stage of CKD and the treatment modality that patients are receiving, renal nurses should be fully aware that poor oral hygiene can lead to oral infection that may predispose these patients to systemic complications, increasing the risk for mortality.

Research has identified the need to address the gap in nurses' knowledge about the importance of oral health, oral health promotion, and oral care provision for people under their care, particularly elderly adults with CKD [45]. Training through didactic and experiential learning program can increase nurses' oral health knowledge and oral care competence. Furthermore, the identification of oral manifestations in people with CKD by using an oral and nutritional assessment tool can help to improve oral care provision and patient's health outcomes, thus enhancing quality of life [7, 46].

12 Implications for Nursing Practice

The underlying causes for oral manifestations in CKD are variable. Renal nurses need to be aware of these so that they can advocate for effective oral hygiene and prevent oral disease. In particular, renal nurses should bear in mind that people receiving dialysis often experience xerostomia which can cause significant deterioration in oral health, in addition to oral discomfort and difficulties eating.

Conditions arising from poor oral health can also result in profound psychosocial effects for the individual, negatively affecting their quality of life. For example:

- Halitosis can cause embarrassment and consequently can interfere with social relationships [47].
- Taste disorder can affect appetite and hence the enjoyment of food [48].
- Missing teeth can affect self-image and lower self-esteem, as well as resulting in problems with speech and eating [49].
- Xerostomia, caries, and mucosa lesions can cause discomfort/pain, resulting in distress and affecting appetite/speech [50].

In these circumstances, early identification, supportive advice, oral care, and encouragement of prevention strategies are essential not only to maintain good oral health but also to reduce complications [31]. As described previously, effective screening for potential oral manifestations will enable early detection and management. These measures can have a positive outcome on the quality of life for people with CKD.

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Pharmacological Management of CKD

Michael Corr

Learning Objectives

- To outline the pharmacological management strategies to reduce disease progression in CKD.
- To describe the pharmacological management in relation to the complications of CKD—cardiovascular disease and renal anemia.
- To outline potential adverse risks of common medication groups in patients with CKD.
- To explain the benefits of self-management and adherence to pharmacological treatment in patients with CKD.

1 Introduction

Pharmacological management of chronic kidney disease (CKD) can often be a difficult task. Those living with CKD are often asymptomatic and management is often centered on prevention to end-stage kidney disease (ESKD) which can be hard to quantify the risk of to an individual [1]. People living with CKD are at increased risk of adverse incidents relating to medications [2]. 50% of all medications are exclusively eliminated by the kidneys making those with CKD vulnerable to increased rates of toxicity and side effects [3]. Furthermore, CKD is often associated with other morbidities such as cardiovascular disease [4]. This means that healthcare professionals with less experience of prescribing in CKD often require assistance and guidance relating to how to modify pharmacological therapies for this vulnerable group.

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Following diagnosis of CKD, it is crucially important to address risk factors associated with rapid progression to ESKD. All patients with CKD should have their blood pressure and proteinuria controlled to reduce ongoing decline in kidney function [1, 4]. Those with diabetic kidney disease should aim for good glycemic control and have a dedicated diabetic specialist to assist in their management [5]. Individuals should receive advice about modifiable lifestyle factors such as healthy diet (specific to needs and level of CKD), physical activity, restricting salt intake, smoking cessation and weight management, and then offered pharmacological strategies to reduce the risk of progression to ESKD [6]. Medications which have been demonstrated to reduce progression of CKD beyond their primary function (e.g., reduce blood pressure) are referred to as renoprotective.

2 Hypertension

Hypertension is one of the leading causes of CKD and through complex physiological processes such as renin–angiotensin–aldosterone activation, endothelial dysfunction and sodium retention CKD causes worsening hypertension. Controlling hypertension in CKD is of paramount importance to reduce progression to ESKD. The Kidney Disease Improving Clinical Outcomes (KDIGO) 2021 updated guideline and other international bodies now recommend a systolic blood pressure target <120 mmHg for patients with CKD [7]. This is largely based on evidence from the SPRINT study (Systolic Blood Pressure Intervention Trial) which showed a significant reduction in cardiovascular events with tighter blood pressure control without a significant increase in adverse outcomes (apart from acute kidney injury (AKI) where there was an increased risk) [8]. National bodies such as the National Institute of Clinical Excellence (NICE) in the UK are yet to adapt guidance to these targets likely due to the issues translating the monitoring in the SPRINT trial into clinical practice [9]. Their guidance for patients with CKD is systolic pressure below 140 mmHg (target range 120–139 mmHg) and clinic diastolic pressure below 90 mmHg even if multiple agents are required. If patients with CKD have an albumin/creatinine ratio (ACR) > 70 mg/mmol, then the BP target should be for a clinic systolic pressure less than 130 mmHg (target range 120–129 mmHg) and diastolic pressure less than 80 mmHg [9].

Caution should be taken when reducing blood pressure in elderly individuals with vascular disease as this may lead to cerebral hypoperfusion precipitating falls or renal hypoperfusion precipitating episodes of acute kidney injury [10].

Angiotensin-converting enzyme inhibitors (ACEi) or angiotensin receptor blockers (ARB) are first line agents for hypertension in patients with CKD following multiple trials demonstrating their benefits in maintaining glomerular filtration rate (GFR) and reducing cardiovascular events [7, 11–13]. These agents should be uptitrated to their maximal dose to get desired reduction in blood pressure (and proteinuria). Changes in blood pressure, serum creatinine, and serum potassium should be checked within 2–4 weeks of initiating or increasing the dose of an ACEi and ARB

[7]. A rise of 30% creatinine and a potassium up to 6 mmol/L should be tolerated due to the overall protective function of these medications [7].

Multiple agents are often required to control blood pressure in patients with CKD and second line agents should be tailored by local guidance and specific patient requirements (e.g., diuretics in patients with edema) [7]. ACEi and ARB combination should not be considered given the high risk of complications such as acute kidney injury and hyperkalemia with no proven benefit in reducing progression to ESKD [14]. There is some limited evidence that the addition of a mineralocorticoid receptor antagonist such as spironolactone, eplerenone, and finerenone in patients already on ACEi/ARB therapy may have overall renoprotective effects in diabetic kidney disease though associated with higher rates of hyperkalemia [15]. There are no adequately powered studies that demonstrate reduction in progression of CKD in spironolactone or eplerenone. However, the recent trials [16, 17] showed finerenone reduced risk of cardiovascular events (despite moderate effects on systolic blood pressure) in patients with proteinuric diabetic CKD.

3 Proteinuria

Proteinuria in CKD is due to abnormal transglomerular passage of proteins due to increased permeability of glomerular capillaries and impaired reabsorption by the epithelial cells in the proximal tubule. Reduction in the overall amount of proteinuria in CKD significantly reduces deterioration in kidney function [18]. Many of the agents that are used as first line medications in the control of hypertension in CKD have noted additional benefits of reducing proteinuria. ACEi/ARB should be offered in patients with CKD to reduce proteinuria [5, 7, 9]. Treatment should be commenced and titrated to maximum tolerated dose in patients with CKD and

- Diabetes with ACR ≥ 3 mg/mmol
- Hypertension with ACR > 30 mg/mmol
- ACR ≥ 70 mg/mmol

Sodium-glucose co-transporter-2 (SGLT2) inhibitors are increasingly being used in individuals with diabetes, CKD, and proteinuria following the impressive results in the CREDENCE (canagliflozin) [19] and DAPA-CKD (dapagliflozin) [20] trials that demonstrated their ability to reduce eGFR decline, slow progression to ESKD and improve cardiovascular outcomes. For those with type 2 diabetes KDIGO recommend commencement of an SGLT2 inhibitor in all patients with an eGFR >20 ml/min/1.73 m² and to continue this therapy until the patient is transplanted or on dialysis therapy [5]. Given the high risk of euglycemic diabetic ketoacidosis patients with type 1 diabetes should not be offered SGLT2 inhibitors [21]. Caution should also be taken in commencing patients on SGLT2 inhibitors if they have evidence of peripheral vascular disease or if they are at high risk of urosepsis [5, 21].

Given the recent publication of EMPA-CKD (empagliflozin) [22] it is likely that the role of SGLT2 medications will be expanded in guidelines beyond patients with

diabetes to most patients with proteinuric CKD. The role of SGLT2 inhibitors in non-proteinuric CKD is still to be fully established.

4 Anemia in CKD

Anemia in CKD is a form of normocytic, hypochromic, hyperproliferative anemia which increases in frequency as renal function declines due to reduction in the production of erythropoietin [23]. Not only can it affect a patient's quality of life with increased levels of fatigue and reduced exercise tolerance but is associated with high rates of cardiovascular events [24]. Once anemia is detected other underlying pathologies which could be contributing (such as gastrointestinal malignancy) should be considered and investigated based on clinical history, examination, and initial investigations [25]. The target hemoglobin for patients with CKD is 11–12 g/dl (normal levels in health 13.2–16.6 g/dl in males and 11.6–15 g/dl in females) balancing between improving cardiovascular outcomes with lower hemoglobin levels and increased cerebrovascular incidents with higher hemoglobin levels [26].

Once a diagnosis of renal anemia has been established iron repletion should be the first line in management [25]. Iron repletion not only improves cardiovascular outcomes of patients with CKD but also reduced their dependence on erythropoietin stimulating agents (ESA) and blood transfusions [27].

Iron therapy should be commenced in patients with CKD with transferrin saturations below 30% and ferritin levels <500 ng/ml [25]. Oral iron absorption is reduced in patients with CKD however for those with earlier stages of CKD could be considered. Oral iron is often poorly tolerated with gastrointestinal side effects being common [28]. However, alternative day dosing has been proven to reduce the side effect profile while enhancing overall absorption [29]. A trial of oral iron should last for 1–3 months and evaluated with repeat iron profile and hemoglobin studies. Intravenous iron is commonly used in patients with CKD, particularly those in advanced stages of the disease or those on hemodialysis (HD) [25]. Intravenous iron should not be given to patients with active systemic infections [30].

Following iron repletion if the target hemoglobin is not met an ESA should be considered for patients with CKD [25]. These agents act to stimulate bone marrow to make red blood cells [31]. Since their introduction in 1989 they have revolutionized the treatment of renal anemia and reduced the requirement of blood transfusions for patients with CKD and particularly those on HD [25, 31]. There are a variety of ESAs available with different dosing schedules based on their bioavailability and pharmacokinetics, this allows a tailored prescription to each individual patient. For example, for the lady in the case vignette an ESA delivered by a subcutaneous injection once a fortnight would be appropriate, while a patient on HD could receive an ESA given intravenously during dialysis once a week. Strict monitoring and follow-up are required for patients on ESA, with careful consideration of the rate of hemoglobin rise due to the risk of hypertension and cerebrovascular events such as strokes associated with their use [25].

Roxadustat is an oral medication that has a hypoxia-inducible factor [prolyl-hydroxylase inhibitor](#) which stimulates endogenous production of erythropoietin and hence increases red blood cell production [32]. Roxadustat has recently been licenced for use in the European Union and trial data would suggest it is non-inferior compared to ESA therapy. It is likely to have an increased role when renal anemia guidelines are next updated [25].

5 Cardiovascular Disease in CKD

People living with CKD are at increased risk of cardiovascular morbidity and mortality than general population [4]. Many of the principles discussed earlier in this chapter are key to reducing an individual with CKD's risk of cardiovascular events. Lifestyle factors, glycemia control, blood pressure management, reduction of proteinuria, and correction of anemia have all been found to reduce cardiovascular mortality in patients with CKD [33]. Many first line medications used in CKD such as ACEi/ARB or SGLT2 inhibitors are used due to their dual renoprotective and cardioprotective roles.

In addition, therapy for dyslipidemia should be considered in patients with CKD to further reduce cardiovascular risk [34]. Cholesterol lowering agents such as statins or statin/ezetimibe combination should be initiated in the following groups of patients with CKD:

- Adults ≥ 50 years old with eGFR < 60 ml/min/1.73 m² but not treated with chronic dialysis or kidney transplantation.
- Adults ≥ 50 years old with eGFR ≥ 60 ml/min/1.73 m² (i.e., G1 and G2 CKD).
- Adults aged 18–49 with CKD and diabetes mellitus, previous ischemic heart disease, prior stroke or estimated risk of cardiovascular event in 10 years of 10%.

There is currently insufficient evidence to support statin use in patients already receiving dialysis therapy [34].

6 Acute Kidney Injury in CKD

This is a very common scenario unfortunately as patients with established CKD are at increased risk of acute kidney injury (AKI) [35]. AKI can cause rapid deterioration in kidney function which may not recover and is also associated with increased mortality [36]. Patients with CKD are particularly at risk of severe AKI due to their routine medications or new medications given to them when they present to hospital. Table 1 outlines commonly used medications with potentially nephrotoxic effects [37, 38]. Other medications while not directly nephrotoxic can through their mechanism of action promote states of hypovolemia leading to acute kidney injury such as diuretics and SGLT2 inhibitors [37, 38].

Table 1 Commonly used medications with potential nephrotoxic effects

Medications	Nephrotoxic effect	Mechanism
Acyclovir Ampicillin Ciprofloxacin Methotrexate	Crystal nephropathy	Precipitates into insoluble crystals within renal tubules
Non-steroidal anti-inflammatory (NSAID) Proton-pump inhibitors Rifampicin	Interstitial nephritis	Drug induced inflammation within the interstitial tissue of the kidney
Aminoglycosides (gentamicin/vancomycin) Bisphosphonates Cisplatin	Tubular injury	Direct toxic effect on proximal tubular epithelial cells
ACEi ARB NSAIDS Tacrolimus	GFR alteration	These medications alter intraglomerular blood flow via effects on afferent and efferent renal arterioles

Reference: [37, 38]

In recent years there have been great efforts made to highlight the potential of these medications to exacerbate AKI, especially in patients with CKD. There is increasing awareness and systems in place to prompt clinicians to hold these medications briefly when patients present with hypovolemia/sepsis [39, 40]. However, the observant reader will note that many of the medications mentioned above are also medications discussed earlier in this chapter for their renoprotective roles. Despite these medications often being labeled as, “nephrotoxic,” we commonly use them to reduce GFR decline and reduce cardiovascular mortality in patients with CKD [41]. Hence, following the episode of AKI it is crucial that plans are made regarding reintroduction of medications such as ACEi/ARB or SGLT2 inhibitors [39–41]. Failure to do so can result in rapidly progressive loss of kidney function due to uncontrolled hypertension or proteinuria in the weeks to months following hospital discharge [2].

7 Prescribing in CKD

Patients with CKD are at increased risk of serious adverse incidents related to prescribed medications [2]. Half of all medications are almost exclusively cleared by the kidneys hence those with CKD often require reduced dosing or altered dosing schedules to avoid harmful side effects [3]. Antimicrobials, anticoagulants, and opioids often require altered prescriptions and particular care should be taken with medications which can increase serum potassium levels such as trimethoprim or potassium sparing diuretics [42].

Any new prescriptions should be checked thoroughly in the local formulary or reliable sources such as the Renal Drug Handbook. Pharmacist can often guide any

enhanced monitoring which is required in patients with CKD for new medications (such as trough levels in aminoglycosides) [42].

8 Self-Management Strategies and Improving Adherence in CKD

There are many reasons why individuals may choose to not take medications related to CKD. Often CKD, hypertension and proteinuria are without symptoms with patients feeling no immediate benefit from taking medications [43]. Risk of progression to ESKD is often within years rather than in an individual's immediate future which can make it challenging to remain motivated. Furthermore, the side effects of some medications may make patients less likely to adhere, particularly if they have been described to them as, "nephrotoxic," after an AKI episode [43].

Healthcare professionals have a key role in helping to engage patients in self-management of CKD and increase adherence to key medications. Following diagnosis patients should receive personalized education about their diagnosis and their individual risk of progression to ESKD (websites like <https://kidneyfailurerisk.co.uk/> can help guide these discussions) [44]. Patients should be granted electronic access to their health records and management plans, allowing them to monitor key test results such as kidney function, ACR, and blood pressure measurements [9]. Side effects of medications should be screened for and fully explored with patients and where appropriate alternatives sought. Patients can be advised how to lower their risk of AKI particularly regarding specific medications and sick day rules. They should avoid NSAIDs and trimethoprim containing antibiotics. Sick day rules should be advised that medications such as diuretics, ACEi/ARB and SGLT2 inhibitors should be temporarily withheld when at risk of dehydration (for example, during vomiting and diarrheal illness) and restarted 2–3 days after recovery to prevent a potential AKI [45]. Self-management strategies like home recording of blood pressure can empower patients to actively manage their condition and improve overall adherence [46].

Self-management promotion strategies healthcare workers can employ are patient education, cognitive based therapy and increasing access to health information for patients [47]. A systematic review has found that self-management strategy interventions have significant improvements on standard treatment in patients with CKD with reductions in proteinuria, blood pressure and increases in exercise capacity [48].

9 Case Vignettes

Case Vignette 1

John is a 53-year-old man who has been diagnosed with diabetic kidney disease (due to type 2 diabetes) CKD stage 3A. He is keen to reduce his risk of progressing to ESKD. He has already made lifestyle modifications but wants to know what

medications may be helpful to his aim. His blood pressure is 160/85 mmHg and his urinary albumin/creatinine ratio is 150 mg/mmol (normal < 3 mg/mol).

What medications may be helpful in reducing John's risk of progressing to ESKD?

John is already engaging in modifying lifestyle risk factors for progression of CKD. He will require a diabetes specialist to help assist him achieving good glycemic control. He is hypertensive as his target blood pressure is < 130/80 mmHg. John should be advised to commence an ACEi/ARB which has the dual benefit of reducing hypertension and proteinuria. This will need to be titrated until target blood pressure is achieved. Given his diagnosis of type 2 diabetes a SGLT2 inhibitor should also be considered. These measures will significantly reduce his risk of progression to ESKD.

Case Vignette 2

Mary is a 62-year-old lady with CKD stage 4. She attended her general practitioner who noted she had a reduced hemoglobin and commenced her on oral iron therapy which she has been unable to tolerate. She has also been told she is at increased risk of cardiovascular events and is keen to reduce her risk.

What steps could be taken to manage Mary's symptoms?

As a person living with CKD how could we reduce Mary's cardiovascular risk?

Mary has anemia that is likely due to her CKD; however, other pathologies such as colorectal malignancy need to be considered and excluded. Like many other patients she has been unable to tolerate oral iron therapy. If her transferrin saturations are below 30% and ferritin levels < 500 ng/ml a trial of intravenous iron therapy would be first line therapy. If following iron repletion her hemoglobin remains below target (11-12 g/dl) an ESA should be commenced and titrated until target hemoglobin is achieved.

Treating renal anemia in itself will reduce Mary's risks of cardiovascular events. Hypertension should be treated as outlined in previous case. To further reduce her cardiovascular risk she should be commenced on a lipid lowering therapy such as a statin (she meets criteria of adults ≥ 50 years old with eGFR < 60 ml/min/1.73 m² but not treated with chronic dialysis or kidney transplantation).

Case Vignette 3

Eva is a 75-year-old lady with stable CKD stage 3. Unfortunately, she was recently admitted into the hospital after fracturing her hip. During her inpatient stay she has developed an acute kidney injury. The renal specialist team is called to assess why her kidney function has deteriorated. On arrival they note Eva had a reduced level of consciousness, a lowered respiratory rate and has "jerky" movements of her limbs.

What medications may have increased Eva's risk of developing an acute kidney injury? What medications in this setting may require a dose reduction or modification given her low kidney function?

Patients with CKD such as Eva are at increased risk of AKI. Many of the medications used to prevent progression of CKD such as ACEi/ARB or SGLT2

inhibitors can exacerbate AKI if a patient experiences dehydration. It is likely Eva was fasting and had reduced fluid intake due to her operation and may have been given non-steroidal anti-inflammatory medications for analgesia which could have precipitated an AKI. Potential nephrotoxic medications (see Table 1) should be held or monitored closely until her kidney function has improved.

Eva has symptoms of opioid toxicity. She is likely receiving opioid medications as analgesia following her operation. Due to her AKI she will have reduced clearance of these medications which can lead to accumulation and toxicity. Immediate treatment for opioid toxicity should be initiated. Her medication list should be carefully reviewed with a pharmacist to assess medications which will require dose alteration, enhanced monitoring or cessation until kidney function improves.

Case Vignette 4

Following discharge Eva's blood pressure and proteinuria control have deteriorated which corresponds to the reduction in her kidney function. She admits she has stopped taking a lot of her medications.

What factors could be affecting Eva's engagement with her pharmacological therapies? What measures could be introduced to help Eva?

Given Eva's experience in hospital she may be concerned about her risk of AKI. Many of her routine medications used to control hypertension and reduce proteinuria (e.g., ACEi, SGLT2 inhibitor) will have been stopped temporarily in hospital. It is likely she was told some of these medications are potentially nephrotoxic and hence is worried about their effect on her kidney function. It is crucial her healthcare professional explains the purposes of these medications to her and reinforces their overall benefit in reducing progression of CKD. Giving Eva access to her medical information and data where she can see her laboratory results may help motivate her and demonstrate that these medications are beneficial. Encouraging home self-measurement of blood pressure may also improve adherence to antihypertensive medications. Finally to reduce her risk of future AKI she should be educated on the "Sick Day Rules" and be empowered to temporarily stop medications such as ACEi (or prompt healthcare providers to do so) during episodes of illness and restart when oral intake has recovered. This may give Eva more confidence in reducing her AKI risk and encourage her to take these crucial medications.

10 Conclusion

Pharmacological management of CKD is of the utmost importance to reduce progression to ESKD. There are new and promising agents to aide in the management of CKD. Patient empowerment and engagement are crucial in the pharmacological management of CKD and prevention of medication related complications.

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Nutrition and Chronic Kidney Disease

Kalliopi-Anna Poulia

Learning Objectives

- To understand the nutritional needs of the people with CKD.
- To gain knowledge about the role of nutrition in the management of people with CKD.
- To recognize the role of plant-based diets on CKD before dialysis.
- To identify different possible ways to provide nutritional support in people with end stage CKD.

1 Introduction

Dietary management of people with chronic kidney disease (CKD) is challenging and yet of high importance, for the overall prognosis of the patients and the preservation of their well-being. Due to the nutritional and metabolic changes alongside with the increased nutritional needs, nutritional assessment and the prevention of malnutrition is of paramount importance. The main goals of nutritional treatment intervention are:

1. Ensuring good nutritional status through adequate nutritional intake and optimum metabolic control.
2. The management and reduction of the consequences of uremia.
3. The delay of the progression of CKD and the initiation of dialysis.

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4. The prevention of obesity and metabolic syndrome in people who have undergone transplantation.

The majority of the complications that follow the progression of CKD affect and are affected by diet. For this reason, nutritional management of people with CKD is one of the most complex problems for a clinical dietitian-nutritionist. Adherence to special diets is difficult and causes stress for most people and their families because they themselves will have to adopt changes in their diet that are usually significantly different from their habits. They must adhere to nutritional restrictions that change their perception of taste, such as limiting salt, and at the same time restricting their protein intake of potassium and phosphorus, created the need for training in new culinary procedures [1].

2 Nutritional Assessment: Anthropometry and Other Indexes

In people with CKD, body weight is a measurement with great variability due to poor fluid management. Therefore, the use of the current body weight is often considered problematic, as fluid retention can mask possible weight loss and provide a false impression of the overall nutritional status of the patient. The problem is more significant in weight extremities, i.e., in obese and underweight patients, as the over or underestimation of weight can lead to overfeeding or underfeeding in terms of energy and protein accordingly. The estimation of dry body weight (edema-free weight) is usually based on clinical experience, physical examination, and anthropometric measurements. It can also be calculated by the following equation, which can be used to estimate edema-free adjusted body weight (aBWef):

$$\text{aBWef} = \text{BWef} + \left[(\text{IBW} - \text{BWef}) \times 0.25 \right]$$

In the formula, BWef stands for the present dry body weight and IBW the ideal body weight as determined by the NHANES II study data or body weight that corresponds to a body mass index (BMI) of 23 kg/m² [2, 3].

Unintended loss of dry body weight exceeding 5% over 3 months or 10% over 6 months, BMI < 23 kg/m² and reduced mid-arm muscle circumference (MAMC) (<10th percentile) are diagnostic tools for protein energy wasting (PEW), while muscle functionality as assessed by dynamometry is also a measurement with significant importance [4, 5].

3 Protein Energy Wasting (PEW)

Nutritional management is of paramount importance for people with CKD, both for the outcome of the disease itself, the treatment complications but also the prevention of malnutrition. Malnutrition is a common problem in people with CKD,

negatively affecting their morbidity, mortality, and quality of life. As a general term denotes the state of nutritional status in which a deficiency or excess (or imbalance) in the intake of energy, protein or other nutrients produces measurable negative effects on the tissues/organism (body shape, size, and body composition) in its function and clinical outcome [6]. The main form of malnutrition is protein-energy malnutrition (PEM) or protein energy wasting (PEW), which refer to the insufficient intake of energy and/or protein to meet the body’s metabolic requirements [7]. The etiology of PEW in CKD is summarized in Table 1. Thus, detailed nutritional assessment is extremely important to provide appropriate care to people with CKD regardless of stage. Classically, there are three main parameters measured to assess nutritional status: dietary intake, biochemical analyses, and body composition.

Table 1 Etiology of PEW in people with CKD. Adapted from Refs [4, 8, 9]

Anorexia due to:
Nausea, vomiting, adverse effects of medications
Uremia
Accumulation of uremic toxins not completely removed dialysis or under-dialysis
Inflammation
Contributing to limited appetite
Increasing metabolic needs
Due to comorbidity
Related to the dialysis itself
Metabolic acidosis
Endocrine disorders
Insulin resistance
Hyperparathyroidism
Impaired response to IGF-1
Comorbidity
Increasing the risk of infections
Such as diabetes mellitus (causing diabetic gastroparesis or impaired glucose metabolism), cardiovascular diseases
Poor denticity
Dialysis-related
Inadequate doses or frequency
Bio-incompatible membranes
Loss of macro- and micronutrients (amino acids, proteins, vitamins, and trace elements)
Reuse with bleach, nausea, hypotension
Psychosocial
Depression
Sedentary life
Loneliness
Economic problems/poverty/unemployment
Inadequate adherence to dietary recommendations
Food insecurity
Mechanical compression of stomach and intestine in polycystic kidney disease

4 Nutritional Scores and Assessment of Dietary Intake

The early detection of nutritional risk is of paramount importance. Therefore, special tools have been developed for the assessment of nutritional risk, which are based on the subjective global assessment (SGA) and aim to include problems concerning this group of patients. The most important of these tools is the malnutrition-inflammation score (malnutrition-inflammation score), which is mainly applied to people on hemodialysis in case it is found to be ≥ 5 and is characteristic of a high risk of malnutrition [4, 5].

To estimate dietary protein and energy intake, dietitians must focus on the quantity and quality of the diet in order to assess dietary adequacy in energy and nutrients but also to rule out excessive intake of nutrients that may have a harmful effect on kidney function (e.g., sodium, phosphorus, and potassium). Regarding nutritional assessment, the most frequently used methods are the recall of dietary intake for short periods of time (e.g., 24 h), the recording of a dietary intake diary with or without an interview with the dietitian, for short periods of time (e.g., 3–7 days) and long-term dietary histories in the form of food frequency questionnaires (FFQs) [2, 10].

5 Laboratory Tests Used in Nutritional Assessment

Laboratory tests allow the determination of the levels of body proteins and the corresponding evaluation of the nutritional status. According to the KDOQI guidelines for the care of people with CKD stage 3–5 before dialysis [11], serum albumin levels <4 g/dl, proalbumin <30 mg/dl, and cholesterol <150 mg/dl are useful indicators to detect the risk of PEM in clinical practice, while the International Society of Renal Nutrition and Metabolism (ISRDM) has included serum albumin <3.8 g/dl as one of the three biochemical diagnostic criteria for PEW (along with proalbumin and cholesterol levels) [10]. However, it should be emphasized that dietary intake is not the only cause of hypoalbuminemia in CKD (Table 2). Serum albumin levels are an indicator of nutritional status, but as an acute phase protein it is an indicator of chronic inflammation [4, 5, 7, 12].

Table 2 Factors that may affect serum albumin levels in people with CKD [4, 5]

Inflammation	Poor energy and protein intake
Catabolic and anabolic processes	Age
Comorbidity (cardiovascular disease, diabetes mellitus)	External protein losses (urine, dialysate)
	Fluid overload

6 Nutritional Management of People with CKD Stage 1–3

The treatment of people with early stages of CKD lies in the improvement of risk factors for cardiovascular diseases, the regulation of blood pressure, and better glycaemic control [13]. Thus, according to the KDOQI Clinical Practice Guideline for Nutrition in CKD 2020, the following criteria are required in order to improve their CKD condition:

- Strict control of blood pressure blood glucose levels, especially in people with diabetes mellitus (DM).
- Achieving a healthy body weight (with a BMI between 20 and 25 m/kg²) and the maintenance of an active lifestyle.
- The regulation of blood lipids.
- The limited alcohol intake (<3 units/day for men and < 2 units/day for women).

Nutritional management of people at this stage of CKD focuses on addressing overweight and obesity, regulating blood pressure, and providing nutritional support when nutritional risk is assessed, aiming at the delay of the disease progression. More specifically, maintaining weight within the normal levels can positively affect proteinuria, blood pressure, and therefore maintain a better kidney function [14]. Moreover, weight reduction improves insulin sensitivity and has a beneficial effect on the blood glucose control and lipids in diabetes and dyslipidemia. People with type 2 diabetes mellitus (T2DM), with a BMI greater than 30 kg/m² and central type of obesity, i.e., with increase waist circumference, will have a greater benefit from losing weight, if CKD is diagnosed [15].

Maintaining a sufficient level of energy intake is very important for people with CKD. In metabolic stable adults with CKD stage 1–3, energy intake of 25–35 kcal/kg body weight per day is recommended, considering the age, sex, level of physical activity, body composition, weight status goals, CKD stage, and concurrent illness or presence of active and/or acute disease, aiming at the maintenance of a good nutritional status [13].

Regarding protein intake, <1.0 g/kg of body weight is recommended or a restriction to 0.6–0.8 g/kg if estimated glomerular filtration rate (eGFR) is <45 ml/min/1.73m², or if the patient shows rapid deterioration of his kidney function [16]. At the same time, a more active way of living is recommended, with aerobic physical activity and weigh bearing exercise, along with individualized nutritional advice based on patients' needs and possible comorbidities. Dietary patterns that have been proposed as beneficial are the ones characterized by increased consumption of fruit and vegetables, such as Mediterranean diet [17] or DASH diet [18], as high potassium intake has a positive impact on blood pressure, blood glucose control, and weight control [13, 19]. Apart from that, a diet high in potassium is rich in fruits and vegetables, and it contributes to a diet that has low acidogenicity and higher dietary fiber intake. Therefore, in these patients a relatively high dietary potassium intake is recommended, i.e., 4.7 g (120 mmol)/day. [20] In people with hyperkalemia, lower

potassium fruit and vegetable alternatives should be provided, aiming to reduce potassium but maintain fiber intake.

Sodium intake is the main restriction in CKD 1–3. According to the current guidelines, salt intake should not exceed 6 g/day [16]. The use of salt substitutes should be discouraged, especially in people with hyperkalemia, due to their content of potassium chloride that can increase potassium levels, and taste can be enhanced by the use of selected herbs and spices [15]. The daily dietary intake of sodium should not exceed 4 g (<174 mmol) for the overall management of CKD and the blood pressure control. In patients with poor fluid control and/or protein losing nephropathies a restriction of <3 g (<131 mmol) of daily sodium is recommended. A more severe restriction of sodium intake, i.e., <1.5 g (<87 mmol) is not recommended as it poses patients at risk of hyponatremia. Moreover in cases of salt losing nephropathies restricting sodium intake should be reviewed and restrictions are usually contraindicated [19].

Regarding fluid consumption, the recommendations in these stages of CKD do not differ from the rest of the population, except for groups of patients with nephrolithiasis. Conversely, in patients with fluid retention or comorbidities that require limited fluid intake (heart failure or liver disease), recommendations must be individualized.

7 Nutritional Management of People with CKD Stage 3–5, Before Dialysis

In adult people with CKD stage 3–5 before hemodialysis, an intake of 25–35 kcal/kg per day is recommended, considering gender, age, physical activity, body composition, the general clinical condition of the patient, and the need to maintain/gain or reduce body weight patient, always aiming to maintain or improve his nutritional status. [13].

According to the latest available dietary recommendations for metabolically stable, non-diabetic people with stage 3–5 CKD (predialysis) protein restriction is recommended under close medical and dietary monitoring, aiming to the delay of the initiation of dialysis and the better Quality of Life (QoL) of the patient improve the patient's quality of life [8, 21]. In particular, dietary intake of 0.55–0.6 g of protein/kg per day is recommended while ensuring sufficient energy intake to maintain nutritional status. If necessary, diets of even lower protein (0.28–0.43 g) can be recommended with the complementary use of keto-analogues of amino acids in proportion sufficient to cover the recommendation of 0.55–0.6 g/kg per day [13]. Keto-analogues of amino acids are analogs of essential amino acids free from nitrogen. Therefore, they contribute to amino acids protecting against protein malnutrition without increasing the levels of nitrogen and therefore urea in the blood [22]. For people with DM, protein intake is suggested to be kept at relatively higher levels. More specifically, for people with DM and CKD stage 3–5 before dialysis, protein intake of 0.6–0.8 g/kg is recommended [13].

Whether the amount or type (of animal or vegetable origin) of protein intake influences the course of CKD has been a matter of debate for nearly a century. According to research data, long-term protein intake exceeding 1.5 g/kg of ideal body weight can cause hyperfiltration and increase the expression of pro-inflammatory genes, increasing the risk of CKD onset and progression in models such as diabetic kidney disease [19]. High-protein diets, which are popular today for weight loss, appear to increase albuminuria in people with diabetes or hypertension, but their effect on kidney function per se is unclear.

Regarding dietary patterns, research interest is focused on diets based on foods of plant origin (plant-based diets). These diets emphasize the importance of the consumption of plant-based foods (fruits, vegetables, nuts, vegetable oils, whole grains, legumes) and include occasional or small consumption of meat, fish, seafood, eggs, and dairy products. Vegetarian and strictly vegetarian diets fall under this diet plan. Other examples of dietary patterns that can be considered plant-based diets are the Mediterranean diet, the DASH diet, and the Okinawa diet [23]. The main advantages of these dietary patterns in relation to CKD are summarized in Table 3. A significant problem with these diets is their potassium content. For this

Table 3 Possible benefits from plant-based diets in CKD [23]

Plant-based nutrients	Characteristics	Possible benefits
Proteins	Proteins of plant origin have less bioavailability than proteins of animal origin Diets with plant-based foods are lower in protein	Positive effect on glomerular filtration rate and proteinuria
Carbohydrates	Plant-based diets are high in fiber and can be low in refined carbohydrates Plant-based diets are rich in starch and complex carbohydrates that are a good source of energy for the body	Increased stool volume contributes to bowel motility, and increase potassium excretion Better regulation of blood glucose Increase nitrogen excretion from the feces. Conversion of gut microbiota from proteolytic to saccharolytic, which leads to increased production of short-chain fatty acids, decreased production of uremic toxins, decreased bacterial allostasis, and decreased inflammation
Fat	These diets are high in mono- and polyunsaturated fatty acids and low in saturated fat	Better lipidemic profile Antioxidant, anti-inflammatory, and anti-atherosclerotic action
Anions and cations	Diets of plant origin have a lower content of non-volatile acids than diets of animal origin	Better control of metabolic acidosis
Phosphate	Phosphate absorption from foods of plant origin is lower than from foods from animal origin	Better control of CKD bone and mineral disorders
Sodium	Plant-based diets are low in sodium	Better blood pressure control

reason, people should be guided to eat foods with a low ratio of potassium per gram of fiber. This approach helps to consume plant-based foods, meet fiber needs, with less risk of hyperkalemia. It is important to emphasize that any nutritional intervention must be closely monitored. As people often report a spontaneous decrease in nutritional intake, which is particularly noticeable when the GFR is approximately 25 ml/min, concomitant with a progressive decrease in body weight and biochemical markers of nutritional status, the limitation of protein intake should be withdrawn if malnutrition is diagnosed.

CKD is a risk factor for cardiovascular disease, due to chronic inflammation, disturbed calcium and phosphate metabolism, and preexisting comorbidities, such as DM. People with CKD should take extra care of quality and quantity of their fat intake. Fat intake should be mainly from monounsaturated fatty acids, which should provide 10–20% of the total energy intake (TEI) and polyunsaturated fat, providing 10% of saturated fat should be limited to <10% of TEI. Saturated fat should be limited to <10% of TEI and cholesterol should not exceed 250 mg/day. Therefore, saturated fat sources should be limited, i.e., full fat dairy and cheese, red meat, poultry with skin, fast food, butter, and full fat cream. Emphasis should be given in ω -3 fatty acid intake. Fatty fish consumption, such as cod or salmon should be encouraged on weekly basis [24].

7.1 Sodium and Fluid Intake

Sodium restriction is extremely important in people with CKD stage 3–5 predialysis. An intake of <3 g is recommended in this group of patients, while an intake of <1.5 g/day of sodium is discouraged especially in patients at risk of hyponatremia [19]. This amount should include sodium intake from bicarbonate of soda, which is recommended for the treatment of metabolic acidosis. Regarding fluids, no restriction is usually advised, except for patients with edema or heart failure. In this case, it is suggested to limit sodium consumption and limit fluids to 500–1000 ml/day plus losses through diuresis [1].

7.2 Potassium Intake

The gradual decline in GFR results in an increased likelihood of dysregulation of blood potassium levels. Since the use of angiotensin-converting enzyme (ACE) inhibitors and angiotensin II type 1 (AT1) receptor blockers for hypertension can also increase blood potassium levels, dietary restriction may contribute to better medication tolerance and better blood pressure control. Maintaining potassium levels within a normal range of values is important, while the values that ensure the

best survival are between 4.1 mmol/l and 5.5 mmol/l [25]. Potassium restriction must be individualized and applied to patients with disturbed levels and the goal is to maintain potassium levels within limits but at the same time ensure a balanced diet. In case of hyperkalemia, potassium intake should be limited to <3 g/day, which means that the patient should be educated to avoid foods rich in potassium and also culinary preparations that can contribute to this direction [19]. Non-essential foods are recommended to be removed first (chocolate and coffee) and to avoid the consumption of foods enriched with potassium (e.g., salt substitute). Consumption of low-potassium fruits and vegetables should be encouraged aiming at the adequate fiber intake to avoid dysbiotic effects and to ensure the good GI function [26, 27]. This can be achieved by avoiding high potassium fruits (bananas, oranges, dried fruits, etc.) and vegetables (potatoes, spinach, etc.). Moreover, diabetics should be trained to treat hypoglycemia with fruit juices low in potassium or with sugar in water to avoid hyperkalemia [28].

7.3 Phosphorus

Elevation of blood phosphorus levels is common in people with eGFR<40 ml/min/1.73 m and reducing the intake of phosphorus from the diet is a way of dealing with these people. An intake of <800 mg of phosphate per day is recommended. In low protein diets keeping phosphorus intake low is usually easier to achieve. However, given the increased absorption of inorganic phosphorus from food, i.e., phosphorus contained in supplements, food preservatives, dark-colored soft drinks, the consumption of processed foods should be discouraged, and the consumption of fresh unprocessed foods should be chosen. In this way, not only phosphorus consumption is reduced but also sodium consumption. At the same time, from protein foods, which are the main source of organic phosphorus (meat, poultry, dairy, egg), those with the lowest ratio of phosphorus to protein should be chosen, emphasizing the adequate coverage of the patient's needs in protein of high biological value [20]. For this reason, in recent years, the use of the “pyramid of phosphorus” has been proposed, in which foods are classified into 6 categories, depending on their phosphorus content, the protein-phosphorus ratio, and the bioavailability of phosphorus (Fig. 1). Each level has a separate color, corresponding to the recommended frequency of consumption of the food, with the highest quantity and frequency for the food items at its base (green color) and virtually unrestricted consumption and the lowest at the top (avoidance of consumption—red color) [29]. Other approaches use the traffic light as a way to educate patients (Fig. 2) [30].

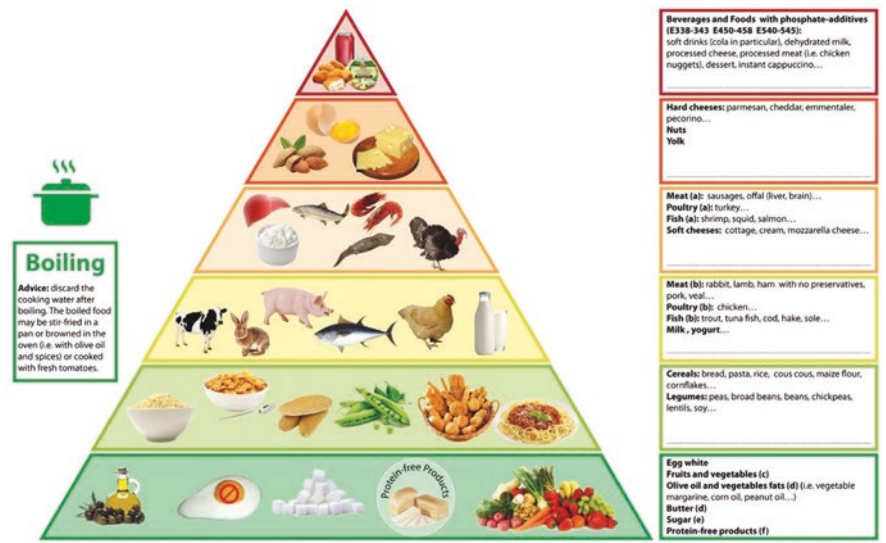


Fig. 1 Phosphate pyramid [29]

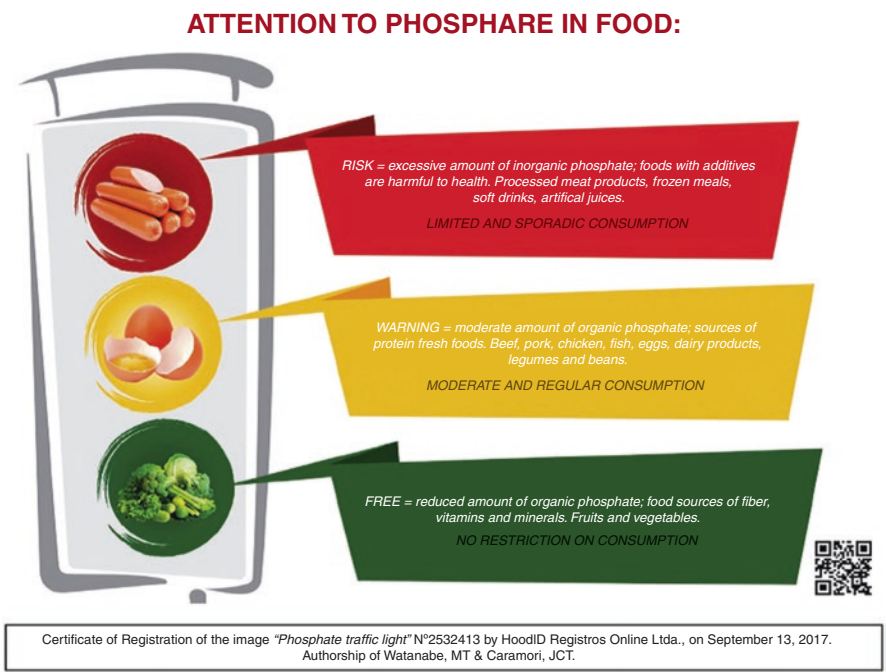


Fig. 2 Traffic light use for the education of people with CKD regarding phosphate intake [30]

8 Nutritional Management of Peoples on Hemodialysis

Malnutrition is a common problem in people on dialysis, negatively affecting morbidity, mortality, and quality of life [31]. The goals of nutritional management of people on hemodialysis (HD) are:

1. Maintaining good nutritional status and preventing deficiencies by providing adequate protein, energy, vitamins, and trace elements.
2. Control of sodium and potassium intake and compliance with fluid restriction.
3. Regulation of parameters related to bone metabolism, through the regulation of calcium, phosphate, and vitamin D.
4. Ensuring balanced diet for the patient.

Ideally, nutritional assessment should be carried out at baseline, at the initiation of HD, aiming at the early detection of individuals who need more intensive dietary support, as well as providing nutritional education for their new nutritional needs and to comply with many dietary restrictions. For this reason, they should be systematically supported and consulted by a clinical dietitian-nutritionist with relevant expertise, who will be able to assess the patient's course over time and make corresponding modifications to the diet according to the people's needs [13, 31].

8.1 Energy Intake

Meeting energy needs of the patient is important to achieve a positive nitrogen balance. Intake of 35 Kcal/kg body weight/day has been associated with a positive nitrogen balance in people with normal body weight [32]. Energy intake for metabolically stable people on HD, according to recent KDOQI recommendations should range from 25 to 35 Kcal/kg, depending on age, sex, physical activity, body composition, presence of acute disease, and goal of maintaining/gaining or reducing body weight [13]. In overweight or malnourished people, energy intake must be adjusted accordingly, to ensure that their needs are met. For people over 60 years of age, energy needs rarely exceed 30 Kcal/kg due to reduced physical activity and the reduction of resting energy expenditure (REE) due to age [11, 33]. At the same time, the physical exercise must be emphasized, as it helps maintaining muscle functionality, improves endurance, and ensures good cardiovascular health [34].

8.2 Protein Intake

Protein requirements of people on HD are higher than those of healthy adults. HD itself is a catabolic process, so getting enough protein is of the utmost importance. During hemodialysis, catabolic hormones such as glucagon, glucocorticoids, and adrenaline are released. Losses of amino acids of the order of 6–8 g/session in the fasting state of people and 8–10 g/session in the postprandial phase are observed. In addition, 2–3 g of peptides are lost/session [35, 36], and these losses should be

replaced. Thus, it is recommended to increase protein intake and administer 1–1.2 g of protein/kg body weight/day [13, 35]. For people on HD with DM, the same protein intake is recommended, except for people experiencing hyper- or hypoglycemia. In that case, it is recommended to increase the amount of protein administered to achieve good glycemic control, through the corresponding reduction of carbohydrates [13]. In people with acute catabolic disease, a further increase in protein intake to >1.2 to 1.3 g/kg/d is suggested [2, 37].

According to the most recent guidelines of National Kidney Foundation's Kidney Disease Outcomes Quality Initiative (KDOQI), there is insufficient evidence to recommend a specific source of protein, animal, or plant [13]. What matters is choosing protein foods with the best possible ratio of essential amino acids, such as egg whites, red meat, poultry, soy, and unsalted white cheeses. Foods high in phosphorus and protein, such as small fish, seafood, hard cheeses, and meat with bones should be limited for better phosphorus regulation or consumed with the use of phosphorus binders. As these people often face taste alterations due to uremia the metallic taste and aversion to protein foods, such as red meat, is making it difficult to reach the people's protein needs. In this case, alternative sources of protein or ways of enrichment with protein supplements must be suggested to the patient to cover their protein needs.

8.3 Sodium and Fluids

People on HD are usually required to restrict sodium and fluid intake, since excessive sodium intake increases thirst and fluid consumption, making compliance with fluid restriction impossible. Limiting sodium intake is desirable even in people who retain a small amount of urine output, because limiting thirst will result in less weight gain between HD sessions. Weight gain between HD sessions is recommended to be 2–2.5 kg or < 4% of their dry body weight. Limiting sodium to 1500–2000 mg/day and limiting fluid intake to 500–1000 ml plus the urine volume if the patient is not anuric is usually sufficient to achieve this goal. Fluid intake includes all foods that are liquid at room temperature (18–20 °C) but not the moisture of solid foods, which can contribute to the total fluid intake of 500–800 ml per day but is considered to cover the invisible losses that reach 500 ml per day [1, 4, 38]. The use of salt substitutes is prohibited as they increase the risk of hyperkalemia. To control thirst people should be trained to satisfy their thirst with the smallest possible volume of fluids. Drinking iced liquids or drinking water in the form of ice packs, using special mouthwashes, chewing gum, and using lemon in water can be helpful actions to reduce thirst.

8.4 Potassium

Maintaining potassium at normal levels is extremely important as hyperkalemia poses the risk of cardiac arrhythmias. In healthy individuals, 90% of potassium is excreted through the kidneys. Reducing dietary intake and adequate dialysis helps maintain potassium levels at acceptable levels. Since almost all foods contain

potassium, severe restrictions should be applied for short periods of time, to ensure adequate dietary intake and QoL for patients. In patients with predialysis potassium levels >6 mmol/l, potassium intake should not exceed 2000–3000 mg/day or 18 mg/kg body weight (1 mmol/kg) [2]. In people with hyperkalemia, it is recommended to reduce the consumption of fruits and vegetables that are rich in potassium and poor in fiber, to meet fiber needs but to reduce potassium intake. At the same time, measures should be taken to reduce the potassium content of foods, such as double-boiling vegetables, boiled fruit, peeled fruit cut into pieces or soaking vegetables in water before boiling, such as potatoes, and avoiding dietary supplements or foods enriched with potassium. Given that in people with CKD, excretion of potassium is increased as a compensating mechanism, the prevention and treatment of constipation is extremely important. Thus, intake of low-potassium fruits and vegetables should be ensured, and if this is not feasible, the use of fiber supplements and prebiotics is recommended [39].

8.5 Phosphate

Hyperphosphatemia is associated with hyperparathyroidism, soft tissue and vascular calcification, and metabolic bone and mineral disease[40]. Phosphorus intake in hemodialysis must be limited, but this should not be done at the expense of protein intake. Phosphorus intake is suggested to be <800 mg/day or <17 mg/kg [2, 37]. The increased protein intake requirements in HD lead to phosphorus accumulation since each dialysis session removes 500–700 mg of phosphate. Choosing foods with lower phosphorus can help reduce phosphorus intake while maintaining increased protein intake. Phosphate binders also contribute to the maintenance of blood phosphate at acceptable levels (Table 4) [41].

8.6 Vitamins

People on HD often experience vitamin deficiencies due to impaired metabolism from CKD, severe dietary restrictions, and dialysis losses. Vitamin deficiencies develop slowly but affect their QoL and people should be evaluated to receive individualized recommendations according to their age, sex, dietary intake, type of dialysis, residual kidney function, symptoms of vitamin deficiency from the clinical examination and their biochemical tests [1].

During HD, water-soluble vitamins are lost in the dialysis solution. Due to the restrictions on fruit and vegetable consumption to control potassium levels, vitamin C deficiency is a common and the supplemental administration of 75–90 mg/day is required. At the same time, adequate intake of folic acid (1–5 mg), B12 and B6 is necessary to ensure adequate hematopoiesis. Thiamine deficiency is also common in hemodialysis, due to insufficient intake and dialysis losses, and for this reason all multivitamin supplements aimed at people with CKD contain thiamine.

Regarding fat-soluble vitamins, they must be treated with special care, since they are stored in the body and the risk of toxicity is increased [2]. Vitamin A is not removed through the dialysis process and the risk of toxicity is great. That is why it

Table 4 Steps to calculate the initial phosphate binder prescription [41]

Step		Example in numeric data
Phosphate intake	Total dietary P intake	1000 per day or 7000/week
Amount absorbed (50–70% of mixed diet in non-kidney) (53% kidney vs 77% in non-kidney)	Dietary intake multiplied by 50–60% absorbed	600 per day or 4200/week
Average HD/PD clearance HD = 800 per treatment PD = 300–315 per day	Amount abs—Dialysis clearance = remaining P to be bound by phosphate binder	HD: 4200–2400 = 1800 mgP/wk. or 257 mg/day PD: 4200–2205 = 1995 mg P/ wk. or 285 mg/day
Divided by estimated binding power or the binder of choice	Remaining P/binding power	257/39 (approx. P bound by 1 g CaCO_3) = 6.5 g CaCO_3 257/45 (approx. P bound by 1 g calcium acetate) = 5.7 g 257/15–30 (approx. P bound by 1 $\text{Al}(\text{OH})_3$ tablet) = 12–17 tablets 257/64 (approx. P bound or 800 mg sevelamer HCl) = 4 tablets 257/32 (approx. P bound per 400 mg sevelamer HCL) = 8 tablets

Note: The above table shows how the initial prescription is estimated based on average phosphorus absorption, the average dialysis clearance, and the approximate binding potential for the binder. The dose should be monitored and adjusted based on the response of the individual patient [41]

Table 5 Recommended vitamin intake from diet and supplements for people on chronic HD [1]

Vitamin	Daily recommendations
<i>Water-soluble vitamins</i>	
Thiamin (B1)	1.1–1.2 supplement
Riboflavin (B2)	1.1–1.3 supplement
Niacin (B3)	14–16 mg supplement
Pantothenic acid (B5)	5 mg supplement
Pyridoxine (B6)	10 mg supplement
Biotin (B8)	30 μg supplement
Folic acid (B9)	1–5 mg supplement
Cobalamine (B12)	2.4 mg supplement
Vitamin C	75–90 mg supplement
<i>Fat soluble vitamins</i>	
Vitamin A	700–900 μg intake—no supplement
Vitamin K	90–120 μg —no supplement

supplementary administration is not recommended. The only exception is the case where the patient receives total parenteral nutrition (TPN), but even in this case the recommended dosage should not exceed 700–900 μg . Regarding vitamin K, there is insufficient scientific data on deficiencies in people on HD. Thus, its supplementary administration is only recommended for people receiving TPN with a dose that should not exceed 7.5 mg/week. The recommendations for vitamin intake are presented in Table 5:

9 Nutrition for People on Peritoneal Dialysis

Nutritional needs in people with CKD on peritoneal dialysis (PD) are different compared to people on HD. The people on PD have higher protein needs due to higher losses from the peritoneum and therefore they require different level of restrictions and choices. More specifically, people on PD have better regulation of blood potassium levels as well as greater freedom in fluid consumption, but at the same time they must limit their energy and carbohydrate intake due to the dextrose supply from the PD solution [1, 15].

9.1 Protein Intake

People on PD lose 5–15 g of protein/day through the peritoneum. These losses increase in episodes of peritonitis by up to 50%, while this increase remains 2–3 weeks after the end of the infection [42]. To deal with the large protein losses during PD, existing guidelines recommend a dietary intake of 1.2 g/kg body weight/day [15]. It should be noted that in cases of peritonitis or other type of infections, protein needs increase and reach up to 1.5 g/kg body weight/day, but in stable patients with good nutritional status the administration of 1.0–1.2 g/kg body weight per day is sufficient [13, 15, 43].

9.2 Energy Intake

Sufficient energy intake is recommended for people on PD, to avoid catabolism protein. Energy needs of these people do not differ significantly from people on HD and are equal to 30–35 Kcal/kg body weight/day [43]. It should be noted that this recommendation includes the calories from glucose absorbed from the PD solution. The amount of calories absorbed depends on the type of PD, since in cyclic continuous peritoneal dialysis (CCPD) approximately 40% of calories are absorbed and in continuous ambulatory PD (CAPD) this percentage is equal to 60%, due to the fact that in the latter case the PD fluids remain in the peritoneal cavity for longer period of time [44]. These calories provide approximately 300–800 Kcal/day and depend on the density of the solutions used by the patient and on the efficiency of the peritoneum [1, 15].

9.3 Sodium and Fluids

Fluid balance is easier to achieve in people on PD, given that dialysis is performed daily and that residual kidney function and diuresis are maintained for a longer period of time. Recommendations for fluid intake are individualized, aiming to reduce the use of hypertonic solutions. Usually, the intake of 2 L of fluids per day is sufficient (500–700 ml + urine + ultrafiltrate) although in people with a greater loss

of urine higher fluid intakes may be allowed, always depending on the control of blood pressure, the existence or not of cardiac failure and the volume of ultrafiltrate [44].

Regarding sodium intake it is recommended to limit intake to 2–3 g/day, a recommendation that should be individualized according to heart function, blood pressure control, and fluid balance [15, 44]. Most people are usually initially allowed to a sodium intake equal to 3 g/day, given that 3–4 g of sodium are cleared daily through the peritoneal membrane. As the efficiency of the peritoneum and residual kidney function decreases, or in cases of uncontrolled blood pressure, then further restriction will be needed [44].

9.4 Potassium

Hyperkalemia in people on PD is less common than people on HD, and potassium restriction is usually not required. The recommended intake of potassium ranges from 3 to 4 g/day or 40 mg/kg, but this recommendation must also be evaluated based on the patient's laboratory values [44].

In case of hyperkalemia, especially in cases where there is co-existing diarrhea or vomiting or insufficient dietary intake, potassium intake should be released and if necessary, potassium supplementation should be given to maintain its levels at normal levels. Conversely, hyperkalemia in these people is indicative of ineffective clearance. Monitoring potassium levels is necessary in order to determine the required nutritional intervention [15].

9.5 Phosphate

According to the available guidelines [13, 42], hyperphosphatemia is also an important problem for people on PD, given the recommendations for high-protein intake. The goal is to maintain phosphate levels within the normal range, but without this being at the expense of the provision of sufficient protein intake. Phosphate intake is recommended to range from 800 to 1000 mg/day and it recommended for the people to use phosphorus binders, aiming to maintain phosphate blood levels at 3.5–5.5 mg/dl [45].

10 Nutritional Management of People with Kidney Transplantation

The goals of nutritional management of people who are about to undergo or have undergone kidney transplantation are:

- **Preoperatively:** The improvement of nutritional status and metabolic disorders as well as weight loss in obese people.

- **Immediately postoperatively:** The monitoring of the nutritional status and the meeting of energy and protein needs. Treating electrolyte disturbances and providing food safety advice.
- **Chronic post-transplantation period:** Provision of adequate protein, depending on kidney function, balanced diet, and prevention of obesity and cardiovascular diseases.

10.1 Nutritional Approach to the Patient Preoperatively

Preoperative interventions aim to improve the immediate and long-term results of transplantation. Ideally, the patient should be evaluated by the therapeutic team, which should assess the nutritional status, consider the need for lifestyle changes (smoking, exercise, alcohol use), and plan interventions to manage problems that endanger the patient perioperatively and possibly negatively affect the good function of the graft (dyslipidemia, DM, obesity, hypertension, malnutrition). Pre-transplant malnutrition and sarcopenia increases the risk of mortality and morbidity for the patient, while it also negatively affects graft function after transplantation. Obesity increases the risk of postoperative complications, especially if the BMI exceeds 35 kg/m² [46, 47].

10.2 Nutritional Approach to the Patient in the Acute and Chronic Postoperative Period

The postoperative management of the patient includes acute management, which includes the first 2 months after the transplantation, and in the chronic postoperative phase for the following period of time that the patient will live with the graft [15].

10.3 Protein and Energy

In the first two postoperative months, a high-protein diet (1.2–1.3 g/kg body weight) is recommended for wound recovery and to cover the increased needs due to the administration of high doses of corticosteroids [15, 47]. Higher amounts of protein intake, i.e., 1.6–2.0 g/kg, are required in cases of fever, infection, or postoperative complications. Caloric intake is suggested to range from 25 to 35 Kcal/kg per day, to avoid a negative nitrogen balance, depending on age, body composition, physical activity, and the goal of maintaining/increasing or reducing body weight [13].

10.4 Sodium and Fluids

In the immediate postoperative stage, most people have intense polyuria. For this reason they should be encouraged to consume large amounts of fluids, and in case

their needs cannot be met, fluids should be administered intravenously to prevent dehydration [15]. Over time, the kidney recovers its ability to condense the urine and gradually the volume of urine returns to normal levels. Regarding electrolytes, it is recommended to limit sodium in the diet (2000–3000 mg/day) to avoid fluid retention and to better regulate blood pressure [15]. In case of hyponatremia, fluid intake should be reassessed, and, for a short time, a higher dietary sodium intake should be allowed.

10.5 Potassium

The use of immunosuppressive drugs can modify K requirements. In particular, the monitoring of K levels in the blood is required, because while the use of cyclosporine can cause hyperkalemia, the administration of non-potassium-sparing diuretics increases the risk of hypokalemia, while the same applies to rapamycin. In the case of hyperkalemia, the causes that cause it must be detected and corresponding dietary restrictions must be put in place. In case of hypokalemia, dietary sources of potassium should be included to the patient's diet based on his tolerance [15].

10.6 Phosphate and Magnesium

Hypophosphatemia and hypomagnesemia, due to high urine losses, are common in people with kidney transplantation. In these cases, appropriate selection of foods is recommended to increase the content of the diet in Mg and phosphate and supplementary intake is also indicated. It goes without saying that in this phase the use of phosphorus binders should be stopped [1, 13].

10.7 Nutritional Approach in the Chronic Post-Transplant Period

In the chronic post-transplant phase, the dose of immunosuppressants is gradually reduced and their catabolic effect is limited. This fact combined with the sedentary lifestyle and the alleviation of most of the dietary restrictions results in a significant risk of overweight and obesity. Weight gain may in part be desirable for malnourished people, but overweight and obesity increase the risk of metabolic disorders, such as T2DM and hyperlipidemia, with a corresponding increase in the risk of cardiovascular events.

Nutritional care aims to achieve and maintain a normal body weight through a balanced diet and active lifestyle. More specifically, the provision 25–35 Kcal/kg of ideal body weight covers most people [13]. Regarding protein intake, 0.8–1 g/kg body weight, combined with a diet low in sodium (2–3 g/day) [15, 47] is recommended for the long-term kidney graft function [48].

Another important issue for people with kidney transplantation is the sufficient intake of calcium. The dietary restrictions imposed to them during HD or PD, the use of high dose of corticosteroids after transplantation and the insufficient production of 1,25 di-hydroxy-calciferol by their kidneys, increase their risk of osteoporosis. For this reason, it is recommended to take 1000–1500 mg of calcium daily, in combination with vitamin D [15].

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Acute Kidney Injury

Fiona Murphy

Learning Objectives

- To discuss the definition and stages of acute kidney injury (AKI) as well as the etiology, pathophysiology, risk factors, and outline its epidemiology.
- To identify acute kidney disease (AKD) term and its interlinkage with AKI and chronic kidney disease (CKD).
- To discuss the initial and ongoing management of AKI including volume status, medication review, pharmacological and nutritional support throughout AKI.
- To highlight the complications of AKI to include hyperkalemia, metabolic acidosis, pulmonary edema, and indications for kidney replacement therapy (KRT).
- To recognize the various types of AKI such as hospital-acquired AKI, community-acquired AKI, drug-induced AKI, COVID-19 associated AKI, sepsis-associated AKI, and contrast-induced AKI.
- To address the relevance of education and emotional support for individuals with AKI and their partners and family members as applicable.
- To outline the relevance of education needs for nurses in the management and preventative measures of AKI.

1 Introduction

This chapter will address the main principles of nursing care for individuals presenting with acute kidney injury (AKI). That old phrase of “prevention is better than cure” is so apt when identifying how to manage AKI with prevention ideally the first line of defence through education and close monitoring of those who are at risk.

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Nurses whether working in primary or community care settings or within secondary or hospital care settings must “Think Kidneys” in their care delivery. There must be effective ongoing communication between nurses and other members of the interdisciplinary team as without this care delivery could deteriorate. The importance of not forgetting basic nursing care is paramount within AKI care delivery. This includes nurses being mindful of risk factors of AKI, assessing clinical history and clinical presentation, close monitoring of vital signs and fluid balance, importance of good hydration, and nutrition, using both clinical judgment and sound intuition along with reporting any concerns in an expedient manner so appropriate management can be promptly delivered.

AKI is exceptionally widespread in adults who are hospitalized ensuing in 10–20% of emergency hospital admissions and coupled with major adversative outcomes. AKI is not just a major concern within secondary care or hospital care settings, but also plays a pivotal role in primary or community care settings in terms of prevention with prompt identification and management along with post AKI care. The adversative outcomes of AKI signify the reality that AKI behaves as a “force multiplier” and enhances the seriousness of co-existing acute illness. AKI basically is an indicator of the “individual who is unwell” who needs timely detection and treatment. Those adults with AKI signify a heterogeneous group seldomly representing with a solitary disease process. Sepsis and multi-organ failure is frequently represented with AKI [1, 2].

2 Definition of AKI

AKI is typified by the accrual of creatinine, urea, and other unmeasured waste products following a sudden decrease in kidney function. It was previously known as acute renal failure. However, “injury” has replaced “failure” to highlight the disease continuum as even discreet reductions in kidney functions are associated with adverse outcomes. AKI is multifactorial in nature. It is not just kidney failure but instead incorporates an extensive spectrum of injury to the kidneys from minor changes in kidney function to the most severe where KRT or renal replacement therapy (RRT) may be essential [3–5]. AKI can occur because of numerous insults to the kidney including decreased kidney perfusion, intrinsic kidney disease, exposure to nephrotoxins, and blockage to urinary outflow. The consequences of this involve reduced clearance, volume regulation, control of metabolic balance homeostasis and distorted acid/ base and electrolyte balance [6]. There is no universally accepted validated risk score for AKI for either primary or secondary care (hospital care settings) [7].

3 Staging of AKI

During the past near 20 years there has been international guideline groups that have endeavored to determine coherent definitions and staging systems for AKI [8]. The RIFLE classification was identified in 2004 as a diagnostic standard of acute

renal failure (ARF) with the intention to improve the morbidity and mortality of ARF. This classification considers three severity classes (risk of kidney dysfunction, injury to the kidney, and failure of kidney function) matching to the changes in serum creatinine and/or urine output and two outcome classes (loss of kidney function and end stage kidney disease (Table 1). Although this chapter is addressing the management of adults with AKI, it is important to recognize that AKI can develop in babies, children, and teenagers with the availability of (p) RIFLE guidelines (pediatric risk, injury, failure, loss, end stage renal disease) to assist nurses and other interdisciplinary team members in both detection and care delivery [3, 4, 8, 9]. The RIFLE guidelines were modified by the AKI Network (AKIN) another group of intensive care and nephrology global experts who enhanced the RIFLE criteria and renamed the classes as stages 1, 2, and 3. The AKIN classification of AKI characterized any individual needing KRT as stage 3 AKI (Table 1) [3, 4, 8–10].

The Kidney Disease Improving Global Outcomes (KDIGO) AKI guidelines in 2012 merged the RIFLE and AKIN classifications so that there is a standardized classification of AKI for the purposes of practice, research, and public health. There is a more definitive timeframe within this definition, although staging remains based upon sCr concentration and UO (Table 1) [3, 4, 11–14].

It has been recommended that the highest stage be considered if the sCr concentration and urinary output does not relate to the same stage. Urine output is a vital kidney function consideration that highlights individuals at increased risk for adverse outcomes. However, its pathophysiological importance in the absence of excesses of oliguria or other substitutes of reduced glomerular filtration rate (GFR) is more contentious. It should be recognized that individuals who develop AKI based on the KDIGO urine output measures irrespective of whether sCr measures

Table 1 Comparison of consensus AKI definitions [3]

AKI Stage	Urine output	KDIGO	AKIN	RIFLE
1	<0.5 ml/kg/h for 6–12 h	sCr to 1.5–1.9 × baseline over 7d or ≥ 0.3 mg/dL absolute increase over 48 h	sCr to 1.5–2.0 × baseline or ≥ 0.3 mg/dL absolute sCr increase within 48 h	<i>Risk:</i> sCr to ≥1.5 × increase within, sustained for ≥24 h
2	<0.5 ml/kg/h for ≥12 h	sCr to 2.0–2.9 × baseline	sCr to ≥3.0 × baseline	<i>Injury:</i> sCr to ≥2.0 × baseline
3	<0.3 ml/kg/h for ≥24 h or anuria for ≥12 h	sCr to ≥3.0 × baseline, or sCr increase to ≥4.0 mg/dL or initiation of KRT	sCr to ≥3.0 × baseline, or sCr increase to ≥4.0 mg/dL (with increase of 0.5 mg/dL) or initiation of KRT	<i>Failure:</i> sCr to ≥3.0 × increase sCr increase to ≥4.0 mg/dL (with increase of 0.5 mg/dL) or initiation of KRT
				<i>Loss:</i> Complete loss of kidney function for >4 weeks
				<i>ESKD:</i> ESKD for >3 months

are available, are endangered to developing fluid overload due to the usually high obligate intake of seriously ill persons [3]. Since the creatinine concentration is not at a stable state throughout AKI the existing eGFR equations (Cockcroft-Gault, CKD-EPI and MDRD study) cannot be applied. The use of equations has been suggested to calculate kinetic GFR when sCr concentration is actively altering, however, this has not been endorsed for extensive use. The premise should be that the GFR is <10 ml/min when urine output is negligible which can occur when the individual is oligo-anuric in severe AKI. However, it has been identified that sCr concentration levels is a shortcoming of the KDIGO classification. It could be viewed as flawed biomarkers of AKI being influenced by various acute or chronic factors making it challenging to determine a precise diagnosis. The rise of sCr concentration levels does not automatically indicate AKI as it is a functional marker [3, 4, 12–14].

The National Institute for Health and Care Excellence (NICE) in the UK identified that AKI in adults can be detected in line with the AKIN or KDIGO definitions by utilizing any of the subsequent criteria [15–17]. While the UK Kidney Association (UKKA) clinical practice guidelines on AKI also endorsed the KDIGO system for the diagnosis and staging of AKI with the current NHS England biochemical detection algorithm being used to apply the sCr based criteria. The incidence of an active episode of AKI arising in the secondary care or hospital care setting can be deduced from regular sCr testing at 12 and 24 h post the index value [2]. However, it is vital to apply clinical judgment in clarifying consequences for individuals involved, including for those who may have pathological AKI and do not meet diagnostic or staging criteria. The core management of AKI is to treat the primary cause therefore irrespective of the stage of AKI, a diagnosis of AKI is only partial without efforts made to delineate its etiology. The degree to which additional investigations are needed will depend upon clinical judgment, for example, when the clinical image implies acute glomerulonephritis but not ischemic AKI a histological confirmation may be required [3].

4 Background and Epidemiology of AKI

AKI is a major public health concern with its associated increased morbidity and mortality rates. However, it is probable that a considerable number of deaths correlated with AKI could be avoided. This has been identified based upon preceding studies that unnecessary deaths from AKI are known to occur because of three distinct settings. These are secondary to public health concerns such as unsanitary water, diarrhea, and widespread infections; secondly delayed or lack of detection, scarcity of access to laboratory studies, insufficient response or iatrogenic issues resulting in further insults to a deteriorating kidney. Finally, insufficient dialysis support to manage hyperkalemia, fluid overload, and acidosis all of which are life-threatening [3, 4, 18, 19]. It was established by the National Confidential Enquiry into Patient Outcome and Death within the United Kingdom (UK) in 2009 that up to 100,000 deaths in hospitals related to AKI and a quarter to a third of these

deaths could potentially have been avoided [20]. Further adverse outcomes associated with episodes of illness convoluted by AKI include increased mortality (both short and long term), cardiovascular events, rehospitalization, development, and progression of chronic kidney disease (CKD) and reduced quality of life [15–17, 21, 22].

AKI can transpire with individuals within primary or community care settings with or without any acute illness [15–17]. It can often ensue in hospitalized patients including those in the emergency department (ED), intensive care unit (ICU), coronary care unit (CCU), high dependency unit (HDU), outpatients, theater, oncology, maternity care, mental health services, along with surgical, medical, and care of the older person's units. One could contend that there is potentially not a clinical area where AKI could not transpire with individuals when delivering their nursing care [5]. Individuals can present with multiple comorbid conditions including older persons with complex health issues [3, 15, 16]. It is imperative therefore that nurses and other members of the interdisciplinary team understand what AKI is, recognize the signs and symptoms, and how to manage it in a prompt effective manner so that holistic care can be delivered to individuals concerned [5, 11].

The International Society of Nephrology (ISN) acknowledging the rising global concerns of AKI instigated in 2013 the AKI 0 by 25 initiative with the impressive aim to eliminate every preventable AKI death globally by 2025 [18]. The incidence of AKI reported as generally either community-acquired or hospital-acquired AKI. Hospital-acquired AKI occurring primarily in high-income countries, while in lower-income settings community-acquired AKI is more widespread. These configurations are applicable internationally to both adults and children [23]. The incidence of AKI within community and hospital care settings has increased with an estimated excess of 13 million individuals. AKI is increasingly observed in primary care settings in persons without any acute illness, and recognition of the condition needs to heighten among primary health care professionals [4, 16] including nurses working within all areas of community care settings. There are limited studies that have concentrated on community-acquired AKI in low-resource settings despite knowledge of the epidemiology of AKI having increased greatly because of the standardized AKI classification system used [19]. The Global Snapshot was an initial large epidemiological study to investigate globally the outcomes related to AKI involving data from patients from both ICU and non-ICU. It highlighted that community-acquired AKI (main causes being dehydration, infection, and sepsis) was more prevalent than hospital-acquired AKI in low middle income countries and correlated with more severe AKI at presentation and adverse outcomes [24].

There is a requirement to increase the awareness of AKI especially the recognition of those individuals who present with earlier stages of AKI based on the findings of this Global Snapshot study [19]. The 0 by 25 initiative recommended the use of the 5R framework (risk, recognition, response, renal support, and rehabilitation) to address the main essentials for a sustainable basis to maintain AKI care. Risk involves recognizing individuals at high risk for prevention of AKI within primary care setting. This includes the use of risk scores and the recognition of modifiable risk factors. Recognition involves rapid diagnosis where there is timely and

successive serum creatinine (sCR) concentration and urinary output (UO) measurement and accessibility of point of care tests and diagnostic devices. Response is wherein there are interventions for emerging and established AKI involving the use of procedure-based management of hemodynamic and fluid status; avoidance of nephrotoxic medications along with the correct medication dose amended for kidney function. Renal support is the use of well timed intervention with kidney replacement therapy (KRT) in AKI. Rehabilitation is the final of the 5R framework involves care of individuals with AKI post discharge including the review of kidney function with follow up appointments along with educational campaigns on the relevance of long term follow up (Fig. 1) [18, 19].

Interestingly AKI identified as an important target for the European nephrology community with a proposed model to promote clinical partnerships including the development of a pan-European network of researchers and clinicians to enhance for example clinical outcomes and promote research on AKI in Europe [25]. “Think Kidneys” is a nationwide program led by the National Health Service (NHS) England in collaboration with the UK Renal Registry (UKRR) with the purpose being to ensure the avoidance of harm connected to AKI is averted in all healthcare settings. This program has a wealth of online educational resources and several best practice guidance to increase knowledge and understanding for healthcare professionals written by experts throughout the UK along with use of “Think Kidneys” AKI app which contain many relevant resources. These resources are not just for those working within a renal healthcare background but instead across spectrum of care delivery such as primary, secondary care (hospital care settings) cancer care, mental health, and residential or care homes. One best practice guidance is an example of the importance of early recognition of AKI through the AKI warning stage test results produced from electronic detection systems. This is based in

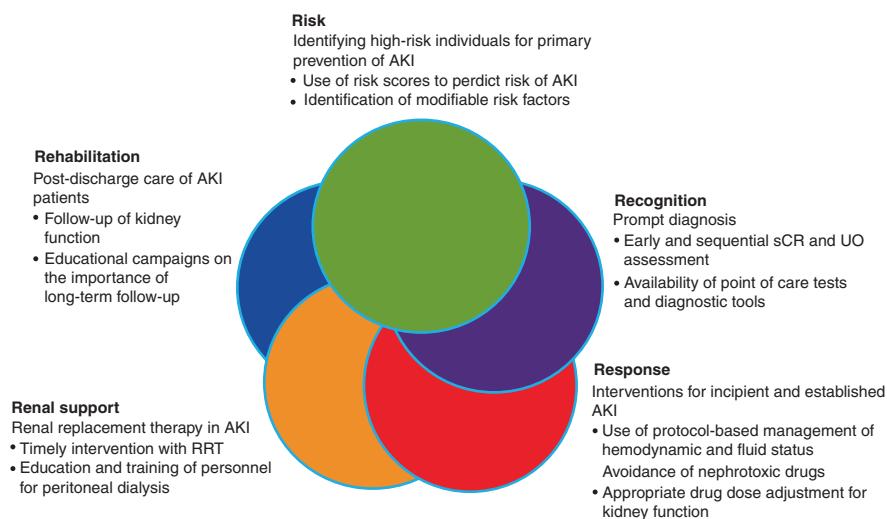


Fig. 1 5R Framework [18, 19]

biochemistry laboratories which are relayed to primary or community care settings with the purpose to make it easier to notice any changes in serum creatinine concentration. However, it is vital to treat individuals and not just the test result as it must be considered in the overall clinical circumstances [26].

The global financial costs of AKI to health care systems remains high [4]. In the UK it estimated that within the NHS the spending on AKI (exclusive of costs in primary care settings) anticipated to be amid £434 million and £620 million annually, which is more than the expenditure combined related to breast cancer, or lung and skin cancer [16]. AKI is associated in the United States (USA) with an escalation in hospitalization costs that range from \$5.4 to \$24.0 billion. The costliest are those individuals with AKI of sufficient severity to necessitate dialysis. Regardless of these costs, there is considerable hospital-level variation still present in the cost of AKI care in the USA. These appraisals only report the inpatient costs of AKI and overlook AKI that ensues in primary care settings and the enduring significances of an AKI episode [27].

5 Acute Kidney Disease (AKD)

It is recognized that both AKI and CKD are well defined and classified, however, there remains a disparity in research, care, and guidance for those individuals with abnormalities in kidney function and/or structure who do not meet the definition of AKI or CKD [28]. Both AKI and CKD embody common presentations for heterogeneous conditions. These presentations in principle could be caused by similar diseases that cause AKI or CKD which could be identified, evaluated, and managed before they develop same. The lack of a recognized definition and nomenclature for these presentations signifies a plausible disparity in the classification of kidney disease (KD) and disorders. This results in individuals and health care professionals lacking management recommendations that could possibly enhance care and outcomes [29]. The KDIGO AKI guidelines proposed a working definition of acute kidney diseases and disorders shortened to acute kidney disease (AKD) to address this disparity and to complement the criteria for the continuum of clinical presentations of AKI, AKD, CKD, and the lack of these presentations or what is identified as no known kidney diseases (NKD) (Table 2) [12, 28, 29].

The Acute Dialysis Quality Initiative (ADQI) 16 report in 2017 suggested an alternative definition and a classification of AKD, as well as an amended definition of AKI. This report perceived in the majority of cases AKI as preceding AKD with AKI having a window of 7 days with continuation beyond this timeframe as being AKD. AKD was classified according to the previous AKI stage [29, 30]. KDIGO arranged a consensus workshop with global experts and researchers online in 2020 to investigate current data and discuss main concepts relative to AKD. The consensus reached include the maintenance of the KDIGO definition of AKD, a recommendation of a classification of KD in harmony with the KDIGO definitions of AKI and CKD along with management approaches, and priorities for research [28–30].

Table 2 Functional and structural criteria for kidney diseases and disorders

	AKI	AKD	CKD	NKD
Duration	Within 7 days	< 3 months	> 3 months	
Functional criteria	Increase in sCr by 50% within 7 days Or Increase in SCr by 0.3 mg/dL (26.5 μ mol/l) within 2 days Or Oliguria for >6 h	AKI Or GFR < 60 ml/min/1.73 m ² Or Decrease in GFR by >35% Or Increase in sCr by >50%	GFR < 60 ml/min/1.73 m ²	GFR >60 ml/min/1.73 m ²
And/or Structural criteria	Not defined	And/or Marker of kidney damage (albuminuria, hematuria, or pyuria are most common)	And/or Marker of kidney damage (albuminuria is most common)	And No kidney damage

AKD Acute kidney disease, AKI acute kidney injury, CKD chronic kidney disease, GFR glomerular filtration rate, NKD no kidney disease, sCr serum creatinine [28].

6 Etiology, Pathophysiology, and Classifications of AKI

The etiology of AKI can be separated based on its pathophysiology into classifications of AKI. The three classifications of AKI are pre-kidney (prerenal) AKI, intrinsic AKI, or post-kidney (post-renal) AKI [6].

6.1 Pre-kidney AKI

This is the most common cause usually seen in about 80% of cases [12, 16]. Pre-kidney AKI is where decreased kidney perfusion causes injury. The response of the kidneys to decreased perfusion pressure is to increase sodium and water reabsorption. In the carotid artery and aortic arch baroreceptors activate the sympathetic nervous system in reaction to the reduced blood pressure. The GFR of the kidneys is maintained within a narrow scale by both vasoconstriction in the efferent arteriole and vasodilation of the afferent arteriole. The reduced perfusion within the kidneys stimulates the activation of the renin-angiotensin-aldosterone hormonal system which is vital for the regulation of blood pressure and fluid balance. The potent vasoconstrictor angiotensin-II stimulates the release of aldosterone encouraging sodium and water reabsorption at the collecting duct. The hypothalamus is stimulated by the reduced blood volume supporting the release of the antidiuretic hormone which amplifies tubular water reabsorption resulting in concentrated urine [6]. The integrity of the kidney parenchymal tissue is preserved and the GFR is corrected quickly with the re-establishment of kidney perfusion with pre-kidney AKI. However, severe kidney hypoperfusion that is untreated could add to the development of ischemic acute tubular necrosis [31].

The major causes of pre-kidney AKI are intravascular volume depletion such as hemorrhage, gastrointestinal losses, renal losses (overzealous diuretic usage, osmotic diuresis, diabetes insipidus), increased insensible losses, “third-space” losses (such as crush syndrome or rhabdomyolysis, pancreatitis). Cardiac failure, systemic vasodilation, sepsis, liver failure, anaphylaxis, drugs such as antihypertensives, anesthetics, afterload reduction and drug overdoses are all examples of decreased cardiac output which is another major origin of pre-kidney AKI. Renal vasoconstriction is another rationale for the development of pre-kidney AKI. This can encompass norepinephrine, ergotamine, hypercalcemia, sepsis and liver disease. Pharmacological agents that severely effect autoregulation and GFR rate in particular settings are all sources of pre-kidney AKI. This includes angiotensin-converting enzyme inhibitors (ACEi) in severe renal hypoperfusion or in renal artery stenosis or nonsteroidal anti-inflammatory drugs (NSAIDs) throughout renal hypoperfusion. Pre-kidney AKI can sporadically be activated by direct renal vasoconstriction minus overt systemic hypotension as transpires with the use of a calcineurin inhibitor (cyclosporin/ tacrolimus), administration of vasoconstrictors or in the presence of hypercalcemia [32].

6.2 Intrinsic AKI

This is where there is direct injury to the kidneys itself. It can be beneficial to label intrinsic AKI as the following: glomerular (such as acute and rapidly progressive types of glomerulonephritis); tubular ischemic (such as extreme pre-kidney AKI, sepsis, pancreatitis), toxic: intrinsic toxins (such as rhabdomyolysis, massive hemolysis, tumor lysis, myeloma) and extrinsic toxins (such as radio contrast and drugs), interstitial (such as autoimmune, toxic, infectious), and vascular: large vessel (such as renal artery stenosis, atheroembolic) and small vessel (such as vasculitis, polyarteritis nodosa, malignant hypertension, hemolytic uremic syndrome, and eclampsia) [33].

Acute tubular necrosis (ATN) accounts for 45% of cases of AKI. It triggered by sepsis in 19% of adults within ICU [6]. ATN is typified by an extreme decrease in GFR. However, it is not fully understood the association between the tubular injury and the loss of glomerular function. There are three processes that are considered to highlight the diminished kidney function in ATN. Firstly, the concept of intratubular obstruction wherein after an ischemic or nephrotoxic injury to the kidneys there is occlusion of the tubule lumen distally following tubular epithelial cells and cellular debris being sluffed from the tubular epithelium. The results of these sluffed cells and fragments shape the granular casts spotted in urine sediment. The construct of tubular back leak occurs because of the sluffing of these necrotic and apoptotic tubular epithelial cells ends. This results in denuding of the tubular basement membrane and unfettered back leak of the glomerular filtrate. These two processes result in reduced urine flow across the tubular lumen. The final process is whereby there is both vasoconstriction and microvascular injury that ensues in diminished glomerular perfusion, directly decreasing the GFR and adding to the enlargement of the initial injury [31].

The kidney is predisposed to drug-induced injury as drugs and metabolites are simply accrued in high easily concentrations in the kidney. Drug-induced AKI is a generic term for recently occurring kidney injury or kidney injury that has been aggravated by the drugs dispensed for diagnosis and management. It can be categorised into the following: acute interstitial nephritis, toxic kidney injury, drug-induced indirect toxicity through decreased blood flow and abnormal electrolytes and drug-induced crystal development and urinary tract obstruction kidney injury for calculus development [14].

Acute interstitial nephritis (AIN) is within the classification of intrinsic AKI and can be known as drug-induced AKI. It is an immune-mediated type of kidney injury that is categorized histologically by immune cells being infiltrated within the tubulointerstitium. Medications are the most prevalent cause of AIN with an estimation of >70% of AIN monitored in high-income countries. There are over 120 drugs identified to cause AIN with most frequent offenders being antibiotics, NSAIDs, proton pump inhibitors (PPIs), and immune-checkpoint inhibitors (ICPs). It is therefore not surprising that it a relatively common cause of hospital-acquired AKI [34]. AIN may also arise due to infections (such as bacterial or viral) malignancy and immunologically mediated systemic disease such as systemic lupus erythematosus (SLE) [31].

6.3 Post-kidney AKI

This is injury to the kidneys because of urinary outflow obstruction. The prevalence of this classification is 5–10% of individuals with AKI primarily in older men who have prostatic problems such as benign prostatic hypertrophy or prostate cancer. These conditions can lead to partial or complete urinary obstruction. Acute urinary obstruction may also be present in young boys with congenital urethral valves. It is important to note that complete urinary tract obstruction is rare in women in the absence of surgery, malignancy, or irradiation within the pelvic region. Kidney, urinary and bladder stones, ascending urinary infection (including pyelonephritis), and urinary retention, retroperitoneal fibrosis, lymphoma, tumor, and trauma are all other causes of post-kidney AKI [6, 33].

7 Clinical Sequence of AKI

Individuals with AKI may have normal urine output, oliguria, or anuria [4]. The clinical sequence of AKI can separate into four stages. The initiating stage develops when the kidneys injured, for example, with hypovolemia or nephrotoxic event. This is when the diagnosis is reached, and therapy established. The timeframe of this stage can last from hours to days. There is a necessity for thorough assessment and prompt intervention at this stage to avoid advancing to the later stages of AKI. It is important to be mindful here of those individuals who are at risk of developing AKI including advanced age, existing CKD, liver failure, heart failure, diabetes,

previous history of AKI, hypertension, use of nephrotoxic medications, hypovolemia, major surgery, history or risk of urological obstruction, use of iodinated contrast agents, sepsis, neurological or cognitive impairment, and hematological malignancy [16, 35, 36].

The oliguric stage is the next phase which may last from 5 to over 15 days. The more protracted this stage the more adverse outcomes there will be for the individual involved who is especially vulnerable to bleeding and infection throughout this stage. This is because of endocrine issues where there is diminished manufacturing of erythropoietin and functional kidney changes including both reduced glomerular filtration and urine formation. The glomerular basement membrane substituted with fibrous scar tissue and the functional units of the kidneys the nephrons will be congested with inflammatory effects as renal healing begins to process [35, 36].

The diuretic stage is whereby the kidney begins to recuperate many of its absent function as it continues to heal, however, this is contingent on how severe the initial kidney injury was. The urinary output begins to increase back to typical levels. However, it is important the individual is closely monitored in terms of polyuria and potential dehydration whereby they could urinate up to 3 l daily in this stage. This can be because of either reduced fluid reabsorption by damaged renal tubules or the osmotic impact of accumulated metabolites. The individual's signs and symptoms related to their initial condition should also begin to recede within this stage. The recovery stage or convalescent phase is the final stage and can last anything from a few months to over a year. It commences when laboratory values stabilize and concludes when kidney function returns to normal. The glomerular basement membrane returned to its former structure with clinically insignificant scar tissue remaining [35, 36].

8 Clinical Presentation of AKI

The clinical appearance of AKI is contingent on the cause and gravity of the renal insult. AKI is often regarded as a “silent disease.” Individuals with most types of AKI lack explicit signs and symptoms initially in the development of the injury. Therefore, detection requires a high degree of suspicion in those at risk especially in those that are acutely ill. They may also present, for example, with symptoms only applicable to the precipitating illness (such as sepsis) [6, 37]. Those individuals with mild to moderate AKI are asymptomatic and are detected based on laboratory analysis. However, individuals with severe AKI usually present with numerous symptoms, for example, fatigue, nausea and vomiting, anorexia, restlessness, confusion, and fluid retention. There can be central nervous system indicators such as uremic encephalopathy with asterixis, polyneuritis, mental status changes, muscle cramps and seizures, platelet dysfunction, and severe anemia in serious and protracted AKI [4].

It is important therefore to assess the individuals' medical and social history and determine their risk factors such as frailty, older age, CKD, diabetes mellitus, liver disease, heart failure, and cognitive and/ or neurological impairments. Their oral

intake should become established along with any gastrointestinal symptoms, manifestation of rash or joint symptoms, urinary output, and any susceptibility to urinary tract infections (UTIs) or any other urinary symptoms and/or history with same. The most common causes of AKI triggering kidney insult include sepsis, hypovolemia and/or hypotension and nephrotoxins. The types and dosages of medications should be reviewed such as nephrotoxic, over the counter, recreational drugs, and the use of herbal therapies [6, 8, 37–39].

Recreational or occupational history should be established such as recent travel, tropical diseases, exposure to sewer systems and rodents. Initially there should be airway, breathing, circulation, disability, exposure (ABCDE) assessment conducted, and observations recorded using the National Early Warning Score 2 (NEWS2). There should be monitoring for any signs of sepsis and palpation of the abdomen examining for a full bladder. Since AKI is so familiar in individuals who are acutely ill the Royal College of Physicians in the UK advocates a NEWS2 score of 5 or above. This should trigger a check concerning fluid intake, urinary output, and kidney function all relative for AKI. It is important to be mindful that some individuals with AKI may not have an escalated early warning score as urinary output is not incorporated in general used scores such as NEWS2. Therefore, oliguria which is an indicator of potential AKI will not generate any escalation in the individual's score [6, 8, 37–39]. The Irish NEWS2 identifies the medical team must be notified if an individuals' urine output is <0.5 ml/kg/h when monitoring their INEWS2 which acts as an aid for nurses to use their clinical judgment and decision making. It identifies this as a small window of opportunity to recognize AKI. The use of ISBAR (identify, situation, background, assessment, and recommendation) communication tool is relevant to escalate the response protocol as required [40].

The “Think Kidneys” AKI best practice guidance responding to AKI warning stage test results for adults in primary care identifies the relevance of this test result and its recognition within this pertinent area of care delivery. The AKI warning stage test result regarded as a two-step process wherein stage one detects the creatinine changes coherent with AKI produced by NHS England detection algorithm. This repeatedly highlights probable causes of AKI from laboratory information in real time and generates a test result (i.e., AKI stage 1, 2 or 3) conveyed together with the serum creatinine result. This test result is known as an “AKI warning stage.” The second step of this process is advising this AKI result to healthcare staff which is the warning phase of this process. Those positive AKI warning stage results will transmit from the relevant laboratory system to general practice (GP) clinical systems. These systems need to ensure timely communications of test results both in and out of standard working hours in primary care services. Primary or community care teams need to determine how responsive to act on the applicable test result. This includes appropriate action to adopt using the guidance provided by “Think Kidneys” to maintain a timely and suitable response to AKI warning stage test results. Questions such as what is the stage of AKI? How severe is the AKI with escalating severity of AKI associated with increased risk of adverse outcomes. Stage 1 being the least severe typically treated in primary care settings while AKI stage 3 being the most severe should treat in hospital care settings [18, 21].

This same guidance identifies the importance of nurses and other members of the interdisciplinary team recognize and respond to adults with AKI within primary care or community care settings. Nurses working in these areas must recognize any AKI risk factors and/or clinical features instigating earlier review including fluid intake and urinary output. Are there any indications of hyperkalemia particularly if moderate or severe? What about reduced immunity, advanced stages of CKD, history of kidney transplant or previous AKI? Is there frailty with comorbidities such as CKD, diabetes, heart failure, liver disease, neurological, cognitive impairments? These should all be reviewed. There are four principal areas here, i.e., “Think” cause, “Think” medication, “Think” fluids, “Think” review [18, 21].

The “Think” cause addresses the following questions which must be deliberated and acted upon such as, is there a history of acute illness? Nurses need to “Think” sepsis, “Think” hypotension; is intrinsic AKI suspected such as vasculitis? “Think” urinalysis; are there any signs of urinary obstruction? [7, 26]. “Think” medications encompasses any medication that could aggravate AKI. Nurses and other members of the interdisciplinary team must be mindful of any types of medications that could accrue resulting in harm throughout AKI and/or any new medications that could cause AKI such as drug-induced AKI. There are an extensive range of common medications including NSAIDs, cardiovascular medications including antihypertensives, diuretics, digoxin, and statins (if rhabdomyolysis depicted) and some antibiotics including trimethoprim and co-trimoxazole which all need to be assessed in terms of withholding, avoiding, stopping, or reducing dosages as clinically assessed and deemed appropriate on an individual basis [7, 26].

The concept of “Think” fluids revolves around individual’s volume status and do they have hypovolemia? When was the last time the individual urinated? Can they increase fluid intake or is there a necessity for hospital admission for monitoring and intravenous (IV) fluid replacement? Finally, another relevant aspect here is does the individual have and/or require carer support? “Think” review is the final principal area and addresses does the individual require acute admission? If not when will the nurse and other members of the interdisciplinary care team review? Is there a thorough handover to colleagues regarding this individual? [7, 26].

9 **Diagnosis of AKI**

A basic metabolic profile should be conducted with creatinine used for AKI diagnosis in conjunction with the potential risk factors for AKI. There is a necessity to ensure that test results are regarded with a recognition of the clinical indicators in which they were derived. The importance of effective communication in terms of a thorough handover, medical records, access to significant clinical information when deriving blood tests using relevant laboratory forms can assist supporting a timely and suitable response to a test result. It is vital to distinguish AKI from a progression of CKD at initial clinical presentation. This can be challenging if there are no current comparison creatinine values. The clinical background will assist whether an increase in serum creatinine has been sudden or transpired over a longer timeframe.

False positives can occur with rises in serum creatinine such as pregnancy wherein an increase in serum creatinine may be a false positive following recent delivery; usually serum creatinine decreases throughout pregnancy [6, 12, 26, 37].

Daily monitoring of bloods tests including urea and electrolytes are vital for individuals in hospital care settings. This is until the AKI resolves as even moderately changes in sCr levels are related to a substantial increase in mortality. The staging of AKI is determined based on sCr or urinary output whichever one provides the higher stage. Liver function tests (LFTs) will assist in diagnosing hepatorenal syndrome. While careful monitoring of serum potassium is important to determine presence of hyperkalemia which can be a severe complication of AKI. A full blood count (FBC) could indicate an infection with leukocytosis and an increased or decreased white blood count (WBC) could transpire with sepsis. Anemia can ensue in AKI consequent to vasculitis, myeloma and/or hemolytic uremic syndrome. Bicarbonate should be queried if it not a facet of a standard panel with decreased levels indicates metabolic acidosis. Venous blood gases should be requested for future appraisal of metabolic acidosis especially if an initial bicarbonate sample was not included with the initial bloods taken which indicated AKI. Venous blood gases can also evaluate acid/ base status which can occur in AKI because of diminished excretion of non-volatile acids. C-reactive protein should be ordered with all adults as increased levels signify infection and vasculitis. Blood cultures are requested if infection assumed. Sepsis is a widespread cause of AKI so a septic screen should instigate if sepsis deduced using a local care bundle such as sepsis six as appropriate [6, 12, 26, 37]. Individuals with AKI are more immunocompromised; therefore, can be more at risk to infection so stringent infection control measures using standard personal protective equipment (PPE) as applicable to local policy within hospital care or primary care settings when conducting procedures and other care delivery.

Further specific bloods tests as determined by the diagnosis include serum creatine kinase which would distinctly raise in rhabdomyolysis. Examples of immunological tests including anti-nuclear antibodies (ANA) which is a wide-ranging screening check (can be normal or elevated) for variety of autoimmune diseases such as kidney dysfunction within SLE. The anti-glomerular basement membrane (anti-GBM) antibody can be raised, for example, with anti-GBM disease or Goodpasture disease. The therapies for which include immunomodulating drugs, corticosteroids, cytotoxic agents, and/or plasma exchange. While anti-neutrophil cytoplasmic antibodies (ANCA) can also be used to diagnose anti-GBM disease as well as ANCA-associated vasculitis. Human immunodeficiency virus (HIV) serology is applicable concerning HIV-associated nephropathy along with nephrotoxicity of some of the drugs used to treat HIV (positive or negative). The acute hepatitis profile is used to ascertain positive serology in active Hepatitis B or C. This relates to kidney conditions, serum electrophoresis (paraprotein highlighted), and urine electrophoresis (Bence Jones protein established) with myeloma. Myeloma is a significant cause of AKI, and management includes use of corticosteroids, cytotoxic agents, plasma exchanges, and KRT as required [6, 12, 26, 37].

There are various urinary investigations that are required as soon as AKI is speculated or identified, including a urine dipstick to test for specific gravity, protein, blood, nitrites, glucose, and leucocytes. Urine PCR is conducted if protein present on urinalysis. Intrinsic AKI may be a potential cause if urinalysis is positive with proteinuria and hematuria with the lack of any apparent different cause such as injury/ insult from urinary catheterization or a UTI. The presence of proteinuria and hematuria may suggest an active urine sediment because of glomerular disease. Individuals who present with glomerular disease have symptoms of proteinuria, hematuria, edema, and hypertension and require timely referral to nephrology. Infection, myoglobinuria (rhabdomyolysis), and calculi are some further examples of other causes of an active urinary sediment. A urine culture is obtained if there is a presence of a UTI with urinalysis for blood, protein, or leukocytes or the individual concerned has clinical presentation of same [6, 12, 26, 37].

The monitoring of urinary output is paramount when caring for individuals with AKI; this can be hourly if the individual has a urinary catheter (u/c) in situ, 4-hourly if they do not. However, the accuracy of urinary output is challenging if the individual is not catheterized. A diagnosis of AKI is confirmed if urine output <0.5 ml/kg/h for at least 6 consecutive hours. There must be a careful risk assessment for using a u/c in individuals with AKI as they are not routine standard in care delivery. The pros and cons of u/c must be assessed on an individual basis. The potential benefits include urine output is difficult to quantify without using a u/c and a continual decrease in urinary output is a diagnostic indicator for verifying AKI. Hourly urinary output monitoring assists the ongoing evaluation of the individuals' outcome to their treatment. The use of u/c can assist with identification and treatment for bladder neck blockage. Should a large volume of urine discharge following u/c insertion, this does direct to an obstruction of the bladder opening. While if there is only minimal residual urine following u/c insertion indicates an advanced level urinary tract obstruction or non-obstructive basis of AKI. However, the cons for a u/c include possibilities of infection, trauma, and risk of falls. The use of u/c is denoted where it is vital to manage fluid balance, wherein the individual concerned is excessively unwell to utilize a bottle or commode, if bladder neck blockage is deduced and this cannot be rapidly established via ultrasound [6, 12, 26, 37]. Nurses must ensure strict infection control measures with catheter care using PPE, in accordance with the hospital's PPE guidance. They should monitor for any potential signs and symptoms of a UTI. This also includes educating the individual if feasible concerning rationale for using a urinary catheter and potential length of time it may be used to monitor urinary output.

Further investigations include PCR testing for Coronavirus Disease 2019 (COVID-19) and appropriate measures taken if positive in accordance with local hospital protocols. The use of a chest X-ray could demonstrate signs of infection, (fluid) pulmonary edema, cardiomegaly, or hemorrhage such as Goodpasture's disease with pulmonary hemorrhage or ANCA-associated vasculitis. An abdominal X-ray is conducted if renal calculi is speculated. An ECG would highlight any associated changes with hyperkalemia. The individual will have an ultrasound if pyonephrosis is inferred; if required they may need a nephrostomy within a 6-h window

owing to the threat of septic shock. The use of a renal tract ultrasound has high sensitivity usually conducted within 24 h. It is not typically required and is only conducted if there is no apparent cause of AKI or should there be any urinary or bladder obstruction, pyelonephritis or pyonephrosis. The ultrasound may need to be repeated post 24 h, for example, if there is high suggestive indicator for hydronephrosis. AKI can also distinguish from CKD occasionally using an ultrasound which can highlight small kidneys (occasionally scarred) coherent with advanced CKD. This is helpful if there are no previous creatinine levels to provide a baseline. An abdominal CT or MRI scan would be required if an ultrasound demonstrated an obstruction to highlight a mass or stone imagery. A cystoscopy may be needed to determine cause of obstruction such as bladder tumor or ureteric stenosis. The kidney biopsy may be needed to further establish the cause of AKI including types of glomerular diseases following positive serological studies [6, 8, 12, 26, 37].

10 Initial Management of AKI

Once diagnosed the management of AKI is mainly supportive. The Royal College of Physicians in the UK recommends the application of the STOP (sepsis, toxins, optimize blood pressure, and prevent harm) AKI acronym as a reminder for health care professionals to elicit the urgent steps required for management of AKI. A local care bundle such as sepsis six (surviving sepsis campaign bundles)/ “Think sepsis,” for example, should be executed within 1 h if sepsis is deduced or verified. The sepsis screen should establish source of infection and treat the same. The use of nephrotoxins should be stopped or avoided such as NSAIDs, iodinated contrast agents, aminoglycoside, and antibiotics. Both volume status and blood pressure must be optimized through the continual assessment of same. An immediate IV bolus of crystalloid should be administered if the patient is hypovolemic. A balanced crystalloid (for example Hartmann’s solution or ringer’s acetate) should be selected except if hyperkalemia is established or questioned then normal saline would be used. The use of ACEi or angiotensin-11 receptor antagonists should be withheld as these can aggravate AKI. The use of diuretics and other antihypertensive medications should also be withheld. If the individual concerned continues to be hypotensive regardless of acceptable volume resuscitation. There should be an escalation to critical care for consideration of vasopressors. The prevention of any harm to the individual is paramount with detecting and managing revocable causes such as the relief of any urinary tract blockage, managing severe acute complications such as hyperkalemia and metabolic acidosis. All medications must be reviewed, and dosages modified as required in accordance with the extent of kidney injury [2, 4, 6, 12, 13, 36]. KRT commenced when these methods fail to deliver a sufficient and safe regulation of homeostasis [13].

“Think Kidneys” national program in England recommend the use of care bundles for AKI within hospital care settings [39]. The UK Kidney Association clinical practice guideline on AKI identify the importance of a personalized approach to detect individuals at risk of AKI based on the subsequent questions. (1) what risk

factors for AKI does this individual have? (2) can the healthcare team reduce this risk? (3) can the applicable healthcare team avert adding to this risk? (4) is the healthcare team able to identify AKI as early as feasible through frequent monitoring of urinary output and kidney blood tests [2].

The **5Rs** approach in managing AKI is another algorithm that could be used to assist nurses and other members of the interdisciplinary team both in the primary care and hospital care settings. This **5Rs** approach (risk, recognition, response, renal support, and rehabilitation) is comparable to the 5R framework for sustainable basis to maintain AKI care already outlined (Fig. 1) [18, 19]. Individuals at risk of AKI should avoid episodes of dehydration and exposure to nephrotoxins. Recognition of AKI is contingent upon reliable clinical judgment, vigilant evaluation of urinary output, and serum creatinine. Rapid response to AKI involves the STOP AKI acronym already highlighted [37]. Individuals with severe AKI should be referred and access renal support. Finally, those adults with AKI or at risk and their partners/family members should obtain applicable rehabilitation including information concerning the risk factors, preventative methods, therapy options, and potential outcomes [41].

11 Ongoing Management of AKI

11.1 Volume Status

It is vital to conduct an initial assessment of the adult with AKI with swift adjustment of volume depletion or volume overload particularly if related with deteriorating cardiac output. This can overturn or improve AKI. Meticulous management of fluid balance is necessary as both hypovolemia and volume overload are related with adversative outcomes. Restoring kidney perfusion is the main factor to enhance the hemodynamic state of the individual concerned which pre-kidney AKI which is frequently a result of hypovolemia and/or hypotension. Signs and symptoms of hypovolemia to observe for include daily weights, capillary refill time, NEWS2 scoring, postural blood pressure, jugular venous pressure, skin turgor, and dry axillae/ mucous membranes. All input and output should be recorded on fluid balance chart with early nutritional assessment (using a standardized nutritional tool) instigated. Blood tests conducted include urea and electrolytes to include bicarbonate, FBC, LFTs, bone profile including phosphate. Signs and symptoms of volume overload are less frequent at initial presentation and include respiratory rate with tachypnoea implies fluid overload and/or acidosis, peripheral, and sacral edema. The presence of crackles on auscultation of lungs suggests pulmonary edema [2, 6, 12, 15, 16, 37, 39].

Fluid resuscitation for hypovolemia involves administering a 500 ml IV bolus (preferably crystalloid fluid) of fluid over 15 min, with the use of a balanced crystalloid except hyperkalemia is speculated or identified, normal saline (0.9% sodium chloride) should be used if hyperkalemia is confirmed. The hemodynamic status must be reassessed following the initial fluid bolus and judge whether further

250–500 ml boluses are needed as well as the individual's response to each fluid challenge using ABCDE approach, NEWS2, clinical assessments including urinary output. The care must be escalated if there is no improvement following two fluid challenges with necessity for critical care support. It is vital to recognize when to decrease IV fluid therapy when the individual concerned is euvoletic and hemodynamic stability reestablished. Should this not be conducted volume overload could occur hastening pulmonary edema. This is more adversative from over-aggressive or overzealous fluid resuscitation if the individual has a history of heart failure or is oliguric/ anuric. The use of IVs must have a clear intention with a clear rationale for administering same [2, 6, 12, 15, 16, 37, 39].

The concept of volume overload can occur in AKI due to oliguria in intrinsic or post-kidney AKI along with overzealous fluid resuscitation which is frequently found in individuals with sepsis who originally exhibited with hypovolemic pre-kidney AKI. There is a necessity again for meticulous monitoring to ameliorate any adversative outcome such as pulmonary edema. Volume overload may be managed by sodium restriction and prudent use of a loop diuretic such as furosemide under consultation with the nephrology team with evaluation of urinary output with said medication ceased if there is no success. Urgent KRT is specified for intractable volume overload or volume overload again following discussions with nephrology team and if there is a poor response of the loop diuretic usage for volume overload [2, 6, 12, 16, 37, 39]. Nurses must deliver ongoing care using NEWS2, addressing signs and symptoms of volume overload, administering oxygen if and as prescribed and frequent monitoring of skin integrity including mouth care. The care delivery should be explained taking on board there may be altered mental status because of AKI such as confusion, lack of concentration and delirium. It is important therefore to reassure and provide emotional support to individuals with AKI and their partners/ family members as this can be a distressing and difficult time for all involved.

11.2 Medication Review

Any medication that lowers blood pressure, circulating volume, or kidney blood flow will enhance the risk of AKI. All medications and dosages must be reviewed particularly if there are nephrotoxic medications prescribed when AKI is inferred or verified. These nephrotoxic medications must be stopped or avoided as they could impact on kidney function. There are numerous common medications that are frequently prescribed including NSAIDs, iodinated contrast agents, aminoglycoside antibiotics, ACEi, angiotensin-II receptor antagonists, diuretics, or other antihypertensive medications. Specialist pharmacist advice should be sought to reduce negative impacts (such as dose amendment, maintain a short course of therapy as possible, evaluate blood levels of the medication if possible) particularly if there are prevailing rationales to maintain the usage of a potential harmful medication. Before the individual concerned is discharged all their medications must be reviewed with a plan created to reestablish any medications that have been suspended at a suitable time with re-titration dosage as applicable in primary care or community care

settings. Medications for pre-existing heart failure would be re-commenced as soon as clinically practical and optimum control of both fluid balance and blood pressure achieved through re-titration. A necessary part of the discharge planning would be ensuring procedure prepared for monitoring of serum creatinine and potassium 1–2 weeks post discharge. Individuals with AKI and nurses along with other members of the interdisciplinary team require suitable and effective education as to the capacity for kidney injury and dysfunction from nephrotoxic agents [2, 6, 26, 39, 42].

11.3 Pharmacological Management

There is currently no evidence to provide the use of a particular pharmacological therapy in the management treatment of AKI secondary to hypoperfusion injury and/or sepsis. There is also no evidence that using loop diuretics minimizes the prevalence or severity of AKI. Loop diuretics should not administer routinely to treat AKI. They may be contemplated for treating fluid overload or edema while an adult is awaiting KRT or if kidney function is improving in an adult not receiving KRT. Loop diuretics are used with adults in oliguric AKI, to expediate the management of fluid and electrolyte disturbances and minimize the necessity for KRT. Diuretics are also used to control fluid balance or edema and allow administration of nutrition and medications. However, diuretics can also be harmful, by unduly minimizing the circulating volume and adjoining a prerenal insult, deteriorating established AKI. It is vital to appraise efficacy of diuretics to enhance outcome of adults with AKI, not solely for fluid management. It has been suggested that dopamine may possibly minimize ischemic cell injury in adults with AKI by enhancing renal blood flow and decreasing oxygen consumption by means of inhibition of sodium transport. There have been numerous studies examining the use of dopamine in the avoidance and management of AKI which identified that there is no good evidence to promote any significant clinical advantages to adults with or at risk of AKI. Regardless of the lack of supportive data loop diuretics and dopamine are still often used inappropriately to try to determine and sustain a urinary output [2, 3, 12, 15, 37].

11.4 Nutritional Support

There are several areas that need to take into consideration when addressing nutritional support for individuals with AKI including exact metabolic disturbances allied with the kidney injury, the primary disease process, the probable nutritional deficits, and benefits during KRT, fluid retention, and preservation of uremic toxins and inflammatory markers. The overall purpose of nutritional support is to sustain nutritional status while curbing the complications of AKI. This comprises averting or reducing malnutrition especially protein energy wasting (PEW), maintaining lean body mass, preventing extra metabolic imbalances, enhancing wound healing,

promoting immune function, and thereby decreasing risk of mortality. Currently there is no endorsed screening tool to detect malnutrition in adults with AKI plus they are frequently not suitable in the critical care setting. There should be an individual assessment conducted by a dietician specifically if the individual is at high risk of malnutrition and if they are receiving KRT as a treatment for AKI [2, 43].

The dietetic classification of AKI is separated into adults with AKI in the non-catabolic state and those adults with AKI in the catabolic state. Usually, adults that are stable with pre-kidney (such as dehydration, certain medications) or post-kidney AKI (such as urinary blockage) depict in a non-catabolic state. Should KRT be required it is frequently supported through standard hemodialysis (HD). These individuals primarily with stage 1 and 2 AKI can manage alone with an oral diet and as necessary, the addendum of nutritionally dense supplementary sip feeds will regularly suffice to match their needs. Should this not be the case artificial nutrition support should be instigated. Usually, individuals with intrinsic AKI (such as sepsis, trauma, and acidosis) depict in a catabolic state. They may have any stages of AKI although mainly stages 2 and 3 AKI and are prone to be treated in ICU. PEW can be a common outcome in this cohort resulting in protracted hospital stays and adverse outcomes including mortality rates. The use of artificial nutritional support ideally via the enteral route is regularly required especially if the individual concerned is intubated and sedated. Nutritionally dense feeds with or without decreased electrolyte substance are beneficial where the regulation of fluid balance and/or serum phosphate and potassium levels demonstrate challenges. There needs to be a cautious approach for adults with AKI in ICU as there can be reduced tolerance for nutritionally dense feeds [2, 43].

12 Management of Complications of AKI

12.1 Hyperkalemia

This is a widespread complication of AKI. The management of hyperkalemia is reliant on the gravity and existence of muscular weakness and/or cardiac complications such as cardiac arrhythmias. Any aggravating aspects should be adjusted such as treating the AKI, suspending culprit medications such as ACEi, potassium sparing diuretics, angiotensin-II receptor antagonists, and limit dietary intake of potassium type foods and fluids [6].

The treatment of hyperkalemia in hospital should follow a 5-step approach according to the UKKA 2020 clinical practice guidelines on acute hyperkalemia in adults. Step 1 protects the heart and advocates that IV calcium chloride or calcium gluconate at an equal dose is administered to the adult with hyperkalemia in the existence of ECG indication of hyperkalemia. Step 2 is shifting potassium (K+) into cells using an insulin-glucose infusion wherein 10 units soluble insulin in 25 g glucose is administered by IV infusion to treat severe hyperkalemia ($K^+ \geq 6.5$ mmol/l) and moderate hyperkalemia ($K^+ 6.0$ – 6.4 mmol/l). It is vital in step 2 to avoid hypoglycemia by preventively initiating an infusion of 10% glucose at 50 ml/h for 5 h

after insulin-glucose therapy in adults with a pre-therapy blood glucose <7.0 mmol/l (target blood glucose 4–7 mmol/l). Step 2 continues with shifting K^+ into cells using salbutamol (10–20 mg) as adjuvant therapy for moderate and severe hyperkalemia. The use of IV sodium bicarbonate is not usually administered for the acute therapy of hyperkalemia within step 2. Step 3 progresses with the use of potassium binders and removal of K^+ from the body. This step recommends that sodium zirconium cyclosilicate is applied in the emergency therapy of acute life-threatening hyperkalemia (serum $K^+ \geq 6.5$ mmol/l) while patiromer is suggested as an option to also treat this level of hyperkalemia. Calcium resonium should not be used in the emergency management of severe hyperkalemia but could be considered in adults with moderate hyperkalemia [44].

It is recommended within step 4 that serum K^+ is closely monitored in all adults with moderate or severe hyperkalemia (at least 1, 2, 4, 6 and 24 h) to evaluate efficacy of therapy and to observe for rebound hyperkalemia. Blood glucose concentration should also be monitored regularly, for example, 0, 15min, 30min, 60min, 90min, 120min, etc. up to 12 h post-administration of insulin-glucose infusion in all adults with hyperkalemia. Individuals who are receiving HD with severe hyperkalemia obtain urgent dialysis therapy. Should they have toxic ECG changes IV calcium salts should be administered to minimize the risk of arrhythmias even if dialysis therapy is instantly accessible. Should dialysis not be instantly accessible then standard medical therapies be used to reduce serum potassium (in those again with severe hyperkalemia). The use of potassium binders may be contemplated throughout the interdialytic timeframe. Specialist referral to local renal or critical care team for an urgent opinion for adults with severe hyperkalemia and potential escalation of care, if necessary, from the start or if the individual concerned fails to react to early therapy [44].

12.2 Metabolic Acidosis (pH <7.25)

This is a frequent metabolic intrusion in AKI. It transpires mainly due to reduced excretion of the usual load of metabolic acid in the context of a reduced GFR. Further circumstances that may also influence is enhanced creation of lactic acid in individuals with sepsis. It is important to recognize there will be comparative challenge to vasopressors in the occurrence of severe metabolic acidosis. IV sodium bicarbonate is a guide for use in severe metabolic acidosis (pH <7.2). However, it is important to access expert support beforehand and throughout this process as it can result in volume overload and/ or hyponatremia. There should be consideration made to refer to ICU. IV sodium bicarbonate should only be administered if there are no signs of volume overload and if venous bicarbonate is <16 mmol/l. Ionized Ca^{2+} is slashed following swift rectification of metabolic acidosis with IV sodium bicarbonate. However, this can initiate tetany, seizures, and cardiac volatility. Before administering IV sodium bicarbonate the low ionized Ca^{2+} must be amended through a distinct IV route because of the inconsistency of bicarbonate and calcium suspensions. The individual concerned would be referred for KRT if there is no

response to initial therapy with refractory acidosis ($\text{pH} < 7.15$) or they have severe acidosis in the context of volume overload [2, 6, 37, 39].

12.3 Pulmonary Edema

This could occur with overzealous IV fluid resuscitation in individuals who depicted hypovolemic pre-kidney AKI. It may also ensue in some forms of AKI such as cardiac failure with AKI and renal tract obstruction with salt and water retention. Acute pulmonary edema is an emergency management with high mortality rates the care delivery is therefore vital. The individual concerned must be sat straight in the bed and administered high-flow oxygen (15 l/min through a reservoir mask) and continuous positive airway pressure ventilation should be considered if accessible. IV glyceryl trinitrate should be administered with the dosage titrated upwards, planning to sustain systolic blood pressure (SBP) > 95 mmHg. A loop diuretic could be considered if the individual is hemodynamically secure. This must be again conducted under specialist supervision with also senior support obtained. The warning for emergency KRT is refractory pulmonary edema as the application of an IV-glyceryl trinitrate and a loop diuretic like furosemide could be a helpful supporting measure. However, this should not suspend advancing to decisive management with kidney support if required [2, 12, 37, 39]. The use again of ABCDE and NEWS2 is vital here, monitoring of bloods including venous blood gases, deep breathing and coughing exercises if tolerated as well as ongoing emotional support for the individual experiencing this serious distressing complication of AKI.

12.4 Indications for Kidney Replacement Therapy

The decision whether to commence continuous or intermittent KRT should be based on clinical presentation of the individual concerned. These extracorporeal modalities should regard as complementary therapies for AKI. The selection of KRT should be directed by clinical condition, expertise of nurses and medical team along with the accessibility of machines [2]. The indications for dialysis in AKI are well recognized and are based primarily on the progression of refractory to diuretics, life-endangering fluid overload and critical solute imbalances attended by hyperkalemia and metabolic acidosis [13]. Those individuals who are hemodynamically unstable or have cerebral edema or acute brain injury should ideally provide with continuous KRT [2]. However, the decision as to when to commence KRT in critically ill individuals with AKI is frequently much more challenging in the absence of these vital indicators. During the last decades, this area remains contentious despite a considerable progress in intensive care medicine. It is important to recognize that while KRT is unavoidable and life-saving in many incidences of severe AKI, it can also adversely influence the outcomes of individuals experiencing same. The process of dialysis subjects the individuals or exacerbates the previously present hemodynamic instability with detrimental intradialytic hypotension,

anticoagulation-induced bleeding, vascular-access-associated bacteremia, and inflammatory stress due to extracorporeal circuit bio-incompatibility. One of the main problematic impacts of KRT is a not completely foreseeable change in the pharmacokinetics of many therapeutic agents particularly antibiotics which presents a fundamental threat of underdosing them [13].

The discontinuation of KRT established on one of three clinical developments: intrinsic kidney function has sufficiently recovered to sustain stresses, the condition that induced renal support has improved, or ongoing KRT is no longer coherent with goals of care [3]. The UKKA clinical guideline on AKI also highlights that progression in the individual's clinical condition, improvement in fluid status, and urinary output would warrant temporary suspension of ongoing renal support to investigate if AKI is improving [2].

13 COVID-19 Associated Acute Kidney Injury (C19-AKI)

COVID-19 originated in Wuhan, China in December 2019 and is an infectious disease instigated by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) [45]. COVID-19 associated AKI (C19-AKI) is multifactorial in origin and may require admittance to ICU and the ensuing use of KRT [13]. AKI is more widespread amid adults hospitalized with COVID-19 than in adults hospitalized because of other illness [46]. The demographic risk factors for C19-AKI are like those for individuals developing AKI from other routine causes including those over 65 years of age, CKD, diabetes mellitus, obesity, smoking, hypertension, cardiovascular disease, and adults who are already immunocompromised. Individuals with COVID-19 may present with AKI or acquire same throughout their hospitalization with those needing admission to ICU have an increased rate of AKI as compared to those that are hospitalized on the wards. A recent systematic review highlighted that AKI commonly complicates the path of COVID-19 hospitalizations and is coupled with enhanced severity of illness, protracted period of hospitalization, and a weak prognosis [47]. There is a high mortality rate for adults who develop C19-AKI. It is therefore vital that there is early detection and response system in position [14]. There is also a necessity for prompt detection of comorbidities and renal complications to enhance the outcomes of individuals with COVID-19 in view of the adverse influence of AKI. There is a requirement for large scale research to enhance comprehension of this disease and devise clinical methods to manage C19-AKI [47].

It was highlighted that many published reports of individuals with COVID-19 do not incorporate definitions or staging of AKI, or data concerning renal recovery or follow-up. The difference between de novo AKI and AKI superimposed on pre-existing CKD is also seldom designated. The reported hospital admission rates of individuals with COVID-19 differs amid and within countries revealing diverse national and regional healthcare structures, procedures for hospitalization and for allocating stages of care, for example, ICU admission. The comparisons of AKI rates centered exclusively on the number of hospitalized persons are all complicated by these aforementioned factors [46].

The pathophysiology and processes of C19-AKI have not fully interpreted. However, it does appear to be similar with the pathophysiology of AKI in other individuals who are acutely ill [46]. The more apparent concepts are hypovolemia, hemodynamic changes, direct cellular invasion, acute respiratory distress syndrome (ARDS), and cytokine eruption. It identified that persons with C19-AKI in their histopathological reports exhibited ATN occasionally with necrosis and failing glomerulopathy or rhabdomyolysis. It may also ally with abnormal serum electrolyte levels, proteinuria, and hematuria [45, 48].

The management for COVID-19 and management of pre-existing conditions may all augment the threat of AKI. In individuals with COVID-19 fever and enhanced respiratory rate increase insensible fluid loss [49], highlighting further challenges in the management process. It is critical for minimizing the incidence of AKI in people with COVID-19 to maintain optimal fluid status (euvolemia) with relevant fluid resuscitation as hypovolemia will aggravate the hypercoagulable status and organ injury encompassing C19-AKI [49]. The emergency management of serious life-threatening hyperkalemia should address as per local hospital guidelines and can include the use of potassium binders such as patiomer if designated. There is a necessity for a complete medication review with drug dose adjustments as required. There is a need for malnutrition screening and assessment for individuals including older adults and polymorbid individuals who are at risk of adverse outcomes and increased mortality following infection with COVID-19. Members of the interdisciplinary team should be mindful of the consequences of choice of continuous and intermittent KRT on fluid balance and pharmacokinetics. The outcome to commence KRT for AKI in COVID-19 should not be based merely on the AKI stage or kidney function but on the specific assessment of the individual concerned. KRT modality will be determined upon local accessibility, preparation, and proficiency of the interdisciplinary team. There is no available high-quality evidence recommending one acute KRT modality over another modality choice [49].

14 Sepsis-Associated AKI

Sepsis-Associated AKI (SA-AKI) or sepsis-induced AKI accounts for 50% of critically ill persons in the ICU with morbidity and mortality rate high. The causes of SA-AKI are sepsis and septic shock. The initial identification and aggressive sepsis management are vital in enhancing patient outcomes and limiting the impact that sepsis can have on kidney function. The main therapy for SA-AKI is the administration of suitable antibiotics, appropriate fluid therapy, vasopressors such as norepinephrine which has been established to increase mean arterial pressure (MAP) and enhance perfusion to the kidneys, avoidance of nephrotoxic medications and the consideration of KRT as required. Nurses are usually educated to “Think sepsis” when minor changes occur in patients with potential infection. They are frequently the frontline personnel in combating sepsis and occupy more time with individuals who are hospitalized than any other members of the interdisciplinary team. They are therefore in leading positions for early sepsis recognition. The importance of early

identification including signs, and symptoms of sepsis along with standard screening protocols must be incorporated within nursing education and ongoing study days. The importance of identifying individuals within the primary or community care settings must also not be underestimated in terms of accessing assistance in a timely manner especially if there is already some degree of kidney function. A recent systematic review identified that long-term consequences relevant to SA-AKI differ from absolute recovery to reliance on KRT with the need for uniform definitions for AKI and a necessity to highlight long-term impact to make evaluations across studies [50, 51].

15 Contrast-Induced AKI

This was previously referred to as contrast-induced nephropathy (CIN) wherein AKI developed after iodinated contrast was administered. The KDIGO international guidelines recommends the term contrast-induced AKI (CI-AKI) using the KDIGO AKI definition. CI-AKI is unusual within the general population with a prevalence of only 1–2%. It usually transpires 24–48 h of receiving iodinated contrast media and the individual concerned typically improves over the subsequent 5 days. However, the prevalence of CI-AKI is enhanced considerably in individuals with risk factors including older age, CKD, diabetic kidney disease, cardiac failure, sepsis, volume depleted states, and exposure to nephrotoxic medications. It is related to protracted hospital stays, compounded mortality, and escalated health care costs [52]. The pathophysiological basis of CI-AKI is based on the interaction of cytotoxicity and viscosity. There is no treatment for CI-AKI, prevention therefore is the best management strategy. Hydration levels should be assessed for all individuals undergoing iodine-based contrast media with safety. This is especially pertinent for those individuals at high risk of CI-AKI as an incorrect fluid balance (oral or IV) could be detrimental leading to fluid overload and cardiovascular events. Individuals in hospital care settings should be supported to drink oral fluids prior to and post when provided with a contrast agent. However, those at exceptionally elevated risk should obtain IV fluids for volume expansion when undergoing a contrast agent. As a result of a lack of evidence the administration of N-Acetylcysteine is no longer recommended although the decision for this remains with the referring medical team. There has been a diversity of other pharmacotherapies considered for individuals with CI-AKI prevention, however, none are identified as noticeably beneficial [3, 16, 52, 53].

16 Education for Individuals with AKI

It is well documented that individuals with severe AKI have weaker outcomes should they not receive suitable follow up reviews including medication reviews post discharge. A service evaluation was conducted with individuals following successful implementation of a nurse-led AKI follow-up clinic in the UK. Adults here were

requested to complete a questionnaire to determine their perceived knowledge concerning AKI pre and after attendance at an AKI-nurse led clinic appointment. The results were overall positive and identified that individuals were more knowledgeable and deemed relatively confident in avoiding future AKI [54].

In another recent study conducted in the USA, several individuals who developed AKI and since discharged were interviewed on their experiences and views on the care they obtained while in the hospital care setting. Many had underlying kidney disease and over half of the individuals interviewed had stage 3 or severe AKI. The study highlighted that despite seen by the inpatient nephrology services that most AKI “survivors” (as they were called within this study) were uninformed of their AKI and possessed limited information as to the cause. It identified that only a few individuals were educated on how to care for their AKI at home when discharged, while others wanted necessary information concerning self-management of their illness. There were issues about the use of medical jargon and terminology and confusion concerning, for example, the term “injury” with some relating same to being “punctured” or “hit.” This study demonstrated that there is a definitive need to engage individuals in their care delivery. The use of shared and information-decision making and the use of individual empowerment throughout their hospital stay and beyond is vital when discharged into primary care settings. It is crucial to individual recovery for shared decision making and communication among care partners, the individual concerned and family members. There remains the necessity for close monitoring on discharge from hospital possibly to rehabilitation facility as the individual recuperates from critical illness and AKI. There is a need for interdisciplinary recovery-concentrated care to ensure sufficient complete recovery to a previous condition of health and well-being [42, 55, 56].

17 Emotional Support for Individuals with AKI

Individuals with AKI should be the core of every part of communication and care. All decisions concerning treatment whenever feasible should be communicated with individuals concerned and their partners/ families and if necessary, every member at the end-of-life care interdisciplinary team. Every type of communication should be delivered in simple lay language at frequent intervals, with the recognition that individuals with AKI may be traumatized [42]. This can remain a time of great uncertainty for all involved with individuals describing themselves as anxious, stunned, shocked, and stressed concerning future damage to their kidneys and potential dialysis related pain [55]. These emotions are also common with individuals living with CKD [57], similarly the individual with AKI must be provided with time to discuss their acute illness with assistance by nurses using open-ended questions and listening skills taking on board their clinical presentation such as uremia, concentration levels, fatigue, and nausea.

Partners and family members should be included with potential referral by nurses for further emotional support as required including the use of kidney support groups [5, 58].

18 Education for Nurses

The importance of education for nurses and other member of the interdisciplinary team is paramount concerning AKI. This highlighted in a recent study of non-renal nurses who completed an AKI knowledge and confidence scale. The results indicated that these nurses seemed knowledgeable and confident in escalating and managing AKI. There were, however, a lack of knowledge and confidence in the significance of atypical physiological parameters and urinalysis and serum biochemistry. This variance in levels of knowledge and confidence in detecting and preventing AKI could infer ineffective management. It is obvious that for AKI detection, deterrence, and management on general wards within hospital care settings to be successful, education must be continual and dispensable within standard workloads [59]. The role of the AKI specialist nurse has implemented within various NHS trusts in the UK. It developed to accelerate time from diagnosis to management of AKI, uphold accurate and suitable intervention, and minimize the length of hospital stay following AKI diagnosis. Education plays a pivotal role in that of the AKI specialist nurse to not only educate nurses but also other members of the interdisciplinary team with clinical, formal, and informal ad hoc teaching sessions depending upon service needs [60]. There needs to be educational and ongoing training days for those nurses and other members of the interdisciplinary team working in primary or community care settings including residential or care homes such as detecting and identifying older adults at risk of AKI and instigating appropriate care in an expedient manner.

19 Prevention of AKI

The best treatment for AKI is “prevention” with the old phrase already highlighted of “prevention is better than cure.” A key to primary prevention is that of good kidney health and its strong interlinkage with other comorbidities such as cardiovascular disease and diabetes. This should not be underestimated. Nurses needs to promote a healthy lifestyle including good hydration, healthy eating, smoking cessation, alcohol reduction, and use of physical activity. Any potential complications such as reduced urinary output and/or gastrointestinal symptoms should be observed and reported. It is imperative that individuals concerned, or their partners/ family members know to report any concerns/ worries initially to their primary or community care teams including their GP in a timely manner [2, 6, 58].

The use of medications that are nephrotoxic to the kidneys should be avoided. Should a nephrotoxic drug become essential, continual evaluation is required to balance any potential damage to the kidneys such as examining therapeutic levels, reducing the duration and dosage of the applicable drug and reviewing concomitant drug administration to detect any interfaces from a nephrotoxic position. The use of recreational drugs and over the counter herbal medications should be avoided. Individuals should be educated concerning signs and symptoms of UTIs including good personal hygiene, good hydration and again seeking further advice when concerned. Kidney, urinary and bladder stones could potentially cause post-renal AKI as already outlined. Nurses need to educate individuals who can be at risk including the importance of good kidney health. Other primary preventative measures include prevention of CI-AKI through use primarily of oral hydration especially if the individual concerned are more increased risk of CI-AKI. The prevention of perioperative AKI highlights individuals' risk factors preceding surgery such as sepsis, hypovolemia, CKD, and individuals over ≥ 65 years [2, 6, 58].

The use of secondary prevention includes nurses advising individuals on potential risk factors of AKI including what measures to undertake to avoid a further incident including involving partners/ family members as applicable. The monitoring and prognosis should be discussed. This should include immediate and long-term therapy options and promotion of self-management and support in cooperation with interdisciplinary members applicable to individuals' distinct requirements. Post-discharge detailed information is necessary for those individuals who require KRT involving what planning may be required such as modality choice, amount and length of dialysis sessions, type of vascular access. Further education and awareness for the individual and their partners/ family members and/ or health care workers in residential or care homes as appropriate concerning the risk of developing future AKI specifically for those with pre-existing CKD, and as already highlighted the avoidance of dehydration and use of medications that can cause or deteriorate kidney injury [2, 6, 28].

20 Conclusion

This chapter addressed AKI and the main principles of nursing care for individuals presenting with AKI. This included the relevance of early detection and identification of AKI throughout primary (community) and secondary care (hospital care) settings. It highlighted the stages of AKI and the pivotal role nurses play throughout the AKI journey for the individual concerned as safety is paramount in this often-critical care delivery. It highlighted the relevance of education and emotional support for individuals alongside their partners/ family members and the necessity for ongoing monitoring and evaluation of good kidney health and potential risk factors on their discharge. There is a possibility that individuals with AKI may need KRT on a short or longer-term basis. Nurses along with other members of the

interdisciplinary team should deliver personalized care, promote self-management, and share decision making with these adults and their partners/ family members. There is a need for ongoing education and support for nurses throughout their applicable healthcare system when it comes to detection and distinguishing AKI in an expedient manner as well as promoting increased awareness of this clinical syndrome. Nurses are valuable members of the interdisciplinary team. They are usually the first point of contact for individuals with AKI. The use of care bundles, best practice guidance, as well as good intuition and clinical judgment should guide and support nurses in their care delivery along with close collaboration with members of the interdisciplinary team so that individuals with AKI will benefit by receiving the best care available and ideally the best outcomes.

21 Reflective Questions

Review the chapter and answer the following questions. Reflect on your own clinical practice area as a nurse and apply your answers to where you work.

Use your clinical judgment as a guide and “Think Kidneys” best practice guidance to support your answers: “Think” cause, “Think” medication, “Think” fluids, “Think” review. The 5Rs approach to managing AKI (risk, recognition, response, renal support, and rehabilitation) can also be used to guide your answers.

- Identify the risk factors for AKI with individuals you nurse in your own clinical practice area?
- What are the 3 stages of AKI?
- What are the classifications of AKI?
- Would you see any of these classifications with individuals you nurse in your own clinical practice area?
- Outline the main clinical investigations conducted to assess if an individual has AKI?
- What are the complications of AKI?
- What advice would you give to individuals with AKI on their discharge from hospital care settings into primary care or community care settings?

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Kidney Replacement Therapies: Hemodialysis

Afra Masià-Plana and Reem Alhameedi

Learning Objectives

- To define hemodialysis and understand the different principles of hemodialysis, filters, and machinery.
- To describe different hemodialysis modalities.
- To identify potential complications when doing hemodialysis therapy.
- To assess fluid management, anticoagulation, and vascular access in individuals who are under hemodialysis therapy.
- To explain nursing care required to attend individuals who are under hemodialysis therapy.

1 Hemodialysis

The best type of renal replacement therapy (RRT) for chronic kidney disease depends on the individual's health status, lifestyle, and personal preferences [1, 2]. Until kidney function is lost completely, that is, before chronic kidney disease (CKD) has reached its end stage, in most cases it is possible to slow the progressive loss of kidney function through appropriate treatment and lifestyle changes. It is recommended that survival expectancy with an acceptable quality of life should be considered when deciding what type of RRT is needed. In any case, the patient and

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their relatives are the ones who finally make the decision on which type of renal replacement therapy to follow, according to their characteristics and competences [3].

Hemodialysis (HD) is a highly complex, demanding therapy and can become very restrictive for the individual in many aspects. It is also associated with high social and economic costs to the health system as indicated by the European guide of recommendations for sustainable care of the individual with renal failure [4]. However, HD is the most common mode of RRT used all over the world. Dialysis was introduced as a potential therapy for renal failure in humans in 1924 by George Haas [5]. According to evidence, there are 2.5 million of adults receiving RRT worldwide and the number is expected to increase to about 5.4 million by 2030 [6].

1.1 Principles of Hemodialysis, Dialyzer, and the Hemodialysis Machine

HD is a form of dialysis that completes part of the kidney functions by an extracorporeal blood circuit filtering the blood through a dialyzer. The main function is to eliminate toxic substances (such as urea, uric acid, and other nitrogenous catabolites), correct electrolyte disturbances, acid-base imbalance, and excess fluid. HD process occurs when water and solutes are exchanged bidirectionally between two solutions of different composition and are separated from each other by a semi-permeable membrane in the dialyzer, interposed between two compartments that are the blood and the dialysis fluid through processes of diffusion, convection, and ultrafiltration. This semi-permeable membrane allows the passage of water and molecules of small and medium molecular weight but prevents the passage of larger molecules such as blood cells (Fig. 1) [7].

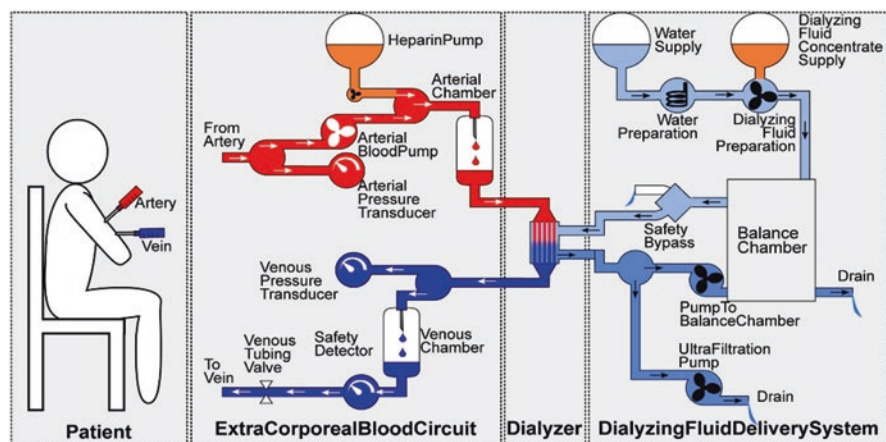


Fig. 1 Hemodialysis circuit. (Reprinted with permission from Leupolz J, Habermaier A, ReifJohn W, Quantitative and qualitative safety analysis of a hemodialysis machine with S#, J Softw: Evol Proc (2018) 30(5)e1942, Wiley & Sons)

Three different mechanisms are at play in order to produce all of these functions. Firstly, the removal of waste products is performed by diffusion which is the spread of elements from a region of high concentration to a region of lower concentration via random motions (Fig. 2). Diffusion states that when two solutions are separated by a semi-permeable membrane, solutes will move from a high-concentration solution to a low-concentration solution attempting to equalize the concentration on either side of the membrane to create equilibrium. In HD, diffusion is used to manipulate the waste. Also, the size of the molecules that need to be removed and the size of the pores in the membrane are aspects to be considered when deciding what type of molecules need removal, this way diffusion allows HD to be selective about what molecules need to be removed; however, it is not of high precision [8].

Secondly, the removal of excess water is performed by ultrafiltration as a type of membrane filtration in which a liquid is pushed against a semi-permeable membrane by hydrostatic pressure from the blood using a dialyzer (Fig. 2). Negative pressure occurs in the dialysate fluid water therefore fluid from the blood is suctioned and driven in the dialysate pathway with different speeds and drawing water across the membrane and into the dialysate fluid.

Thirdly, solids and solutes of high molecular weight are retained, while water and low-molecular weight solutes pass through the membrane. This principle is named convection or osmosis (Fig. 2). It is important to take into consideration the small, middle, and large size of the molecules that need to be removed as large molecules such as red blood cells should maintain their position; however, potassium, phosphate, and urea of low size molecules should be removed as a result of convection (rather than convention).

To perform HD a dialyzer (Fig. 3) is essential, where it is made of thousands of strands of fiber where the blood flows through them, and the dialysate fluid flows into opposite directions through the outer part of the tubes. The strands are tube-like structures. They are formed of a semi-permeable membrane in such a way that it can

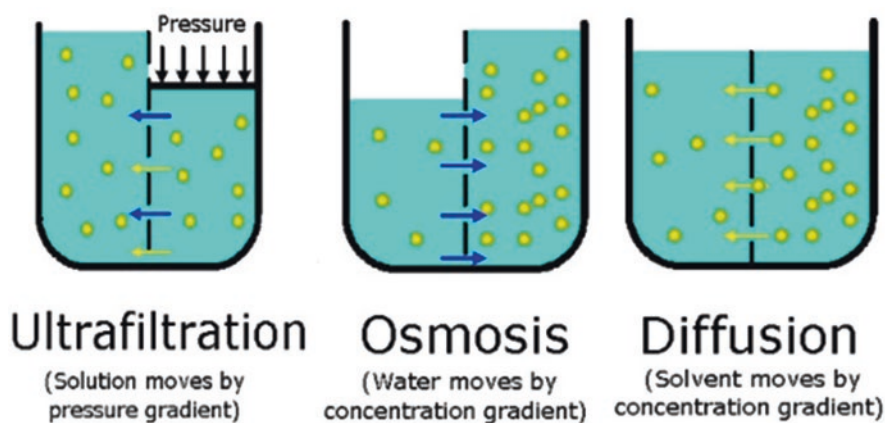


Fig. 2 Three processes of dialysis. (Source: own source, based on Toltec international Inc. http://www.toltec.biz/contact_us.htm)

Fig. 3 Dialyzer**Fig. 4** Hemodialysis machine and extracorporeal blood circuit. (Source: <https://www.kdf.org.sg/Hemodialysis>)

separate the waste products of the blood, normally removed by the kidneys. Inside the dialyzer is where diffusion, osmosis convection, and ultrafiltration take place.

The HD machine is of high complexity as it can control many different functions to ensure safe administration of the HD prescription. Starting from the dialysate fluid where sensors ensure it has the correct composition and it can be modified when needed. HD machine also monitors the extracorporeal blood circuit and maintains safe conditions for the blood filtration (Fig. 4). The vascular access and

extracorporeal circuit deliver the blood to the dialyzer safely and then return the blood to the individual. The whole process of maintaining a safe HD therapy and monitoring patient's response to the therapy requires skilled and expert nurses.

1.2 Hemodialysis Fluid and Dialysate

To perform HD the most indispensable components are the dialyzer and dialysate fluid. The dialysate fluid is composed to eliminate excess electrolytes, waste products, and excess fluid out of the blood. The chemical composition of the dialysate is individualized for each patient, and it can have modifications according to the needs of each patient. Blood tests of each patient are performed routinely not only to assess patient's clinical condition but also to make any specific adjustments to the dialysate prescribed.

In Chap. “[Dialysis Fluid for Hemodialysis and Associated Treatments](#),” further details are exposed.

2 Hemodialysis Modalities

Considering the physiological needs of each individual and the possibility of maintaining an adequate level of quality of life, KDOQI clinical guideline of the National Kidney Foundation [1] concludes that a minimum of 12 h of blood filtration per week is necessary, which are generally carried out 3 days per week for 4 h in each session [9, 10].

Patients' perspectives and experiences of specific dialysis modalities are affected by a range of factors. Patients want to be informed about all options available to them, and they want their treatment conditions to be least disruptive to their lives, their day-to-day activities, and their caregivers' lives [11].

2.1 Conventional Hemodialysis

Conventional HD is described as high-flux HD (HF-HD). Since 1995 it is the main form of dialysis. This modality uses high-flux synthetic membranes, and it provides the most efficient modality to clear small-middle to large uremic toxins and offers high therapeutic biocompatibility by using ultrapure dialysis fluid [12].

One downside of HD therapy is the intermittent sessions which leads to peaks and troughs in the body. Removal of waste products occurs rapidly during HD therapy but then accumulates in-between sessions. Therefore, several issues can occur such as difficulty to tolerate the rapid fluid correction as well as the electrolytes and acidosis and waste removal. Once the HD session is completed, fluid, electrolytes, and waste products of metabolism start to build up within the body and the time between HD sessions causes some of the long-term complications that patients can experience [13].

A good way to reduce the intermittent effect of HD is to perform them more frequently. Studies prove that more frequent HD therapy leads to mortality reduction, improved heart function and blood pressure, better fluid status control. More frequent HD treatments led to better outcomes. The literature agrees that this promotes more physiological functions of the body [14].

During pregnancy, women with end-stage kidney disease should receive long frequent HD either in-center or at home, depending on convenience [15].

2.2 Hemodiafiltration

Hemodiafiltration (HDF) is a modality that includes fluid exchange. Extra fluid is removed in the dialyzer via ultrafiltration. As extra fluid is removed it also has to be replaced and an infusion into the circuit is performed. During this whole process the fluid exchange leads to extra fluid moving across the membrane in the dialysis which triggers more convection in the treatment and better outcomes than standard HD. This is often known as online HDF. HD machines are of high advanced technology to allow an increase in the volume of exchanges performed and to ensure it does not interfere with the individual's fluid balance.

There is evidence from some randomized studies that indicate that online-HDF(OL-HDF) can improve hemodynamic stability and response to erythropoiesis-stimulating agent and also can reduce the incidence of HD-associated amyloidosis and chronic inflammation. The clinical- and cost-effectiveness of high-volume HDF compared with high-flux HD in the treatment of kidney failure is under discussion as H4RT trial is hoping to provide evidence to inform accurate management for UK and international individuals [16].

2.3 Home Hemodialysis

Clinical guidelines [17] recommend that all individuals who require chronic HD therapy should be encouraged to do home therapies. Home hemodialysis (HHD) provides flexibility, compared to in-center dialysis as it allows for longer sessions.

For the patient to become competent in home HD, training takes about 3–8 weeks, also follow-up visits to the patient home by the training nurse and 24 h on-call staff, equipment maintenance and supply services for the patients should all be considered before starting home HD program. There is a lot of advantages of home HD, such as patient's independence, flexibility with the dialysis schedules and better quality of life and decrease exposure to blood borne viruses and other hospital related infection. However, home HD can also cause patients and carers concerns including feeling of vulnerability in relation to potential complications, social isolation, and disconnection from medical personnel [18].

Performing HHD can be individualized to individual's clinical, psychological, and social needs. Even clinical guidelines [17] are in development to increase the number of individuals accessing home therapies and HHD in order to encourage them to become more involved in their care and independent. Modality choice needs to be a balance between what is proven to have the best clinical outcome and what suits the individual's lifestyle and concerns.

2.4 Nocturnal Hemodialysis

Nocturnal hemodialysis (NHD) is an alternative home HD therapy in which the individual can dialyze frequently and longer hours at home while sleeping. In NHD, patient dialyzes for 7–10 h a night, five to seven times a week. While NHD can offer the same physiological benefits as home HD such as improved survival, cardiac markers, phosphate control, blood pressure control, clearance, it also offers benefits in quality of life and independence [19].

3 Hemodialysis Vascular Access

Vascular access is an essential part of the HD therapy as without it HD cannot be performed. However, it can be a point of vulnerability as the provision of good quality access can be difficult to achieve.

There are three types of HD vascular access: Arteria Venous Fistula (AVF) (Fig. 5) as it is described in Chap. “[Vascular Access Management and Care: Arteriovenous Fistula \(AVF\)](#),” Arteria Venous Graft (AVG) (Fig. 6) as it is described in Chap. “[Vascular Access Management and Care: Arteria-Venous Graft \(AVG\)](#),”

Fig. 5 Arterial venous fistula (AVF). (Source: Modified with permission from Springer Nature: Lawson, J.H., Niklason, L.E. & Roy-Chaudhury, P. Challenges and novel therapies for vascular access in Hemodialysis. *Nat Rev. Nephrol* 16, 586–602 (2020))

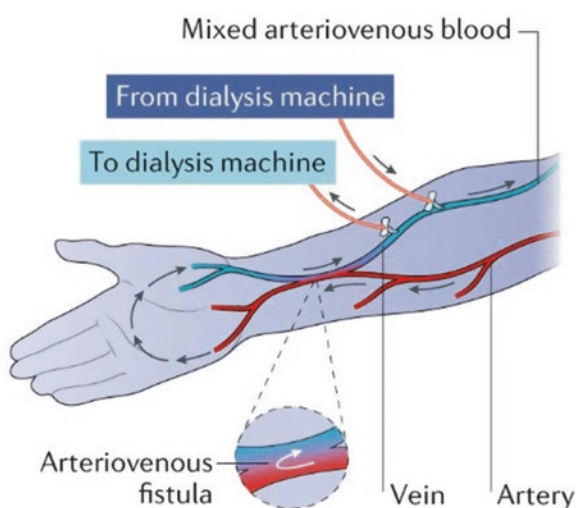
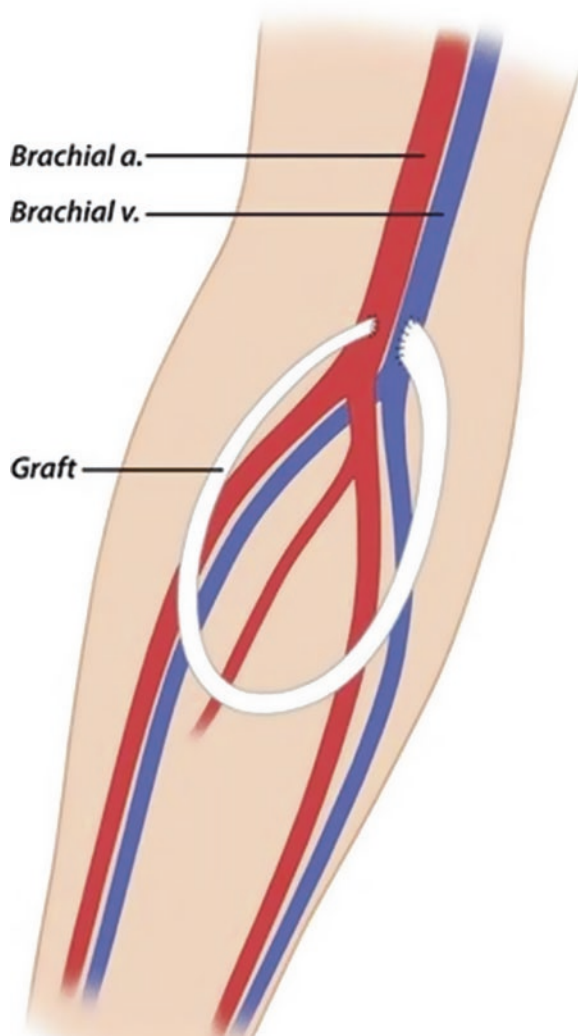


Fig. 6 Arterial venous graft. (With permission from Cherukuri, A.R., Gahtan, V. (2015) Arteriovenous Hemodialysis Access. In: Gahtan, V., Costanza, M. (eds) *Essentials of Vascular Surgery for the General Surgeon*. Springer, New York, NY)



and Central Venous Catheter (CVC) (Fig. 7a, b) as it is described in Chap. “[Vascular Access Management and Care: CVC](#).”

Clinical guidelines [2] agree in recommending the formation of a native internal arterial venous fistula (AVF) as the vascular access of primary choice. The UK Renal Association standards recommend that 80% of the dialysis population should dialyze via definitive access, which includes AVF and AVG [20].

Achieving definitive vascular access provision depends on many factors including individual’s choice, preparation for HD, service structure, staff training, surveillance programs to detect failing vascular access. Moreover, the puncture area, the technique used, and the appropriate material are essential to keep the fistula patent [21].

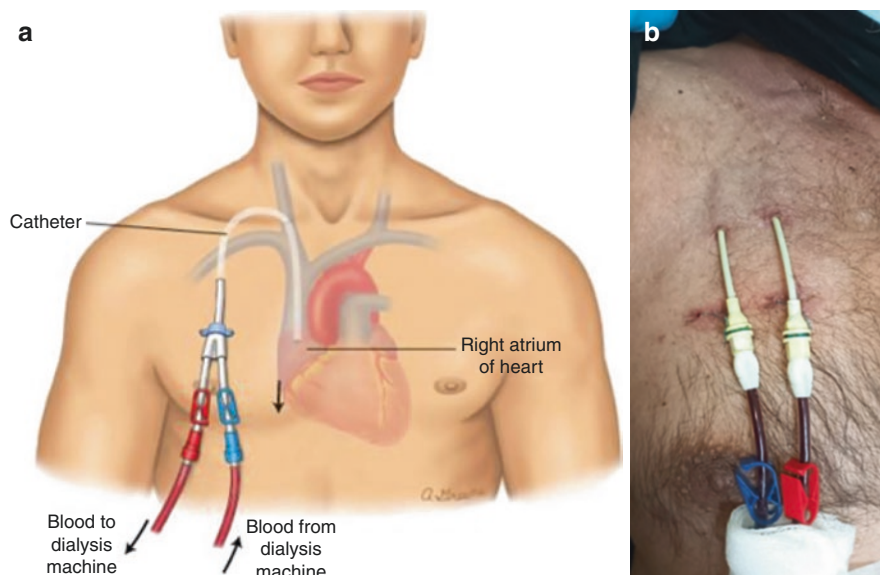


Fig. 7 (a) Central venous catheter (CVC). (Source: <http://www.vascularfirst.in/>). (b) Central venous catheter (CVC): Tunneled CATHETER (Source: own source)

Cannulation Techniques to Preserve Vascular Access

Good cannulation for HD therapy requires experience and strategic planning. Nursing teams should consider how they can communicate the plan of cannulation, to allow knowledge of individual's cannulations to be handed over between staff. This may implicate facilitating individual involvement in the cannulation, so he/she can provide guidance [22].

Self-awareness of cannulation is key to perform a successful performance and need to ask for help from others. It is recommended that nurses only attempt cannulation twice before getting assistance from others. Cannulators need skill to balance empathy with an anxious patient and pragmatism to perform the needling procedure.

The different steps that many clinical guidelines recommend performing a successful cannulation for HD therapy is developed in Chap. “[Vascular Access Management and Care: Arteriovenous Fistula \(AVF\)](#).”

3.1 Buttonhole Technique

Buttonhole technique requires needling each cannulation site in the same method each time. The needle enters the same hole in the skin, travels the same route to the vein both in depth and direction, and then enters the vein the same point. The repetition of the needle insertion develops a track of scar tissue and weak point in the vein

wall. The technique involves removal of the scab from the previous needle insertion, a track development phase, after 6–12 cannulations, conversion to blunt/dull needles. It is recommended that buttonhole technique is performed by the same nurse or self-cannulation of the individual to ensure same route in depth and direction. This technique is currently recommended for AVF, and it can involve two to four different sites allowing resting sites for some HD sessions.

Buttonhole technique has been associated with high infectious risk heading to low use in some units. However, some units have been able to use this technique without any infection problems (Fig. 8) [23].

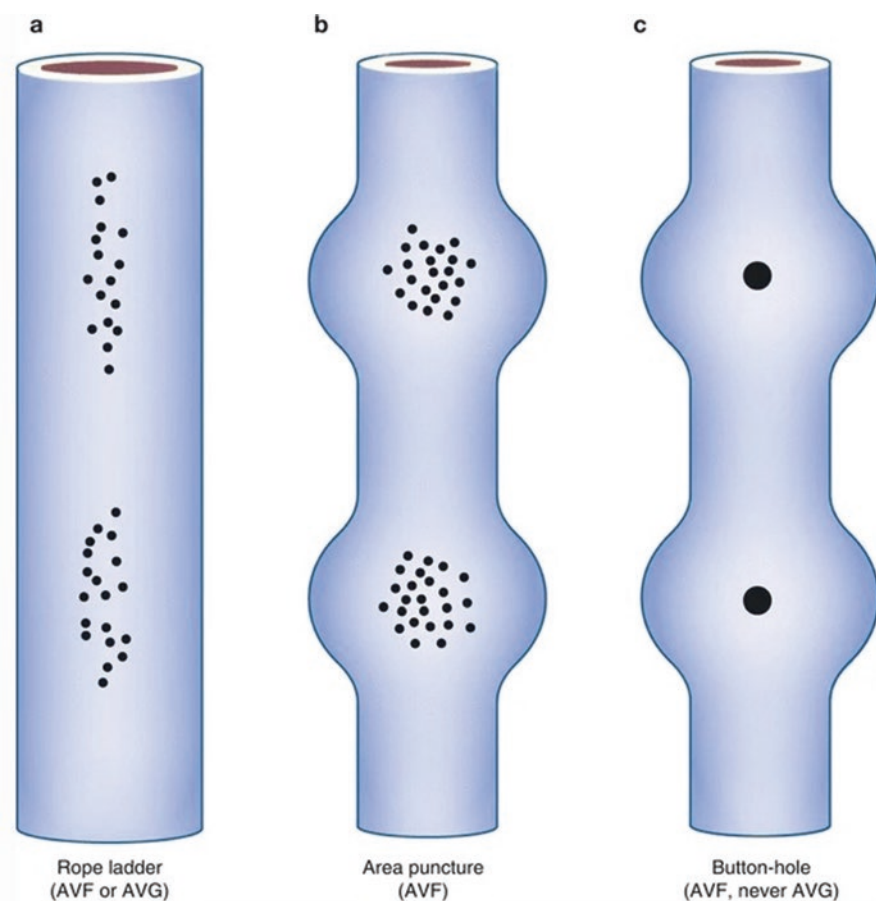


Fig. 8 (a) Rope ladder, (b) area cannulation, and (c) buttonhole cannulation technique within the vessel. (With permission from Chesterton, L., Lindsey, B., Fluck, R.J. (2014). *Vascular Access: Improving Outcomes for Hemodialysis Patients*. In: Harber, M. (eds) *Practical Nephrology*. Springer, London)

3.2 Rope Ladder Technique

Rope ladder technique is the equal distribution of punctures along the whole length of the fistula vein. Each cannulation should occur 0.5–1 cm above the previous site, each cannulation moves up the vein in systematic manner and once the top of the vein is reached, cannulation starts at the bottom again. Cannulation sites should cover a minimum distance of 8 cm when both arterial and venous needle site are on the same segment of vein; 5 cm for each site, when cannulation sites are on different segments of vein. Rope ladder technique can be used in both AVF and AVG (Fig. 9) and it is recommended for AVG [24].

Area cannulation is when cannulating in the same area each time but not in a systematic manner. This technique is not recommended for use as it is associated with aneurysm, stenosis development, and earlier AVF/AVG failure (Fig. 10) [22].

Nursing professional has a primary role in the maintenance of the vascular access to perform a successful needling considering the best outcomes for each individual. Training and experience are critical for successful cannulation as well as monitoring of cannulation practice to ensure procedures are adhered to it.

Fig. 9 Rope ladder cannulation in an AVG. (Source: Own source)



Fig. 10 Area cannulation in an AVF. (Source: Own source)



4 Hemodialysis Adequacy

The dose of dialysis that a patient needs is called HD adequacy and the fractional urea clearance (Kt/V) is used to assess HD clearance. Kt/V is the most precise and tested measure of the dialyzer effect on patient survival and is the most frequently applied measure of the delivered dialysis dose. Measurement of adequacy is now achievable for every dialysis session, with results available immediately through the use of online conductivity monitoring [25].

Kt/V as calculated using the equilibrated post-dialysis blood urea nitrogen (BUN) level (eKt/V) is recommended by some as a more accurate determinant of the dialysis effect. For thrice-weekly HD in patients with low residual native kidney clearance, the target $spKt/V$ dose remains 1.4 volumes per dialysis, minimum dose 1.2 [26].

Another indicator and widely utilized measure of dialysis dose is the urea reduction ratio (URR). URR is the percentage of reduction in the blood urea nitrogen (BUN) over the course of a single HD treatment. The extent of the reduction in BUN reflects dialytic urea clearance adjusted for body water. The calculation of the URR is:

$$URR = 100\% \times \frac{\text{predialysis BUN} - \text{postdialysis BUN}}{\text{predialysis BUN}}$$

where BUN_{pre} and BUN_{post} are blood samples obtained immediately before and after dialysis. The use of the URR to monitor dialysis dose ignores the significant urea clearance that results from ultrafiltration. This requires both prescription of an adequate dose of HD and regular assessment that the delivered treatments are adequate. URR is a measure of the proportionate reduction in BUN over the course of dialysis.

Both methods of dialysis adequacy are largely considered interchangeable, and both are endorsed by guideline committees as valid markers of dialysis adequacy. NKF-DOQI guidelines [1] recommend a monthly interval blood assessment for each patient. They acknowledge that this is a pragmatic rather than an ideal recommendation and that there is often a delay between measurement and reporting of Kt/V of up to a week. Increased frequency of measurement of Kt/V is only suggested in cases of underdialysis.

The degree of intra-patient variability in the efficiency of blood purification is influenced most strongly by time on dialysis, but also by a combination of measures related to vascular access function (blood pump speed, minimum and mean arterial line pressures, and both maximum and minimum venous line pressures).

In clinical practice, absolute control of all these variables is not possible in every dialysis session and some degree of variability in Kt is therefore inevitable. Continuous monitoring of dialysis adequacy allows physicians to ensure that an adequate dose of dialysis is being consistently delivered to chronic HD patients.

5 Hemodialysis Potential Complications

Monitoring HD therapy as well as the individual who goes through it is a significant part of the HD nurse's role. While technology has provided high quality HD therapy, nurses need to monitor, interpretate, and apply the specific modality to each individual situation. Hemodialysis is not exempt of potential complications and monitoring of the individual who goes through HD therapy requires knowledge of potential complications that can occur during therapy in order to avoid adverse events [27, 28].

HD potential complications are numerous. Acute complications during hemodialysis are shown in Table 1.

5.1 Cardiovascular Complications

The main problems of HD are those associated with vascular access. For example, thrombosis is the most common cause of short-term access failure and hospitalization. Infection is the common form of vascular access loss in long-term HD patients. In addition, vascular access bleeding, vascular occlusion, aneurysm and ischemia

Table 1 Acute complications during hemodialysis

Acute complications during hemodialysis	
4.1 Cardiovascular	Intradialytic hypotension Intradialytic hypertension Arrhythmias Sudden death
4.2 Neuromuscular	Muscle cramps Restless legs syndrome Seizures Headache
4.3 Hematological	Hemolysis Hemorrhage Hyponatremia Electrolyte imbalance Hyperkalemia Dialysis disequilibrium syndrome Fluid overload
4.4 Pulmonary	Hypoxemia
4.5 Technical malfunction	Air embolism Incorrect dialysate composition Clotting of the dialysis circuit
4.6 Dialysis reaction	Dialyzer reaction Febrile reaction
4.7 Vascular access	Catheter infection Venous needle dislodgement
4.8 Miscellaneous complications	Post-dialysis fatigue Pruritus

Source: [29]

related to arteriovenous fistula or graft. Central venous stenosis and central venous dysfunction are potential complications when having a CVC as HD vascular access. Vascular-related complication are serious conditions that can have direct effects not only to the patient's health but also to the HD adequacy as it can have a direct impact to a problematic blood flow [30].

Hypotension

Hypotension is a low blood pressure which is a reading lower than 90 millimeters of mercury (mm Hg) for systolic or 60 mm Hg for diastolic. Hypotension is considered the most common complication during HD because of the rapid decrease in the circulating blood volume caused by ultrafiltration (UF). Intradialytic hypotension (IDH) is associated with higher risk of vascular access thrombosis, ischemia cardiovascular event hospital admission and mortality.

Signs and symptoms of intradialytic hypotension include feeling of hot or light-headed, blurred vision or nausea, among early treatment of hypotension includes placing the patients in the Trendelenburg position, decreasing the UF, or giving replacement fluid such as normal saline bolus. Measures to prevent hypotension

include sodium modeling and UF profiling, BP monitoring, constant dry weight assessment, use of low temperature dialysate.

5.2 Neuromuscular

Muscle Cramps

Muscle cramps are a common cause of intradialytic discomfort and a frequent complication with an incidence of 5–20% in HD sessions. It frequently involves the leg and leads to premature termination of HD. Pathogenesis is unknown and largely attributed to dialysis-induced volume contraction and hypo-osmolality. Management strategy includes increasing plasma osmolality by infusion of hypertonic saline (15 ml of 23.5%), or 50% dextrose in water (25–50 ml), or mannitol 25% (50 ml). Evaluating for other causes of muscle cramps like thyroid disorder and electrolyte disturbances. Prevention includes dietary counseling about excessive fluid gain [29].

5.3 Hematological Complications

Hemolysis

Hemolysis is the contamination of water supplies for HD with chloramine cooper, zinc, or nitrate. The main symptoms that occur are bright, red, frothy blood, chest pain, hyperkalemia, anemia, and pancreatitis. Appropriate water systems and continuous testing should be carried out. When hemolysis occurs, HD therapy should be immediately discontinued and do not washback individuals' blood, cardiac monitoring, medical review and treatment of hyperkalemia and anemia.

Electrolyte Imbalance

It is understood that patients with CKD receiving HD therapy can have changes in serum electrolyte as a result of the treatment. As mentioned before, HD utilizes convection and diffusion to remove excessive electrolytes and fluid over semi-permeable membrane. Therefore, the dialysate prescriptions are a critical component in this process and require a detailed understanding of the changes in electrolytes concentrations that occur as a result of the HD treatment. The most common and critical electrolytes disturbance for patients during HD treatment are serum potassium and sodium and are mainly (hyperkalemia and hyponatremia) [31].

Hyperkalemia

Severe hyperkalemia is defined as serum potassium >6 or 5.5 mEq/l with clinical signs such as arrhythmia or electrocardiogram (ECG) abnormalities (e.g., T-wave elevation, loss of P-wave or sinus-wave QRS patterns), the main cause of

hyperkalemia in patients with CKD is impaired potassium excretion due to an acute or permanent loss of function of nephrons, impaired distal tubular flow [32].

Intradialytic potassium removal essentially occurs in the first 2 h of HD treatment and it is driven by convection and diffusive transfer and in clinical practice, dialysate potassium of 4 mEq/l is regularly used when pre-dialysis serum potassium levels are ≤ 4 mEq/l in order to avoid postdialytic hypokalemia. However, persisting hyperkalemia should be followed by a careful evaluation of patient's diet and medication. Therefore, a potassium restricted diet and the use of potassium binder such as the inhibitors of the renin-angiotensin-aldosterone-system (RAAS) are common in practice.

Hyponatremia

Hyponatremia is defined as serum sodium concentration ≤ 135 mEq/l. The most common symptoms include nausea, headache, confusion, muscle weakness, and cramps. Severe hyponatremia (i.e., serum sodium <120 mEq/l) is potentially life-threatening disorder with severe neurological complication, dialysate sodium prescription ranges from 136 to 145 mEq/l and is based on pre-dialysis sodium levels [33].

Fluid Overload

Fluid overload is a common and an important complication in individuals who receive HD therapy. Fluid overload leads to increased incidence of adverse outcomes such as edema, shortness of breath and in the longer term can lead to hypertension and left ventricular hypertrophy and heart failure. Moreover, it is related to hospitalization and mortality [34]. Therefore it is paramount to identify effective and reliable methods to determine fluid status in such patients.

Dialysis Disequilibrium Syndrome

Dialysis disequilibrium syndrome (DDS) is a neurological disorder with varying severity which is primarily caused by the rapid removal of urea during hemodialysis. DDS is characterized by neurological symptoms such as fatigue, mild headaches, nausea, vomiting, disturbed consciences. High cerebral urea level has been suggested to be the main cause for DES. Symptoms are present usually in patients with very high plasma urea concentrations [35]. The main pathophysiology is not known but it may attribute to cerebral edema secondary to water movement into the brain. The management of DES is based on preventive measures to decrease the development of cerebral edema specially during the starting of HD in new patients such as slow initial dialysis for patients with CKD by decreasing the dialysis time and decrease the blood flow rate or the use of small dialyzer. Also, the administration of osmotic agent such as (sodium, mannitol, and glucose) to the blood stream [36].

5.4 Pulmonary Complications

During dialysis arterial PaO₂ decreases by 5–20 mmHg reaching a nadir at 30–60 min which then resolves within 60–120 min after discontinuation of dialysis. This is usually of no significance unless patient has pre-existing cardiopulmonary disease.

In high-risk patients, preventive measures include intradialytic use of oxygen, conventional bicarbonate dialysate, and biocompatible membranes. Further optimizing hematocrit and performing sequential isolated UF followed by HD may reduce the likelihood of hypoxemia.

5.5 Technical Malfunction Complications

Air Embolism

Air embolism can be a fatal complication, though it is very rare. The main cause of an air embolism could be the inadequate priming of the extracorporeal circuit and loose connections. When air is introduced to the vascular system, the main symptoms are chest pain, dyspnoea, altered mental status, seizures, hypotension, and tachycardia and a rapid response from health professionals is needed. Preventive measures include checking air detecting alarm system prior to initiating hemodialysis, flushing dialysis catheter prior to dialysis, and dialyzer rinsing before use.

Immediate management includes clamping the venous blood line, stopping the blood pump, placing the patient in Trendelenburg position, providing CPR if required, aspirating air from right ventricle and/or hyperbaric oxygen therapy as required [29].

5.6 Dialysis Reaction

A complication related to dialysis includes disequilibrium syndrome [36], which consists of headache, nausea, and confusion, resulting from the rapid removal of urea from the extracellular fluid, rather than from the brain, which leads to cerebral edema. Other common complications are bleeding, vomiting, muscle cramps, and hypotension during dialysis sessions. The disadvantages of HD also include the physical fluctuations of the patients, the use of needles, the dietary restrictions, and the need for transportation to and from the dialysis center [37].

5.7 Vascular Access Complications

Catheter Infection or Catheter-Related Bloodstream Infections (CRBSI)

Infection and septicemia occur when HD is conducted by catheter. More than 50% of patients with ESRD are suffering from infection. Catheter-related bloodstream

infection (CRBSI) are associated with high burden of morbidity and mortality. Sign and symptoms of CRBSI include fever (temperature ≥ 37.8 °C), rigors, and hypotension. Common microbial organisms include *S. aureus* and *S. epidermidis* and Gram negative bacteria. Patients with *S. aureus* CRBSI were most likely to need hospitalization and intensive care unit admission [38]. Uremia is the main factor to cause infection and low immunity of most patients. Catheter-related infection also occurs due to contamination from the service providers and not following the infection control measures such as hand hygiene, use of sterile equipment.

Venous Needle Dislodgement

Venous needle dislodgement (VND) is a life-threatening risk to the HD individuals if there is not prompt detection. Inadequate taping of the venous needle, insecure lines attached to the access, patient agitation are some of the major causes of the VND. When VND occurs, there is severe blood loss, hypovolemia, hypotension, tachycardia, and anemia. In order to prevent VND, there are a few actions that nursing professionals can consider such as the use of butterfly taping method, keep visible venous access at all times among others (Fig. 11). If symptoms are maintained, we can replace the lost volume of blood through blood transfusions and normal saline infusion [39].

5.8 Miscellaneous Complications

Pruritus is a debilitating condition, characterized by moderate-to-severe itch, affecting patients with end-stage renal disease undergoing HD [40].

The clinical presentation of CKD-associated Pruritus is variable, and no specific profile can characterize a typical patient, since itching has a range of severity, it can be sporadic or continuous and it may occur anytime during the day. Moreover, the skin of affected patients may often be unchanged (being dry and scaly like that of unaffected patients), or present with skin changes secondary to intense scratching activity (excoriations with and without impetigo, crusts, papules, ulcerations, erosions, and less commonly prurigo nodularis) [41].

Other long-term complications are also identified and need assessment (Fig. 12).

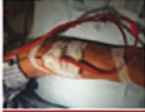


VENOUS NEEDLE DISLODGE (VND)

HOW TO MINIMIZE THE RISKS

Recommendations for Nephrology Nurses



1	AWARENESS	Staff, patients and carers should be aware of VND and the consequences. Ref: Hunt, RN, CLNC, Venous Needle Dislodgement - A Universal Concern, European Nephrology, Volume 5, Issue 2, Winter 2011
2		An area around the vascular access large enough for taping should be cleaned, properly disinfected, and air dried before cannulation.
3		Haemodialysis units should have appropriate training and a secure, clean, and consistent procedure for taping needles and bloodlines.
4		Bloodlines should be looped loosely to allow movement of the patient and to prevent bloodlines pulling on the needles.
5	REPOSITIONING	If it is necessary to reposition a needle, lower the blood flow to 150ml/min and replace all taping.
6		Staff to patient ratio should be adequate to allow routine monitoring of vascular access during treatment, if not report it as a near miss.
7	ASSESSMENT	All patients should be assessed for level of risk of VND and, if appropriate, an alarm device intended for monitoring venous needle dislodgement used.
8		Vascular access and needles should be visible at all times during haemodialysis.
9	ALARM ACTIVATION	When the venous pressure alarm is activated, the vascular access and fixation of needles and bloodlines should always be inspected prior to resetting the alarm limits.
10		The lower limit of the venous pressure alarm should be set as close as possible to the current venous pressure.
11	DETECTION FAILURE	Staff, patients and carers should be aware that the venous pressure monitoring system of the dialysis machine will often fail to detect VND.
12		Additional protection can be provided by devices intended to detect blood loss to the environment.

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Fig. 11 Actions to minimize the risk of VND. (Source: EDTNA/ERCA)

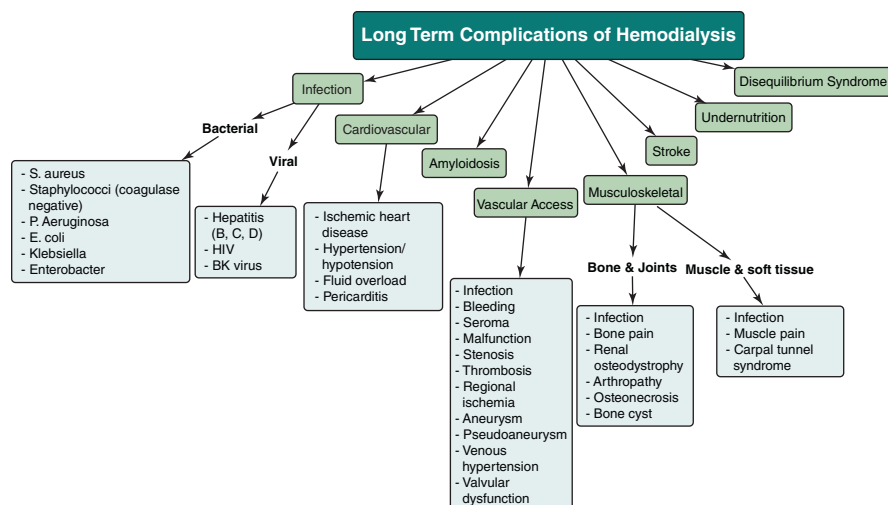


Fig. 12 Long-term complications of HD. (Source: [27])

6 Fluid Managements

Volume overload is a common complication in patients who receive HD. One of the most common ways to manage fluid in patients with ESRD receiving HD is setting the target post-dialysis weight refereed as dry weight (DW).

Objective methods have been proposed for defining fluid overload: inferior vena cava collapse index, left atrial volume on echocardiography, fat slopes on plasma volume slope monitoring, evaluation of NT-proBNP, lung ultrasonography, or bioimpedance. The most utilized and increasingly validated approach to objectively assess hydration is the use of bioimpedance. Bioimpedance spectroscopy (BIS) device has been validated against gold standard methods of volume assessment which can improve blood pressure control, overall overhydration, and arterial stiffness measurements. The BIS allows to estimate the subject's body composition and, in particular, the distribution of body fluids. The presence of overhydration, as determined through the BIS, is predictive of an increased mortality [42].

7 Anticoagulation

Part of the HD prescription is also the anticoagulation regime. During HD many factors contribute to the clotting and fibrine formation in the extracorporeal circuit. Causes are the contact with foreign plastics in the circuit, blood pump action, stasis during blood pump stoppages and chambers, among others. To defuse clotting within the circuit, heparin is generally administered into the arterial side of the circuit, either in the form of unfractionated heparin or low-molecular weight heparin.

Clotting can have many detrimental effects during HD therapy including blockage of the circuit, frequent alarms, and blood pump stoppages due to pressure in the circuit and this will exacerbate clotting further, reduction in clearance, reduction in vascular access function due to fibrin [43].

Prevention of clotting is essential together with a balance with bleeding risk. Nurses are the professionals managing clotting within the extracorporeal circuit during HD therapy.

8 Implications for Nursing Practice in HD Individuals

Nursing care standards involve assessment, diagnosis, outcome identification, planning, implementation, and evaluation. The nursing process considers principles and fundamentals of clinical decision making, clinical guidelines and compasses all important activities of nurses in providing care to all patients [44].

In order to maintain a safe HD therapy, monitoring patient's response and acceptance to the therapy requires skilled and knowledgeable HD nurses. Nurses need to have the competencies to detect patient's changing prescription and respond accurately to their needs. Moreover, they need to be prepared to prevent and respond to any event in order to preserve individual's safety [45, 46].

9 Conclusions

This chapter discussed the different types of HD as a kidney replacement therapy. Also, the most common complications of HD and the sign and symptoms of the common electrolyte imbalances occur during HD therapy and their managements were discussed. Fluid overload, management, and prevention are also highlighted in this chapter.

The nurse's role in monitoring the person who goes through HD therapy and preventing complications optimizes clinical outcomes and minimizes the burden that individuals experience due to their chronic kidney disease and also that caused by the HD itself. Skilled and knowledgeable HD nurses are essential to give individual patient's outcomes to relieve the burden of HD.

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Dialysis Fluid for Hemodialysis and Associated Treatments

José Jesús Broseta, Diana Rodríguez-Espinosa,
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Learning Objectives

- To recognize the importance of dialysate as part of hemodialysis treatment.
- To understand the importance of water treatment for use in dialysis.
- To know the most important chemical elements that make up the dialysate.
- To learn the chemical elements' standard concentrations, potential modifications, and clinical implications.

1 Introduction

The function of dialysis fluid is to correct the composition of uremic blood by returning the levels of its components to physiological figures, both by reducing the concentration of uremic toxins and by correcting electrolyte and acid-base balance abnormalities [1]. This balance is achieved mainly by diffusion of solutes from patients' blood onto the dialysate, thereby exposing patients to 400–700 mL/min in hemodialysis (HD), and an additional infusion of about 50–100 mL/min the case of hemodiafiltration, that add up to 200 L per session [1]. Therefore, its composition is an essential element of dialysis prescription, as well as dialyzer membrane, blood and dialysate flow rates, and treatment time [1–3]; and healthcare professionals in the care of patients on HD need to know what water treatment HD centers require for this therapy to be unharmed and which elements can be chosen or added to dialysis solutions to improve the quality of the treatment administered during each session as well as achieve the highest biocompatibility of the dialysate.

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Dialysate comprises a mixture of treated water, a buffer, usually bicarbonate, and the so-called acid concentrate, which combines a series of ions, glucose, and a weak acid, as described below.

2 Water Treatment

The same diffusion principle that allows the movement of solutes by concentration gradients from the blood compartment to the dialysate applies in the other direction, and, thus, molecules from dialysis solutions can also move toward the patients' blood and act therapeutically or cause harm by passing toxic molecules in patients who are unable to excrete them. This makes the treatment of the water used to create the dialysate vitally important.

The first HD sessions performed in the mid-twentieth century taught us that the use of untreated water caused harmful side effects. For instance, exposure to chloramines, which are added to drinkable tap water to avoid bacterial proliferation, can cause hemolytic anemia in HD patients [4]. Similarly, copper and zinc can detach from water pipes, also increasing the risk of hemolytic anemia in these patients. Aluminum, an agent frequently used in water treatment plants to ease the removal of solid waste, caused adynamic bone disease, osteomalacia, and, most strikingly, dialysis encephalopathy syndrome [5].

Before tap water can be used for HD, it must go through the following steps in order to have a safe treatment (Fig. 1). Firstly, most of the suspended particles of the water deposits are eliminated by sedimentation or sand filters. This process is followed by water passing through a series of filters with 500 to 5 μm pore diameter. Afterwards, water is softened by eliminating divalent cations such as calcium and

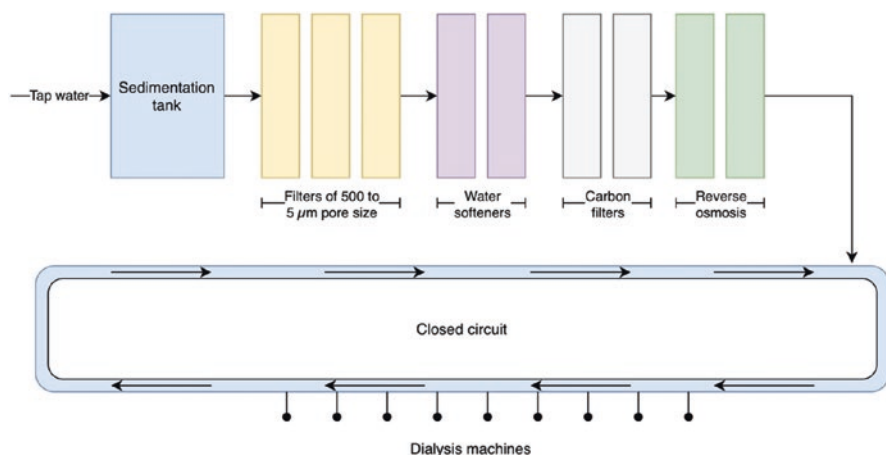


Fig. 1 Water treatment for dialysis scheme

magnesium through their exchange with sodium. Later, chloramines and other organic acids are removed by activated carbon [6]. After that, reverse osmosis is performed, a process by which carbon particles and most remaining compounds, together with endotoxins and bacteria, are removed by passing water across a semi-permeable membrane by applying hydrostatic pressure [7]. Then, water is deionized by exchanging cations for hydrogen ions (H⁺) and anions for hydroxide ions (OH⁻), which recombine to form water again. Once the water has been purified, it is distributed by a pressure pump through a closed circuit to a velocity of 1 m/seg, thereby reducing the risk of bacteria biofilm formation [8]. The materials used for the piping system should be made of stainless steel or cross-linked polyethene to avoid contamination. Regular check-ups are performed to assure water quality control and patient safety as specified by the European Best Practices Group guidelines, and periodic thermal or chemical disinfections are also carried out [9].

Although some differences can be found according to local regulations, in general terms, we classify pure or ultrapure water according to the resulting water, the latter being the only one appropriate for convective treatments. In Table 1, the dialysis fluid biological contamination quality standards are presented. Although increasingly infrequent, alterations in water due to poor treatment can have clinical consequences (Table 2).

Table 1 Dialysis fluid biological contamination quality standards

	Pure water	Ultrapure water
Bacteria (CFU/mL)	<100	<0.1
Endotoxins (EU/mL)	<0.25	<0.03

Source: Adapted from Pérez-García R, et al. *Nefrología* (2016) [6].

Table 2 Clinical consequences of a bad water treatment

Water component	Clinical consequence
Chloramines	Hemolytic anemia
Copper and zinc	Hemolytic anemia
Nitrate	Hemolytic anemia
Aluminum	Dialysis encephalopathy syndrome Adynamic bone disease
High water hardness	Hypercalcemia
Microbiological contaminants (bacteria and endotoxin)	Chronic inflammation Pyrogenic fever
Fluoride	Pruritus Nausea Arrhythmias

Source: Adapted from Water Treatment for Hemodialysis [10].

3 Dialysate Components

Once the water is treated, the resulting ultrapure water needs to be transformed into dialysates by adding and combining key components involved in maintaining homeostasis. To assure the chemical stability of the dialysate, the pure or ultrapure water is mixed in situ in the dialysis machine, in a dilution proportion of 1:45, with two separate elements, the bicarbonate (HCO_3^-) and the so-called acid concentrate, that can be added individually at each HD monitor or in a centralized fashion simultaneously for a group of HD monitors. It contains sodium (Na^+), potassium (K^+), calcium (Ca^{2+}), chloride (Cl^-), magnesium (Mg^{2+}), a weak acid, phosphorus (PO_4^{3-}), and glucose [3].

4 Bicarbonate: The Currently Most Widely Used Buffer

Correcting metabolic acidosis is one of the goals of dialysis therapy, a frequent complication of kidney disease due to the retention of acids, phosphates, and sulfates and the decreased generation of ammonia [1].

Although from 1964 to 1980 approximately, acetate was the selected buffer because of its chemical and microbiological stability and low production costs, and while other chemical products like lactate have been tested; currently, most dialysis fluids use a bicarbonate concentrate of 32–35 mmol/L as a source for the gain of bases and, ultimately, the correction of acid-base balance [1, 11, 12]. The optimal dialysate bicarbonate concentration is one that prevents acidosis at the beginning of the next HD session (a pre-dialysis bicarbonate >22 mmol/L) while avoiding post-dialysis alkalosis (post-dialysis bicarbonate ≤ 29 mmol/L) [1]. In that sense, individualization has been proposed to achieve both ranges [13, 14].

5 The Weak Acid

One of the most challenging aspects of dialysis fluid production is to allow the coexistence of a solution of divalent cations (Ca^{2+} and Mg^{2+}) and such concentrations of bicarbonate without salt precipitation [2, 12]. The bicarbonate is separated from the acid concentrate since it mixes in the dialysis machine with the treated water. However, it is insufficient to prevent precipitation, so a weak acid must be added to the dialysate to lower the pH without diminishing the bicarbonate in the dialysate so metabolic acidosis can be corrected appropriately [12, 15].

The weak acid most widely used has been acetic, as it was the main buffer some years ago and is thus well-known. However, more biocompatible alternatives have recently risen such as chloride and citric acids. Both of them have been tested and proved that the elimination of acetic acid prevents hyperacetatemia, which has deleterious effects [2, 16–20]. Nevertheless, citric acid has some extra advantages; it

chelates calcium and magnesium, thereby inhibiting the coagulation and complement cascades [12, 15, 19] and has been proposed as a safe acetate replacement from the dialysate in most patients [21].

6 Sodium

Na^+ is the main extracellular ion defining osmolarity and the extracellular volume amount. The prescription of Na^+ in the dialysate is one of the key points in dialysis treatment, as the kidneys manage the regulation of Na^+ and water [22]. Patients on HD rely on dialysis machines and the physician's prescription to keep Na and water balanced.

In the beginnings of HD, low Na^+ concentrations, with values around 126 and 135 mmol/L, were prescribed in the dialysate, but when the technique evolved, times shortened, ultrafiltration increased, and glucose concentrations were reduced, patients presented episodes of intradialytic hypotension, which led to an increase in prescribed sodium to values around 139–140 mmol/L. [23]

Modifications of Na^+ concentrations in the dialysate exert noticeable changes in patients. For instance, high Na^+ concentrations are often used to promote hemodynamic stability, as more Na leads to better intravascular refilling; however, this practice leads to increased thirst during the interdialytic period and, thus, more weight gain. Conversely, lower dialysate Na^+ concentrations reduce thirst and, therefore, volume expansion, though increasing intradialytic hemodynamic instability. In an attempt to seize the benefits of a high dialysate Na and avoid its side effects, HD with Na^+ modeling or profiling emerged as an alternative. This technique is characterized by the use of high Na during the beginning of the dialysis session and is lowered as the dialysis progresses. Nevertheless, most protocols of sodium profiling actually led to a net Na^+ gain as the overall Na^+ exposure, when averaged across the time of the dialysis session, is higher, with values ranging from 140 to 145 mmol/L, approximately. As a matter of fact, the regular Na^+ prescription of 139–140 mmol/L actually also results in Na^+ gain in most cases. This is because most HD patients usually have pre-dialysis serum Na^+ concentrations from 135 to 139 mmol/L [22, 24].

However, the contrary is not beneficial either. HD patients with hyponatremia (i.e., serum sodium concentrations lower than 136 mmol/L) are at an increased mortality risk. This has been associated with the delta sodium, which represents the fluctuation in serum Na^+ concentration throughout the dialysis treatment as the difference between the post- and pre-dialysis serum Na^+ levels and, when higher than 4 mmol/L, is related to higher mortality rates [24]. Thus, the goal of dialysis in terms of natremia is to achieve a neutral balance during the session with the least amount of fluctuation between the pre- and post-dialysis periods.

Moreover, although pre-dialysis Na serum values are highly variable between patients (high inter-patient variability), these levels remain mostly the same before every dialysis treatment when measured in the same individual (low intra-patient variability). The ability to maintain unchanged basal Na levels has led to the concept of Na^+ set-point [24].

7 Potassium

K^+ serum levels, which have a narrow range of normality, are vital in maintaining normal muscle contraction and neurological transmissions [25]. Thus, a fundamental objective of HD is to keep K^+ levels within a desired physiological range, avoiding extreme concentrations during the intradialytic and interdialytic periods, which could cause severe symptoms and be potentially life-threatening [26].

A typical intermittent HD may incur in extremely high pre-dialysis and low intradialytic K^+ serum concentrations that can alter cells' transmembrane action potentials [27], producing muscle paralysis or arrhythmias during the intradialytic period [26]. The beginning of a HD session is when the largest gradient between the patient's serum K^+ and the dialysate's concentration exists, leading to a swift decline in kalemia. As time progresses, the gradient is reduced, thus decreasing diffusion speed until K levels become steady. However, approximately 30 min after the HD treatment is finished, there is a physiological rebound when intracellular K^+ moves toward the intravascular space [28]. This is something to take into account when evaluating immediate post-dialysis K^+ levels.

Regarding the interdialytic period, the highest risk has been associated with pre-dialysis K^+ serum levels above 5.5 mEq/L, increasing patients' odds of presenting sudden cardiac arrest [29]. On the contrary, pre-dialytic K^+ concentrations below 4 mEq/L have been linked with increased mortality though, in this case, due to its association with malnutritional states [30].

In order to avoid such fluctuations, the ideal prescribed dialysate K^+ concentration that manages to avoid such fluctuations is not clear, as there are only expert recommendations and low-grade evidence to aid us in this task. For instance, some clinicians apply the "Rule of 7s" which states that the sum of the patient's pre-dialysis serum K^+ and the dialysate K^+ concentration must add up 7 [30]. However, this rule is limited by the fact that it could lead to very wide K^+ gradients between serum and dialysate, potentially increasing the risk for arrhythmias by destabilization of cell membranes, QT interval alterations, and increasing ventricular ectopics [31]. For instance, there is evidence associating the use of dialysate K^+ concentrations below 2 mEq/L with an increased risk of sudden cardiac death, particularly among those patients with a low-normal pre-dialysis serum K^+ level, whereas this risk was not seen in those with high pre-dialysis K^+ levels (i.e., above 5 mEq/L) [32].

Given the uncertainty on this issue, there is currently a need for further study in this field where individualized prescriptions in combination with pharmacological treatments may be the real solution in the search for the optimal K^+ dialysate prescription [33]. Nevertheless, based on available evidence, a standard 2 mEq/L K^+ dialysate concentration is widely recommended, and if needed, it can be increased to a maximum of 4 mEq/L in patients with pre-dialysis values below 4 mEq/L, or decreased, although a K^+ 0 mEq/L dialysate is never recommended as it could trigger unwanted side effect due to drastic fluctuations [34].

8 Magnesium

Mg^{2+} is often a forgotten ion, or at least, thought as an irrelevant one. On the contrary, hypomagnesemia has been related to an increased mortality. For instance, it can induce a prolonged QT interval and increase the risk of ventricular arrhythmias, a risk increased when combined with hypokalemia [26]. In the HD setting, serum Mg^{2+} is not readily dialyzable given that approximately 25% is protein bound, and 5–15% forms complexes with phosphate, citrate, and bicarbonate [35]. Despite this, hypomagnesemia can occur in a third of patients when a Mg^{2+} dialysate concentration of 0.5 mEq/L is used, which can be reduced to only 5% when increased to 1 mEq/L, an increase that has also been associated with a lower incidence of muscle cramps [36]. Additionally, maintaining normal Mg^{2+} levels has been shown to limit vascular calcification [37], although there is evidence that it cannot reverse severe arterial calcification once it is established [36].

Another important aspect to consider is that citrate-containing dialysates induce a negative Mg^{2+} balance, [38] enhancing the risk of hypokalemia by favoring intracellular K^+ shift [3].

Given the arrhythmogenic risk of hypomagnesemia, a Mg^{2+} dialysate concentration of 1 mEq/L is recommended. Supplementation in the case of citrate-containing dialysates seems necessary but it remains to be clarified in what quantity [12].

9 Calcium

Only 1% of body Ca^{2+} is found in plasma and only half of this circulates in an ionized form. It is this ionized Ca^{2+} that plays a vital role in muscle contractility, neurological transmission, and vascular contraction. HD patients gain Ca^{2+} from their diet, the use of calcium-based phosphate binders, and diffusion from the dialysate. The Ca^{2+} transferred intra-dialysis has been associated with both short- and long-term effects summarized in Table 3 [12, 39, 40].

Table 3 Calcium dialysate concentrations and clinical effects

Dialysate calcium	Advantages	Disadvantages
Low 1.25 mmol/L = 2.5 mEq/L	Lower risk of hypercalcemia Permits greater use of vitamin D and calcium-containing phosphate binders Benefit in adynamic bone disease	Potential for negative calcium balance and stimulation of PTH Increase in intra-dialytic hypotension
High 1.5– 1.75 mmol/L = 3–3.5 mEq/L	Improves hemodynamic stability Suppresses PTH Beneficial for bone protection in nocturnal hemodialysis	Greater risk of hypercalcemia Limits use of vitamin D and calcium-based binders Increased risk of vascular calcification

Source: Adapted from Toussaint N, et al. *Hemodialysis International* (2006) [42].

Short-term effects: Most of the immediate effects of intradialytic Ca^{2+} balance are hemodynamic. Low Ca^{2+} dialysates are related with a reduced cardiac contractility, QT interval prolongation with the consequent increased arrhythmogenic and sudden cardiac death risk, and reduced HD tolerance due to intradialytic hypotension in relation to a reduced vascular tonicity [3, 41]. In total, these events would suggest that higher Ca^{2+} dialysate concentrations may be beneficial by improving hemodynamic stability; however, there are greater harms associated with dialysate Ca^{2+} concentrations above 3 mEq/L [42].

Long-term effects: Cardiovascular disease is the main mortality cause of HD patients and vascular calcification plays an important role in this increased risk. High levels of Ca^{2+} and phosphorus lead to their precipitation in soft tissues, are to blame for medial arterial calcification, and their combination heightens tissue calcification in the presence of the inflammatory milieu observed in most HD patients. In fact, the product of Ca^{2+} and phosphate is independently associated with an increased cardiovascular mortality [43]. Most importantly, a positive Ca^{2+} balance has been shown to increase calcification even in the absence of hypercalcemia [44]. Moreover, not only a low but also a high Ca^{2+} dialysate concentration (3.5 mEq/L) has also been correlated with ventricular dysfunction [45].

The usual Ca^{2+} dialysate concentrations available are 1.5 and 3 mEq/L; however, the recommended Ca^{2+} dialysate concentration by the Kidney Disease Outcome Quality Initiative (K/DOQI) guidelines is 1.5 mEq/L, intended to reduce the net Ca^{2+} gain during dialysis and reduce the risk of vascular calcification while mostly avoiding hemodynamic instability associated with low Ca^{2+} concentrations [42].

10 Phosphate

Phosphorus kinetics are different from other small molecules, with its levels dropping rapidly during the first hour though later it stagnates. PO_4^{3-} removal behaves like a middle molecule and is driven mainly by the length of each dialysis session rather than their frequency [46]. Despite the high prevalence of hyperphosphatemia, a small but not negligible percentage of patients present hypophosphatemia [47]. It is important to avoid severe hypophosphatemia as it has been associated with rhabdomyolysis, hemolysis, leucocyte dysfunction, reduced myocardial contractility, and increased mortality [46, 48–51]. The higher risk of death is probably related to malnutrition and an inflammatory state.

Therefore, the presence of pre-dialysis PO_4^{3-} levels below 2.5 mg/dL requires medical intervention. First, patients should be asked about their use of binders, and their diet should be adjusted. If, despite this, they continue to have low phosphate levels, the dialysate should be supplemented as acid-concentrates used for intermittent HD do not contain phosphorus in their composition, mainly when post-dialysis phosphorus is lower than 1 mg/dL. Supplementation can be easily done with sodium

phosphate, a compound commonly used in enemas, to produce a concentration of 1.5 mg/dL [47]. Nevertheless, the addition of PO_4^{3-} to the dialysate is infrequent, as hyperphosphemia, is highly prevalent in patients on HD, so much so that most individuals require phosphate binders on thrice-weekly four-hour sessions [49].

11 Glucose

The use of glucose in dialysate has played different roles over the course of time. Early in the history of HD, the use of glucose in dialysate was important for effective osmotic ultrafiltration. However, over time, ultrafiltration by hydrostatic pressure was found to be superior to osmotic ultrafiltration and the concentration of glucose in dialysate was drastically decreased [52, 53]. Moreover, glucose is associated with induction of inflammatory cytokines [54], so it seems logical to suspect that the exposure to a high dialysate glucose concentration may be a causative factor in the inflammation associated state of HD patients.

On the contrary, when a glucose-free dialysate is used, the body accommodates by switching to a catabolic state (gluconeogenesis and glycogenolysis) to maintain a stable blood glucose level. In that sense, it has been shown that comparing glucose-free vs glucose-containing dialysates, the first results in lower post-dialysis levels of lactate and pyruvate, as they are important substrates for gluconeogenesis, and a significant rise in acetoacetate and β -hydroxybutyrate secondary to the oxidation of fatty acids to provide the energy for gluconeogenesis [55]. Thus, the decrease in serum glucose concentration is not as high as would be expected by the amount of glucose loss in the dialysate. However, while many patients are able to tolerate this state, the more debilitated/malnourished patients will not have the reserve to respond, and glucose-free dialysate would place them at risk for hypoglycemia.

Taking those considerations into account, the use of a more physiological dialysate glucose concentration and a dialysate containing 100 mg/dL is currently the standard of care. It appears to be safe with minimal metabolic consequences, but, given the potential inter-individual variability, checking glycemia in diabetic patients is highly recommendable [52].

12 Conclusions

Water treatment is of vital importance to ensure clinical safety for HD patients. In addition, from the bases of this, the health professional involved in dialysis must know the chemical composition of the dialysate and its potential desired modifications to individualize the treatment. The final goal is to achieve the best dialysis treatment for each patient, or what is the same, to achieve the best efficacy under maximum safety.

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Vascular Access Management and Care: Arteriovenous Fistula (AVF)

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Learning Objectives

- To define AVF as the main vascular access for hemodialysis, as well as to identify the main vessels of the arm in order to recognize the benefits for hemodialysis therapy
- To understand the creation and maturation process of an AVF in order to assess and manage the vascular access of the patient maintaining his/her safety
- To describe the pre-cannulation care of the AVF access
- To analyze home care interventions that a patient and health professionals need to consider in order to prolong the life of the AVF
- To identify the main principles to prevent complications of an AVF

1 Definitions

The survival and people's quality of life undergoing dialysis treatment depend on the efficiency of the vascular access and its duration over time [1]. Proper monitoring offers proven benefits in terms of survival of vascular access but implies proper and thorough training of the medical and nursing staff. The venous access must be able to allow a high performance, in order to guarantee the filtration and purification

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processes of hemodialysis (HD). The gold standard of vascular accesses in HD is the native arteriovenous fistula (AVF), followed by prosthetic arteriovenous implants (Grafts), and finally by indwelling central venous catheters (CVC) [2].

Compared to CVC and grafts, the AVF is associated with:

- Prolonged patency (lower risk of thrombosis)
- Lower incidence of infections
- Optimal dialysis dose QB 300/350 ml/m
- Fewer number of hospital admissions
- Cost reduction.

However, as described in a recent review, the idea that AVF is always the best access for all people is outdated. Indeed, the choice of the optimal vascular access for HD is best achieved with a patient-centered approach, which aligns the patient's life plan (life expectancy, comorbidities, personal preferences, etc.) and the renal disease in terminal stage. Naturally, an individualized therapeutic approach is essential to achieve this, including the selection of the dialysis modality peritoneal dialysis (PD) vs. HD and the most suitable access to dialysis. This complex decision-making process should take place with a multidisciplinary approach and be dynamic, in order to meet the changing needs of patients, life circumstances and health, as shown in Fig. 1 [3].

AVF is the direct surgical communication, through an anastomosis, between a high-strength arterial vascular bed and a low-resistance venous bed, thus creating a new vascular structure that allows dialysis treatment [4]. An AVF is a small miracle, it is extraordinary to see how the starting vein becomes, after maturation, able to sustain six punctures a week, for 52 weeks a year. We are talking about 312 bites in a year [5]. The creation of an AVF should ideally take place several months before the patient enters dialysis to allow for adequate maturation. There are some factors potentially affecting the outcome of the AVF to be considered before the creation of a native AVF [4] such as:

- Previous CVC, pacemaker (subclavian vein stenosis)
- Prolonged oncological therapies (deterioration of the vascular bed)
- Diabetes mellitus (development of peripheral vascular disease, with the formation of atherosclerotic plaques)
- Heart valve replacement (increased risk of related infections)
- Objective and Doppler examination of arterial and venous vessels
- Evaluation of edema of the arms (indicates problems with venous outflow which could limit the development of the fav)
- Congestive heart failure (worsening due to high AVF flow)
- Anticoagulant therapy (bleeding)
- Dominant arm (the dominant arm should be avoided, if possible, to ensure an adequate quality of life for the patient)
- Trauma (can damage the vessels)
- Trypophobia (fear of needles)

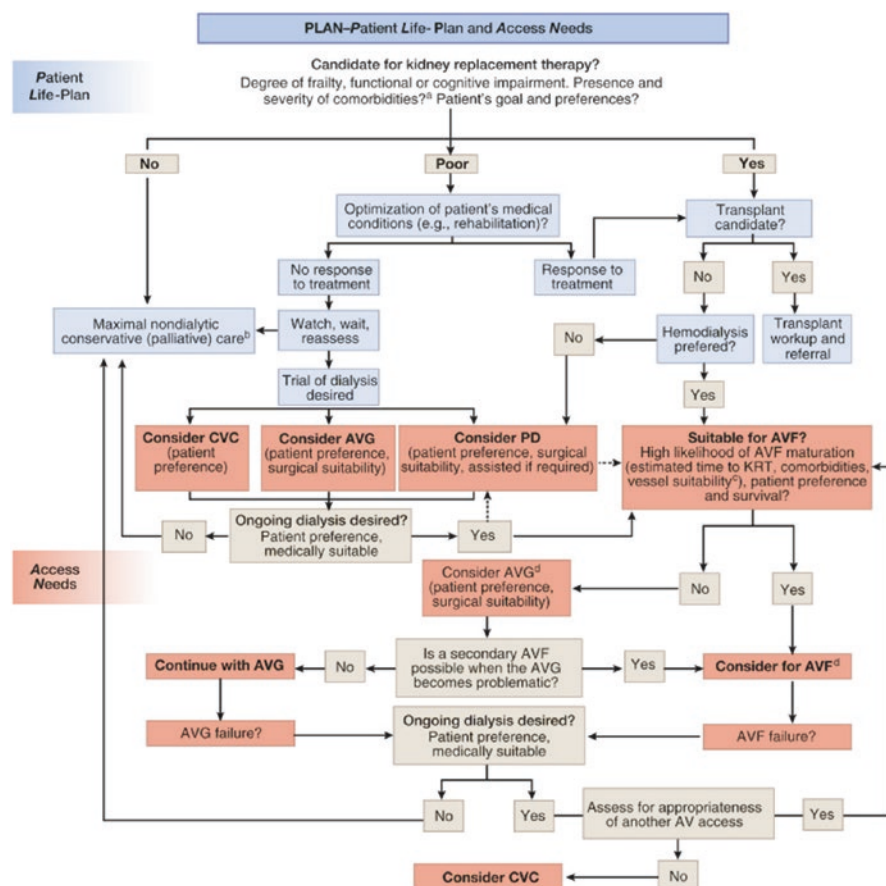


Fig. 1 Flow diagram of the Patient Life Plan and Access Needs [3]

- BMI > 35 Kg/m² M2 (in obese patients vein transposition could be considered)

The selection of the spots to be used is as follows; as regards the artery, it must be considered that the main artery of the arm is the brachialis, which runs from shoulder to elbow, where it branches into two further arteries, radial and ulnar. The requirements that the arteries must possess are, a flow unobstructed inlet, and a greater luminary diameter equal to 2.0 mm. On the other hand, there are several veins in the arm that can be used: radial, ulnar, interosseous, basilica, cephalic, axillary. The optimal requirements of candidate veins when used for the AVF preparation process are, an unobstructed outflow, a luminary diameter greater than 2.5 mm, a vein depth less than 1 cm from the skin surface, a contiguity of the selected vein with central veins, and ultimately must have a linear segment for venipuncture [4, 6].

2 Creation and Maturation Phase of AVF

The creation of a vascular access is a process that takes time. The education of the patient, the vascular evaluation, the surgical intervention, and the subsequent maturation are of fundamental importance in this phase.

All guidelines recommend that every patient should start dialysis with a well-functioning vascular access [2, 4, 7]. AVF packaging should occur when renal failure patients reach stage 4 and the glomerular filtrate value is $<30\text{--}25\text{ ml/min/1.73m}^2$.

The maturation time of the AVF vary from no less than a month to 3–4 months. Ideally, using the non-dominant arm, the AVF should be created in the most distal anatomical site, that is the radio-cephalic anastomosis [4]. It could be created at the base of the thumb, on the wrist according to Cimino, cephalic on the back of the forearm, cephalic in the middle forearm, cephalic in the crease of the elbow.

The most proximal anastomosis, on the other hand, is that at the level of the elbow fold. These AVFs generate a very high blood flow and have a lower incidence of infections and thrombosis than the distal ones. The main disadvantage of these high-flow AVFs is the risk of distal hypoperfusion, which can lead to symptomatic ischemia of the hand (theft syndrome). According to the type of anastomosis, the AVFs are also classified into:

- End-to-end, the two vessels are faced according to the transverse diameter. Typically abandoned, due to the high ischemic complications of the hand.
- Latero-lateral, both vessels are dissected along the lateral wall and then placed side by side. It is only possible if the artery and vein are in close proximity.
- Latero-terminal, in which the lateral wall of the artery is joined to the transversely sectioned vein. It is the best solution [4].
- The purpose of AVF packaging is to provide adequate blood flow to the vein. The flow of the fistula depends mainly on two factors: the difference in pressure (gradient) between the artery and the vein and the width of the communication between the two vessels.
- From a physiological point of view, the blood flow increases after the creation of the anastomosis due to the dilation and remodeling of the vessel.
- Venous dilation is associated with a reduction in shear stress which turns back to normality after 3 months, with a progressive increase in the diameter of the vein and artery.
- The maturation time of an AVF differ from patient to patient.
- The European Renal Best Practice recommends that the maturation period is ideally 4 weeks [7].
- To confirm the maturation of the fistula, it is used the rule of 6:
 - Adequate flow, greater than 600 ml/min
 - Diameter wider than 6 mm
 - Depth less than 6 mm
 - Assessment and punctuality within 6 weeks

A flow rate (Qa) measured on the first and seventh day of packaging greater than 400 ml/min is the best indicator of a fistula maturation [2].

A recent technology related to the creation of human vessels concerns bioengineered vessels, that were developed in the last century but only recently enhanced. Many new approaches are targeting the biological and mechanical aspects of vascular access, such as the creation and maturation of an arteriovenous anastomosis, and the development of a biological conduit for solving central vein stenosis problems. The creation of an arteriovenous fistula can solve some of the logistical problems involved in obtaining a timely AVF [8].

3 Pre-Cannulation Care

AVF management is a complex aspect of the nursing care process. Extending the life of the AVF and maintaining its patency are crucial objectives, therefore it is essential that nurses are highly qualified for. Particular importance is given to the environment of the HD unit; the dialysis room must be clean, the windows closed; there, must be sinks with running water, soap dispensers, antiseptic and disposable towels in order to ensure that every time the nurse approaches the patient, he/she follow hand washing hygiene according to World Health Organization (WHO) protocols [9]. The lighting must be adequate, the stethoscope must always be present, the connection and detachment kits available, the presence of beds or armchairs balance to ensure greater comfort for the assisted person. All sharps and non-sharp waste containers must be easily accessible [4].

There are different techniques for puncturing the AVF, however, the procedures implemented of needle insertion, can be divided as follows:

- The nurse inspects own hands thoroughly according to WHO guidelines [9] and wears personal protective equipment.
- Place the necessary material on a clean surface.
- Make sure that the patient is relaxed.
- Always explain to the patient all the steps and procedures carried out.
- Check that the person is wearing comfortable clothes.
- Make sure the person has washed the AVF arm with soap and water [4].
- Before each puncture, physical examination is necessary, to assess functionality and identify any critical issues, through a series of steps: “look, hear, touch.”
- LOOK indicates visual inspection, to recognize edema, redness, swelling, hematoma, rash, bleeding, exudation, aneurysm, pseudoaneurysm.
- HEAR indicates auscultation of the breath along the vein which should be strong and continuous. The instrument used is the stethoscope. The correct auscultation must be carried out starting from the AVF anastomosis along the entire stretch of vein and artery to highlight variations of sound along the course. The stethoscope must be used without pressing so as not to alter the flow. It is difficult to find a univocal description of normal auscultable sound on an AVF. The most truthful is “an intense murmur in systole which extends into diastole, albeit with reduced

intensity.” The electronic stethoscope offers objective data which cannot be influenced by external environmental factors and by the operator’s ability, furthermore it allows the recording of the trace and the comparison of it over time [5].

- TOUCH indicates palpation, evaluating the course of the pulsation, the change in temperature, the atypical heat, the consistency, the thrill should be felt as a continuous vibration.

The puncture of the AVF must be performed by experienced and qualified personnel, and involves several steps:

- Hand washing and use of individual protective devices.
- Look, hear, touch.
- Disinfection of the skin with chlorhexidine 2% since it has a greater penetrating power of the first layers of the epithelium. This characteristic is confirmed using the technique defined back and forth, side to side, namely a vigorous friction back and forth from right to left, or concentric circles movements [10].
- Apply tourniquet.
- Place 16 G or 17 G needles at least 4.5 cm from the anastomosis, the venous needle must always be placed in the direction of flow. The arterial needle can be placed in both directions, antegrade in the direction of the flow, that is preferable, retrograde is in the counter-flow direction and is not recommended because it increases the formation of aneurysms, the arterial needle must always be positioned first [11].
- Stabilize the venous access by using the thumb and forefinger and stretching the skin downstream of the insertion point. This technique is useful to decompress the dermis and epidermis, temporarily stopping the pain, helping to decongest the AVF.
- Needle insertion with 20–35 degrees inclination; with the bevel of the needle upwards. Once inserted, a return of blood is visible along the tube connected to the needle.
- Lower the needle and slowly advance along the vessel axis.
- Do not rotate the needle flute beak 180 degrees, as this may cause the insertion site to dilate, cause oozing, and injury to the intima of the vessel.
- Fix the needles adequately, preventing the movement of the wings [4] (Refer to Fig. 11. p.133).
- Choosing the right puncture site and the right technique are key factors in ensuring an optimal dialysis session.

Puncture of the AVF should be performed using one of the following techniques [12] (Refer to Fig. 8 p.124):

- A rope ladder puncture. (Refer to Chap. 7 Fig. 9, p. 125)
- Buttonhole puncture
- Area puncture. (Refer to Chap. 7 Fig. 10, p. 126)

Rope ladder puncture is a technique that requires new selected side in each puncture maintaining an ideal distance of about 5 mm from the previously used site. It is pricked along the entire length of the vessel, the main advantages of this technique are a reduction in the risk of aneurysm formation, it allows a healing of the previously used sites, it reduces the risk of infection. However, this technique can include greater pain during venipuncture, and the presence of scars along the course of the blood vessels used [2]. In the initial phase of use of the AVF, lacerations of the vessel can occur for various reasons. It will therefore be observed in some cases thickening of the area, hematoma and changes in the color of the skin. The slightly inclined angle of insertion could cause injuries to the upper wall of the vessel and possible infiltrations. On the other hand, too much inclined angle could damage the lower part. If resistance is felt during needle advance, the needle must be retracted, and the angle changed. The area punching technique should be considered a procedural error, both international guidelines strongly advise against it [2, 7]. This latest technique consists in always pricking in the same area, damaging the elasticity of the vessel wall and the skin, favoring the formation of aneurysms, increasing the hemostasis time, and negatively impacting the patient's physicality.

The buttonhole puncture consists in puncturing the AVF at a constant point always at the same angle in order to create a sort of subcutaneous canal, a cylindrical tunnel formed by scar tissue. Recent evidence has obtained conflicting results on the theoretical advantages of the buttonhole puncture technique, such as a lower probability of aneurysmal formations, the buttonhole technique seems to be closely related to an increased risk of local and systemic infections [7, 13]. A systematic review also does not support the preferential use of the buttonhole over rope ladder cannulation in either hospital HD or home dialysis. This does not exclude that buttonhole cannulation is appropriate for some patients with difficult-to-access AVF [14]. It is essential that the same operator is always present in the formation of the canal in order to always guarantee the same angle and depth during puncture. It is important to use sharp 16 g needles for about 12 dialysis sessions, since the canal formation takes about 3–4 weeks. After this period the venipuncture will be performed with blunt needles. Selected patients should be screened for *Staphylococcus Aureus* and, in case of positive, administer therapy for its eradication. The procedure for carrying out the buttonhole technique involves an insertion phase, and a needle removal phase. The procedure for removing the needle by the nurse is just as important as inserting it. A correct procedure allows to avoid the laceration of the vessel, to contain the trauma as much as possible, the optimal hemostasis reduces the risk of hematoma formation. The steps of the two phases should take place consecutively as follows in Table 1.

The use of hemostasis devices increases the risk of complications [2]. A recent study showed that the use of plastic cannula needles was associated with better HD adequacy, significantly better hemostasis times, and greater probability of success, compared to metal needles. However, the pain perception of the patients, and the difficulty of cannulation of the nursing staff were higher in the plastic group, underlining the great importance of the practice in the use of plastic cannulas [15].

Table 1 Steps of Insertion and removal of puncture needles [11]

Insertion phase	Removal phase
Intact skin	Prepare the take-off kit and a glove to be worn by the patient
Absence of aneurysm or scar tissue	Remove the patches with utmost care
Absence of inflammatory processes	Remove the needle while maintaining the same inclination
Straight section of the vessel and adequate distance between the two sites to prevent recirculation	Apply pressure on the insertion point after having completely extracted the needle with two fingers
Before venipuncture wash the arm with soap and water	Remove the venous needle first, the pressure of the venous site has a tourniquet effect on the arterial one
Disinfection with 2% chlorhexidine, if allergy switch to povidone iodine	To obtain good hemostasis and avoid bruising, it is essential to measure the pressure exerted
Remove the blood crusts formed by previous punctures using the sterile caps of the blunt needles	The thrill during this maneuver must always be felt, if it is absent reduce the pressure until the flow is felt again
Correct removal of the crusts is essential to minimize the risk of infection due to the migration of bacterial colonies present on the crust itself inside the vessel	The hemostasis time varies from patient to patient, but is between 8 and 12 min
It is strongly not recommended to moisten the crust with physiological solution to facilitate its removal, causing it to fragment	In the first bites, the hemostasis time can reach up to 20 min
Disinfect the insertion sites again	Remove the second needle
Introduce the blunt fistula needles with partial rotary maneuver	Apply a sterile hemostatic patch or bandage
Secure the needles	Remove the patient's glove if he has actively participated in acupressure

4 Home Care

Educating a patient with Stage 4 CKD as well as the family members means much more than providing information. Most patients need advice in order to participate in their care process and their state of health. It is essential to know that uremia, depression, age, anger, denial of the problem, are factors that could make hard to understand information. Providing written material and imagines can be useful educational tools. Patients must be aware from the outset that the fistula represents their own lifeline and that it is not possible to create an infinite number of native AVFs. For this reason, the vascular heritage of the AVF arm must be preserved as much as possible [2]:

- Avoiding withdrawals and infusion
- Pressure measurement
- Catheterisms

In the immediate post-operative period, the person should be informed of the following [3]:

- To keep the arm warm and dry
- To monitor the wound to make sure there is no change in temperature, redness, pain.
- To raise the arm slightly in case of swelling
- To check for thrills three times a day
- To avoid sleeping on the AVF arm
- To avoid wearing clothes with tight sleeves
- To avoid lifting weights
- To avoid violent sports that can lead to AV trauma
- In case of hospitalization, not to use the AVF arm for invasive procedures.
- Post-operatively, when the wound has healed, perform exercises 5–6 times a day using the hand of the AVF arm and squeeze a soft ball, opening or closing the hand, or open and close a clothespin.

Excessive heat such as sauna or Turkish bath causes vasodilation, reducing blood pressure and blood flow. Excessive cold, on the other hand, causes vasoconstriction, reducing blood flow in the extremities of the AVF arm. Patients should be taught to recognize signs of infection, hematoma, bleeding, and AVF malfunction, such as:

- Swelling
- Ache
- Heat
- Exudate
- Redness
- Fever

Upon the appearance of one or more of the preceding signs, the person carrying AVF should be asked to contact the dialysis facility that supports them as soon as possible [4].

5 Main Principles to Prevent Complication and Failure

An important criticality in the management of vascular accesses in dialysis is represented by complications, these can be obstructive (stenosis, thrombosis), infectious, and other times linked to a series of personal and environmental variables such as theft syndrome or formation of aneurysms. The major complications are better covered below.

Many factors contribute to the onset of the obstructive complication of AVF such as [16]:

- Poor maturation of access after packaging
- Repeated blood extravasations
- Frequent hypotensive episodes
- Extreme variability of hemodynamics in dialysis

- Incorrect puncture techniques
- Intrinsic factors

Furthermore, it must be remembered that the obstructive event is rarely sudden, but occurs over time, stenoses develop slowly, progressively reducing the flow up to complete thrombosis of the vessel. From this it is clear how fundamental is the management oriented toward the prevention and early treatment of complications. A possible strategy to deal with this eventuality is to implement monitoring and surveillance programs. The KDOQUI 2019 guidelines recommend implementing standardized and periodic monitoring and surveillance programs. By monitoring, the assessment of vascular access by physical examination is meant look, hear, touch. Surveillance means the periodic assessment of vascular access using tests and diagnostic tools that can early detect the presence of dysfunctions. The nurses' contribution in surveillance and monitoring programs is crucial in preventing major complications such as strictures, thrombosis, and infections. Stenosis is defined as the reduction of the vascular lumen greater than 50% associated with a progressive reduction of the flow, up to the closure of the AVF (thrombosis). Clinical manifestations vary according to the location of the stenosis [2]:

- Arterial stenosis: difficult puncture, post dialysis bleeding, inability to maintain high blood flows, high negative pressure. On physical examination, on auscultation sophisticated and sibilating noise in systole and absent in diastole. Palpation detects a reduced thrill and a tense vessel. The pulse is drastically reduced or even disappears.
- Stenosis located in the central part of the AVF can be caused by an inadequate puncture technique or following infections. Arterial and venous pressures can be normal if the arterial needle is placed downstream the stenosis and the venous needle upstream of it.
- Venous stenosis can be caused by a local infection, needle trauma or neointimal hyperplasia, the venous pressure during dialysis will be increased.

The stenoses located on the arterial and venous side of the AVF lead to a reduction in the dialysis dose due to the reduced blood flow and high recirculation. High blood pressure during dialysis can be an indicator of a stricture. A tool used in clinical practice for the detection of outflow stenosis is the arm elevation test, which can be reached through a basic physical examination [16]. A recent study sought to supplement the daily assessment of the AVF by recording the sounds produced by the AVF and evaluating them using deep learning methods to provide an objective index. Extracted AVF sounds were sent to a spectrogram and evaluated using a learning model, in which AVF stenosis grade was assigned to one of five sound types (normal, hard, loud, intermittent, and sibilant). After 100 training measurements, the method showed an accuracy rate between 70% and 93% in recognizing degrees of stenosis. Sound analysis of AVF using deep learning has the potential to be used as an objective index in daily medical care [17].

Another complication that can occur after the preparation of an AVF is thrombosis, this can be early or late, and has various causes; the mains are [2]:

- Hypercoagulability
- Hypotension
- infections
- Stenosis with reduced flow
- Overly tight bandages
- Formation of hematomas after extravasation

Frequently the patient is the first to notice a loss of pulsation and thrill.

Careful monitoring will detect

- Absence of the murmur
- Absence of the thrill
- Absence of blood following venipuncture

Then, the ultrasound evaluation and the appropriate surgical procedure (percutaneous transluminal angioplasty) to restore the flow within the AVF will follow. The use of aspirin and clopidogrel has been recommended but the scientific evidence is controversial and limited [2]. A recent study, based on machine learning, succeeded in predicting AVF complete stenosis within three months, among people on dialysis, with good results, combining clinical and sensor data, collected daily, which did not require an additional effort for health personnel [18].

The aneurysm consists of a dilation of the Vascular wall greater than 150% of the AVF diameter, it can also be considered a complication of the AVF, in fact every puncture involves the genesis of a scar of fibrotic tissue, and it will contribute to the loss of elasticity and to the development of aneurysmal areas. Possible contributing causes can be considered [11]:

- Stenosis
- FAV puncture with area technique
- Immunosuppression
- Infections

In relation to the symptoms, the syndrome manifests itself in four stages as follows [2]:

Steal syndrome: Steal syndrome is a complication of Fav due to an excessive deviation of the blood flow from its natural path, within the AVF with consequent ischemia of the hand.

- Pale and cold hand
- Intermittent pain during dialysis
- Ischemic pain at rest
- Ulceration and necrosis

In case of stage 3 or 4, it is necessary to proceed with the surgical revision of the AVF. Finally, one of the most feared complications are infections, that are responsible for about 20% of the causes of loss of vascular accesses. The most frequent pathogens are *Staphylococcus Aureus* and *Epidermidis*. The risk factors are mainly as follows [8]:

- Hematomas
- Pseudoaneurysm
- Itching with skin lesions
- Use of AVF for intravenous therapy

In some studies, eye puncture has been associated with a high risk of infections with a rate ranging from 0.15 to 0.6 per 1000 patient days [2]. Predisposing factors can predominantly be poor hygiene, non-aseptic puncture technique, or post-surgical contamination. Clinical signs are localized redness, warmth, edema, serous fluid leakage, increased body temperature, increased inflammatory indices [4].

In the following paragraph, a series of attitudes to use during clinical practice or to avoid will be listed, in accordance with the literature and with what has been written in this chapter.

6 Do's

- Adopt a multidisciplinary approach, which includes nephrologists, surgeons, interventional radiologists, and nurses, improves the outcome of HD by promoting the use of AVF [19].
- Obtain the success of the Fav cannulation, it is required that the nurse has clinical experience and knowledge on the management of different types of vascular access, including the different cannulation techniques [20].
- Constant and careful care, a crucial role is played by the patient himself, in collaboration with dedicated clinical staff, in which qualified nurses, nephrologists, surgeons, radiologists, and sonographers participate [21].
- The self-care actions of patients, must guide a nursing care policy, oriented to the implementation of protocols, which help to identify problems related to self-care actions [22].
- An adequate blood pump flow rate should be maintained during treatment, in fact, an appropriate increase in the blood pump has little effect on cardiac function in HD patients [23].
- In a recent study, the first human evaluation of an automated robotic venipuncture device was presented. It was designed to safely perform blood sampling on the peripheral veins of the forearm. The device combines ultrasound imaging and miniaturized robotics to identify suitable vessels for cannulation and robotically guide a needle toward the center of the vessel, with a 97% success rate on participants with non-difficult venous access and a time procedure average of 93 ± 30 s. In the future, this device may be extended to other areas of vascular access such

as catheterization, central venous access, dialysis, and arterial line positioning [24].

7 Don'ts

- Adopt a monodisciplinary approach, discrediting the use of the FAV.
- Obtain the successful cannulation of the AVF, no experience and no knowledge on the management of the various types of vascular access and cannulation techniques is required by the nurse.
- The Fav does not require care and no role must be played by the dialysis or by the healthcare staff.
- The self-care actions of patient must not guide any nursing professional policy.
- During treatment the flow rate of the blood pump should be reduced as this can damage heart function.
- Being caught unprepared by the arrival of new technologies, repositioning their professional skills in time, directing them, for example, to the entire governance of the care process, of people on HD.

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Vascular Access Management and Care: Arterio-Venous Grafts (AVG)

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Learning Objectives

- To define arteriovenous graft for hemodialysis vascular access.
- To identify the vascular access care when a patient has an arteriovenous graft.
- To detect the early symptoms of vascular access failure when having an arteriovenous graft.
- To prevent any complications when having an arteriovenous graft.

1 Introduction

The ideal vascular access should provide safe and effective therapy by enabling the removal and return of blood via an extracorporeal circuit. Vascular access should be easy to use, reliable, and have minimal risk to the individual receiving hemodialysis (HD). However, the provision of good quality access, while it is a fundamental aspect of the treatment of HD patients, remains difficult to achieve. Native access, in particular arteriovenous fistulae, requires prior planning and has a high primary failure rate. Arteriovenous grafts utilizing replacement of synthetic or biological

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material in conjunction with native vessels again require planning and surgical expertise.

Prosthetic bridge grafts, also known as arteriovenous grafts (AVG), are artificial conduits connected to arteries and veins by means of surgery. An arteriovenous graft (AVG) is a purposeful union of an artery and vein made by inserting graft material therein [1, 2]. AVG is superficially tunneled through the skin to facilitate cannulation [3]. The conduit's diameter ranges from 4 to 8 mm and it can be straight or looped [4, 5].

2 Types of AVG

The forearm loop graft, which joins the brachial artery and cephalic vein in the antecubital fossa, is a typical arrangement for AVG. Due to its alleged improved patency, the forearm loop graft is typically chosen to a straight form [3, 4]. The brachial or axillary artery and vein are frequently the locations for AVG placement in the upper arm. Axillary-femoral placement, a necklace arrangement across the chest, loops from the axillary or subclavian artery to the jugular vein, and other inventive surgical techniques have all been used into grafts [6, 7]. Polytetrafluoroethylene, also known as PTFE, was historically the material used most frequently to make AVG [8]. Based on its availability, ease of implantation, structural integrity, ease of cannulation, prolonged patency, and lower risk of disintegration with infection, this synthetic material was chosen above alternative synthetic or biological materials [6]. Additionally, ovine collagen with mesh, homologous saphenous vein, polyurethane (PU), silicon, Dacron, and bovine carotid or mesenteric vein have all been used to make prosthetic bridge grafts [9]. None of these has demonstrated superior patency or survival than PTFE grafts.

PTFE grafts can typically be cannulated in 2–3 weeks after the insertion of the graft [3, 10]. The composite/PU graft has the benefit of a self-sealing feature that enables it to be cannulated for dialysis, as short as 24–48 hours, if necessary, and even immediately after insertion [11]. As a result, in some circumstances, the composite/PU graft can be implanted without the need for a central venous catheter (CVC) to start the dialysis therapy. Expanded polytetrafluoroethylene (ePTFE), in part as a result of improvements in graft design and surgical procedures to lessen problems and increase patency rates has emerged as the predominant material for such grafts [12, 13]. A transverse incision is made, after which a tunnel is built either in a loop or a straight design (depending on the location and anastomosis). The graft is passed through a counter incision using a tunneling device, typically 6 mm in diameter [13, 14]. Once the graft has been tunneled, the patient can be heparinized. The anastomosis of the arterial and venous systems is carried outside to side. The patient may need to wait a few weeks after implantation for the AVG to heal before being cannulated. Typically, during this period, the tissue, that stabilizes the transplant, grows into the outer wall. This is crucial for preventing hematomas and infections [15–18].

2.1 Pre-cannulation Care

Before healing occurs, the physician can occasionally suggest that the patient starts HD therapy. Patients undergoing HD in the initial stages of the postoperative period benefit greatly from vascular grafts with an early cannulation indication. To avoid a central venous catheter or to allow earlier removal of the catheter, early cannulation grafts may be considered. This is vital to limit the usage of HD catheters and the issues that go along with it. Recent research showed comparable patency rates at 6 and 12 months without noticeable different complication rates after randomly assigning approximately 500 patients to receive standard or early cannulation AVG [19, 20]. For patients to whom an AV graft is the best HD vascular access and the need for chronic HD is imminent, these results support the use of early cannulation AV grafts [20, 21]. In some circumstances, a physician may determine that a patient has to start HD sessions soon after the vascular access graft has been placed. These patients require extra care since there is a high risk of hematoma formation, infection, and venous outflow impairment. It could be challenging to find the graft and implant the needle due to postoperative swelling. The dialysis nurse performs a critical technique called AVG cannulation [22].

3 AVG Cannulation

For each HD treatment, the fistula is cannulated usually with two needles. One, the arterial needle, allows the blood to be withdrawn from the patient into the dialysis circuit and then it is returned by the second one or venous needle. A misplaced needle could pierce the back wall or harm the graft. The swelling can be momentarily displaced by applying light digital pressure. This makes it simpler to feel for the graft or hear the bruit using a stethoscope. In these situations, the surgeon's sketch can be of great use.

Ultrasonography is being used in some dialysis centers to help with successful cannulation [23]. In early cannulation, strict attention to the aseptic technique is essential.

Since surgical wounds have not had enough time to heal completely, it is advised to wear sterile gloves and a face mask [24]. Within 2 weeks of implantation, several dialysis units effectively use the following requirements for cannulation [25]:

- lidocaine infiltration locally (first to arterial and then to venous site, using separate sterile needles)
- prevent graft movement during cannulation
- swift, clean puncture
- 17 gauge needles (small)
- 200–250 ml/min blood flow rate during the entire dialysis session
- low dose heparin

The avoidance of CVCs, with their inherent high risk of infection, may be a crucial factor for AVG use, particularly “early cannulation grafts,” especially when (sub)acute HD treatment is required and AVF creation or maturation is challenging. Within 24 hours following implantation, this graft can be cannulated. A GORE® ACUSEAL Vascular Graft was reported to be cannulated 2 hours after implantation. There was no central venous catheter present in this patient. The patient can avoid a central venous catheter and the associated morbidity by implanting the graft and early cannulation [26, 27].

The maintenance of vascular access and a successful dialysis session depends critically on the selection of the appropriate cannulation location and technique.

Table 1 New AVG cannulation procedure

Step 0	Inspection and evaluation of blood flow direction, puncture site, and vessel’s course should be performed
Step 1	The skin should be pulled over the cannulation site taut in the opposite direction of needle insertion Excessive pressure to the cannulation site may cause the graft to flatten making cannulation difficult The use of tourniquet must not be an option.
Step 2	Usually, the bevel of the needle faces upward and is introduced into the skin at an angle determined by graft configuration, location, and depth For dialysis using two needles, the arterial needle may be positioned either with or against, the blood flow Less turbulence will result if the needle points in the direction of the blood flow The venous (or return needle) must always be positioned in the direction of blood flow In single-needle dialysis, the needle must always point in the direction of blood flow
Step 3	The needle gently inserted through the graft wall while maintaining this angle
Step 4	The needle should be inserted further and further until it reaches the hub. Accurately penetrating the graft wall might be made easier by holding the graft in situ. A blood reflux into the cannula should be avoided. The needle location should be verified by attempting to irrigate the needle and tubing with a syringe if the blood flashback is absent or feels sluggish. Reflux with little or no blood could happen as a result of: the needle’s bevel is in contact with the graft wall it is only partially in the lumen; and it has pierced the graft’s rear wall patient has low blood pressure, and the obstruction is causing limited blood flow in the graft. After creating a sufficient blood flow, the needle should be inserted for no longer than one-eighth of an inch to ensure the needle tip is appropriately positioned inside the graft.
Step 5	By bringing the shaft roughly parallel to the skin’s surface, the risk that the graft’s rear wall will be punctured after full insertion is reduced. There should be caution not to contaminate the region that has been cleaned up surrounding the puncture site during any stage of needle insertion. Any unexpected pain or resistance that occurs during cannulation should be examined. The patient should not feel any pain after the needle has been fully placed and the wings have been taped. A needle puncture of the rear wall of the graft may be the cause of ongoing pain. Aspiration will typically be sluggish and irregular in this situation. Before continuing with dialysis, any problems with the needles must be fixed [29, 30].

Font: Refs. [26, 28]

Needles must be positioned 3 cm apart, and access sites must be able to be rotated, for AVG. For this reason, a 6- to 8-cm straight segment of AVG is ideal.

A strict procedure must be followed for a new AVG cannulation to be successful (Table 1) [26, 28].

4 Needle Removal and Hemostasis Care

The technique of needle removal is equally as crucial to the success of appropriate hemostasis and the protection of the AVG as cannulation. When the dialysis is finished, the needle should be carefully removed at almost the same angle as it was inserted. After the needle is completely out, mild direct pressure for 10–15 minutes must be applied to each needle site, using sterile gauze and a two digit technique, one finger at the vein site (internal) and one finger at the skin exit site (external) [31]. To avoid damaging the AVG, pressure is applied to the puncture site only after the needle has been entirely removed [32]. Mild compression works better when it is administered to the spot where the needle entered the graft as opposed to the skin. Once the graft puncture site has stopped bleeding, mild pressure with a cotton ball or folded gauze dressing has to be applied. AVGs generally take longer than AVFs to reach hemostasis. It is crucial to make sure the AVG feels a flow while compressing [33, 34]. To reach hemostasis, compression is often required for 10–15 minutes. There must be a careful balance between applying just enough pressure to stop needle holes from bleeding and pressing too hard, which could cause graft thrombosis. Clamps should not be used to help with hemostasis. In order to prevent restricting blood flow to the VA, a dressing should be placed at the cannulation sites using any variety of techniques (with or without a hemostatic substance) [35]. The quality of the bruit and thrill should be evaluated and recorded before the patient leaves the facility. When a patient has typical bleeding times, difficulties with cannulation or attaining hemostasis after needle removal may indicate venous outflow stenosis. Dynamic venous pressure readings, the anticoagulant regimen, and AVG flow investigations should all be evaluated if prolonged hemostasis is still present in order to rule out stenosis as the root cause. Check the puncture site for any indications of unusual bleeding from the outside. On the patient's chart, note and date the location of the needle puncture [36, 37].

5 Home Care When Having an AVG

The nursing staff must invest time and effort in educating patients, but once the fundamentals of patient education are established, morbidity and mortality can only decrease [38].

A patient can take good care of and safeguard vascular access as follows:

- ensure that the health care provider checks the access for signs of infection or problems with blood flow before each HD treatment, even if the patient is inserting the needles.
- always keep the access clean.
- use the access site only for dialysis.
- be careful not to bump or cut the access.
- check the thrill in the access every day. The thrill is the rhythmic vibration a person can feel over the vascular access.
- watch for and report signs of infection, including redness, tenderness, or pus.
- do not let anyone put a blood pressure cuff on the access arm.
- do not wear jewelry or tight clothes over the access site.
- do not sleep with the access arm under the head or body.
- do not lift heavy objects or putting pressure on the access arm.

The patient should also examine the flow through the graft on a regular basis. Graft occlusion and difficult blood removal might result from insufficient blood flow through the graft. The patient needs to learn how to feel a strong thrill along the full length of the arm to make sure the transplant is receiving enough blood flow.

6 Main Principles to Prevent Complications and Failure

For patients receiving HD to be managed as effectively as possible, the AVG function and patency is crucial. HD delivery is restricted by low flow and loss of patency, which lengthens treatment periods and could lead to underdialysis, which raises morbidity and mortality [39]. Thrombosis is the primary factor in the loss of AVG patency in long-term VAs, particularly AVGs, and it raises healthcare costs [40]. Almost 15–20% of individuals having HD hospitalizations are due to AVG-related problems [24, 25]. The fundamental idea behind AVG monitoring and surveillance is that, in the vast majority of AVG's, stenoses form over a variable period of time. If they are identified and treated, underdialysis can be minimized or completely avoided (dialysis dose protection), and the rate of thrombosis can be lowered. Whether future surveillance and monitoring can increase AVG survival has not yet been established.

There are several monitoring and surveillance techniques available:

- sequential AVG flow
- sequential dynamic or static pressures
- recirculation measurements
- physical examination [6, 40]

Each HD center should establish a multidisciplinary team, with a coordinator for the VA team actively ensuring the patient is receiving an adequate HD dose by preserving VA function and patency [27–29].

When compared to natural AV fistulas, arteriovenous grafts have a shorter lifespan and are typically more prone to problems, necessitating numerous salvage treatments to keep them intact. Thrombotic and non-thrombotic problems of arteriovenous grafts are different types of complications.

The following are thrombotic side effects of AV access:

- venous outflow stenosis
- arterial inflow stenosis

Non-thrombotic complications of AV access include:

- bleeding
- pseudoaneurysms
- seroma
- arterial steal
- venous hypertension
- neuropathy and cardiopulmonary complications [35, 40]

Loss of HD arteriovenous vascular access is the major outcome of a lot of complications, which can be avoided or solved if proper surveillance and management procedures were taken. Management of arteriovenous graft complications was and is still a major part of any vascular surgeon's daily practice. In the majority of situations, surgical intervention, such as ligation or revision surgery, is still preferable to endovascular management. Because it provides straightforward yet efficient ways to deal with and overcome the difficulty.

7 Actions to Maintain a Healthy Vascular Access

The patient needs healthy vascular access with an arteriovenous (AV) fistula or an AV graft that provides enough blood flow for HD to be most successful. Follow the policies and procedures of each facility and the following professional advice to safeguard vascular access is crucial to prevent problems including infection, stenosis, thrombosis, and hemorrhage [25, 33]. Initiating with removing any restrictive clothing or jewelry from the arm where the vascular access is. During the period of HD the arm with the vascular access (either AVG or AVF) must be positioned in a way that can be easily visualized. Hand hygiene must be performed before assessing or touching the vascular access. If it is a new vascular access with a wound, gloves must be used. Avoid trauma to or excessive pressure on the affected arm when the patient is moved or helped with ambulation. Palpation of the vascular access is necessary to feel for a thrill or vibration that indicates arterial and venous blood flow and patency. If necessary, use a stethoscope to detect a bruit or “swishing” sound that indicates patency. On the other side, tourniquets cannot be used in the AVG or AVF arm, as well as no blood pressure measurements, venipunctures, or injections on the vascular access arm (a warning armband can help). Patient's

circulation must be checked by palpating his/her pulses distal to the vascular access, observing capillary refill in his fingers, and assessing for numbness, tingling, altered sensation, coldness, and pallor in the affected extremity. Moreover, vascular access must be assessed to look for signs and symptoms of infection such as redness, warmth, tenderness, purulent drainage, open sores, or swelling. Also assess vascular access for blebs (ballooning or bulging) of the vascular access that may indicate an aneurysm that can rupture and cause hemorrhage. Healthcare provider should be notified promptly if clotting is suspected. After dialysis, assess the vascular access for any bleeding or hemorrhage and check patency at least every 8 hours. Finally, it is very recommended to monitor serum electrolytes, blood urea nitrogen, creatinine, and hemoglobin and hematocrit levels and coagulation (as heparin is used to prevent clotting during dialysis) before and after dialysis, following each unit's protocol. Monitor fluid status.

Patient should be trained:

- to make sure that dialysis cannulation locations are rotated to prevent stenosis and thrombus formation,
- to check the function of the vascular access several times a day by palpating it and feeling for vibration,
- to monitor for any bleeding after dialysis,
- to monitor for signs of infection,
- to keep the site clean,
- to avoid wearing any clothing or jewelry that restricts access and to prevent anyone from using the extremity to obtain BP or perform venipuncture,
- not to use the arm with vascular access to carry heavy objects and not to sleep on the arm.

Record the results of the evaluation, any interventions, patient reactions, patient instruction, and the patient's level of comprehension [6, 31].

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Vascular Access Management and Care: CVC

Afra Masià-Plana and Massimo Fontò

Learning Objectives

- To describe the use and insertion of a CVC for HD therapy purposes.
- To explain step by step the nursing care while connecting/disconnecting to HD machine via CVC.
- To identify the procedure when doing a new dressing in the CVC site.
- To describe the home care to follow up when having a CVC.
- To understand potential complications that may arise for a person whose vascular access for HD therapy is a CVC.
- To name general dos and don'ts when utilizing a CVC.

1 Definition

A central venous catheter for HD (HD CVC) is a medical device that provides a viable alternative for vascular access when long-term access cannot be established. CVCs used in dialysis have a larger lumen diameter than the CVCs used for intravenous infusions, to support adequate flows for HD treatment [1]. The choice to use a CVC for HD is determined by the difficulty of creating an AVF and the lack of maturation processes at the AVF. The possibility of CVC insertion in different sites

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is also an advantage. In fact, once the CVC is implanted, it is ready for use, which makes it useful even in an acute situation [2].

Depending on the patient's clinical condition and the necessity of the use of the CVC, the access points most commonly used for placement of a CVC are the external/internal jugular and femoral. The subclavian vein is generally avoided due to the high risk of developing central venous stenosis [3]. In addition to the implantation site, CVCs can be classified into short-term CVCs (non-tunneled; non-cuffed) and long-term CVCs (tunneled; implanted venous access devices). Regardless of the type of CVCs, it is crucial that healthcare professionals take precautions to avoid complications such as infections, dislocations, or coagulation, which could shorten the lifetime of the CVCs and directly influence the patient's quality of life.

Dialysis care has improved, and patients are now living longer. It is important that they have all the opportunities for a lifetime journey of renal replacement. Guidelines can assist in decision making, but ultimately, the quality approach should be the right access for the right patient, at the right time [4].

2 Implantation Care

The insertion procedure involves informing the patient and obtaining informed consent of a non-emergency situation. However, an exception to this rule can be made when having to insert a CVC in an emergency context. Blood tests should be checked to ensure that clotting values are normal. Furthermore, it is to be ensured that the insertion site is visibly clean before applying the aseptic solution, usually alcohol-based chlorhexidine with dye, to identify the area that has actually been disinfected.

The guidelines recommend using a checklist for entry and a standardized trolley containing all the necessary materials [5].

The steps to be followed for proper care during the implantation of CVC are:

1. Hand hygiene and aseptic technique [6]:

Perform hand hygiene procedures, either by washing hands with conventional soap and water or with alcohol-based hand rubs (ABHR). Hand hygiene should be performed before and after palpating catheter insertion sites, as well as before and after inserting, replacing, accessing, repairing, or dressing an intravascular catheter. Palpation of the insertion site should not be performed after the application of antiseptic unless the aseptic technique is maintained.

2. Maximal Sterile Barrier Precautions:

Use maximal sterile barrier precautions, including the use of a cap, mask, sterile gown, sterile gloves, and a sterile full body drape for the insertion of CVCs, PICCs, or guidewire exchange.

3. Skin Preparation:

- To improve the adherence of the dressing that will be applied later, hairs at the insertion site must be removed by medical personnel, which must be done before applying the antiseptic, using a clipper, and not a shaver, to avoid skin lesions.

- Prior to inserting the catheter, a thorough cleaning of the skin is recommended before applying the antiseptic solution, for example, 70% alcohol, a tincture of iodine, or an alcoholic chlorhexidine gluconate solution.
 - Prepare clean skin with a > 0.5% chlorhexidine preparation with alcohol before insertion of the central venous catheter and peripheral arterial catheter and during dressing changes. If there is a contraindication to chlorhexidine, a tincture of iodine, an iodophor, or 70% alcohol can be used as alternatives.
4. Catheter Site Dressing Regimens:
- Use either sterile gauze or a sterile, transparent, semipermeable dressing to cover the catheter site.
 - If the patient has excessive sweating or if the site is bleeding or oozing, use a gauze dressing until this is resolved.
 - Replace the catheter site dressing if it becomes damp, loosened, or visibly soiled.

Apply the standard precautions for any patient care, regardless of the suspected or confirmed infection status of the patient, in all settings where health care is delivered [6].

3 Connection Procedure to HD Therapy with CVC

Before starting HD treatment using a CVC, ensure that the surrounding environment is clean and risk-free. The HD machine, usually positioned on the same side as the CVC, must be ready for use, fully primed, and all alarms silenced. Ensure the patient's comfort and privacy before starting the connection procedure. All connection materials should be ready, and there should be a container for medical waste and a container for sharps.

3.1 Materials Needed for the Connection Procedure with CVC

All the materials necessary for the connection should be available on site, using a specially prepared trolley. The trolley should contain:

A. Personal Protection Equipment:

- Goggle or face shield
- Apron
- Face masks (one for the patient, one for the clinician)

B. 1 CVC connection kit:

- 1 sterile drape with a side to center cut
- 2 × 5 ml Luer-lock syringes
- 4 × 2% chlorhexidine in 70% isopropyl alcohol wipes
- 1 pair of sterile gloves

If a pre-set kit is not available and wipes are not available, use sterile gauze soaked in 2% chlorhexidine in a 70% isopropyl alcohol solution.

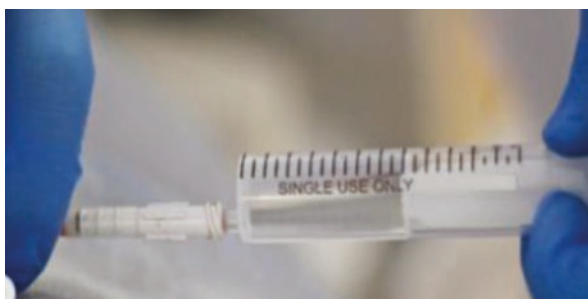
A rigorous procedure should be followed when connecting a person to the HD machine via CVC in order to reduce infections. According to the guidelines' recommendations, the step-by-step procedure should be as follows [4]:

1. Perform hand hygiene according to the World Health Organization (WHO) recommendations [6].
2. Put on the apron, mask, goggles or face shield, and non-sterile gloves and keep them on for the duration of the procedure.
3. Clean the work surface (table, trolley, or tray) with a disposable wipe, and the work surface should be clear.
4. Check that the waste container is available on site. Remove gloves and dispose of them in the waste container, and perform hand hygiene.
5. Check the patient temperature (if the temperature is above normal, notify the doctor or nurse in charge immediately), the patient's blood pressure, the patient's pulse, and ask the patient to wear a mask.
6. Dressing the exit site (see paragraph: Exit site care).
7. Use the "non-touch" aseptic technique, such as ANTT®, avoiding touching the key parts and key sites throughout the procedure [8, 9].
8. Perform sterile hand hygiene and put on sterile gloves to initiate the connection.
9. Open the first clean gauze and wrap it around the arterial branch. Open the second clean gauze and wrap it around the venous branch (Fig. 1).
10. Place the sterile drape under the CVC branches and simultaneously lift both lumens.
11. Rub the arterial branch of the catheter and the cap with an ascending mechanical action for at least 15 s. Rub the venous branch of the catheter and the cap with an ascending mechanical action for at least 15 s. The friction removes blood residues and improves antibacterial efficacy.
12. Dispose of the gauze in the waste container.
13. Lift the arterial branch with new gauze. Take a 5 ml syringe in the other hand, remove the protective cap, and immediately connect the 5 ml syringe. Dispose of the protective cap in the waste container.
14. Wipe the lumen of the CVC attached to the syringe for at least 15 s. Make sure that the "non-touch" technique is strictly used.
15. Open the clamp and withdraw the anticoagulant solution lock. Make sure you can visualize a clot coming out. Also, make sure you can assess the blood coming out. Close the clamp. Remove and dispose of the 5 ml syringe in the waste container.
16. Connect immediately a 10 ml syringe with saline (Fig. 2). Rub for at least 15 s around the CVC lumen. Open the clamp and flush the lumen. Close the clamp leaving the syringe connected to the CVC lumen.

Fig. 1 Central Venous Catheter (CVC) connected to HD machine. Both lumens wrapped with a sterile gauze to avoid infections at the connection side



Fig. 2 5 ml syringe with normal saline to flush the lumen of the CVC



17. Repeat the previous actions for the other CVC lumen. Remove the 10 ml syringe from the venous lumen. Dispose of the syringe in the waste container.
18. Immediately connect the syringe with the heparin, if prescribed. Scrub for at least 15 s around the CVC hub site. Open the clamp and inject the heparin. Flush the heparin with saline.

19. Take the venous line from the HD set. Remove the syringe from the venous lumen and immediately connect the venous blood line to the CVC.
20. Take the arterial blood line. Remove the syringe from the arterial lumen and immediately connect the arterial blood line to the CVC.
21. Open the bloodline clamps and CVC clamps.
22. Remove and dispose of gloves, perform hand hygiene, and start treatment.

3.2 Disconnection Procedure to HD Therapy with CVC Vascular Access

The disconnection of the CVC after dialysis must follow the same precautions as the connection before the start of the procedure. All connection materials should be ready and there should be a container for medical waste and a container for sharps.

3.3 Materials Needed While Disconnecting from CVC

All the materials necessary for the disconnection should be available on site, using a specially prepared trolley. The trolley should contain:

- CVC disconnection kit:
 - 4 × 2% chlorhexidine in 70% isopropyl alcohol wipes
 - 1 pouch/pocket dressing for the branches of the CVC
 - 1 pair of sterile gloves
- 2 × 10 ml Luer-lock syringes
- Sodium chloride 0.9% (NaCl)
- 2 catheter caps. If available, the use of TEGO ® caps as it is a needle-free capping device that closes the end of a catheter, creating a mechanically closed system that prohibits microbial ingress, when attached to the hub of a catheter. Tego will permit access to the catheter without the use of needles and therefore passively aid in the reduction of needlestick injuries [7, 8].
- 1 pair of non-sterile gloves to clean the work surface
- Face shield and mask, or goggles and mask
- 1 mask for the patient
- 1 apron
- Adequate surface disinfectant
- 70% alcohol-based hand rub solution
- Anticoagulant locking solution according to prescription

If an ON/OFF kit is not available and wipes are not available, use sterile gauze soaked in 2% chlorhexidine in 70% isopropyl alcohol solution.

3.4 Step-by-Step Process When Disconnecting from HD Therapy with CVC

1. Perform hand hygiene, in accordance with the WHO recommendations [5].
2. Put on the apron, mask, goggles or face shield, and single use gloves. Wear PPE correctly for the duration of the procedure.
3. Clean the work surface (table, trolley, or tray) with a disposable wipe.
4. Remove gloves, dispose of them in the waste container, and perform hand hygiene. Check that the waste container is available on site.
5. Explain the procedure, prepare the patient, and uncover the CVC area. Ask the patient to wear the mask.
6. Use an aseptic and “non-touch” technique like ANTT®, avoiding touching key parts and key sites throughout the entire procedure. The use of aseptic technique using a “non-touch” technique reduces the risk of infection. ANTT® underlying principles: Always wash hands effectively; never contaminate key parts, touch non-key parts safely, take appropriate infection precautions.
7. Perform sterile hand hygiene [5].
8. Open the CVC disconnection pack and put on sterile gloves.
9. Place the sterile drape under the CVC branches and simultaneously lift both lumens. Open and wrap first wipe around the arterial catheter hub/bloodline connection site. Open and wrap the second wipe around the venous catheter hub/bloodline connection site. If wipes are not available, use sterile gauzes soaked with 2% chlorhexidine in a 70% isopropyl alcohol solution.
10. Scrub thoroughly each catheter/bloodline connection site for at least 15 s leaving the wipes in place (Fig. 3).
11. Stop the HD blood pump. Close the clamp in the arterial branch, close the clamp of the arterial bloodline, hold 10 ml syringe with saline.
12. Disconnect the arterial blood line from the catheter arterial branch and hold the blood line. Connect immediately the 10 ml syringe with saline. Open the clamp and flush the lumen. Close the clamp and leave the syringe in place.
13. Connect the end of the arterial line to the infusion line/port for rinse back. Open the clamps of the arterial line and of the catheter branch. Resume with blood flow rate of no more than 100/200 ml/min. Stop the blood flow pump after rinse back. Disconnect the venous bloodline from the catheter venous branch and repeat the procedure as for the arterial line.
14. Open 2 new sterile wipes; wrap first wipe around the arterial catheter hub and the tip of the syringe. Wrap the second wipe around the venous catheter hub and the tip of the syringe. If wipes are not available, use sterile gauzes soaked with 2% chlorhexidine in a 70% isopropyl alcohol solution.
15. Scrub for at least 15 s the site around the CVC arterial hub and the syringe tip. Leave the wipe under the CVC limb.
16. Hold the syringe with the anticoagulant locking solution in one hand. Remove the 10 ml syringe from the arterial branch. Dispose of the syringe and connect immediately the syringe with the anticoagulant locking solution to the arterial

Fig. 3 Always leave the wipes in place in order to reduce the risk of infection



hub of the CVC. Inject the anticoagulant solution and repeat this for the venous limb.

17. Hold 1 sterile cap in one hand. With the other remove the locking solution syringe. Immediately connect the cap. Repeat for both branches.
18. Place both CVC catheter branches inside the pouch/pocket dressing. Remove sterile gloves and dispose of in the waste container and perform hand hygiene.

4 CVC Exit Site Care

The exit site is the point of contact between the CVC and where the skin is no longer intact. It is essential that it is inspected during all phases of CVC care and that any modifications or changes that may occur are noted. The evaluation of the exit site includes signs of: infection, allergy to dressing or disinfectant solution, skin peeling, rash, swelling, and exudate.

All CVCs, regardless of their type, must be protected by a dressing that reduces both the possibility of infection and dislocation. Additionally, the dressings should be as comfortable as possible in order to improve the patient's quality of life [10].

For a correct disinfection of the exit site use 2% chlorhexidine in isopropyl alcohol (action time 30 s) should be used or alternatively 10% Povidone Iodine (IA) in an alcoholic or aqueous solution. The exit site should be cleaned with sterile gauze

or gauze already soaked in disinfectant, making circular movements starting from the center outwards without ever going over the same point with the same angle of the gauze.

Use an aseptic and “non- touch” technique like ANTT®, avoiding touching key parts and key sites throughout the entire procedure.

After disinfection of the exit site, it is necessary to cover it with a dressing. The various types of dressing are:

A. Transparent polyurethane dressing

Frequency: every 7 days if intact, well tolerated, and free of serum-blood secretions

B. Sterile gauze dressing and transparent patch

Frequency: every 48 h if intact, well tolerated, and free of serum-blood secretions

C. Tegaderm® with chlorhexidine gluconate gel pad

Frequency: every 7 days

According to the latest studies conducted by the SIAN (Society of Nurses in the Nephrological Area), it is also possible to use advanced dressings:

- (a) Absorbent antimicrobial dressing in polyurethane foam with slow release of chlorhexidine gluconate, lyophilized
- (b) Dressing with a silver-based non-stick net
- (c) Antimicrobial dressing in non-woven fabric soaked in 0.2% polyoxymethylene biguanide with guaranteed efficacy up to 72 h and active on methicillin resistant *Staphylococcus aureus*
- (d) Green colored acetate gauze with bacterial uptake (DACC: dialkylcarbomoyl chloride)

4.1 Actions When Caring for the CVC Site

It is important to replace the exit site dressing at the right time and with the correct procedure. It is necessary to change the dressing:

- At every HD treatment if a gauze-based dressing is used and always before treatment.
- Once a week if a transparent film dressing is used and at any time during the treatment.
- If inflammation or infection signs are visible, or if the transparent dressing is not totally adhesive to the skin change the dressing before treatment.

4.2 Materials Used When Caring for the CVC Site

Gather the following supplies and equipment:

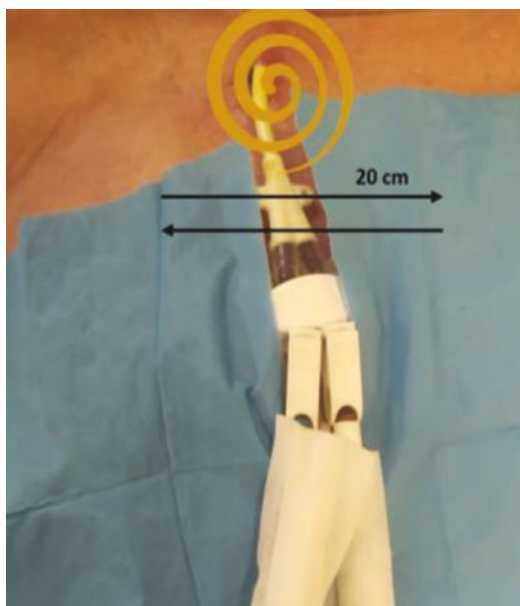
- 1 × CVC ON kit which includes:
 - 1 × drape
 - 4 × 2% chlorhexidine in 70% isopropyl alcohol wipes
 - 1 × pair of sterile gloves
- 1 gauze-based dressing or 1 transparent film dressing (as per the patient's care plan)
- Cleaning agent for the exit site (usually Chloraprep formulations)
- 1 × Bio-Patch (refer to protocols)
- 2 pairs of non-sterile gloves
- Face shield and mask
- 1 apron
- 1 mask for the patient
- 1 thermometer
- Adequate surface disinfectant
- 70% alcohol-based hand rub solution

4.3 Dressing Replacement in 30 Steps

1. Ensure the waste container is within immediate reach, and at the point of use.
2. Perform hand hygiene.
3. Use an apron, mask, goggles, or face shield and non-sterile gloves.
4. Clean the dressing trolley with a disposable wipe.
5. Remove the gloves and dispose of in the waste container.
6. Perform hand hygiene.
7. Place all supplies for the dressing change on the bottom shelf of the dressing trolley.
8. Explain the procedure, prepare the patient. and uncover the dressing site and CVC area.
9. Place the drape in a way to protect the CVC exit site from the patient's clothes.
10. The CVC exit site area should be uncovered, easily accessible and patient's clothes out of the way.
11. Place the mask on the patient.
12. Ask the patient to turn their face to the opposite side of the catheter exit site.
13. Use an aseptic and "non-touch" technique like ANTT®, avoiding touching key parts and key sites throughout the entire procedure.
14. Perform hand hygiene and put on non-sterile gloves.
15. Remove the pouch dressing from the CVC limbs and the dressing from the CVC exit site.

16. Dispose of the dressings in the waste container.
17. Remove and dispose of gloves in the waste container.
18. Perform sterile hand hygiene.
19. Put on sterile gloves. Usually, they are provided in the CVC connection pack.
20. Open one wipe and wrap it around the catheter branches.
21. Lift the wrapped branches of the CVC with one hand.
22. With the cleaning agent (usually Chloraprep solutions) in the other hand, starting at the exit site and moving outwards, disinfect the skin in a circular motion clockwise up to a radius of 10 cm (total 20 cm diameter area) (Fig. 4).
23. Dispose of the used wipes in the waste container.
24. Disinfect with a new wipe any portion of the catheter lumen that is exposed down to the hub (downward movement), complying with disinfectant contact time and always keeping the wrapped branches up.
25. 15 s is the minimum contact time for a 2% chlorhexidine in a 70% isopropyl alcohol solution.
26. Dispose of the used wipes in the waste container.
27. Allow to air dry for up to 30 s before applying the sterile dressing over the exit site when the skin area is dry.
28. Where Bio-Patch ® is used, this must be applied correctly on dry skin around the exit site, prior to applying the dressing.
29. Remove sterile gloves and perform hand hygiene.
30. Apply a dated tape-strip to the dressing.

Fig. 4 Circular disinfection of the exit site, from inside to outside



5 CVC Exit Side Home Care

CVC home care requires no action on the part of the patient or caregivers, other than to check that the CVC is not damaged or exposed to risk; nevertheless, home care of the central venous catheter is a key point of all patient care. Often the CVC is inserted in an emergency situation and therefore during very critical conditions and it is therefore important that all the actions that are performed for the patient's assistance are done following the correct procedures.

A fundamental part of these actions is certainly the training of the patient and family to ensure that they:

- know the CVC in its main characteristics (what it is used for and what its components are),
- know the main signs of CVC complications (signs of infection, dislocation),
- know what to do and who to contact in case of need,
- know what to do and what not to do to manage CVC in the best way,
- maintain thorough hand and body hygiene,
- do not touch the CVC,
- avoid getting the CVC wet (water, sweating, sneezing, coughing).

It is important to provide this training to the patient and family as soon as possible. It might be useful to create a leaflet with the main information on home care, so that the patient always knows what to do ® (and what not). The manual must be written in simple, non-technical language to make it easy for all different cultural levels.

When training is delivered, it is relevant to take into consideration the individual needs and lifestyle of each patient; therefore, training needs to be individualized. Comorbidity, CVC site, cognitive level, or other problems can greatly affect the quality of life and care of the CVC. A multi-disciplinary approach is therefore essential to understanding the individual's needs [11].

6 Main Principles to Prevent Complications and Failures

Failures and complications of the CVC can occur (Table 1). Appropriate actions can prevent or minimize the impact of the potential complications and can have a direct effect to people's quality of life. Complications should be recognized by patients and carers so as to avoid major issues [12]:

6.1 Dos and Don'ts When Having a CVC

For many people who suffer from CKD and need renal replacement therapy, CVC is the ultimate alternative to vascular access. It is crucial to pay the utmost attention

Table 1 Potential complications and indications when having a CVC

Complications	Indications
Infection	One of the biggest risks for CVC is infection. It is important to be able to recognize CVC infections to avoid more serious harm to the patient (such as septicemia). Patients and caregivers must be able to recognize this problem and immediately notify their referring physician
Dislodgement	Dislocation of the CVC can be life-threatening Patients and caregivers must be able to recognize this and immediately notify their referring physician
Damage	Damage to the CVC clamps or lumens can cause bleeding and/or embolism. Patients and caregivers should be instructed to report the damage immediately to the referring physician
Leakage	It may happen that fluid leaks from the CVC lumens. Instructing caregivers and patients so that they are able to verify that the clamps are closed and the caps tightened and to reposition everything correctly is necessary. If the CVC has been accidentally pulled, it is recommended to apply a cold compress and contact the referring physician
Thrombosis	Thrombosis of the CVC may occur more rarely. These usually occur with specific signs: Swelling of the face, neck, chest, or arm Tingling in the arm or leg Cold limb Teach patients and caregivers how to recognize these signs to avoid major complications (pulmonary embolism)

Table 2 Dos and don'ts that patients and caregivers should consider

Dos	Don'ts
Recognize all the problems facing the CVC	Remove the dressing for any reason
Always maintain clean skin and body hygiene	Touch the ends of the CVC directly
Live in a clean domestic environment	Open the clamps or remove the protective caps
Wear clean clothing	Get the dressing wet
Keep the dressing dry	Immerse in water (even if using a waterproof dressing)
Always have the dressing changed by the health care professionals	Use scissors or sharp materials near the CVC
Contact the HCPs for any doubts or serious situations	Modify the dressing performed by the health care professional
	Wait long to seek assistance when complications or a critical situation arises

to its care and management whether this takes place in a healthcare setting or at the patient's home. In Table 2 it is indicated what the dos and don'ts patients need for a proper management of the CVC at home.

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Use of the Ultrasound in Hemodialysis

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and Giuseppe Fenoglio

Learning Objectives

- To understand the technical use of ultrasound.
- To identify the characteristics of the ultrasound images.
- To describe the training and practice needed in order to achieve positive outcomes of the ultrasound technique.
- To acknowledge the different cannulation techniques using ultrasound.
- To recognize the use of the ultrasound device in nursing practice.

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1 Introduction

Nursing professionals have greatly improved their knowledge and education during the last decades, having reached senior positions in the healthcare systems of many countries. The work of nurses has changed and grown along with the technology used. Even though nursing care is technified, the human approach and empathy always take priority during nursing interventions in order to provide high quality care.

Ultrasound has lately become a useful instrument not only for physicians but also for a wide range of different professionals involved in healthcare. This range includes nurses who can use US as an aid in caring procedures of a technical nature. This means that those procedures can become safer, easier, and this ultimately drives the quality of nursing care to a higher level [1, 2]. US within the nursing profile will not lead to any diagnosis, and this needs to be clear at the outset to avoid any possible misunderstanding or conflict of interest [3].

As like in many other scientific fields, in US of the Vascular Access there must be a common and strict “language” established, with shared “points of reference” when talking about skills, so that every professional can compare his/her experience with others. Therefore, establishing the technique, the orientation system, and the patterns expected to be found during the examination are needed.

2 The Use of Ultrasound in Hemodialysis

Nurses can use US to improve their knowledge of the areas of the human body, including vascular system. All nurses in their respective professional careers could probably need to gain vascular access for their patients.

Hemodialysis (HD) is one of the key areas where US works the best, both for the professional and the patient alike. Having high-quality vascular access such as Arterio-Venous Fistula (AVF) or Arterio-Venous Graft (AVG) is crucial for all people receiving HD. Professionals should make every effort to benefit from its best use since the needling and choice of puncture sites make a big difference in many aspects specially to the life of the AVF and to avoid complications [4–6]. Therefore, the key points for the application of US for AVF in the field of HD are:

- Study the vascular system with a pre-surgery evaluation (vascular surgeon/nephrologist)
- Evaluate the maturation of the AVF after surgery (vascular surgeon/nephrologist and nurse)
- Start the venepuncture correctly and safely (nurse)
- Monitoring and surveillance of the AVF (vascular surgeon/nephrologist and nurse)

US is not the only instrument to evaluate an AVF, but it is surely the most relevant after “*the use of senses*,” which is the foundation of monitoring: touch and feel, hearing and sight. Together with clinical and physical assessment, Point of Care

Ultrasound (POCUS) represents an easy way to evaluate the health of an AVF or an AVG. POCUS, since its first definition in the 1990s, has nowadays a large variety of applications in several settings, not only in clinics and hospitals, but also in the patient's home, in an emergency setting. In HD, POCUS becomes almost essential to assess and manage difficult cannulations in overweight patients, in unstable or deep veins, when there is damage to the wall of the vein, partially thrombosed lumen or stenosis, and to avoid pseudoaneurysms or extravasated sites [7].

Finally, Doppler evaluation enables the measurement of blood flow in the AVF in the case of poor clinical signs such as a weak AVF thrill or bruit, blood pump rate QB reduction (QB = Quantity of Blood=Blood flow), increased recirculation rate, decreased KT/V (KT/V=formula for fractional urea clearance) or other HD quality indicators, abnormal arterial or venous pressure, or for regular monitoring. As previously mentioned, US can be used in many different situations. Regardless of the reason, the US support is needed, there are some simple resources to obtain the best outcomes in terms of image quality and safe needle insertion:

- Set the right depth (the focus of study should be in the middle of the screen and big enough to be seen properly)
- Set the right focus (at the height of the focus of study)
- Set the right gain (general/sectorial gain and/or Time Gain Compensation)

When using US technique, three main elements should be assessed prior the use in order to achieve positive outcomes: those are the patient, the US device, and the healthcare professionals (Table 1).

POCUS helps healthcare professionals to answer questions such as if the vein lumen is clear, and if the diameter of the blood vessel is big enough for the needle, or if the blood vessel is superficial enough to be cannulated. Answers should always be a “yes” or “no.” Questions change according to the reason why the AVF is

Table 1 Elements that need to be assessed when using ultrasound technique

Patient	Ultrasound device	Healthcare professional
• Lying on the bed, comfortable, seat back and slightly lifted • Arm in abduction-external rotation • In case of cannulation the arm cannot be moved after AVF ultrasound assessment	• Place the device next to the head of the patient, on the same side of the AVF for evaluation, opposite site for cannulation • Select vascular pre-set • High frequency linear probe • Gel as required, sterile for cannulation • Room's lights and glares on the screen should be reduced	• Sitting or standing on the same side of the AVF • The right hand should hold the probe while assessing the right arm. The left hand should hold the probe while assessing the left arm. During US-guided cannulation, needle is held by dominant hand in any case^a • Smooth probe movements like sliding, rotation, tilting, and rocking • Vessel assessment both on transversal view and longitudinal view • Do not lift the probe and maintain all the surface in contact and perpendicular to the skin

^a Hand position during examination (not needling) can vary depending on operator's habit

evaluated: is it to evaluate the AVF maturation? Is it needed to assess what happened to the fistula after a poor cannulation or an extravasation?

If the questions change, criteria used in assessment or evaluation remain the same:

- Blood vessel's patency (Figs. 1 and 2), depth, diameter, development, wall integrity
- Anastomosis
- Presence of aneurysms (Fig. 3)
- Presence of stenosis (Fig. 3)
- Presence of pseudoaneurysms (Fig. 4)
- Nearby anatomical structures such as nerves (Fig. 5)
- Presence of blood flow and its measurement, if necessary (Figs. 7 and 8)
- Presence of extravasation (Figs. 4, 5, 6, 7, 8, and 9)

It is essential for every evaluated structure to include both the cross axis (*transversal* view) and the lengthwise axis (*longitudinal* view) of the blood vessel. It is a basic requirement to check that the probe's marker is directed to the left side of the healthcare professional in the cross axis and to the head of the patient in the lengthwise axis. Anyway, the right check for the probe's orientation is to tap on the probe and see the effect on the screen. In this way the image generated on the screen accurately reproduces the relationship between muscles, veins, arteries, nerves, and bones in the subject arm. Clockwise rotation is required to move from short to long axis (transverse to longitudinal view), while anticlockwise is needed from the opposite. No sterile gel is needed in the case of no cannulation.

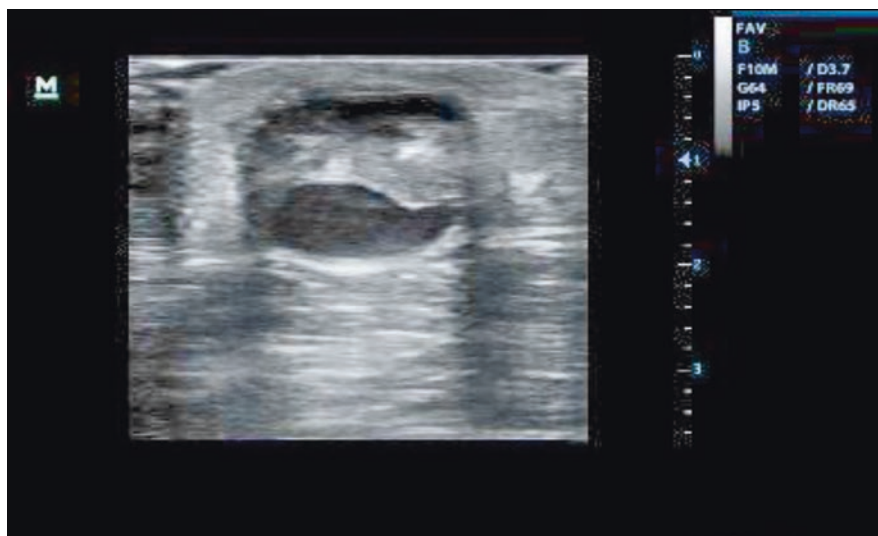


Fig. 1 Presence of a clot in the vessel. A clot is usually a hypoechoic area, of variable size. It may contain hyper-echoic zones, an indication of possible calcifications

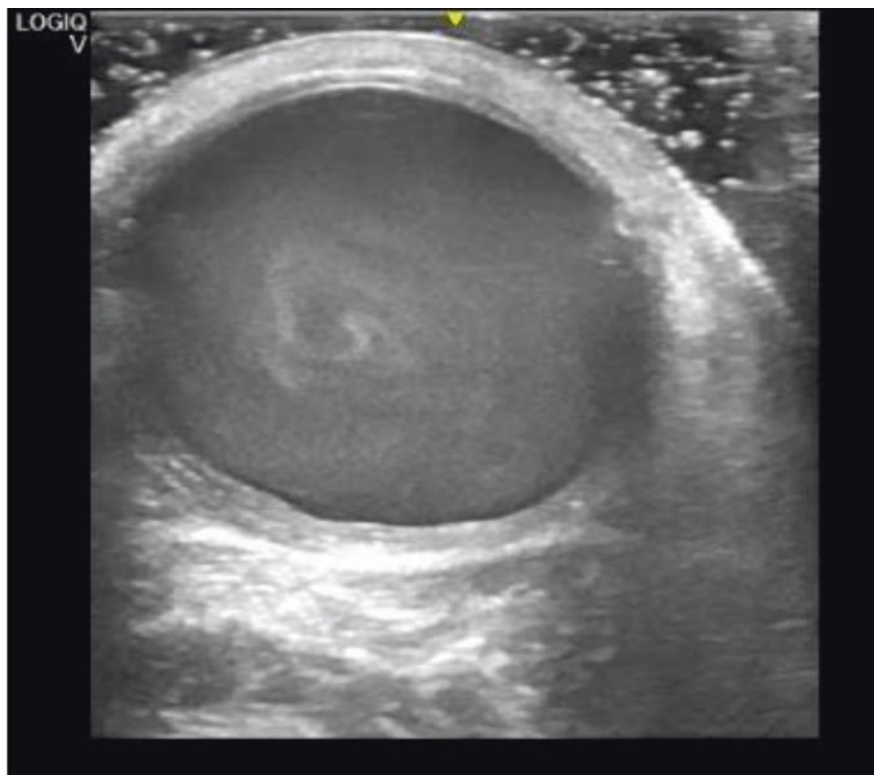


Fig. 2 “Smoke-like.” The smoke-like effect is displayed when there is a slowdown in blood flow. In this condition the vascular lumen seems to contain hypo-echoic, moving swirls of smoke. Unfortunately, the static image does not show this effect

A normal US pattern can be described as:

- Blood vessels lumen free, Compression by Ultrasound probe (CUS) negative (Fig. 6)
- No aneurysms, pseudoaneurysms, stenosis, or extravasation
- Enough blood flow for the treatment

US can be set in several modes (A, B, C, M Mode).

In daily use, and in the pictures above is used “B-Mode” (Brightness Mode), a bi-dimensional mode where the brightness reflects the echo’s intensity.

“Doppler Mode,” according to the physics Doppler law, is able to visualize and measure the blood flow through vessels.

“Color” is an additional mode that doesn’t define a vein or an artery but shows the direction and speed of the blood flow through a color scale. The direction of the flow can be toward the probe (color shown above) or away from it (color shown below), and it depends on the probe’s marker position. The operator can also switch the colors from above to below. The speed on both directions is shown by “extreme” colors: red turns into yellow and blue turns into white.

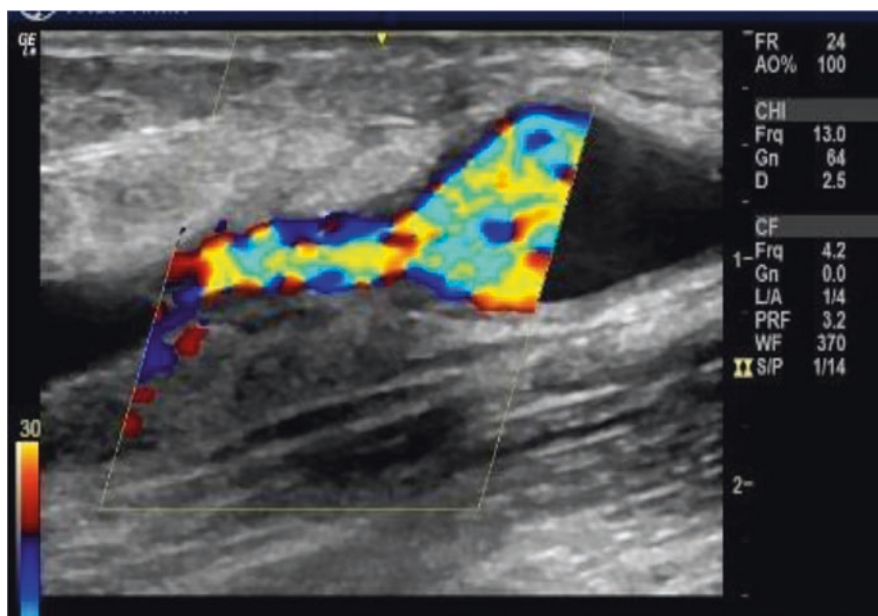


Fig. 3 Aneurysm, stenosis. An aneurysm is a dilatation of the vessel lumen, partially physiological and partially due to the cannulation method. A stenosis is a narrowing of the vessel lumen, due to several factors. Increased speeds can be identified with the doppler, and color mode shows heterogenic pixels

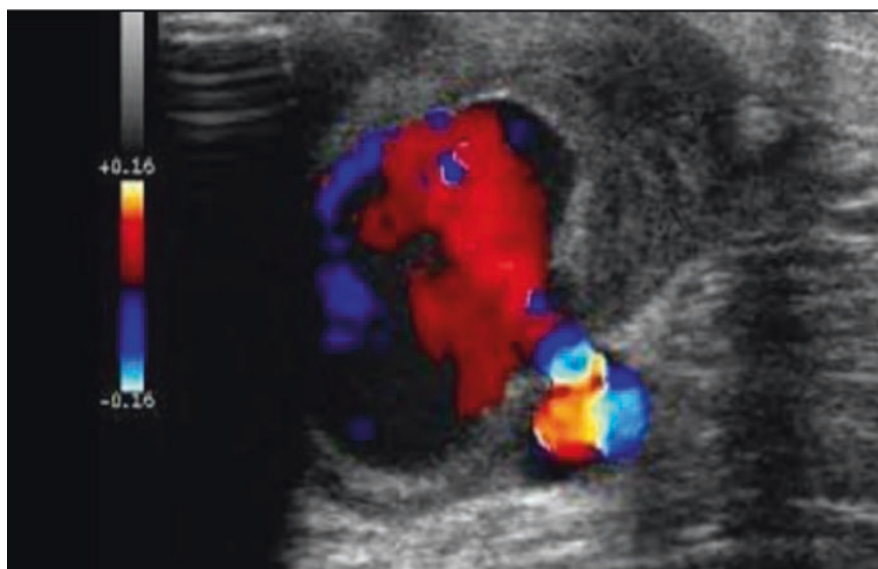


Fig. 4 Pseudoaneurysm. A pseudoaneurysm is visualized as a roundish anechoic zone of variable size, connected to the main vessel and supplied by its flow. Often the only way to be sure of the connection between the two structures is the use of color, as in this picture, where the vein is represented by the larger colored area and the pseudoaneurysm by the smaller one below

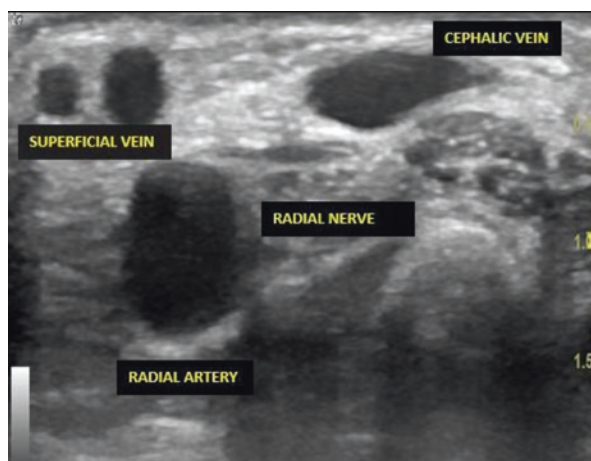


Fig. 5 Nearby anatomical frameworks. In order to use the ultrasound image correctly, it is essential to recognize the anatomical structures displayed. In this picture you can see two veins (*superficial vein*), and arterialized cephalic vein (*cephalic vein*), with the radial artery and radial nerve. Veins and arteries can be a similar size, but walls and motility vary; veins are stable, easy to be compressed with the probe and not pulsating (but AVF often pulsates); arteries are always pulsating, even more when compressed and has thicker walls (more visible in longitudinal view). Nerves have a hyper-echoic pattern, usually honeycomb-like

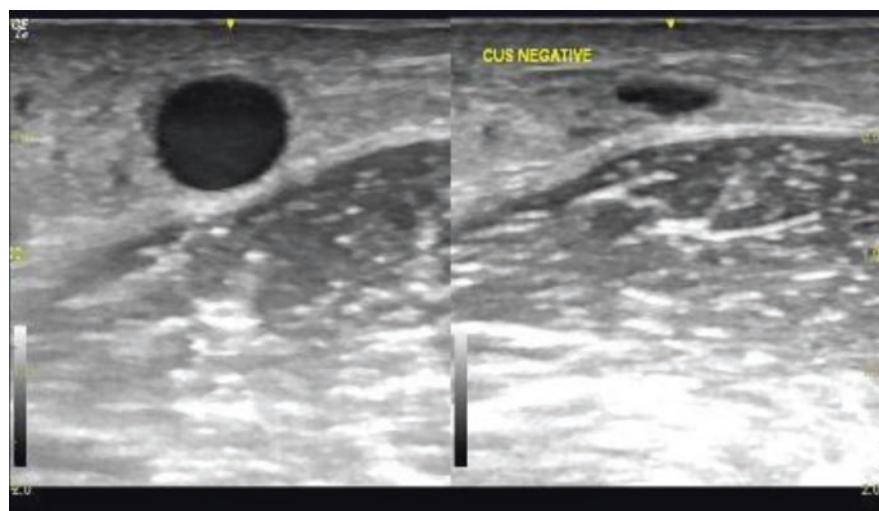


Fig. 6 Negative CUS. Remember, CUS needs to be done in cross axis. Probe must be pressed gently while maintaining pressure for a few seconds. The test is negative when AVF is both compressible and pulsating

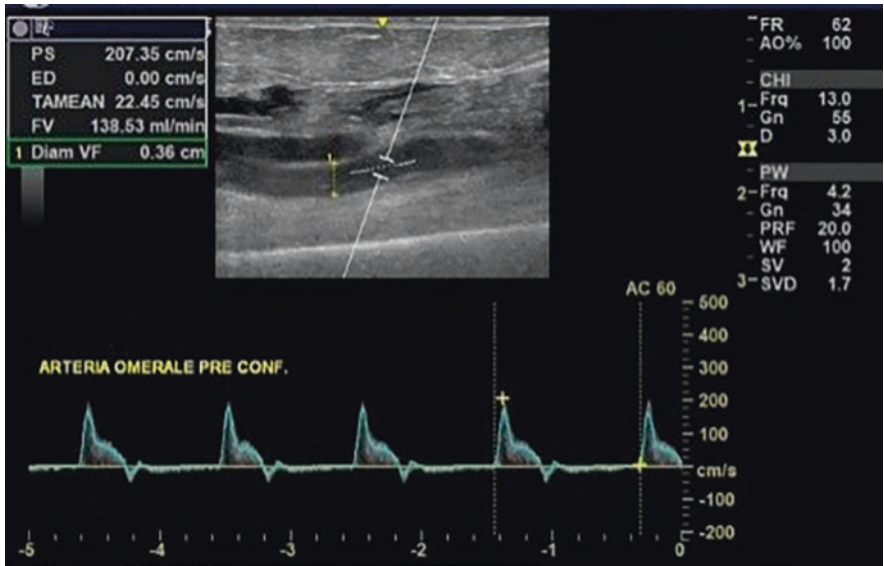


Fig. 7 Pre-surgical flow assessment. The typical wave of the muscular arteries, prior to the creation of the AVF, is defined as three phase. In the image you can see how a first phase with positive flow velocity follows one with negative velocity, due to the propagation of the sphygmic wave. The blood flow is about 138 mL/min

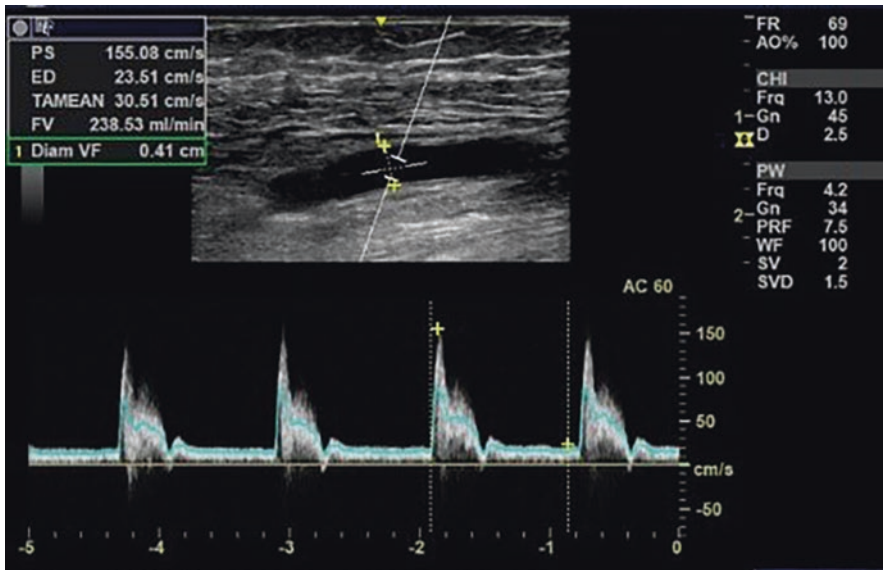


Fig. 8 Post-surgical flow assessment. After only 2 days post-surgery, Doppler shows an increase in the diameter of the artery (from 0.36 to 0.41 cm), the almost total disappearance of the negative wave and an increase in flow of about 100 mL, going from 138 to 238 mL/min

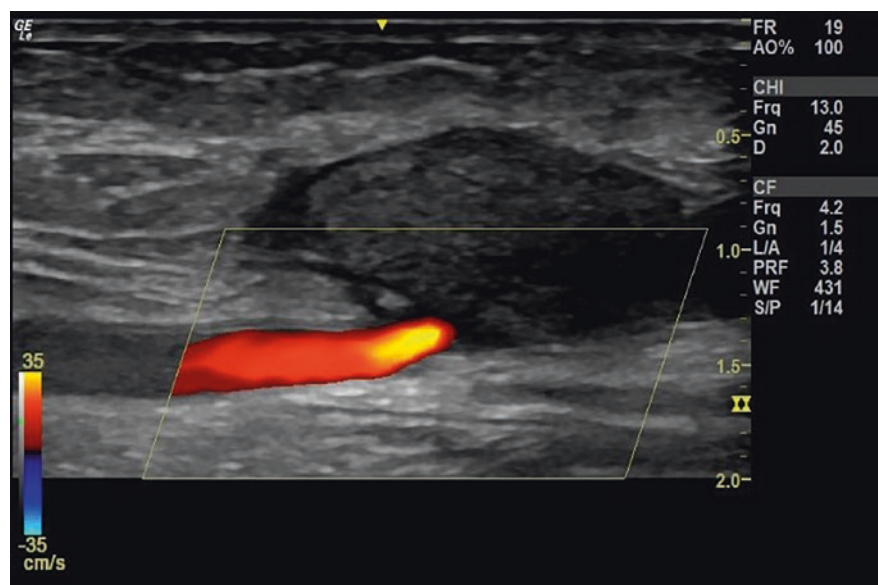


Fig. 9 Extravasation stops blood flow. Extravasation, indicated by the arrow, interrupts blood flow, represented by the colored area. In the image the flow is from left to right, as it is an AVF with retrograde flow

3 Postsurgical AVFs Maturation Monitoring

Maturation is a complex event in which lots of changes and factors take place in both the artery and anastomosed vein. The vein's diameter increases, just like the blood flow in the artery and the thickness of the vein wall. Using US to assess and manage the maturation process helps to guide on the treatment and process needed as well as improve the quality of life of the patient.

The Doppler's wave changes from a three-phase to a double-phase shape (also called low resistance wave), according to the decrease of the resistance opposed by the AVF to the blood flow. It must be remembered that the blood passes from a high resistance system (artery) to a low resistance one (vein), which is the reason for the change (Figs. 7 and 8). The US in the right position helps to assess the blood flow of the AVF [8, 9].

4 Site Choice for Cannulations

The use of ultrasound can help to identify the best site for cannulation as ultrasound use can highlight changes not observed through physical examination. However, US can confirm or disprove the existence and origin of findings that appeared during the examination. The aspects to be focused on in the examination are: patency, depth,

diameter, development, and wall integrity. Nearby anatomical structures are also important to avoid damaging them with the needle, or to choose whether to use a standard needle or a plastic cannula. Patency should be inspected by CUS approximately every 2 cm along the AVF and using Color in the event of doubtful findings.

Recent American Clinical Practice Guideline for vascular access [10] and European Clinical practice guideline on peri- and post-operative care of arteriovenous fistulas and grafts for HD in adults' guidelines [11] do not provide standards regarding AVF's ideal depth, diameter, and blood flow. So previous recommendations (like "the rule of 6s") are considered to be useful parameters, remembering that they can be helpful but not mandatory. Latest guidelines such as KDOQI 2019 [10] suggest that the right and efficient AVF patency is the one that allows the right treatment (right QB) for that particular patient, leading to a more flexible and closer-to-practice rule for the professionals.

5 Assessment After Extravasation

Extravasation is often a dramatic occurrence associated with pain, swelling of the arm, and both the patient and nurse's anxiety.

US, and color mode in particular, represents the only way to know exactly and instantly the dimensions of the extravasation and how these impact on patency, development, and wall integrity of the AVF. US is also essential to find new sites for cannulation that are possibly far from the extravasation site, if the treatment needs to be completed.

US highlights potential pseudoaneurysm as a complication of the extravasation. In this case compression by a US probe immediately after the damage represents the best way to improve this dangerous condition.

Finally, modifications in dimensions, patency, development, and wall integrity of the AVF can be assessed using the US device [12].

6 Training in the Use of US

It is strongly recommended to consider compulsory training in the use of US prior to any examination or US-guided cannulation of the HD access, even if no guide, protocol, or rules exist. There is a lack of studies about the use of US by nurses and also in US-guided cannulation and training. Despite this, Marticorena et al. [8] described the competences acquired by nurses for the examination and cannulation of the HD vascular access. It describes levels of competence and suggests that theoretical and practical sessions are required using simulation models before beginning with patients.

There are no clinical shared guidelines about training in the use of US for HD vascular access. The guidelines say that US has to be performed by an experienced professional but does not provide the details of training that is needed [13, 14].

Worldwide there are currently lots of training programs varying in both content and length. Despite this, in many other countries there is no official and recognized

qualification that allows nursing to practice with ultrasound. Conversely, there is no law that prohibits it. Therefore, in most of the countries there is a legal void [15].

Training courses should focus on numerous aspects such as examination using all modes, anatomical structure of the upper and lower limbs, usefulness of US for vascular access, pathology screening, and applicability for cannulation.

7 Cannulation

The use of US for the puncture of the Arteriovenous Fistula is carried out in two techniques that have the same purpose by two different approaches. The particular technique has to be chosen by the operator based on the results of the previous US examination, the possible cannulation sites found, and the access characteristics [16]. There are two cannulation techniques using the US.

7.1 US-Guided Cannulation

In this case, the US is used to map all the vessels of the AVF and to determine and set the best place to insert the needles in the AVF. Using this technique, US is not used at the moment of cannulation. To reach the objective, it must establish the best section, measure the AVF flow (to determine if it is suitable to cannulate), measure depth and diameter of the vessels chosen, and then take into account the structures near them. After that and based on the findings, the puncture technique to use has to be applied (*rope ladder* or *buttonhole*). It is well known by guidelines and publications that the *area technique* is not recommended. Finally, when the technique to use is clear and the best sites to insert the needle are determined, they have to be marked with a dermatographic pencil or marker. Once marked, the AVF is cannulated with the technique, choosing the “blind” technique [5, 17].

In practice and in addition to the usual palpation, the necessary information will have been acquired through the images just produced. This type of technique is particularly suitable with very superficial veins, which can be crushed by the probe and with those veins such as the brachialis which tend to move easily with a high risk of puncture failure and extravasations. In these cases, it is recommended to hold the vein firmly with the fingers of the non-dominant hand and to pull the skin a little backwards to stabilize it as much as possible. Once inserted, the needle position can be checked with the US [5, 10].

7.2 US-Guided Cannulation in Practice

In this technique, the operator relies completely on the ultrasound for the insertion of the needle. Firstly, the standard access assessment is carried out with palpation and with ultrasound examination of the entire course of the AVF, where the vessel to use and the cannulation site are determined. Once the puncture sites have been

identified, the cannulation process should start with the arterial needle, since placing the venous needle first could then create a barrier for the arterial needle. The position of where the staff will cannulate is very important; it can be considered one of the key points to success:

- The nurse must be in a comfortable position (that is the most important rule, and should be explained to the patient, as their position may be temporarily uncomfortable).
- The bed must be elevated so that the nurse does not need to lean over it.
- The arm holding the probe must lean on their own elbow and wrist, in order to be absolutely stable.
- US device screen must be in front of the nurse's line of vision, usually positioned on the opposite side of the AVF.

The insertion of the needle can be performed using two different approaches: in plane or out of plane. Both approaching techniques have advantages and disadvantages. To explain them both, there are three factors that should be considered: the US plane or view, the needle, and the vessel.

The terms “Out of plane” and “In plane” refer to the relationship between the needle and the plane of the ultrasound beam. So, there is a difference with the terms “longitudinal” and “transversal” that refer to the visualization on the screen and the relationship between the US beam and the vessel (Figs. 10, 11, 12, and 13).

Advantages and Disadvantages

- Out of plane:
 - Advantages: Structures near the vessel like arteries and nerves can be seen and avoided; it is easier to get and maintain the image on the screen.
 - Disadvantages: The needle is shown as a bright point but there is no evidence of which part is it, so the tip is not controlled all the time unless you apply the probe using the “tilting” movement.
- In plane:

Fig. 10 Out of plane insertion. In the “Out of plane” insertion mode, the needle is perpendicular to the intonation axis. The image of the fistula, generally displayed in transverse scanning, must be placed in the center of the screen, corresponding to the center of the probe, the point where the cannulation begins



Fig. 11 Image of needle inserted in out of plane. The needle appears in the image as a hyper-echoic dot/spot in the center of the vessel. Note that, although the correct position has been lost, control of the procedure is still maintained

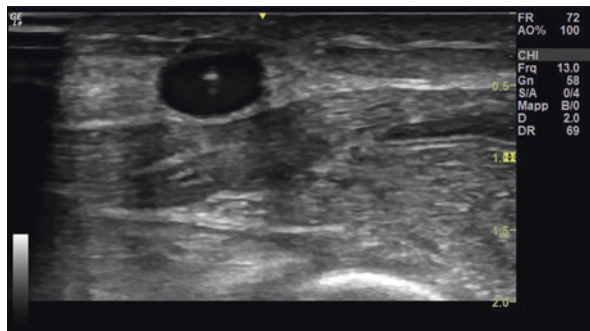
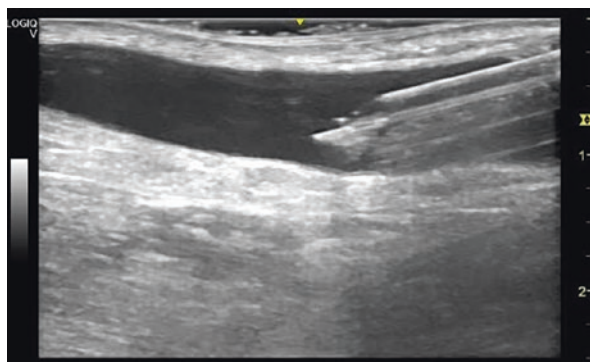


Fig. 12 In plane insertion. In “In plane” mode the needle is parallel to the intonation axis. The image of the fistula, generally displayed in a long axis, must be held firmly to be sure that the needle enters the point of greatest diameter



Fig. 13 Image of needle inserted In Plane. The needle appears in the image in its length, the tip pointing to the left. Unlike the out of plane mode, every small movement of the probe causes the loss of the image, which must be promptly recovered to keep the procedure safe



- Advantages: The needle is shown from when it gets into the skin until it gets into the vessel, so the tip is always under control. The final position of the needle can be seen.
- Disadvantage: Is more difficult to maintain the image and the correct plane and avoid probe movements.

The technique is chosen by the operator, depending on his/her comfort and expertise.

8 Needle Insertion Procedure

Out of plane technique:

- Find the vessel and position the probe above it.
- Enter the needle pulling back the skin with a free finger, approximately 2–3 mm toward the center of the probe.
- The inclination depends on the depth of the vessel; first phase should be more superficial, then more vertical depending on the view.
- Visualize the tip of the needle under the probe.
- “Fan” movement in the distal direction of the probe for maintaining a constant view of the tip of the needle as it enters the vessel. The right position evidence is an echogenic spot in the center of the vessel, free to move with the movements of the needle.

In plane technique:

- Find the vessel and position the probe above it longitudinally, checking the probe’s marker.
- Enter the needle pulling back the skin with a free finger, approximately 2–3 mm from the probe.
- Continuously check the needle as it proceeds through the skin and as it enters the vessel, adjusting the angle according to depth.
- As the needle tip has entered the vessel, lower the angle and push the needle in, stopping before touching the lower wall.

Whatever technique the operator chooses, the right position of the needle should be checked on both transversal and longitudinal view before positioning the tape on the needle. Every movement needed to re-position the needle must be done re-aligning the vessel on the center of the screen and then follow the marker to get the right depth or to increase the curvature.

9 Conclusions

Ultrasound can dramatically affect the daily work of nurses in a HD unit and have positive clinical results in terms of healthcare quality for the patients. Yet, the training and practice is a long process and needs to be planned and shared among the nursing staff. Despite the fact that the US technology appears to work immediately, there is nothing easy about its use and gaining familiarity. It requires time, support, and a strong teamwork. Nurses can find a useful ally in the US during several practical daily procedures and for a variety of clinical situations/monitoring, with cannulation of the AVF being just one of them. All nursing interventions are designed and planned in order to give a positive health outcome, and US-guided cannulations contribute directly to the life of vascular access of HD individuals, and therefore to their quality of life improving morbidity outcomes.

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Kidney Replacement Therapies: Peritoneal Dialysis

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Learning Objectives

- To recognize the anatomy, physiology, and solute transportation of the peritoneum.
- To understand the importance of continuous assessment for the dialysis adequacy of people on peritoneal dialysis.
- To identify the potential complications of peritoneal dialysis.
- To review the nursing care in the peritoneal dialysis catheter and exit site.
- To describe different peritoneal dialysis modalities according to the individual needs.
- To examine education and training for those on peritoneal dialysis.

1 Introduction

Peritoneal dialysis (PD) is a renal replacement therapy that eliminates toxins and removes fluid through convection and diffusion, by the inflow and outflow of PD solutions into the peritoneal cavity. Dialysis is performed when the solute moves from a high concentration area to an area of low concentration, through the semipermeable membrane (peritoneum) until balance is achieved in both areas. The

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function of each person's peritoneal membrane varies from one person to another, and the therapy has to be prescribed individually in order to have good results [28].

2 The Anatomy, Physiology, and Solute Transportation of the Peritoneum

The peritoneal membrane is a semipermeable membrane which lines the abdominal wall (parietal peritoneum) covering the abdominal organs (visceral peritoneum) and its size approximates the total body surface area. In a normal individual's peritoneal cavity, there is approximately 100 ml of fluid.

Arteries in the abdominal wall provide blood to the parietal peritoneum which drains into the systemic circulation, and the mesenteric and coeliac arteries provide blood to the viscera which drain into the portal vein. The drainage procedure happens with the help of subdiaphragmatic lymphatics, which are then absorbed into the venous circulation straight through the right lymph duct and the left thoracic lymph duct. In the interstitial tissue maintenance of fluids and solute balance occurs which happens by fluid absorption from the peritoneal cavity. The drainage from the peritoneal cavity happens due to subdiaphragmatic lymphatics. Those are responsible for 80% of the drainage. Furthermore, drainage is absorbed into venous circulation from the right lymph duct and also the left thoracic lymph duct. There is a balance of solutes and fluid into the interstitial tissue by the absorption of fluid from the peritoneal cavity. In an adult individual on PD, there is an average lymphatic rate absorption of 0.5–1.0 ml/min. Some factors such as intra-abdominal pressure, posture, and respiratory rate can affect the absorption rate [39].

Peritoneal transportation of water and solutes depends on four simultaneously occurring mechanisms: diffusion, osmosis, convection, and fluid absorption. Ultrafiltration occurs when there is an osmotic pressure between the hypertonic dialysis solution and the hypotonic peritoneal capillary blood. Hypertonic solutions in PD lead to ultrafiltration with more fluid removal and solutes. Osmosis is defined as the movement of a solvent (i.e., water) from one area of low solute concentration to another area of higher solute concentration through a semipermeable membrane [3].

PD manages macromolecules and small solute transportation. Three sets of pores are responsible for the transportation: ultra-small, small, and large pores (Fig. 1). Across the large pores there is transportation of macromolecules as proteins, and from the small there is diffusion of uremic toxins such as urea, potassium, creatinine, and glucose. Solute diffusion depends on peritoneal surface region effectiveness and increases with large dialysate volumes. The diffusion can be managed when solute molecules move from an area where there is high concentration to an area of low concentration through the semipermeable peritoneal membrane. Finally, concentrations are balanced in both areas of the peritoneal membrane, with the movement in each area to reach an equilibrium [14, 24].

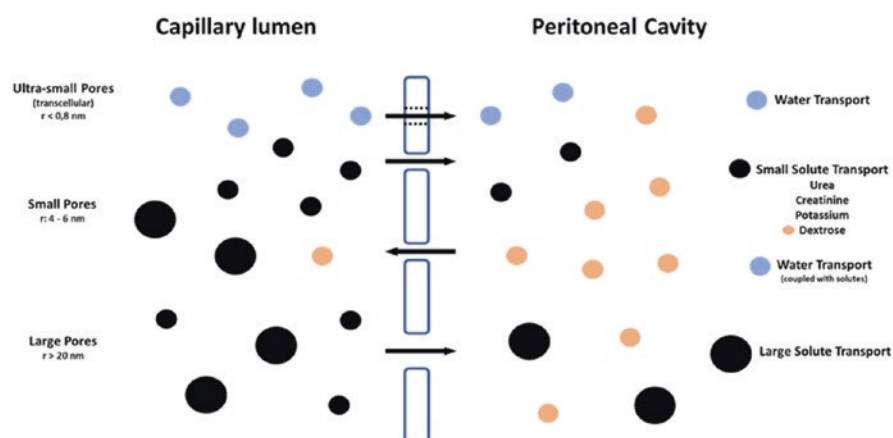


Fig. 1 Representation of the three-pore model for peritoneal transport [4]

3 Principles of Peritoneal Dialysis

The osmotic agent for PD uses dextrose solutions with concentrations of 0.5%, 1.5%, 2.3%/2.5% (depends on the company's supplies), and 4.25% [14].

The effectiveness of the surface of the peritoneal cavity membrane can be determined by the peritoneal equilibration test (PET) or peritoneal function test (PFT). Effectiveness varies from patient to patient and tests can help professionals to assess the peritoneal membrane's solute transportation through capillaries [25]. The accelerated peritoneal examination (APEX) test can summarize urea and glucose peritoneal permeability [38] (Fig. 2).

4 Catheter Care in PD

4.1 Introduction

Richard Ruben was the first scientist who used PD in 1959 and in 1968 Henry Tenckhoff developed the well-known "indwelling peritoneal catheter" that was then situated using the open surgical technique. In the following years, the technique of percutaneous placement followed and later on laparoscopic placement.

There are many descriptions in the bibliography about modifications and techniques for the PD catheters' insertion. We describe the currently available catheter designs and insertion techniques with its early and late complications. The following description concerns catheters shape and design.

PD catheters are in several types: the straight shape, swan neck, and curled. Also, they have a number of Dacron cuffs to enable optimal ingrowth and are long. They

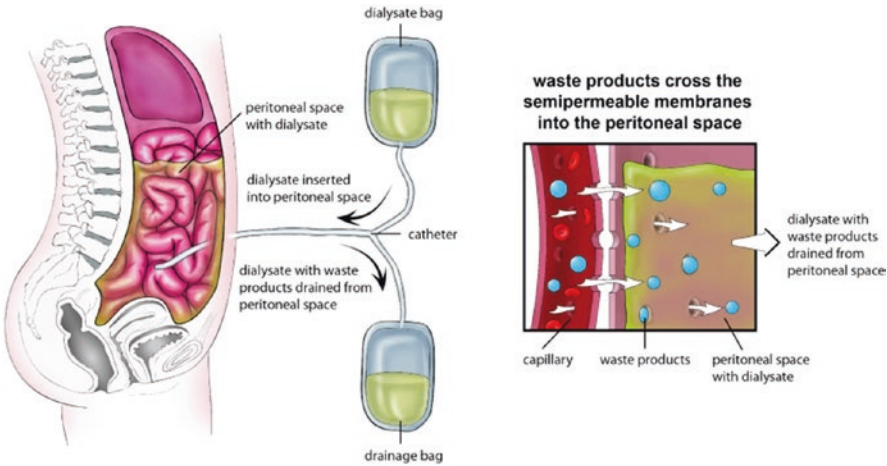


Fig. 2 Peritoneal dialysis [32]

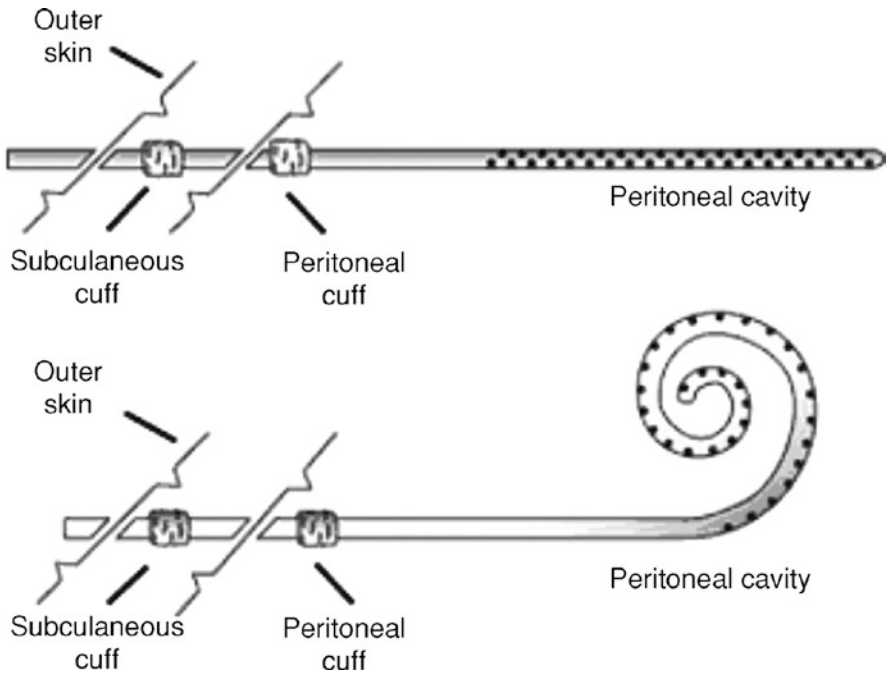


Fig. 3 Peritoneal dialysis catheter placement technique and complications [2]

are made from silicone and are flexible, with the tube having an open port at the end and several smaller openings along the side (Fig. 3).

The PD catheter should be placed 4 weeks before initiating PD therapy in order to ensure that the internal cuffs and exit site healing process is achieved [27].

Its design consists of cuffs, a subcutaneous (swan neck, straight), and an intra-peritoneal tract (coiled, straight) [31]. Figure 4 shows the placement sites of the catheters and applications:

- A. Straight inter-cuff segment catheter (laterally directed exit site emerging above a low-lying belt line).
- B. Swan neck inter-cuff arc curved catheter (downwardly directed exit site emerging below a highflying belt line).
- C. Extended catheter (upper abdominal exit site for an obese rotund abdomen, lower abdominal skin folds, or incontinence).

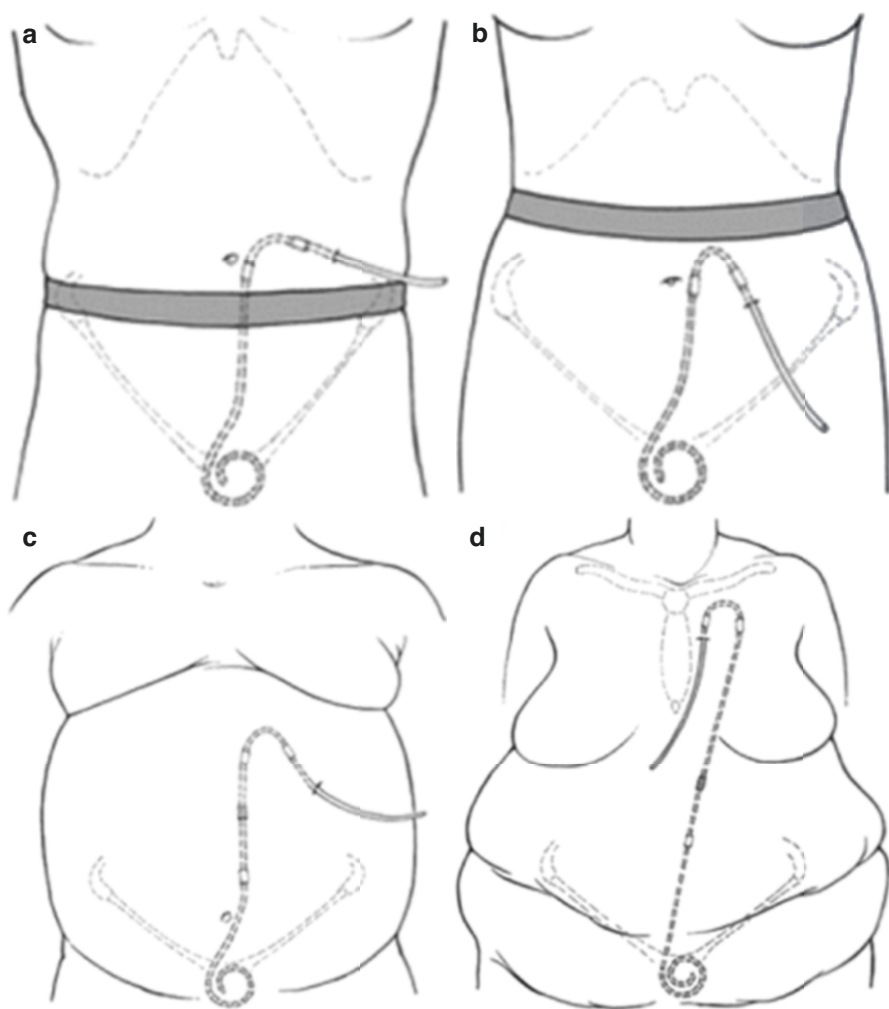


Fig. 4 The method of catheter insertion [33]

- D. Extended catheter (parasternal exit site for severe obesity, multiple abdominal skin folds, intestinal stomas, or incontinence) [10].

5 PD Modalities for Adults

5.1 Continuous Ambulatory Peritoneal Dialysis (CAPD)

CAPD (Fig. 4) is based on utilizing the concept of equilibrium in dialysis. To summarize, 2 liters of dialysis fluid are administered intraperitoneally through the catheter into the patient's peritoneal cavity and stays (dwell) for 4–6 hours. Within the peritoneal cavity the process of equilibrium of small solutes concentration between plasma and dialysate ($D/P = 1$) takes place. In theory in a patient using CAPD we can achieve 10 L of equilibrated effluent in a day and this allows 4 exchanges/day, using 2,5 liters intraperitoneally fitting them in as appropriately as possible with their normal lifestyle.

The whole duration of the exchange procedure takes about 20–30 minutes, with dialysate drainage lasting about twenty (20) min (Fig. 5), {20}, {24} and then 10 min is approximately the time required for the solutions' infusion. Depending on the patient's needs the dwell time takes from three (3) to eight (8) hours.

5.2 Automated Peritoneal Dialysis (APD)

The APD method is an automated procedure using a machine for the exchanges while the patient sleeps. The goal with the machine is the achievement of higher fluid removal and solute than with CAPD.

5.3 Continuous Cyclic Peritoneal Dialysis (CCPD)

The CCPD offers flexibility in the volume and number of exchanges during sleep without the need for extra time. Also, this method has other advantages as a therapeutic option because:

- It minimizes infections as patients perform one connection at night and one disconnection in the morning.
- It can use large volumes with good tolerance because patients are in a supine position.
- Usually, the patient does not have to do an exchange during the daytime. It provides better environmental control and less patient fatigue [20, 24].

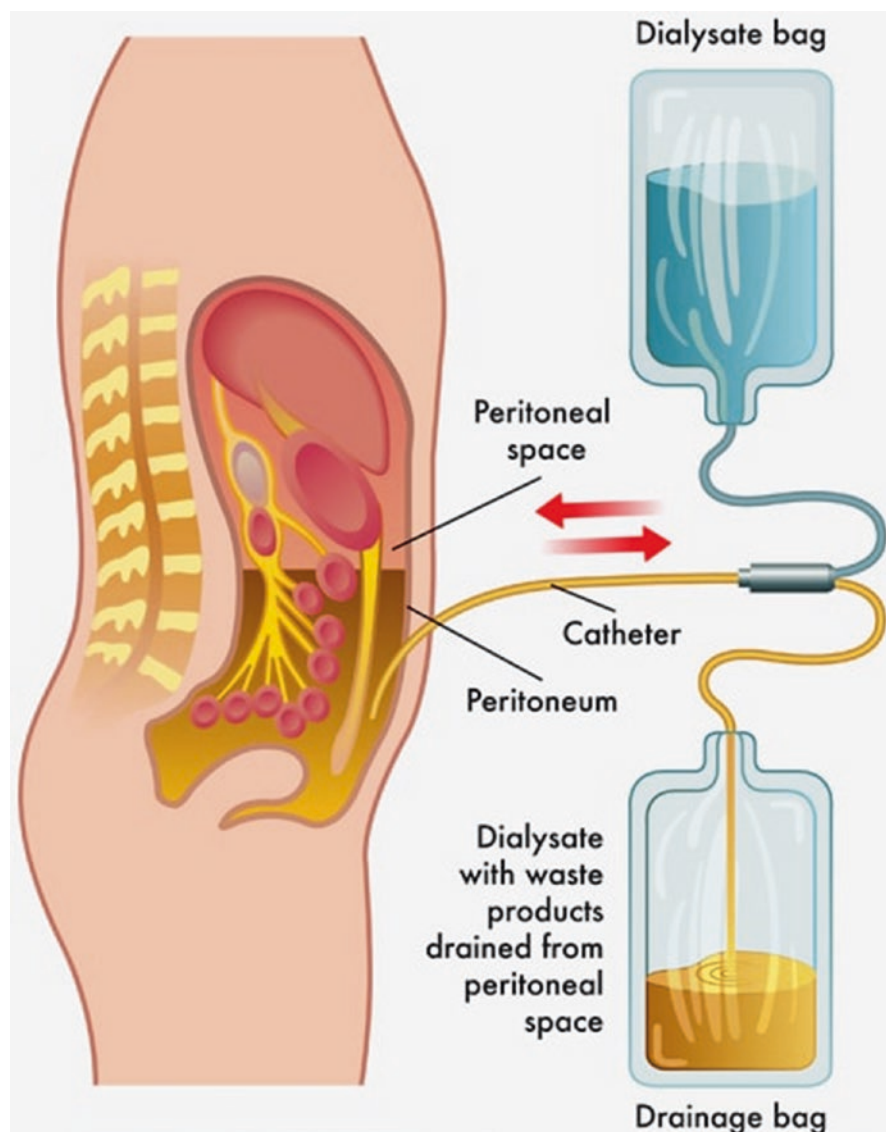


Fig. 5 Peritoneal dialysis process when introducing dialysate and waste products are drained [35]

5.4 Intermittent Peritoneal Dialysis (IPD)

IPD is characterized by using short and frequent cycles with a time of treatment of up to 8–10 hours per session, three times per week. Between the sessions the patient has the peritoneal cavity drained. In some patients this might be used as a nightly therapy and is called nocturnal IPD (NIPD) [20].

5.5 The PD Plus Prescription

The PD plus prescription consists of an extra daily exchange in the CCPD circuit. The machine is programmed to inflow 2000 ml of solution at the last inflow into the patient's peritoneal cavity and the patient can either remove it manually (CAPD) or the machine performs this process automatically, which stays in a pause mode. The benefits of this therapy are that it uses fewer daytime volume exchanges for the patient's comfort and larger volume exchanges when the patient sleeps. Also, this can provide better clearance and ultrafiltration [20, 24].

5.6 Tidal PD (TPD)

TPD's purpose is to enhance small solutes clearance by the reduction of normal dialytic loss time. It is used when there is a need to speed the time of drainage and optimize the duration of treatment. This can reduce drainage alarms and sometimes is being used in patients with peritoneal catheter problems such as slow drainage, or when they complain about inflow/outflow pain. The main disadvantages of TPD are its increased cost and complexity [15, 20, 24].

5.7 Adapted Automated Peritoneal Dialysis (Adapted APD)

With adapted APD a professional can prescribe PD therapy by using a variety of dwell times and volumes. Usually, this prescription involves about two short dwell time cycles with a small volume for ultrafiltration, and three with long dwell time and large volumes for the removal of uremic toxins [16, 17, 30].

5.8 Assisted Peritoneal Dialysis (aPD)

Assisted PD is used for the treatment of patients that cannot perform the therapy by themselves. This might be because of psychosocial or physical problems [19].

The method is supported by a trained carer or a family member who is performing the therapy for the patient instead of himself or herself at home. In PD therapy, the lifestyle, family, and carers of the patient are taken into account. Assistance also can be given from a healthcare professional, for example, a PD nurse, to assist either with CAPD or APD [19]. Other assistance provided to patients on PD by professionals can be home visits two to four times a day, although this is not provided in all countries as an option. The general goal of PD therapy is to promote independence for the patient, his/her family, and caregiver [28].

There are suggested guidelines for PD adequacy from the National Kidney Foundation Dialysis Outcomes Initiative (KDOQI™). They recommend the PD prescription dose to achieve the weekly total $Kt/V > 1.7$ [7]. Although they did not indicate any difference between the CAPD therapy and APD or include the status of

residual renal function (RRF). Also, there was an absence of any recommendations for creatinine clearance [23]. After this a re-analysis study (CANUSA 2001) reports that the RFF has to be considered for peritoneal clearance, because it is associated directly with improvement in survival [18]. Guidelines also addressed the importance of an adequate volume control, good nutrition, and the other main components of optimal renal care. There were many clinical studies after those already mentioned, but they failed to give a result according to the dialysis dose, and the measurement either of urea or creatinine clearance for PD patients' clinical benefit. End stage chronic renal disease leads to many kidney dysfunctions which need to be controlled (protein catabolites excretion, fluid removal, blood pressure control, mineral metabolism, anemia, nutrition, acid-base balance, and others). It would seem that in order for patients on PD to have a good prognosis, there is a need for clear and established "adequate ranges" of indications.

6 The Management of PD Complications

PD treatment also has the potential for complications. These can be classified into non-infectious and infectious [8]. Additionally, there might be other complications associated with patients with chronic kidney disease (CKD) on dialysis, such as mineral bone disorders or cardiovascular disease, amongst others [1].

6.1 Abdominal Pain During Outflow or Inflow

Outflow abdominal pain might have presented because of peritoneal infection or due to pelvic irritation by the catheter's tip over a long period of time. Another pain or discomfort can occur during dialysate inflow. This can be due to solution's pH or temperature and after several days, it disappears when the optimal volume has been reached [8, 22].

Nursing management interventions [8, 22]:

- Check for peritonitis.
- Change the patient's position during inflow.
- Check the solution's temperature (must be body temperature).
- Check solution's expiry date.
- Check whether the patient is constipated.
- Slow down the solution's inflow rate.
- Make use of bicarbonate-lactate buffered fluids.

- Order an abdominal X-ray for PD catheter position (might be necessary for catheters' surgical reposition).

6.2 Bloody PD Outflow Solution

Pinkish color or grossly bloody dialysate might be present. This might be due to:

- Pre-menopausal women
- Post-catheter placement
- Presence of retroperitoneal pathology

Nursing management interventions [8, 22]:

- Bleeding severity evaluation (hemodynamic stability, pulse, and blood pressure) and quantity (recurrent, continuous, or self-limiting).
- Check for peritonitis.
- Assess the patient's background for potential causes (menstrual cycle, catheter placement date, exaggerated physical activity or abdominal trauma, recent procedures (sigmoidoscopy or colonoscopy), surgical causes (rupture of the spleen, cholecystitis, pancreatitis), medical causes (coagulation disorders, anticoagulants, polycystic kidney disease, administration of recombinant tissue plasminogen activator (tPA), carcinomatosis, encapsulating peritoneal sclerosis).
- The presence of abdominal pain in combination with hematocrit (Hct) level above 2% needs surgical evaluation.
- The immediate response to the episode is abdomen flushing (500–1000 mL heparinized (500 U/L) dialysis fluid at room temperature with few cycles).
- Monitoring the patient and continue the heparinized dialysis until no blood appears in the outflow fluid.

6.3 Catheter Malfunction

Catheter malfunction can be noticed from late installation of fluid (more than 15 min/2 liters) and in outflow procedure (more than 1 min/2000 liters).

This could happen due to a blocked catheter caused by migration of the catheter's tip, closed clamps or kinks, blood clots, adhesions, constipation, or fibrin. Sometimes in outflow dysfunction an omental wrap might be involved. This condition can allow the inflow but blocks the outflow.

Nursing management interventions [11]:

- Check if anything is blocking the catheter (transfer set kinking, clamps, catheter kinks).
- Change the patient's position.
- Exclude peritonitis.
- Check for constipation and catheter's intraperitoneal tip position with an abdominal X-ray.
- Give laxatives for constipation.

If the problem still exists, then a forceful flushing of the catheter can be carried out (pressure exerted using normal saline inflow with a syringe; if the patient has pain, stop immediately or clamp the catheter) 20. If migration of catheter's tip occurs, then, surgical intervention might be needed.

- If there is no migration of the catheter's tip and none of the previous actions has achieved a successful result, then administration of recombinant tissue plasminogen (tPA) can be tried (1 mg/mL; in concentration);
- Also, heparin (500 U/L) in the inflow (in each exchange) is the solution of an obstruction due to fibrin.

6.4 Fracture of PD Catheter or Accidental Contamination

Any damage that occurs to the catheter on the exit tube might be due to chemical damage, or catheter adapter tears, organic solvents or antibiotic ointments, punctures or cuts from sharp instruments.

Nursing management interventions [11]:

- Locate the exact catheter's point of leakage.
- Any leakage is a possible infection. Check for peritonitis and give antibiotics as a precaution.
- If the tube is damaged 2 cm above the exit site, shorten the catheter with the use of repair kits and connect a new catheter extension.
- If the tube is damaged under 2 cm from the exit site, replacement of the catheter might be required.
- Train the patient about this possible condition if it happens at home: (clamp the catheter between the leak point and exit site, cover it with a sterile dressing, and go immediately to the PD clinic).
- For any accidental connector disconnection or missing MiniCap, solution bag leakage in the dialysate or any other possible condition that might occur causing a possible infection risk, the patient must visit the PD clinic immediately to exclude peritonitis and start prophylactic antibiotics.

6.5 Fluid (PD Outflow Solution) Leakage

Any fluid loss from the peritoneal cavity through the exit site is defined as leakage.

This could be because of the catheter implantation and the interval before commencing PD. The time between starting PD and implantation of catheter insertion can increase the pressure in the peritoneal cavity. The reason for this condition might be due to a high fluid volume, polycystic kidney disease, and small body mass. High risk patients are the elderly patients, the malnourished, the diabetic patients, and those on high dose corticosteroids [11, 12].

Nursing management interventions [11]:

- Start sessions after 2–4 weeks of catheter placement.
- Usage of strip to verify the dialysate leakage.
- Use low volumes of fluid exchanges in supine position (night changes preferred).
- Prophylactic antibiotics might be needed for peritonitis prevention.
- Presence of subcutaneous leakage might lead to edema (abdominal wall or genital), patient might gain weight or have a low volume outflow.
- If dyspnoea is present, decrease ultrafiltration and observe pleuritic pain; possible cause might be hydrothorax.
- Genetic diaphragmatic defects can cause this condition.
- It can be caused by the patient lifting a heavy object.
- Peripheral monitoring for subcutaneous edema, and labial or scrotal edema.
- Keep the patient PD dialysate free during the day.
- Discontinue the therapy if the patient's condition allows (1–3 weeks).
- If persistent, evaluate whether anatomical defect, surgical repair, or catheter replacement is required.
- Chest X-ray imaging can identify conditions such as pleural effusion. Thoracentesis might be needed for the identification of fluids high in glucose and low in protein, indicating the presence of peritoneal fluid; alternative investigations are an MRI or peritoneal scintigraphy.
- However, the conservative treatment for PD discontinuation (temporarily) is rarely successful.
- Thoracoscopic pleurodesis which reports good results can be the solution [11, 12].

6.6 Hernia

Regular fluid infusions into the peritoneal cavity can elevate the intra-abdominal pressure and cause a hernia. If a hernia is present before the catheter implantation, this must be repaired prior to or during the catheter implantation procedure. Common hernias in patients on PD are inguinal, umbilical, incisional, or pericatheter [20].

Nursing management interventions [11, 12]:

- Examination for previous surgical scars or protrusions at genitalia, abdominal area, and catheter exit site.
- Determine size, pain, reducibility, or presence of inflammation.
- Refer to a surgeon; surgical hernia repair may be necessary.
- Lower the IP volume to to minimize the intra-abdominal pressure.
- Instructions for constipation treatment including no straining, avoidance of coughing, stair climbing, and lifting heavy objects.
- The use of an abdominal belt (Velcro binder) if the patient uses CAPD might be helpful in midline and umbilical hernias until the surgical procedure.
- After surgery, start with low volumes and gradually increase for about 2 weeks until the normal volumes are achieved.
- If the patient's condition allows cease PD therapy for 2 days after surgery.
- HD can be considered as a backup option, but only if the patient begins to present azotemia.

6.7 Encapsulating Peritoneal Sclerosis (EPS)

Although EPS is a rare condition, patients who have been undergoing PD therapy for several years are high risk of presenting with EPS and are associated with poor mortality and morbidity. EPS can be diagnosed clinically and by radiography or laparotomy. EPS is best described as peritoneal fibrosis and bowel obstruction [7].

Nursing management interventions [4, 5, 13]:

- Might occur after 5 years of PD therapy but has very low occurrence rate.
- Symptoms might be weight loss, nausea, anorexia and vomiting, or bowel obstruction.
- A radiology examination might show a cocoon around the bowel.
- The solution is to immediately transfer the patient from PD to HD; however, sometimes EPS gets worse even when PD ceases.
- Treatment depends on the stage of the disease.
- Usually, parenteral nutritional support is needed.
- Medication treatment might include tamoxifen, corticosteroids, and immunosuppressive medications.
- If there is no improvement in the bowel obstruction, surgery is necessary.

7 Infection Complications

7.1 Catheter Related Infections

7.1.1 Exit-Site Infection (ESI)

An exit-site infection is the presence of purulent drainage with or without skin erythema at the catheter's epidermal area. A tunnel infection is described as any signs and symptoms of infection, or a collection of fluid (can be located by ultrasound)

along the catheter tunnel >2 cm from exit site, which usually occurs after an exit site infection. Both of these infections in PD are considered serious, because they might progress to peritonitis (see “Classification of Catheter Exit Sites in Peritoneal Dialysis” in Fig. 6) [29, 32].

Nursing management interventions [12, 32]:

- Check for: induration, erythema, or tenderness over the tunnel or at the exit site (Fig. 6).
- Any erythema around the exit site, with no purulent drainage might be an indication of infection, catheter trauma, or allergic skin reaction (Fig. 6).
- A wound swab sample for culture is necessary from the site.
- Apply gentle pressure to the catheter’s exit site, to express the possible hidden excretion, press the cuff under the skin with movements toward the exit site, or gently pull on catheter.
- The most common pathogens for both conditions are *S. Aureus* and *P. aeruginosa*.
- A good evaluation is needed (exit site and tunnel) (Fig. 6).
- Subcutaneous pathway ultrasound might be helpful.
- Schedule follow-up.
- Check for signs and symptoms of peritonitis.
- Commence antibiotic treatment in time—usually orally.
- If culture results positive to *S. Aureus* or *Pseudomonas* antibiotic therapy treatment according to the antibiogram and clinic protocols.
- Dressing once or twice a day according to clinic protocols.
- If the exit site infection is severe, intraperitoneal antibiotics may be added to therapy.
- Some instructions recommend to wrap the catheter with a sterile gauze soaked in a solution of 1 pint (500 ml) sterile water and 1 tablespoon of salt, peripherally to the exit site, 1 to 2 times daily.
- Check for any other contributing or precipitating factors.
- When PD changes occur, consistency is needed with hand washing, mask use, and exit site prophylaxis.
- Always check if patient is *S. Aureus* carrier.
- If the first catheter’s cuff comes out of the exit site and the infection persists, then this can be removed (extirpated).
- A catheter can be removed in the case of catheter infection in combination with peritonitis episodes, or with persistent or repetitive catheter infections that failed to clear up after 3 weeks’ antibiotic therapy.
- Exit site care re-training (carer or patient).
- Application daily of mupirocin cream topical or gentamicin (according to Gram + or Gram – culture).
- Daily exit site dressing and after a shower.
- Classify the condition of exit site every time patient visits the clinic (Fig. 6) [36, 28].
- Retrain the patient or caregiver about daily exit site care.

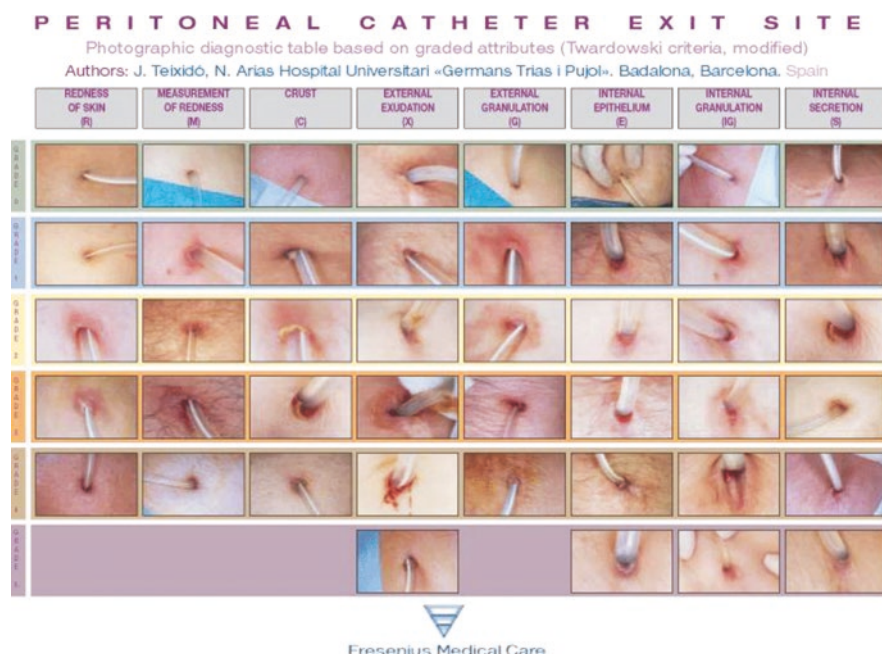


Fig. 6 Classification of catheter exit sites in peritoneal dialysis [28, 34, 36]

7.2 Peritonitis

Peritonitis is a serious complication of PD. The patient might need admitted to the hospital for treatment. Peritonitis could lead to PD technique failure and is also a condition that raises the risk of mortality. However, it usually responds well to treatment [29, 39].

When at least two of the data shown below are described, this is a clear indication that peritonitis is present:

- Clinical observation of cloudy dialysate after outflow and/or abdominal pain;
- Outflow's solution lab counts after 1–2 hours of dwell time: white cell $>100/\mu\text{l}$ or $>0.1 \times 10^9/\text{L}$, and polymorphonuclear $>50\%$;
- Positive dialysate culture fluid, after outflow and 1–2 hours of dwell time [21].

Nursing management interventions [12, 21]:

- Abdominal palpation, tunnel and exit site assessment.
- Send after 1–2 hours' dwell time the outflow solution to the lab for white blood cell count, differential, culture, and Gram stain.
- Instill 1 liter of PD fluid and leave it intra-peritoneally for 1–2 hours if the patient is dry.

- If the fluid is cloudy, initiate clinic protocol for IP antibiotic therapy for peritonitis immediately, until lab results are known. Also add heparin 500 U/L to the dialysate bag: (antibiotics and heparin in each change).
- If patient is on APD change to CAPD until antibiotics prescription is finished and fluid is clear.
- For a differential diagnosis of peritonitis, it is important to consider non-infectious and infectious factors (chylous effluent, calcium channel blockers, malignancy, positive specimen culture, hemoperitoneum, infectious peritonitis, chemical peritonitis, eosinophilia of the effluent).
- Pain management may be needed.
- Perform outflow fluid cultures and cell counts (repeat them after 48 h if there is no improvement).
- Antibiotic treatment for Gram + and Gram-organisms, adjust when culture sensitivities and results are known.
- The preferred method of antibiotics administration is intraperitoneal (except if there are systemic sepsis features).
- Treatment length for Gram positive organisms continues for 14 days, except for *S. Aureus* and *Enterococcus* which continue for 3 weeks and also 3 weeks for Gram-negative.
- Antibiotics need dwell time of at least 6 hours with intermittent dosing.
- Hospitalization is usually needed.
- Look for conditions such as: tunnel infection, exit site infection, mask use, hand washing, compliance in PD technique, prophylaxis of exit site, diarrhea, antibiotic use, constipation, recent PD procedures, or interventional examinations.
- Reasons that the catheter may need to be removed in peritonitis include fungal peritonitis, or in cases where the PD outflow remains cloudy after 5 days of targeted antibiotics. Another reason is if there is relapsing peritonitis caused by the same organism, or a sterile episode within 4 weeks after the last antibiotics have finished.
- Repeated peritonitis also might occur by mycobacterial and by multiple enteric organisms.
- Re-training technique is needed (Fig. 7).

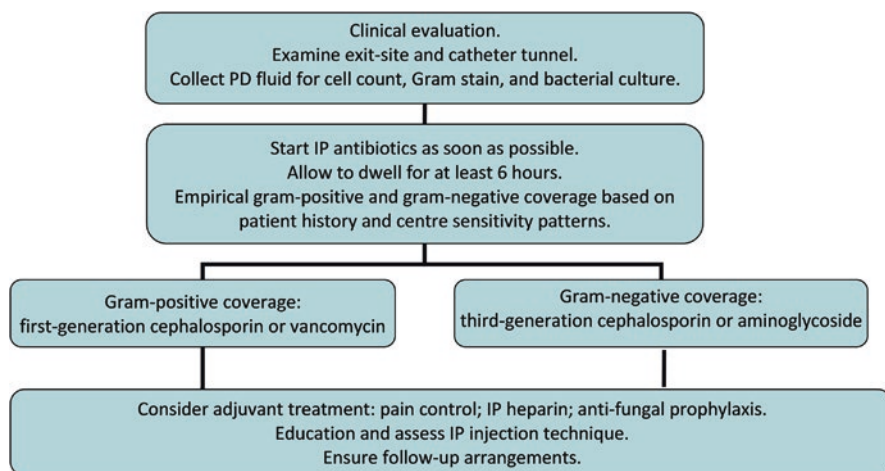


Fig. 7 Initial management of peritonitis [21]

8 Education and Training for Individuals on PD [1]

Education of patients, caregivers, and family members is the key for the treatment's success and is used by all PD clinics [37].

PD nurses implement the training process, which varies from health organization to health organization and from country to country. Although all have the same basic training, the successful implementation of proper information is paramount in order to have a successful and safe PD therapy at home [26].

Training is not only about how to manage the method at home but also how to have good outcomes, how to avoid infections and how to recognize signs or symptoms of peritonitis. It is also about teaching how to record results and report to the PD nurse any problems that occur [6, 21].

PD nurses as trainers usually follow the International Society Peritoneal Dialysis (ISPD) recommendations and guidelines for training published in 1994 with good results [9].

9 Nursing Perspectives in PD

In cooperation with other health care professionals (HCP) through their expertise in nephrology care services, PD nurses provide a high quality of care to their patients. They are fully aware of their role in this field, and they recognize the impact of knowledge, skills, and good practice for the patients benefit. The specialist nurse in nephrology is trained to deal with conditions other than only CKD due to all the complex aspects of the disease, including HD, PD and transplantation. Furthermore,

due to the patients' co-morbidity, dialysis nurses also manage patients suffering from other correlated diseases such as diabetes, hypertension, and heart disease.

PD nurses as trainers are training PD patients and caregivers to manage PD in their homes. A nurse trainer needs to have the knowledge and the skills for teaching, but also to be an expert on the subject of teaching to be able to do so. In conclusion, the PD trainer must be a qualified trainer and also a qualified PD nurse in order to manage to influence and encourage patients and caregivers to engage in their own health care.

The implementation of training knowledge and educational health, in a pedagogical and effective way, using pedagogical learning methods and models, can motivate and empower patients and trainees, leading to successful treatment management.

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Infection Prevention and Control: The Importance of Hygiene in Dialysis Care

Candice Halinski

Learning Objectives

- To Identify the purpose and benefits of infection prevention and control in the dialysis setting.
- To understand the importance of applying the principles of infection prevention as it relates to patient risk factors.
- To find and understand the barriers in adhering to infection control practices.
- To explain the importance of hand hygiene and PPE for both patients and team members.
- To define preventative measures and infection prevention practice utilized to reduce patient related complications in the dialysis setting.
- To distinguish the environmental risk factors in the dialysis setting.
- To recognize the importance of safe injection and medication preparation.
- To refer to infection related risk factors for fistulas, grafts, and catheters.
- To explain the dialysis nurses' role in infection prevention and the reduction of morbidity and mortality for dialysis patients.

1 Hygiene and Infection Prevention as a Global Priority

The emergence of global pathogens such as Ebola virus, the Middle East respiratory syndrome coronavirus (MERS-CoV), and the corona virus disease pandemic (COVID-19) has validated the idea that the transmission of epidemic prone pathogens

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can be accelerated through the activities and behaviors of health care personnel inside of health care settings [2, 23]. Regardless of national income or availability of resources, gaps in infection prevention and control have been exposed through major outbreaks. Underscoring this challenge is the fact that significant variability exists in the framework and clinical practices that uphold principles of infection prevention. In fact, a 2022 report from the World Health Organization revealed that 11% of countries participating in a global study reported that they did not have an infection prevention and control (IPC) program. Furthermore, 54% reported that they had national IPC programs or operational plans that had not been implemented or that were being implemented only in selected health facilities [2]. This practice variation contributes substantially to the global rate of healthcare associated infections.

2 The Importance of Infection Control for Dialysis Patients

It is estimated that at least 10% of the global population is affected by chronic kidney disease (CKD) [12]. This represents a worldwide health crisis, especially as the emergence of corresponding risk factors such as diabetes and obesity continues to rise. In addition, CKD is widely recognized as one of the leading causes of mortality worldwide. Experts have projected that the global rates of CKD will continue to rise [12]. Because CKD is progressive in nature, dialysis facilities will continue to face an increasing patient population that is medically complex. This makes corresponding complications such as infection a relevant risk factor for mortality. Substantial reduction in the rising morbidity and mortality amongst dialysis patients can be facilitated by the application of the principles of hygiene of infection prevention.

Dialysis patients are uniquely challenged because their treatment regime places them at higher risk of infection due to the prolonged and frequent exposure of possible contaminants inside of the dialysis setting. In addition, a variety of predisposing factors such as immune compromise, the frequent need to access a sterile bloodstream, and frequent contact with healthcare workers makes infection the second leading cause of death for dialysis patients. The increased potential for transmission of infection makes it necessary for the implementation of rigorous infection prevention and control measures in addition to universal precautions [11].

This need for enhanced infection control practices has prompted a variety of international organizations to develop guidelines and best practice standards surrounding infection control in the dialysis setting. Such organizations include the Centers for Disease Control and Prevention, the Association of Professionals in Infection Control, the Kidney Disease Outcomes Quality Initiative, the European Best Practice Guidelines/European Renal Best Practice, and the Kidney Disease: Improving Global Outcomes [13]. Despite the emergence of such guidelines, there is considerable variation amongst organizations and in practice.

Kakar et al. [19] posed that the increased risk of dialysis patients developing healthcare associated infection is a direct result of six contributing factors. They include (1) immune compromised status, (2) frequent and prolonged blood

exposure during dialysis treatments via the vascular access and machine circuit, (3) close proximity to surrounding patients, (4) frequent contact with healthcare workers, (5) increased rates of hospitalization and surgery, and (6) non-adherence to infection control best practices and guidelines [13]. While most of the corresponding factors are inherent to dialysis care, adherence to infection control standards remains the most modifiable factor that definitively responds to intervention. Breaks in infection control standards are a direct result of healthcare team members action or inaction to internal and external stressors. Such stressors include: poor staffing ratios, a high rate of attrition in nursing, poor training and low competency levels amongst healthcare team members, limited provision of the necessary supplies and equipment, poor design and layout of the dialysis unit leading to inadequate isolation, and response urgency related to dialysis complications (which can sacrifice adherence to standard precautions especially when life-threatening). For these reasons it becomes principally important for nurses to appreciate their role in decreasing morbidity and mortality for dialysis patients through the application of the principles and practices of infection prevention [7, 13].

3 Infection Control in the Dialysis Setting

The chronicity of end stage kidney disease (ESKD) makes dialysis patients more vulnerable to infection because the maintenance of their health relies on the frequent and intensive use of out-patient care thus making them more likely to be exposed to a variety of risk factors in the dialysis units. Examples can include co-location of patients and frequent exposure to healthcare team members. For this reason, it is critical that the delivery of dialysis care be provided under environments that contribute to minimizing or eliminating the risk of healthcare associated infections [14]. Some of the most impactful infection prevention practices to minimize healthcare associated infections in the dialysis unit are highlighted in the sections ahead.

4 Hand Hygiene

Experts maintain that the main route of transmission for healthcare associated infections is via contaminated hands of healthcare workers [2–4, 7, 14], thus making hand hygiene the primary intervention in infection prevention in dialysis units. While the practice of handwashing remains relatively simplistic, it is estimated that accordance with this practice remains at an alarmingly low level of compliance. In dialysis units, this estimation may be significantly decreased resulting in an even lower level of compliance. The process of dialysis demands that team members perform hand hygiene at a significantly higher level than that of other team members. This necessity may contribute to a decrease in compliance levels amongst dialysis team members. Compliance rates may be improved through a variety of interventions (Fig. 1).



Fig. 1 Key interventions to improve the compliance of hand hygiene in the dialysis unit [7, 13–15]

The utilization of alcohol-based hand rubs (ABHR) is the preferred method of hand hygiene because of its ability to improve compliance rates amongst healthcare workers. The application of ABHR requires less time, irritates hands less, facilitates utilization directly at the bedside, has superior efficacy, and best ease of use [14]. For these reasons, the World Health Organization and the Centers for Disease Control recommend it as the main method [13, 14]. While this modality has distinct advantages in improving compliance rates, it is recommended that soap and water be applied when hands are visibly soiled with blood or bodily fluids, after caring for a patient confirmed to have *Clostridium difficile* or other bacterial spores (i.e., *Bacillus anthracis*), or during a norovirus outbreak. Clinical team members should also be aware of key situations that require the application of hand hygiene. This can include before contact with a patient, before performing a procedure that requires sterile technique, after contact with the patient or objects in their vicinity, when hands are moving from a contaminated body site to a clean body site during patient care and following the removal of personal protective equipment [1, 14]. Additional information and guidance regarding hand hygiene can be accessed via the CDC

website at: Guideline for Hand Hygiene in Health-Care Settings (available at: <http://www.cdc.gov/mmwr/PDF/rr/rr5116.pdf>).

5 Additional Components of Standard Precautions and Infection Prevention

While experts agree that the significance and importance of hand hygiene is the cornerstone of standard precautions and infection prevention, it is important to consider how additional elements can be implemented to advance the effects of hand hygiene in the dialysis setting. Nurses should be knowledgeable of the additional practices utilized in standard precautions as well as the procedures that can be added to maximize the effectiveness of standard precautions. Additional elements of standard precautions include the utilization of personal protective equipment, respiratory etiquette, sharps safety, and the cleaning and disinfection of environmental surfaces and equipment. Practices that enhance standard precautions in the dialysis unit can include processes such as screening and routine serological testing, immunization of patients and healthcare personnel, disinfection of internal machine pathways, water treatment and testing, and vascular access care [13].

6 Personal Protective Equipment (PPE)

The barriers and respirators utilized alone or in combination can be referred to as personal protective equipment. Items often include gloves, gowns, shields, masks, and respirators. In dialysis units, it is highly likely that there is frequent utilization of all the mentioned items. According to the CDC, gloves should be worn routinely during situations that involve possible contact with blood or body fluids, mucous membranes, non-intact skin, or other potentially infectious materials [15], and contaminated surfaces [13]. In between patients and stations, best practice standards are that gloves are removed, and hand hygiene is performed. This practice requires an enormous amount of glove supply that may not be realistic in all dialysis unit settings, so the fundamentals are often applied. This makes it mandatory for gloves to be utilized whenever soiling is present and contact precautions are indicated. In addition, sterile gloves are required for all aseptic procedures [13].

It is commonplace for gowns to be found over the uniforms of dialysis team members. Wearing fluid resistant gowns with full coverage of arms and body front with the combination of a face mask and eye goggles or a face shield is recommended during procedures where blood exposure can be anticipated (dialysis initiation and take-off). When accessing the central venous catheter, additional PPE should include the incorporation of a surgical mask to protect the patient from exposure to respiratory droplets via the catheter ports. This practice is also recommended for patients to prevent self-contamination via respiratory droplets [13]. Lastly, respiratory protection (N95 respirator) is required when entering the room of a patient with a known or suspected airborne infectious disease [13, 16].

7 Respiratory Etiquette

Respiratory etiquette (also referred to as respiratory hygiene or cough etiquette) is an element of standard precautions that requires prompt intervention and deployment of infection prevention measures at the first patient encounter within a facility [14]. In the dialysis setting, it is probable that this intervention would begin in the waiting area. Respiratory hygiene practices aim to limit the transmission of respiratory pathogens in persons suspected of having a transmissible respiratory infection (may or may not be diagnosed). Persons presenting with signs of respiratory illness such as cough, congestion, runny nose, or increased production of respiratory secretion should receive prompt intervention. Respiratory hygiene practices aim to minimize exposure of patients and healthcare team members to respiratory secretions [7, 14, 15]. The CDC recommends a variety of action items as part of respiratory hygiene [15] (Fig. 2). Nurses and relevant team members should be knowledgeable about such practices to implement at points of entry. In addition, routine screening can serve to minimize exposure because signs and symptoms may be recognized early and segregation practices such as isolation or cohorting may be deployed [7].

8 Medication and Sharps Safety in the Dialysis Setting

Injection and sharps safety is designed to minimize outbreaks and exposure related to unsafe injection and medication administration practices [7, 14]. Examples of this include reuse of syringes, sharing of insulin pens and blood glucose monitoring equipment, administration of contaminated medications that have been diluted or compounded, preparation of medications in close proximity to contaminated supplies or equipment, failure to wear a facemask (e.g., surgical mask) when placing or flushing a catheter [7, 14] or injecting medications into the catheter lumens. A 2001 article featured in the New England Journal of Medicine (NEJM) validates the importance of diligence in medication safety. In one month, ten bloodstream infections and 6 pyrogenic reactions were reported in a dialysis unit. This occurred as a result of puncturing single use vials and pooling doses of epoetin alfa multiple times [17].

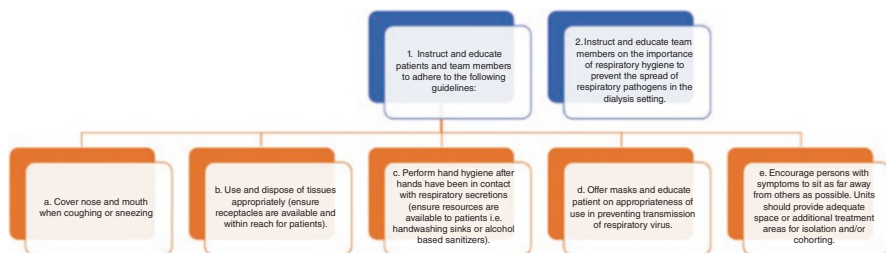


Fig. 2 Key action items in ensuring respiratory hygiene [15]

Recommendations for medication safety and safe injection practices in dialysis units have been published by the Association for Professionals in Infection Control and Epidemiology and the Centers for Disease Control [13]. Recommendations made to ensure safe medication practices include those in Table 1. In addition, adoption of standards such as the OSHA bloodborne pathogens standard has aided in the improved protection [14] of dialysis team members from blood exposure and sharps injury. The CDC asserts that most sharps related injuries and bloodborne exposures are preventable; therefore, [15] best practice standards are that dialysis units design and deploy policies and procedures addressing medication and sharps safety.

In the dialysis unit, nurses play a central role in the administration of medications. As such, it is compulsory for them to be knowledgeable in the process of medication preparation and administration, injection, and sharps device use. Competency should also exist in all aspects of medication preparation, handling, and administration [7]. Clinical leaders in the dialysis setting should also work to validate their knowledge base. This must include the capacity for dialysis nurses to identify care situations that pose risks such as inappropriate medication compounding by others, failure to use protective equipment during high-risk injections and catheter care, and other shortcuts that may compromise medication and sharps safety standards. Identification of such instances will work to minimize complications in the dialysis setting and improve patient related outcomes [14, 15].

Table 1 Medication safety in the dialysis unit: a summary of CDC recommendations [13–15, 18]

1. Unused medications or supplies taken to the patient’s dialysis treatment station should be used for that patient only and never returned to a common clean area. They are never to be used on other patients. Unused medications or supplies may include multi-dose vials, or those containing dilutants.
2. Prepare individual patient medication doses in a clean centralized area, away from dialysis stations. Deliver each medication separately to each patient. Do not carry multiple dose medication vials from station to station.
3. Avoid the use of common medication carts to deliver to patients. Never carry medication vials, syringes, alcohol swabs or supplies in pockets. When trays are utilized for medication delivery to patients, they must be cleaned in between uses.
4. The handling and storage of medications and unused supplies and equipment should take place in clean, designated areas that are clearly separated from contaminated areas where used supplies and equipment are handled. Never handle or store medications or clean supplies in the same or near an area where used equipment or blood samples are handled.
5. Place used disposable syringes and needles, scalpel blades, and other sharp items in appropriate puncture-resistant containers (SHARPS containers) located as close as possible to the area where the items are used.
6. IV sets and infusion lines should never be used for more than one patient.
7. Disinfect the rubber septum on a medication vial with alcohol before penetrating with a syringe.
8. Single vials, multidose vials, ampules, and bags are always entered using a new needle and new syringe (even when obtaining additional doses for the same patient).

9 Cleaning and Disinfection of Environmental Surfaces in the Dialysis Unit

The transmission of organisms, viruses, and bacteria can be facilitated by the physical environment [7]. For this reason, it is important for dialysis professionals to understand the interventions that minimize contamination and spread. Cleaning and disinfection of surfaces, equipment, and supplies is an important component of standard precautions in that it serves to minimize the transmission of organisms via the contaminated hands of healthcare workers. The frequency of contact with which healthcare professionals have with their physical surroundings makes it crucial for cleaning and disinfection to be incorporated into the daily workflow. In addition, part of the infection prevention plan for out-patient facilities should include policies and procedures for routine cleaning and disinfection of environmental surfaces as well as those for decontamination in the event of the occurrence of spills, blood [14], or other potential sources of exposure to bodily fluids.

The CDC advises that emphasis should be placed on those surfaces that could potentially be sources of transmission. This includes those surfaces that are in close proximity to or in contact with the patient [14] (i.e., bedrails, doorknobs, phones, chairs). In the dialysis setting, this can be particularly challenging because the nature and frequency of treatments as well as the high rate of patient turnover makes it highly likely that surfaces can become contaminated. In addition, the utilization of extracorporeal circuits make bloodborne pathogen exposure common. Persons can be exposed to bloodborne pathogens such as HBV, HCV, HIV as well as other infectious agents such as methicillin-resistant staphylococcus aureus, vancomycin-resistant enterococci, and clostridium difficile. Staff members should be particularly mindful of the fact that microorganisms can survive on environmental surfaces for varying periods of time (hours, to days, to months). Prevention and control of spread requires frequent cleaning and disinfection of a multitude of surfaces [13]. This can include dialysis machines, treatment chairs, procedure trays and carts, internal dialysis machine pathways, ancillary equipment and supplies, and water treatment.

Compounding the issues related to cleaning and disinfection in the dialysis unit is the additional use of auxiliary equipment. Items in this category can include reusable jugs for mixing bicarbonate solution, reusable priming buckets, external pressure transducers, and crit lines. Recommendations are that such items are cleaned and disinfected prior to being used on other patients [19]. While auxiliary equipment is a contributing source of contamination, staff must also be competent in the cleaning and disinfection of the external surfaces and internal fluid pathways of the dialysis machine. External machine surfaces should be cleaned following each treatment session using a low-level disinfectant or an EPA registered disinfectant solution. In the case of contamination with blood or bodily fluids, it is recommended to use an intermediate level disinfectant or tuberculocidal agent or a 1:100 dilution of hypochlorite solution.

Dialysis machines should be cleansed and wiped along all external surfaces paying careful attention to the frequently touched front panel, including the IV pole, the side, back, and base of the machine. The internal fluid pathways of the hemodialysis

(HD) machine pose another potential risk to the infection control process as they may serve as a potential source of cross contamination. It is recommended that routine disinfection and rinsing take place as per manufacturers guidance. In the event of blood leak, the machine should be immediately disinfected [13].

As clinical leaders, nurses should be aware of microorganisms that are particularly challenging (i.e., C-diff, HBV, Hep C) to minimizing potential sources of exposure and be prepared to collaborate with additional staff and team members to ensure proper protocols and procedures are followed [13]. The recognition of contamination risk factors in the dialysis setting is a function of nursing practice; as they may be aware of practice deviations, failures in point of care cleaning processes, or other environmental risk factors and be able to respond in real time. Clinical leaders, in the dialysis setting, should only assign disinfection to appropriately trained team members. In addition, the processes and procedures related to cleaning and disinfection should be routinely monitored to ensure competency and compliance [14].

10 Screening and Routine Serological Testing

Detecting and preventing the transmission of disease in the dialysis setting demands screening and serological testing of patients [11]. In fact, there is international consensus from experts surrounding the need to universally screen for HBV and HCV on admission and routinely thereafter [13]. The requirement for routine testing of HBV allows units the opportunity to minimize risk and possible transmission through isolation and enhanced cleaning and disinfection protocols for those persons who are positive. In addition, it allows for identification of those persons who are susceptible to proactively vaccinate those in need [11, 13]. Routine testing for hepatitis C simultaneously affords patients the chance to become treatment candidates while also monitoring for cases of seroconversion. Consensus surrounding screening of patients on HD for tuberculosis has also been agreed upon by the APIC, CDC, KDOQI, and ERBP. The recommendation here is that this is done at baseline admission and whenever exposure is suspected [13]. Tuberculin skin testing is the most simplistic and fiscally responsible means of screening for TB.

The incidence and prevalence of infections decrease significantly when patients are segregated according to virology status. It is believed that this can be attributed to the existence of physical space between susceptible patients to those who have been colonized with pathogenic microorganisms. When segregation and/or isolation procedures are deployed, this limits staff movements between susceptible and infected patients. In addition, it limits the possibility of contamination as a result of equipment and supplies sharing [13]. The creation and deployment of system standards, policies, and procedures for screening, early detection, and management of potentially infectious patients in the dialysis setting is instrumental to infection prevention and improved patient outcomes.

11 Immunization

Protection of susceptible patients can be enhanced through immunization. This is especially important for the population because patients on dialysis have higher incidence of respiratory infection associated with increased morbidity and mortality. For this reason, it is recommended that they be vaccinated against pneumococcal disease, influenza, and COVID-19 [11]. Their frequent exposure to blood in the dialysis setting also makes it essential to be vaccinated for HBV. In working to schedule vaccinations for the dialysis population, it is important for nurses to consider the immune response in patients with ESKD. Because of changes in the immune system, patients with ESKD may have a less robust immune response, making some vaccine schedules different than that of the general population. It may also result in low titer levels or non-responders. Dosage and vaccine schedules for ESKD patients need to be consistently reviewed to ensure accuracy and effectiveness. Lastly, it is important to consider the risk factors associated with non-vaccinated staff members and to maintain vaccine status of all team members. Staff members should be vaccinated for (a) hepatitis B, (b) influenza, (c) measles, mumps, and rubella, (d) varicella, (e) tetanus, diphtheria, acellular pertussis [13].

12 Disinfection of Internal Machine Pathways

Guidelines from the CDC and APIC do not advise that disinfection of the internal fluid pathways takes place between patient uses of “single pass” HD machines except for the occurrence of a blood leak [13]. It is possible for dialysis fluid to become contaminated with blood when a dialyzer leak occurs; however, this fluid is discarded through a drain and does not return to the dialysis machine to contaminate pre-dialyzer surfaces. Internal pathways could become contaminated following a blood leak when operating a machine that has a dialysate recirculating system (e.g., some ultrafiltration control machines and those that regenerate the dialysate). This in turn could contaminate the dialysate fluid of subsequent patients. The risk here is minimized because of the routine procedure of draining the dialysis fluid and rinsing and disinfecting the machine [18]. For machines that have been in standby mode, chemical disinfection, according to the manufacturer’s recommendations, should be completed prior to utilization. Machines that are inactive for extended periods of time could be prone to developing bacterial growth [13].

13 Water Treatment and Testing

In dialysis units, water treatment and infection control are closely aligned. Ensuring the quality of water used in dialysis is a fundamental component in the delivery of high-quality patient care that incorporates infection prevention standards. Poor water quality assurance and the failure to meet water standards can directly contribute to increased morbidity and mortality in the dialysis setting. In fact, experts have

proven that ultrapure dialysis fluid can be associated with reductions in inflammatory markers, reduced chronic inflammation, decreased erythropoietin resistance, preservation of residual renal function, and reduced cardiovascular morbidity [20]. For these reasons, water safety is a crucial part of infection prevention in dialysis settings.

It is commonplace to find small amounts of bacteria in municipal systems that are relatively safe when ingested; however, when utilized internally for dialysis, it could prove lethal. This is because the bacteria bypass the body's normal defence mechanisms such as the skin and stomach acid and are directly introduced into the bloodstream via dialysis. Dialysis nurses must also consider the fact that dialysis patients' bloodstreams are exposed to 300–600 L of water per week, this significantly magnifies the exposure level to the minute bacteria permitted in the municipal supply [11].

Team members must be knowledgeable in water systems, principles of reverse osmosis, water standards, and water testing in order to maintain the “purest” water possible. Achieving this standard requires that dialysis units adhere to the standards set by the Association for the Advancement of Medical Instrumentation. The microbiological quality of water used in dialysis can be divided into three levels: standard, ultrapure, and sterile. Each level sets the standard for the maximum allowable levels of microbiological contaminants [20]. Best practice standards support the routine monitoring of water products for bacteria and endotoxins as well as periodic disinfection of the water system [11], to reduce patient risk factors and ensure sufficient infection prevention standards are met.

14 Minimizing Risk of Infection in Vascular Access

Infectious complications of the dialysis access are one of the greatest contributors to increased morbidity and mortality for dialysis patients. They are the second leading cause of mortality for dialysis patients. In the USA, vascular access infections account for 28% of all infections for ESKD patients. Central venous catheters carry the highest risk of infection when compared with arteriovenous fistulas. Grafts assume an intermediate risk level as compared with AV fistulas [21]. The prevention of access related infections requires the application of principles of infection control as well as the ability to accurately assess and monitor access sites. The clinical expertise of dialysis nurses may allow for early identification and mitigation of infection related complications.

15 Infection Prevention of the AV Fistula

Infections of the AV fistula are generally that of perivascular cellulitis. Classic signs include erythema, swelling, and tenderness. Dialysis nurses may also observe additional abnormalities related to infection. This can include aneurysm with ulcerated skin or abscess from an infected needle puncture site. Ulcers are of significant

concern because they can result in life-threatening hemorrhage. Buttonhole cannulation carries an added risk of puncture site infection because it is associated with bacterial colonization that lacks classical clinical signs and symptoms [21].

A large majority of fistula related infections can be correlated with poor aseptic technique during the cannulation procedure. This makes it essential for staff and patients to be educated, trained, and knowledge tested in aseptic technique when caring for the AVF. For this reason, a standardized approach has been endorsed by international bodies such as EBPG, APIC, ERA/EDTA, and NKF KDOQI [13]. Infection prevention measures include the following best practice recommendations [19] when caring for the AV fistula:

- Handwashing is the essential first step prior to performing any procedure such as vascular access care.
- Ensure appropriate utilization of PPE. Fluid resistant gowns with full coverage of the arms and front of body over uniform with the utilization of face mask and eye goggles. This is especially important during initiation and discontinuation of dialysis because there is a possibility of blood splashes.
- Best practices endorse the utilization of gloves to be worn whenever caring for a dialysis patient, whether touching patient's intact skin or equipment. At completion of interaction or procedure, gloves should be removed and followed by hand hygiene.
- Cleanse access site with antibacterial soap and water prior to every cannulation.
- Identify needle insertion site and palpate access site prior to prep with antiseptic solution.
- Skin prep at access site using an antiseptic solution (alcohol-based chlorhexidine or 10% povidone iodine solution and/or 70% alcohol).

Infection prevention in access care begins with thorough and comprehensive assessments of the access site. Nurses should be vigilant and mindful during this process to reduce the rate of access related infections. Appropriate selection of needle insertion sites is of paramount importance; especially when utilizing buttonhole technique because *S. aureus* is reported to be problematic for those using buttonhole technique. For those who utilize buttonhole and dialyze at home, the problem is compounded with three times the rate of infection than those who receive treatment in center [21].

While the rate of infection for AV fistulas has considerably decreased over the last decade, infection prevention continues to be a priority in the care and assessment of the AV fistula. For this reason, it is important for dialysis team members to be continuously trained and educated in preventative measures and aseptic techniques [5]. When education and competency is combined with standardized process and procedures for cannulation of the AV fistula, infectious complication can be dramatically decreased.

16 Infection Prevention and Care of the AV Graft

The infection of an AV graft can pose substantial risk for dialysis patients. This can result in considerable mortality, prolonged dependence on dialysis catheters, and multiple vascular access procedures. In addition, they are associated with poorly predictable outcomes as well as increased mortality [5]. As a result, team members must be adept at assessment of the AVG. Signs and symptoms of infection may be variable and could present as cellulitis, edema around the graft site, erythema, tenderness, pain, purulent drainage, and/or thrombosis [21]. While it is likely that patients will present with S/S of graft infection, team members cannot exclude the possibility of silent graft infections. This should be considered in cases of unexplained sepsis, leucocytosis, or fever of unknown origin.

AV grafts require repetitive cannulation of synthetic material for dialytic purposes. In addition, the added complexity of accessing synthetic material increases the risk of infection. Contributing factors can also include perigraft hematoma formation, prolonged post-dialysis bleeding from the graft, and breaks in sterile technique. Additionally, patient associated risk factors can include poor patient hygiene, hypoalbuminemia, advanced age, high serum ferritin, and chronic illness such as diabetes mellitus. Lastly, team members should consider infection as a result of transient bacteria when distant access sites are present (i.e., chemo ports, picc. Lines, central venous catheter) [22].

As described with the AV fistula, cannulation of the AV graft requires strict adherence to infection control guidelines. Infection control measures include those referenced in the AV fistula section above. Nurses are instrumental in ensuring that infection risk factors are minimized in the dialysis setting. Their expertise and knowledge significantly contribute to improving a complex multi-disciplinary approach to infection prevention for patients with AV grafts.

17 Infection Prevention and Care of the Central Venous Catheter

The prevention of catheter related infections begins with proper infection control and hand hygiene measures. It is essential for staff members to be knowledgeable about organization specific policies and procedures related to infection prevention with the utilization of central venous catheters (CVCs). Best practice begins with the creation of uniform infection prevention policies for cleansing catheter exit sites, accessing blood lines, and discontinuing treatments.

Being that catheters are synthetic foreign objects, they represent an unphysiological phenomenon that is prone to infectious complications. The most common complication associated with their use remains catheter related bacteremia primarily caused by gram-positive organisms (*staphylococcus aureus* and *staphylococcus epidermis*). Unfortunately, most sources of infection begin at the hands of healthcare workers and potential modes of infection are from external sources. This can include the hands and breath of team members, contaminated sterile solutions, inept or

careless dressing changes (failure to adhere to sterile procedure), or internal colonization due to thrombi or fibrin sleeve formation [5].

Recent reports indicate that nurses are the most identified healthcare professionals responsible for central venous catheter care. Their responsibilities include maintaining access integrity, preventing access failure, and reducing complications associated with access functioning. While it has been clearly established that nurses play a central role in CVC care, studies in other clinical settings reveal that the knowledge and skills of nurses caring for CVCs are often lacking or inadequate. This finding has not been validated in the dialysis setting; however, it is evident that further investigation is warranted [6]. Additional research into the knowledge and practice patterns of nephrology nurses could contribute substantially to remediation efforts that improve upon nurse specific education and training as well as best practice procedures.

Continued education and training are essential components in the delivery of safe and effective nursing care. Experts suggest that a core component of the education process should focus on those areas where performance does not meet expectations to target improvement in knowledge and practice [7]. In the dialysis setting, targeted areas of education and knowledge related to catheter care can be multifaceted and nursing leaders should focus on specific educational topics, processes, and procedures that contribute to identified outcome measures. While it is necessary to provide continuous educational opportunities, the education and training process should not be considered complete without validation through competency. This process works to ensure that knowledge is applied into practice and applies to specific nursing care delivered in the dialysis setting. A targeted approach that is unit specific will contribute positively to patient outcomes in the dialysis setting.

18 Nursing Care and Assessment of CVC Catheter

In the dialysis setting, routine catheter care including assessment, maintenance, monitoring, accessing, and capping are most often the responsibility of nursing professionals. As such, they must be adept at recognizing catheter related complications that may include signs and symptoms of infection, hematoma, thrombosis, dislodgement, pneumothorax, and bleeding. In addition, they are tasked with routine catheter care that includes scheduled sterile dressing changes [8]. Their role in ensuring positive patient outcomes is of monumental importance.

Care of the dialysis catheter begins at the “chairside” with each dialysis treatment. Thorough assessment of the access site should be made prior to each treatment initiation. This begins with visual inspection of the dressing and/or catheter entrance site. When transparent dressings are utilized, the formal assessment process can begin prior to removal of the exit site dressing. When the dressing is opaque

Table 2 Signs and symptoms of central venous catheter infection [9]

Signs and symptoms	Patient Reported
• Pain at exit site • Pain surrounding exit site or radiating to chest or extremities • Feeling of warmth at exit site • Drainage at exit site • Swelling at exit site • Redness at exit site • N/V, diarrhea • Loss of appetite • Fever	
Signs and symptoms	Physical Assessment
• Drainage at exit site • Redness at exit site • Solid and/or discolored gauze (non-transparent) • Odor at exit site • Elevated temperature • Swelling at exit site	
Signs and symptoms	Laboratory Analysis
• Elevated White Blood Cell Count • (+) Blood cultures • Elevated neutrophil count • Elevated lymphocytes • Elevated C reactive Protein (CRP) • Elevated Monocyte distribution width (MDW)	

and visualization is not obvious, it becomes necessary to remove the dressing. Current best practice recommends that dressing changes are standardized and that there is a weekly cadence. It may however become necessary to increase the frequency of such changes when dressings are visibly soiled or loose or the patient presents with signs and symptoms of infection (Table 2) [9].

Recent recommendations advise that direct contact with the CVC and the patient or provider’s integument, as well as external objects should be avoided. Physical contact with skin and surfaces increases the risk of infection. Decreasing the risk of infection through contamination requires utilization of both a “no touch” and sterile technique. Sterile technique is advised when exit sites are exposed during dressing changes. The utilization of these techniques will necessitate education, knowledge, and competency in infection prevention, utilization of PPE, handwashing technique, and sterile technique [9].

19 Accessing the Dialysis Catheter

Utilization of a central venous catheter for dialysis demands that universal precautions are maintained, and best practices are integrated into the nursing process in order to protect against a variety of microorganisms. The essential components of

catheter care can be simplified into a consolidated seven step process (see Fig. 3) that incorporates utilization and maintenance of infection control practices and aseptic technique. It demands the ability of the nursing professionals to be vigilant in applying the principles and practices of universal precautions while simultaneously performing sterile technique. Here, adherence to the most stringent of rules (i.e., sterile technique) will work to decrease the risk of infection. This process can be utilized for connection and disconnection of the central venous catheter.

Maintenance of sterile technique involves a non-touch approach and the application of various barriers to ensure the prevention of transfer of microorganisms that can be transferred from the environment or the nurse to the patient. In addition, it demands assembly of associated materials and supplies as well as exit site preparation. Additional elements include monitoring and deployment of environmental scans (see Table 3) as well as preservation of contact guidelines that ensures only sterile-to-sterile contact [10]. When nursing assessment and organizational policy and procedure confirms eligibility for the catheter to be accessed, nurses may prepare the dialysis catheter for treatment initiation or discontinuation.

The connection of a patient utilizing a CVC requires highly competent nursing staff who are proficient in knowledge of infection control practices, HD principles, aseptic technique, patient assessment, and patient education. Nurses play a central role in the maintenance and management of central venous catheters. Their expertise is integral in the prevention and identification of catheter dysfunction and infection (Fig. 3 and Table 3).

20 Conclusions

Infection continues to be a chief factor in increased morbidity and mortality for the dialysis population. While several international guidelines and recommendations have been published regarding infection control in the dialysis setting, reducing the risk of infection demands the diligence of dialysis team members, training, and ongoing education. Core components of a dialysis infection prevention program that utilizes best practice standards should work to incorporate the topics highlighted throughout the chapter. The adoption and application of infection prevention in the dialysis setting contributes substantially to risk reduction for patients on dialysis.

Fig. 3 Essential components of catheter care [1, 9, 10]



Table 3 Environmental scan in the dialysis setting [11, 13, 14]

Components of environmental survey	
1. Survey of safety conditions	
	Are surroundings safe to initiate patient care? (adequate lighting, floors are suitable for walking, no equipment or electrical cords obstructing pathway)
	Is there adequate space for necessary supplies and materials?
	Traffic through treatment area is minimal
	Unnecessary personnel and visitors are excluded from treatment area during connection process
2. Analysis of treatment room	
	Are surfaces clean and dry? Disinfect surfaces prior to equipment assembly and allow them to dry completely.
	Be aware of possible sources of contamination. (proximity of machine and blood lines)
	Dialysis machine is prepared and in ready mode. Station is clean and machine has no visible contamination.
3. Materials and supplies are accessible	
	Clean gloves
	Sterile dressing change kit
	Cleansing solution

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General Vaccination Scheme for Patients with CKD: Management of Kidney Care During the COVID-19 Pandemia-Vaccination for COVID-19

Faith Lynch

1 General Vaccination Scheme for Patients with CKD

A *vaccine* is made from very small amounts of weak or dead germs that can cause diseases. The introduction of these germs prepares your body to fight the disease faster and more effectively so that you do not get sick.

Vaccination is the act of getting a vaccine, usually as a shot.

Immunization is the process of becoming immune to or protected against a disease.

According to the Centre for Disease Control website [2], persons, including the healthcare team, need to understand how vaccines work in order to be best prepared to educate. To better understand this process, it helps to first look at how the body fights off illness. When germs, such as bacteria or viruses, invade the body, they attack and multiply. This invasion, called infection, is what causes disease in persons. The immune system uses white blood cells such as macrophages, B-lymphocytes, and T-lymphocytes to fight infection.

Macrophages media ikon are white blood cells that swallow up and digest germs, plus dead or dying cells. The macrophages leave behind parts of the invading germs called antigens. The body identifies antigens as dangerous and stimulates antibodies to attack them. B-lymphocytes are considered the defensive white blood cells; they can produce antibodies to fight off infections. T-lymphocytes are another type of defensive white blood cell that recognizes a familiar germ, if the body is exposed again to the same disease.

The first time the body becomes infected with any type of germ, it can take several days for the immune system to make and use all the tools needed to fight off the infection. After the infection is cured, the immune system remembers what it learned about how to protect the body against that specific disease. If your body encounters

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the same germ again, the T-lymphocytes recognize the familiar germ and the B-lymphocytes produce antibodies to fight off the infection [2].

Vaccines can help protect against certain diseases in different methods including by imitating an infection which the immune system learns how to fight the future real infection as it keeps in memory. When receiving a vaccination there are potential side effects such as fever, headache, aches depending on the individual and personal response. Full protection from the virus should appear after a few weeks of the vaccine administration; however, there are cases that present the development of the disease anyway.

2 Introduction to CKD and ESKD Population and Vaccinations

The second leading cause of morbidity and mortality among patients with chronic kidney disease (CKD) and end stage kidney disease (ESKD) are infection diseases. Patients with CKD, by virtue of their immunosuppressive state, are always at risk for infection [3]. This is due to their highly dysfunctional immune system, especially in the advanced stages of CKD. Vaccination represents an important prevention strategy in this population of patients, as several studies have reported lower infection rates and significantly reduced morbidity and mortality when hospitals and clinics start adopting vaccination protocols [8]. Even though this population has particularly lower vaccination administration rates, the diminished immune responsiveness remains the main issue of vaccination in CKD persons [8].

The relatively low antibody response to vaccination also appears to correlate with the degree of kidney failure but not with the specific mode of dialysis. It appears that disturbances in T-lymphocytes and antigen-presenting cells may be responsible for the altered acquired immunity in this population [3]. Other reasons why vaccinations are a complex task in this population are because there are various immunization protocols across the world in the absence of optimal universal vaccination policies [8]. Despite the decreased antibody response, vaccination remains an important preventative measure for this population by providing some protection and positively influencing clinical outcomes [1].

3 Vaccinations in the CKD Population

Patients with CKD, by virtue of their immunosuppressive state, are always at risk for infection. The three major vaccines that are recommended for patients with CKD are hepatitis B, pneumococcal, and influenza. With the 2020 pandemic, these people should also be vaccinated against COVID-19, as with any vaccine, education is of utmost importance.

4 Importance of Vaccination in CKD Population

The lack of an optimal universal policy, difficulties the management of vaccination scheme as there are variations in immunization for CKD between countries, mainly due to epidemiological priorities [8]. In fact, the European Centre for Disease Prevention and Control guidelines for vaccination in CKD recommend for all adults the diphtheria/tetanus, the annual inactivated influenza vaccine, the measles/mumps/rubella (MMR), and the varicella vaccine if not contraindicated [1]. In persons with CKD and ESKD on dialysis, it adds the hepatitis B vaccine as well as the pneumococcal vaccine.

When it comes to vaccinations in patients with CKD it is important to take into consideration that [8] people with early-stage CKD can and should be vaccinated as they have mild immune impairment and ESRD patients should not be excluded from routine vaccination with live-attenuated vaccines (LAV). Moreover, the immune status of transplant candidates must be assessed. A complete appropriate vaccination assessment must be performed in the pretransplant period at least 4 weeks prior to kidney transplantation. LAVs are contraindicated in kidney transplant recipients.

Moreover, KDIGO (2021) recommends the following guidelines in persons with CKD in relation to vaccination [8]:

- (a) Annual influenza vaccination in adults with CKD, unless contraindicated.
- (b) Vaccination with polyvalent pneumococcus vaccine every 5 years unless contraindicated in CKD stages 4 and 5 and persons at high risk of pneumococcal infection (nephrotic syndrome, diabetes, or those undergoing immunosuppression).
- (c) Immunization against hepatitis B in adults with a progressive CKD and have GFR <30 mL/min/1.73 m². The response should be evaluated by an appropriate serological testing.
- (d) Furthermore, guidelines of vaccination in adult solid organ transplantation updated by the American Society of Transplantation (AST) and the Infectious Disease Society of America in 2013 recommend that vaccination status should be documented during pretransplant workup and necessary immunizations must be administered as soon as possible afterwards [8].

5 Hepatitis B Vaccine (HBV)

The hepatitis B vaccine is recommended for all patients with CKD. This vaccination series is especially important for patients on hemodialysis (HD) as this population can be exposed to blood and bodily fluids. Patients on HD should be highly encouraged to get vaccination series. Even though the prevalence and incidence of the hepatitis B infections are about 7.6% and 3.2%, respectively, the vaccine provides effective protection against the HBV [4]. Vaccination in early stages of CKD has a better seroconversion rate than if given in later stages of CKD. The recombinant

hepatitis B vaccine is recommended with a dose schedule of 0, 1, 2, and 6 months. The vaccine should be given intramuscularly in deltoid regions. The antibody titer to hepatitis B surface antigen (anti-HBs) needs to be assessed as well [3, 5]. The first titer should be done 1–2 months after the primary course is completed and then checked annually thereafter. Booster dose should be given if anti-HBs titer falls below 10 mIU/mL. Revaccination with full doses is recommended for persons who do not develop protective antibody titer after primary course. HBsAg can be transiently positive for 1–18 days after vaccination. This should be considered when drawing bloodwork [3, 5].

6 Pneumococcal Vaccine

The burden of pneumococcal infections in patients with CKD is extremely high. Pneumococcal infections have an increased risk for mortality in patients with multiple underlying comorbidities [5]. This vaccine should be administered as early in the disease as possible. All patients with CKD or ESKD should receive a pneumococcal vaccination. This approach is consistent with the recommendations of the Advisory Committee on Immunization Practices (ACIP). Vaccination against pneumococcal disease is associated with decreased mortality among patients with ESKD. Despite this data, and the recommendations of the ACIP, overall pneumococcal vaccination rates among patients ESKD remain suboptimal. The antibody response to the pneumococcal vaccine can be variable among patients with CKD and ESKD [3, 5]. The vaccine schedule recommended is that all patients with CKD over the age of 19 should receive a dose of PCV13 first, followed by a dose of PPSV23 at least 8 weeks later. Subsequent doses of PPSV23 should follow current PPSV23 recommendations for adults at high risk. Specifically, the second PPSV23 dose is recommended 5 years after the first PPSV23 dose for persons aged 19–64 years [3, 5].

7 Influenza Vaccine

Patients on dialysis are at increased risk of influenza-related mortality which is why persons with CKD or ESKD should receive an inactivated influenza vaccine annually [3, 5]. Studies show that a fourfold increase in serum antibody titer against influenza antigens has been observed in 50% of dialysis patients compared to 40% healthy controls [3]. Presently, no systemic reactions to the influenza vaccine have been reported in patients on dialysis [3, 5]. Many dialysis units have low vaccine rates due to lack of education. The nephrology health care team must reinforce the need for protection against influenza [5]. It should be given annually before the beginning of the flu season for any dialysis patient who is at least 6 months of age and older. The Centre for Disease Control recommends that any person who comes in contact with a patient on dialysis should also be vaccinated. This includes the health care team and family who lives with the patient. This will decrease the risk of

transmission and mitigate the potential morbidity and mortality risk of an influenza infection.

8 Tetanus, Diphtheria, and Pertussis Vaccine

Patients with ESKD should receive vaccination with the tetanus, diphtheria, and pertussis (Tdap) vaccine as recommended for the general population. Data on the efficacy of the tetanus vaccine in patients with CKD are limited but suggest that the response is less than in patients with normal kidney function [3, 5].

The recommended adult immunization schedule can vary according to the medical condition patients suffer from as some of the vaccinations are contraindicated and others are fully recommended (Table 1).

9 Reflection Question

Which vaccine is most likely to help decrease the spread of blood borne pathogen?

Table 1 Recommended adult immunization schedule by medical condition or other indication, United States, 2022

Vaccine	Pregnancy	Immuno-compromised (excluding HIV infection)	HIV infection CD4 percentage and count	Asplenia, complement deficiencies	End-stage renal disease, or on hemodialysis	Heart or lung disease, alcoholism ¹	Chronic liver disease	Diabetes	Heart care personnel ²	Men who have sex with men
IIV4 or RIV4										
or										
LAIV4										
Tdap or Td										
MMR										
VAR										
RZV										
HPV										
Pneumococcal (PCV15, PCV20, PPSV23)										
HepA										
HepB										
MenACWY										
MenB										
Hib										

Recommended vaccination for adults who meet age requirement, lack documentation of vaccination, or lack evidence of past infection

Recommended vaccination for adults with an additional risk factor or another indication

Recommended vaccination based on shared clinical decision-making

Precaution—vaccination might be indicated if benefit of protection outweighs risk of adverse reaction

Contraindicated or not recommended—vaccine should not be administered. *Vaccinate after pregnancy.

No recommendation/ Not applicable

1. Precaution for LAIV4 does not apply to alcoholism. 2. See notes for influenza; hepatitis B; measles, mumps, and rubella; and varicella vaccinations. 3. Hematopoietic stem cell transplant.

10 Management of Kidney Care During the COVID-19 Pandemia- Vaccination for COVID-19

10.1 COVID-19

With regard to the COVID-19 pandemic, the ESRD population was and does remain at particular risk of hospitalization and mortality. Chronic kidney disease is an important independent risk factor for severe COVID-19 that can lead to severe illness and as we have witnessed, a fatal outcome. Mortality among persons receiving dialysis who develop COVID-19 is high, and CKD outcompetes other risk factors for severe disease, such as age, diabetes, and cardiovascular disease [7]. Patients who are treated with HD are also particularly susceptible to SARS-CoV-2 infection, especially those who attend dialysis centers or reside in nursing homes [9]. Patients on in-center hemodialysis face multiple hazards that range from severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). First, although the majority of the population with CKD is able to adhere to infection control measures, the need to attend dialysis creates a greater a large exposure to infection. Second, as a group with multiple comorbidities and impaired immune responses, infection is more severe once acquired. As a consequence, in these persons there is a high relative risk of morbidity and mortality across all age groups [4].

Vaccinations targeted against the COVID-19 virus represent a key preventative strategy. The rapid development of vaccination against SARS-CoV-2 had and still does a major role in controlling COVID-19 spread because vaccines have shown a dramatic efficacy in preventing symptomatic forms of COVID-19, both in clinical trials and in worldwide studies [6]. However, persons on HD have been largely excluded from these vaccine trials for safety reasons. Moreover, altered vaccine responses have been previously described in the dialysis population, which justified urgently characterizing SARS-CoV-2 vaccine responses in dialysis patients. To date, this characterization remains mainly based on humoral responses after mRNA vaccines: most studies showed an 80–95% rate of positive serology in dialysis patients after complete vaccination [6], although this response appeared delayed and antibody levels slightly lower when compared with the nondialysis population [8]. These results led to the prioritization of vaccination in dialysis patients in France in early 2021, leading to a high vaccination coverage compared with the nondialysis population. However, the evaluation of vaccine effectiveness against severe forms of COVID-19 in this population remains an unmet need [9].

The clinical effectiveness of vaccination remains a pressing concern in this group of vulnerable patients and is vital for supporting vaccine promotion among hesitant patients. The Clinical Journal of the American Society of Nephrology (CJASN) published a study based in London. In-center HD is provided to approximately 5500 patients in London across seven nephrology centers, with enhanced infection surveillance and isolation of cases during the pandemic as described elsewhere [11]. All London nephrology centers were included. The main study population included all patients on prevalent in-center HD with SARS-CoV-2 infection identified by positive PCR. In this multicenter study of patients on HD with SARS-CoV-2

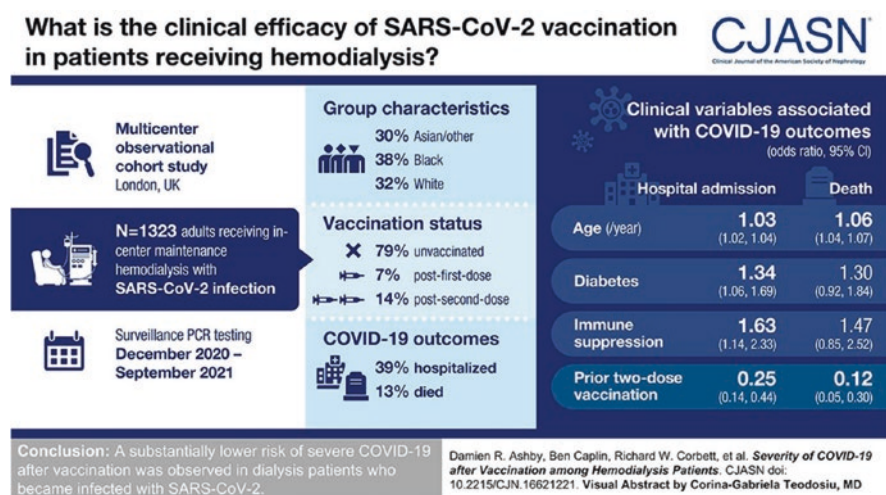


Fig. 1 Efficacy of SARS-CoV-2 vaccination in patients receiving HD

infection, significant protection from severe disease was seen after two-dose vaccination, with hospitalizations 75% lower (95% CI, 56–86) and risk of death 88% lower (95% CI, 70–95). This suggests a substantial clinical benefit from vaccination in a population that is particularly vulnerable. Some efficacy was seen after a single dose, underlining the importance of early vaccination in vulnerable groups (Fig. 1) [4].

In summary, nearly all patients requiring maintenance dialysis who received a booster dose of mRNA vaccine developed a robust antibody response 14–60 days after vaccination. Perhaps most importantly, we found that a third dose of mRNA vaccine was effective in providing high levels of antibody among older patients who were not uniformly protected after the initial vaccine series [6].

Persons with CKD or ESKD who are not up to date on other routinely recommended vaccines (based on age and other risk factors) should receive any needed vaccines. In order to keep this population safe, we must encourage vaccinations and immunizations. Many infections, viruses, and diseases have vaccinations to help decrease the chance that mortality occurs. Healthcare workers and patient advocates need to work together to continue constant education on how this topic is important to keep everyone safe.

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Further Reading

For more information on vaccinations and immunization, you can use the resources below:
<https://www.cdc.gov/vaccines/schedules/hcp/imz/adult-conditions.html>.
<https://www.ecdc.europa.eu/en/immunisation-and-vaccines>.

Management of Conservative and Palliative Care in CKD

Claire Carswell

Learning Objectives

- To understand the role of conservative management in kidney care.
- To identify which people with kidney failure may benefit from conservative management.
- To describe what conservative management involves, including the conservative kidney management pathway.
- To review the role of a palliative approach to care for people receiving renal replacement therapies, including those considering withdrawal from dialysis.
- To understand the importance of working in partnership with patients and their families when making decisions about the end of life.

1 Conservative Management

There are several different treatment modalities available to people who progress to advanced kidney disease. The main types of treatment are renal replacement therapies (RRT), including peritoneal dialysis (PD), hemodialysis (HD), and kidney transplantation. Significant advances in the treatment and management of kidney disease mean that older people, and those with high levels of comorbidity, are being successfully treated with RRT. While kidney transplantation is the gold standard RRT, this option frequently is not available for older people due to their levels of frailty, comorbidity, and risk of undergoing an invasive surgery. Therefore, the most common RRT for older people who reach kidney failure is HD [1]. In general, the

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HD population is getting older as the overall population ages, meaning that the average age for people who start HD is 66.8 years old [2].

Despite these advances in RRT, it is important to recognize that RRT is not the most appropriate, or the most beneficial option, for all people who reach advanced kidney disease. For certain people who are older, frail, and have multiple co-existing conditions, RRT does not necessarily result in improved outcomes and is unlikely to prolong life.

HD is a treatment associated with a significant treatment burden and risk of complications, adverse effects, further morbidity, and hospitalization. Consequently, HD can reduce a person's quality of life. While for many people the burden and risks are worth the fact that HD prolongs life, there are diminishing returns for people as they age. It is not clear whether people who over the age of 80 years, and who have multiple co-morbidities, will live longer on HD compared to those who opt not to start RRT [3]. HD may therefore offer an invasive and burdensome treatment with limited benefits for some older people who are frail, have multiple conditions alongside kidney failure, and who want to avoid hospitalization. An alternative approach, which prioritizes quality over quantity of life, is called conservative management.

Definition: Conservative Management

Conservative management is an approach to care where a person with kidney failure choose not to receive dialysis or a kidney transplant. Instead, the focus is on symptom management and improving quality of life. Quality of life can mean different things to different people, but for some people there is a focus on reducing the frequency of potentially unnecessary interventions, such as painful treatments or hospital admissions. Conservative management is sometimes also referred to as “palliative care” or “supportive care” [4].

1.1 Conservative Kidney Management Pathway

The Kidney Supportive Care Research Group, based at the University of Alberta [5], has developed a pathway to delivering conservative management for renal healthcare professionals. The Conservative Kidney Management Pathway [5] was developed as a resource for both patients and healthcare professionals to help understand the process of conservative management, including supporting decisions on management choice through a decision aid, clinical guidelines on how to manage symptoms that patients may experience, educational content and supportive tools including advanced care planning, and details on the co-ordination of relevant palliative and primary care services. Overall, the pathway serves as a tool to standardize and improve the quality of care for patients receiving conservative management.

1.1.1 Making the Decision

The first step of any treatment pathway is choosing the preferred procedure. It is important that people who have kidney failure are provided with all their available options and are active participants in the decision-making about their care. Healthcare professionals, including renal nurses, are responsible for providing people with their possibilities, explaining them in a way that is easily understood and allows the person to weigh up the relative risks and benefits of each choice. One way to support people with advanced kidney disease to make these decisions is to use a decision aid [6], like the one provided with the conservative kidney management pathway. Some of the following questions are key in the decision-making process [5]:

- How does each treatment work?
- How will each treatment make me feel?
- How long will I live on each treatment?
- What are the side effects?
- How much time does each treatment take?
- Will I need surgery?
- Who will provide the treatments?
- Will I have food and fluid restrictions with this treatment?
- Can I change from one treatment to the other?

1.1.2 Initiate Care Planning

Once the person has chosen conservative management, the next step is to carry out initial care planning. While this step is part of the Conservative Kidney Management Pathway [5], care planning is a key part of all nursing practice.

Care planning should be person-centered and can be used to monitor the care of a person with kidney failure. The care plan should be created collaboratively with the person who has kidney failure, as well as their family and other close friends who are important to their care. A care plan for someone who chooses conservative management may include crisis management plans, strategies for managing their symptoms and any potential complications that may arise from their kidney failure, and documentation of referrals to other specialties. All teams involved in the person's care, including primary care services and their GP, should be informed that they have chosen to receive conservative management for their kidney failure [7].

1.1.3 Clinical Assessments: Symptom Management

Symptom management is one of the key priorities during provision conservative management. Kidney failure has a significant symptom burden; however, symptoms tend to be under-reported when people are left to self-report [8]. It is therefore important that people who have chosen conservative management are routinely

screened for the presence and severity of symptoms. The screening for symptoms can be carried out using psychometrically validated instruments such as the Kidney Disease Quality of Life Short Form (KDQOL-SF), which encompasses not only physical symptoms but also aspects of the psychological and social consequences of kidney disease [9].

Common symptoms experienced by people with kidney failure receiving conservative management:

- Restless leg syndrome
- Nausea and vomiting
- Breathlessness
- Fatigue and sleep disturbances
- Nociceptive pain
- Neuropathic pain

Davison et al. [10] recommend that the following steps are taken to address symptoms when a person is receiving conservative management:

1. Assessment of the person with kidney failure to identify or rule out any reversible factors that are contributing to the presence and severity of symptoms.
2. Consider non-pharmacological interventions, to avoid increasing pill or treatment burden and avoid any side effects.
3. Use pharmacological interventions if the contributing factor is not reversible and non-pharmacological interventions have not been effective.

One common symptom amongst people who have kidney failure and are receiving conservative management is breathlessness. There could be a few reversible factors that could cause or exacerbate this symptom, such as anxiety, anemia, an infection, or pulmonary edema. If these are not the cause, or they cannot be successfully addressed, there are non-pharmacological options that have been shown to improve breathlessness. These include being sat in an upright position, having cold air blown gently across the face, complementary therapy, and supplemental oxygen to name a few. If these are unsuccessful, then furosemide may be helpful if the person is intravascularly overload, or opioids can be used to improve the sensation of breathlessness, particularly toward the end of life. It is not always possible to eliminate symptoms completely, and a balance must be maintained between managing symptoms and reducing the risk of further side effects caused by additional medication and intervention [10].

1.1.4 Clinical Assessments: Kidney Disease Management

Typical management of CKD prioritizes slowing the progression of disease. While slowing progression is not antithetical to conservative management, the priority is symptom management and promoting quality of life. Therefore, the management of kidney disease and kidney failure is slightly different when a conservative management pathway is chosen. An example of this would be the use of statins in kidney disease. Statins can benefit people with kidney disease as it can slow down the rate of progression while also providing cardioprotective benefits [11]. However, statins are associated with several side effects, including headache, nausea, dizziness, fatigue, muscle pain, and sleep problems. People with advanced kidney disease who are receiving conservative management are unlikely to benefit from the treatment effects of statins and are more likely to experience the side effects, and therefore frequently the decision is made to stop treatment with statins. This approach to management will also prioritize optimizing physical function in the short-term, for example, by reducing fatigue and pain by ceasing medication with difficult side effects, as opposed to long-term health promotion [12].

Table 1 Management of anemia [10]

Management of anemia	
Symptoms of anemia	Side effects and burden of treatment
Fatigue and tiredness	<i>Iron supplementation (oral)</i>
Breathlessness	Nausea and vomiting
Chest pain	Loss of appetite
Dizziness	Constipation or diarrhea
Headaches	Black feces
Problems concentrating	Heart burn
Body aches	<i>Iron supplementation (intravenous)</i>
Weakness	Dizziness or light-headedness when standing up
Fast or irregular heartbeat	Low blood pressure
Problems with sleep	Gastrointestinal distress (nausea and cramps)
Fainting	Rash
	Chest pain
	Bloating or swelling of the face and limbs
	Problems breathing
	<i>Epoetin injection</i>
	Chest pain
	Fever
	Headache
	Increased blood pressure
	Swelling of the face and extremities
	Weight gain
	Nausea
	Pain (including in the limbs, jaw, back, groin, chest)
	Blurred or double vision
	Cough
	(and more)

It is also important to manage and treat complications of advanced kidney disease, although again the priority here is slightly different compared to typical treatment. Typical management of chronic kidney disease frequently aims to address and treat complications by addressing and resolving the underlying cause; however, in conservative management, the priority is to enhance the patient's quality of life by focusing on symptom management. Therefore, there should be a consistent and constant assessment of the impact that treatments are having in relation to burden and side effects and weighing this up against the benefits of treating the complication [10]. For example, competing adverse effects and symptoms that may impact the treatment of anemia are numerous (Table 1).

1.1.5 Advanced Care Planning

Reflection: Advanced Care Planning and End-of-Life Discussions

What are your experiences having conversations with patients about the end of life?

How comfortable have you been having these conversations?

If you feel uncomfortable discussing these issues, why do you think that is?

Advance care planning is not a practice that should be restricted to patients who choose conservative management, as it is important for everyone. However, for people who are experiencing a life-limiting illness, and particularly for those approaching the end of life, good advance care planning is essential.

Advance care planning involves discussing with the patient their wishes and preferences about their healthcare in the future if they are unable to make, or communicate, decisions themselves at the time. Inviting them to think about different circumstances can help them consider what their priorities and goals of care are, and it is important that decisions and preferences are documented, to ensure that the patient's voice is always heard.

Advance care planning should start once the person decides not to undertake a renal replacement therapy and chooses to receive conservative management [5, 13]. As the patient's condition progresses make sure that their choices are consistently revisited and that their care plan is kept up to date, so that as they approach the end of life their decisions can be implemented, and their wishes can be honored.

Some of the important issues to be considered when working with a patient on an advance care plan [5, 14]:

- The involvement of the person's family and friends if the patient wishes.
- The involvement of specific healthcare professionals outside of the team if the patient wishes.

- The person's history, social circumstances, religious or cultural beliefs, aspirations and goals, and feelings.
- How their needs might change in the future as the disease progresses.
- Any support needed for communication, including interpreters, advocates, or family members and friends.

It is important that the advance care planning process centers on making sure that the person has the information they need to make decisions in autonomy, such as: their ability to change decisions while they still have capacity; how decisions will be made when they lose capacity; and other services available to the person to help with advance care planning or the decisions that they are trying to make [14]. Guidance for recording and implementing advance care plans will differ across teams, healthcare systems, and countries.

1.1.6 Establish Community Support and Referrals

Another important step to ensure that patients are appropriately supported is making timely referrals to community supports that are available [5]. These referrals should be made according to the patient's needs. Patient's needs can change very quickly, particularly as the person approaches end of life and their condition deteriorates. Palliative care services can be essential to ensure that patients symptoms are adequately managed and can be helpful if a person has experienced multiple acute or emergency admissions or requires placement in a hospital or hospice. It may also be beneficial to consider referrals to provide support for the patient's family and friends, particularly if they are closely involved in their care. Some referrals may include [5]:

- Community palliative care services
- Nephrology services
- Carers support groups
- Patient support groups
- Home care services
- Supported living services
- Nursing facilities
- Hospice

1.1.7 Crisis Management Plan

In the event of a crisis, there should be a management plan so every member of the family and patient knows what needs to be done. This plan should be developed with the patient and their family and should include information about what to do in an emergency, methods for managing difficult symptoms, and who they can contact when they need support. An essential component of this plan will be to ensure that

healthcare professionals who are responding to any crisis or emergency and may be outside of the patient's usual care team are made aware of the patient's decision not to go undergo dialysis. One option may be to ensure that the patient or their family keep a copy of the advance care plan with them at home, so that they have it to hand in case of an emergency [5].

1.1.8 End-of-Life Plan

While a patient may choose to receive conservative management and forego dialysis, this will not necessarily mean that death will be imminent. It can depend on the rate of decline and the residual kidney function that patients have at the time of starting conservative management. However, it is still important that patients understand their disease, how it will progress and their overall prognosis [15].

eGFR: 10–15 (mL/min), Last 0–5 Years of Life

When a person's eGFR is between 10 and 15 and they are experiencing a slow decline of renal function, it is still important to provide them with education about their condition and the fact they have a life-limiting disease. Some of the early discussions around priorities of care can happen to understand their values and wishes and develop an advance care plan.

eGFR: 5–10 (mL/min), Last 0–3 Years of Life

When a person's kidney disease is progresses, they may experience more difficult symptoms and require more intensive input from their care team. This is when conversations around end-of-life preferences can happen, as well as providing the patient with some information around the dying process and what they can expect. End-of-life planning should happen at this stage too, including where people would like to receive end-of-life care, whether this be at home, in a hospice, or in a hospital. Involving family and friends in these discussions can also be very beneficial.

eGFR: 0–5 (mL/min), Last 0–2 Months of Life

This is the stage where the patients end-of-life care plan will be implemented. What this will mean will depend on the individual patient and what their preferences were. Typically, it does involve ensuring that the patients plan for their place of death are implemented, so you may support the patient to remain at home during this time or assist in a transfer to an appropriate setting such as a hospice. It can be helpful to have palliative care services involved in the patient's care by this point, to ensure they are comfortable and that their symptoms are well managed.

1.1.9 Grief and Loss

It is important to remember that most patients will have family and/or friends who will be impacted by their disease and their death [16]. While involving family and/or friends in the care planning processes can help ensure that patients have their

needs met in a way that meets their values and wishes, it can also help support family and friends, by educating them on the dying process and what to expect toward the end of life [17].

The involvement of family and friends at end of life also means that care does not stop when the patient dies. An important part of end-of-life care is the provision of bereavement and grief support for people who were close to the patient during their life. However, less than 40% of families who have experienced a family member dying from end-stage kidney disease have been offered bereavement support [18].

Family members and friends who do not receive support following the death of a patient can feel abruptly abandoned by healthcare services as the intense input of healthcare professionals up to and during end-of-life care is quickly withdrawn [19]. There may be specialized bereavement services or carer support groups that family and friends could benefit from either following the death of their loved one or even beforehand.

Healthcare professionals can still make small gestures of support that can have a profound impact on the family and friends of the person who has died, for example, a phone call from a healthcare professional who was involved in the care of the family member can be helpful for the bereavement process [20].

Anticipatory Grief [21]

We tend to view grief as an experience that occurs after a loss has occurred, for example, after a loved one has died. However, there are different types of grief, and in some cases, they can occur before a person has experienced a loss.

Anticipatory grief is an experience that some people have when they know that a loved one is going to die soon, or that they have a life-limiting illness that will significantly decrease their life expectancy.

As the exact timing and nature of a person's death is hard to predict, even when they are dying from a progressive disease such as kidney failure, their family and friends may experience significant fear, anxiety, dread, and panic on a consistent basis, as they are constantly on high alert and wondering what is happening next and what could go wrong. This can have a significant impact on a person's mental health and well-being.

There are some steps you can take to support a family or friend of a person with kidney disease who is experiencing anticipatory grief:

- *Remind them that what they are feeling is normal.* Some people may wish that the process was over because it is so difficult to cope with, and therefore feel guilty and like a bad person. It is important they are aware that this is a normal and understandable part of the process and that they are not a bad person for feeling the way they do.
- *Encourage them to acknowledge what they are feeling and talk about it.* Hiding how they are feeling can lead to further feelings of shame and isolation. Reminding them they have a non-judgmental supportive person to reach out to can be reassuring.

- *Sign post them for further support.* There may be support groups for carers of people who have kidney disease that they can access, or social workers within the renal team that they can speak to. If there are specialized support programs for carers within the service, they can take advantage of these. There may also be carer support services provided by palliative care teams that they could access for support.

Encourage them to prioritize self-care. People who are providing informal care can struggle to find time for themselves, which can further exacerbate distress and mental health issues. They may need additional support, such as respite services or home care services, to achieve this.

1.2 Palliative Approach to People Receiving Dialysis

While the focus of this chapter so far has been on people with kidney disease who choose conservative management, and therefore choose not to dialyze, these are not the only people who require a palliative approach to care or who need to consider their plans for end of life. People who do choose to receive dialysis can benefit significantly from a palliative approach. While some people can live well on dialysis for decades, up to 30 years, the average life expectancy for people who start dialysis is 5–10 years. It is important that people who have kidney disease are made aware that it is a life-limiting illness, and that dialysis is not a cure to kidney disease. People who receive dialysis also experience a gradual decline in their physical health over time, which can lead to disability and increasing risk of mortality [22]. Certain factors do contribute to the rate of decline and the morbidity and mortality risk, including the age of the person, co-morbidities, frailty, and other determinants of health.

Advance care planning, therefore, should not be reserved only to those who choose conservative management, or only those who are imminently approaching the end of life. Instead, these discussions around advanced care planning should start early and should happen consistently throughout the person's disease trajectory, to ensure that their goals of care and wishes around end-of-life are up to date.

Dialysis, while increasing longevity for some patients, does not resolve all the symptoms associated with kidney disease. There are some particularly prevalent symptoms that are under-treated, including fatigue, pruritus (itchy skin), and pain. These symptoms tend to be frequent and severe and negatively impact people's quality of life and mental health [18]. A palliative approach that focuses on maintaining quality of life by emphasizing the importance of symptom management could help develop care plans that can reduce the impact of these symptoms [23].

Advance care planning rarely happens with people who are receiving dialysis, even though conversations about the goals of care are essential to ensure adequate treatment and support, particularly as the person approaches end of life [24].

1.2.1 Withdrawal from Dialysis

Dialysis withdrawal, or dialysis discontinuation, occurs when a decision is made to stop dialysis permanently. This decision is typically made by the patient, the family, or the healthcare team. Unlike conservative management, where the decision not to commence dialysis can result in a gradual progression of disease and eventual death, people who receive dialysis and then choose to stop experience a much more rapid deterioration and death. Typically, stopping dialysis results in death within weeks, depending on the amount of residual function that a person has [25].

The decision to withdrawal from dialysis can be made for several reasons, but typically the decision is made when the person who has kidney disease lacks capacity to make the decision themselves. Therefore, it is crucial to start advance care planning in a timely manner for people who are receiving dialysis, so that family members and healthcare professionals can be guided by the person's priorities and wishes when making these decisions. This can prevent ethical dilemmas and, at times, challenging legal processes, from impacting a person's end-of-life care [14, 26].

Healthcare professionals can find discussions around the withdrawal of dialysis difficult to have with people who have kidney disease and their family, and there are several communication barriers that can complicate the decision [26, 27].

Patient level barriers:

- A lack of awareness of palliative care
- Viewing dialysis withdrawal as “giving up” or “suicide”
- Unrealistic expectations about disease progression and prognosis
- Lack of capacity to make decisions
- Concerns or pressure from family

Healthcare service barriers:

- Lack of communication with the patient about their prognosis
- Lack of communication with the patient about their wishes and priorities
- Unrealistic expectations about prognosis
- Failure to communicate the option of palliative care
- Lack of availability of a palliative care service or a conservative management service

The Kidney Disease Improving Global Outcomes (KDIGO) highlighted the process of introducing a conservative or palliative approach to care for people with kidney disease who choose to withdraw from dialysis [28]. In response to this Macaden and colleagues (2014) [29] developed a stepwise approach to the withdrawal of dialysis:

1. Identify a decision-maker for the person with kidney disease (this may be the person themselves or a family member).

2. Assess their understanding of the clinical situation including prognosis, and the benefit versus burden of the disease.
3. Provide an explanation for dialysis withdrawal, what it is and what it involves, and a rationale as to why this decision may be made.
4. Reassess their understanding and decision and evaluate consistency across both.
5. Introduce palliative care services and explain their purpose and scope of their service in the management of the disease.
6. Document the decision to withdraw from dialysis and inform the wider care team including the primary care doctor, nephrologist, and palliative care team.
7. Implement withdrawal from dialysis and change focus of care to symptom control and provision of dignified and comfortable end-of-life care.
8. If conflict arises, take steps to resolve it and review the care process.
9. Provide bereavement care for the family.

1.3 Conclusion

Conservative management is an important treatment option for many people who have kidney disease, and palliative care is a crucial component of care for all people, including those who suffer from CKD. Communication that is clear, effective, and consistent is essential for successful delivery of conservative management, palliative care, and decision-making. Therefore, timely regular discussions around priorities of care and future wishes need to happen at the earliest opportunity. Involving family, friends, and other caregivers in the decision-making process is important to not only ensure that the wishes of the person with kidney disease can be carried out, but also to provide adequate support to the wider circle of people who will be impacted by the person's death.

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Kidney Transplantation

Jen Lumsdaine

Learning Objectives

- To raise awareness of the barriers to access transplantation
- To identify the effects of early education for transplantation in order to avoiding dialysis
- To describe the management of transplant lists and organ availability
- To create an effective assessment of the living donor and recipient
- To understand the post-transplant follow-up care

1 Introduction

Transplantation is one of the most successful advances in modern medicine and remains the only life-saving treatment for many types of end organ failure [1]. Since the first successful kidney transplant in the world was performed in 1954 between identical twins in the USA it is now routine practice in more than 80 countries [2]. This has resulted in the lives of people with kidney failure being offered the opportunity to live life without the restrictions of other forms of renal replacement therapy.

There is worldwide recognition that a kidney transplant results in improved quality of life, increased survival, and lower healthcare costs. However, not all patients benefit from a transplant. The selection, assessment, and listing of a patient with renal failure for pre-emptive transplant is dependent on timely referral [3]. For a successful program it was clear even before the first transplant that the success of transplantation has depended on a multi-disciplinary approach [1].

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The key aim to ensure that patients are referred for transplantation before dialysis has yet to be achieved in many countries worldwide. Exploration of some of the barriers to transplantation and what support the renal community can provide is a stepping stone to improving equity of access to the most beneficial form of treatment for individual patients. In optimizing the use of living kidney donation, kidney transplantation rates can substantially increase in many European countries. This would improve access to transplantation for patients in need with the potential for significant savings in dialysis costs [4].

Data clearly demonstrates that on average transplantation achieves superior medical outcomes [such as survival and quality of life] at lower cost as compared to dialysis [5]. Yet disparity continues throughout all countries with both deceased and living donor transplant rates. We know that donor/recipient selection and infrastructure all impact on transplant outcomes. How can healthcare professionals support all patients who would benefit from a transplant access this best form of treatment?

The role of the specialist nurse/transplant coordinator is pivotal in all transplant programs. Due to the complexities and multi-disciplinary liaison at all stages of the pathway, from assessment to transplant and longer term follow-up, the transplant coordinator is a key team member. Supporting transplant recipients and their families and providing the expert education and care during a lifechanging experience provides a challenging and fulfilling role.

Reflection

Mrs. A is a 54 year South East Asian lady who lives in London, UK, with her husband and 3 children. She has been attending a nephrology clinic for a number of years, and recently was informed by the nephrology team that her eGFR was 20mls/min. She hasn't discussed her kidney disease with any of her family members and is reluctant to raise the subject of living donation. Other than tiredness she has no symptoms and feels well. The team feel that she would be a good transplant candidate when she requires renal replacement therapy

- What support would the renal team provide for Mrs. A to choose her treatment option?
- Would you anticipate that Mrs. A would receive a pre-emptive transplant if she had a suitable living donor?
- What barriers would you envisage would prevent her from receiving a pre-emptive transplant?

2 The Benefits of Kidney Transplantation

When a person is told that they are approaching end stage kidney disease (ESKD) and they will require some form of renal replacement therapy (RRT), a number of treatment options are available. Not every person with kidney failure is deemed

suitable for the rigors of general anesthesia, kidney transplant surgery, and/or complications associated with long-term need for immunosuppression [6]. Each individual needs to be carefully assessed to ensure that on balance, a transplant is likely to improve their quality of life and survival. It is important for the person to be aware that a kidney transplant is not a cure for kidney disease, as there are risks as well as benefits.

2.1 Clinical Benefits for Kidney Transplant

For those suitable, the data is very clear that the treatment option that offers the best long-term survival is a kidney transplant from a living donor, ideally before any form of dialysis is required. A study of UNOS (United Network for Organ Sharing) predicts for those transplanted between 2014 to 2017 from a deceased donor the kidney would be expected to function for 11.7 years, and from a living donor 19.2 years [7]. This is variable depending on the age of the donor and recipient, and other medical issues, but on average the current estimate would be a living donor kidney lasts for 20–25 years and a kidney from a deceased donor 15–20 years [8].

In a review of the literature, Tonelli et al. concluded kidney transplantation was associated with reduced risk of mortality and cardiovascular events and improved quality of life [9]. Importantly this review encompassed kidney transplants from both deceased and living donors and across countries with differing health systems [9]. A more recent review in 2022 by Chaudry et al. agreed with the overwhelming evidence showing significant survival benefit with transplantation compared to dialysis, but urged caution that personalized risk–benefit decisions for individuals remains a clinical challenge [6].

For patients with insulin dependent diabetes and associated kidney failure referral may be made for combined kidney and pancreas transplantation. This can allow the recipient to be free of both dialysis and insulin, however, careful consideration is made due to the complications of this type of surgery [8].

2.2 Quality of Life Benefits of Kidney Transplant

While much of the literature and data shows the improved graft and person survival from transplantation, impact of quality of life following transplantation is important information for patients [10]. The time spent on dialysis and lifestyle restrictions can often be immediately alleviated following transplantation. People report more energy and able to cope with day-to-day activities, less restrictions on being able to work and go on holiday, improvement in sex life and fertility, and being fewer restrictions on what the patient can eat and drink [8].

The improvement in quality of life will be often dependent on the timing of the transplant. In the Access to Transplantation and Transplant Outcomes (ATTOM) program, it was identified that many living donor transplant recipients were not on dialysis before they received their transplant, so the benefits they perceived from

transplantation were fewer than those who have experienced dialysis. The study suggested it is important to manage patient expectations (e.g., recovery times) to avoid disappointment and promote effective coping with physical and psychosocial changes following transplant [10].

It is important that all persons who would benefit from a kidney transplant are aware of these statistics and supported in discussing living donor transplantation with potential donors at an early stage. Pre-emptive or early transplantation with minimal time on dialysis is of most benefit to the person, and along with the other benefits of living donor transplantation such as short ischemic time and a well-functioning kidney. Timing of a transplant from a deceased donor depends on organ availability in the country the patient lives and is listed. However, it is important to note that even in countries such as Spain, with high organ donation and deceased donor organ transplantation rates, implement strategy changes to promote living donor transplantation [11].

3 Barriers to Transplantation

What are the barriers facing healthcare professionals to ensure that patients receive the optimum therapy when choosing treatment options? Despite all the evidence that a transplant is the best option for patients with ESKD who would clinically benefit from a transplant, barriers remain for people either accepting a living donor or joining the deceased donor list.

For the potential transplant recipient there are a number of medical contraindications which may preclude listing for transplant—these may include multiple myeloma; severe lung or cardiac disease; progressive neurodegenerative disease. Further consideration needs to be for patients with known non-adherence; unstable psychiatric disorder; substance abuse; active infection or malignancy [5]. Guidance is constantly changing and the specialist nurse should monitor local and national policies.

The literature indicates the two main barriers to accessing transplantation are socio-economic status and ethnicity [12, 13]. This is particularly apparent in areas when non-White ethnicity people are living in areas of high deprivation. Much work is being done to overcome these barriers and support those who are identified as experiencing difficulty in accessing living donor transplantation. The kidney team at home initiative in the Netherlands has shown that a home-based educational intervention for people with chronic kidney disease results in better knowledge and communication, and more living donor kidney transplants [14].

3.1 Organ Availability

The shortage of organs available for transplant is the primary barrier to transplantation. No country in the world has solved this problem – despite implementation of law changes for “opt-out” of organ donation; national structure reorganization for

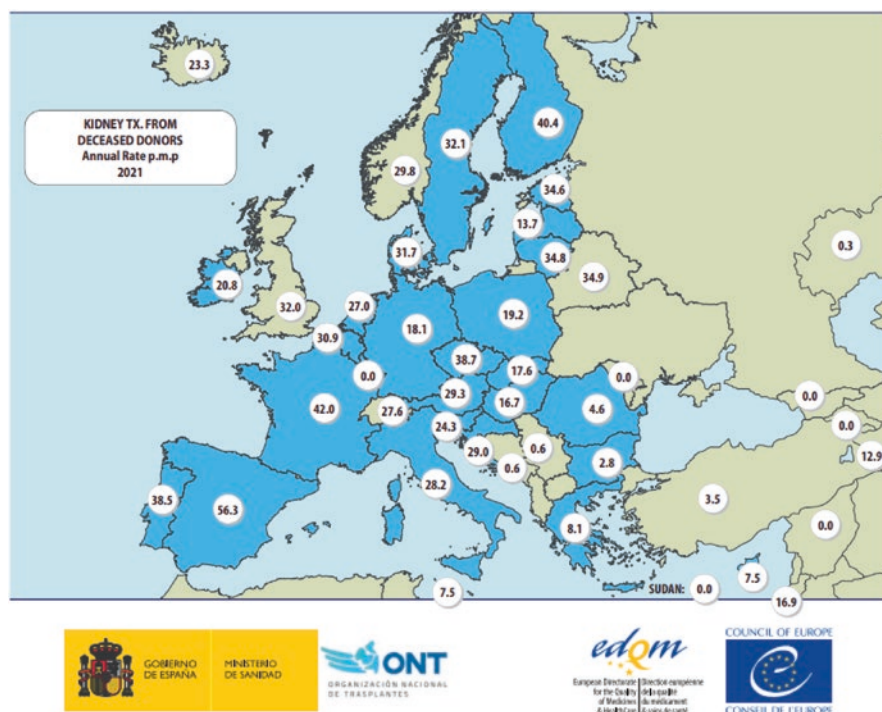


Fig. 1 Council of Europe Rate pmp deceased donor transplants [19]. (Reproduced with permission from Newsletter Transplant 2021, European Directorate for the Quality of Medicines & HealthCare and Organización Nacional de Trasplantes, Spain; ISSN 2171-4118; Volume 27, Strasbourg, 2022. © 2022, Council of Europe and Organización Nacional de Trasplantes)

donor identification in intensive care units; ongoing publicity campaigns [15]. Figure 1 demonstrates the variability of donation and transplant rates within Europe.

Importantly, organ trafficking and transplant tourism is condemned by the worldwide transplant community - The Declaration of Istanbul on Organ Trafficking and Transplant Tourism expresses the determination of donation and transplant professionals that the benefits of transplantation should be maximized and shared equally with reliance on unethical and exploitative practices that have harmed poor and powerless persons around the world [17].

When organs for transplantation are such a precious resource, we need to ensure that each individual patient maximizes their opportunity for a transplant. Along with the initiatives to maximize the number and quality of organs from deceased donors there is potential to increase the living donor pool [18].

In recent years, increasing innovative forms of donation and transplantation has increased the number of living donor transplants. Since the law changed in the UK in 2004 altruistic (anonymous) kidney donation has been allowed. By entering all altruistic donors into the kidney exchange scheme, the actual number of living donor transplants has been maximized.

4 Recipient Assessment

All persons who are approaching end stage kidney failure should be considered for transplantation and the decision documented in their clinical record. This will assist renal unit staff in knowledge of treatment planning and whether it is appropriate to discuss deceased donor listing and living donor transplantation with the person and family. There is known variability in the referral and acceptance onto transplant lists. As many people with kidney disease may be older with more co-morbidities not all are suitable for transplantation. Some studies have shown that less than 30% of those on dialysis are on the transplant list, but this does vary [20, 21].

The Kidney Disease – Improving Global Outcomes (KDIGO) Guidelines have made a series of recommendations to ensure timely and equitable access to transplantation [5]:

All patients with chronic kidney disease (CKD) G4-G5 (glomerular filtration rate [GFR] < 30 ml/min/1.73 m²) who are expected to reach end stage kidney disease (ESKD) should be informed of, educated about, and considered for kidney transplantation

Potential kidney transplant candidates for evaluation should be referred at least 6 to 12 months before anticipated dialysis initiation to facilitate identification/work-up of living donors and plan for possible pre-emptive transplantation

Pre-emptive transplantation with a living kidney donor is the preferred treatment for transplant-eligible patients with CKD

4.1 KDIGO 2020

Many centers will not have age as an actual barrier for transplantation, but increasing co-morbidities may exclude more persons in their older years from a risk/benefit analysis [22]. Complete contraindications to transplantation include severe respiratory or cardiovascular disease, certain malignancies or central neurodegenerative disease. However, these guidelines are continually being revised and all co-morbidities should be taken into context, including adherence and frailty [5].

Routine test for transplant suitability include:

- Laboratory tests such as blood chemistries, full blood count, coagulation profile, liver function tests, virology studies (including CMV, varicella zoster, EBV, hepatitis B, C, and HIV), bone profile (PTH, calcium, phosphate), and prostatic specific antigen (for men above 50–60 years old).

- Chest X-ray, electrocardiogram, breast ultrasound or mammogram (for women aged 50 years and older and for those with a family history of breast cancer) and Pap smear.
- Immunological evaluation: Immunological evaluation includes human leukocyte antigen (HLA) typing; antibody screening to HLA antibodies, and ABO blood group identification.
- Special procedures might be considered in a number of patients based on relevant history and physical assessment, such as etiology of kidney disease and risk of recurrence, history of sensitization (pregnancy, transfusion history, former transplant), old and active infections (hepatitis, TB), cardiovascular risks (smoking, diabetes, hypertension), pulmonary, genitourinary disease, gastrointestinal disease, malignancy, psychiatric and surgical issues (such as obesity, iliac vessels disease, urine outflow, and earlier abdominal surgery). Concerns about adherence to post-transplant medications and treatments require referral prior to listing [23].

Psychological assessment of the recipient is especially important in view of the treatment regimens post-transplant. Failure to adhere to immunosuppressive therapy will increase the risk of loss of the transplanted kidney. It is important that the recipient accepts the support post-transplant [24].

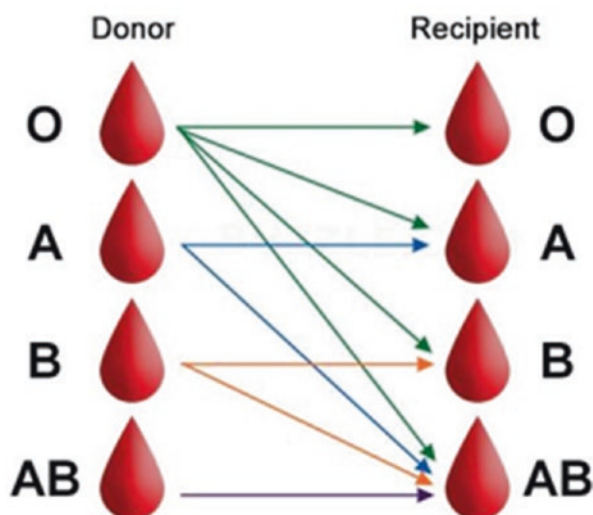
Overall, the assessment of the transplant recipient is similar whether the person is receiving a kidney from a deceased donor or a living donor, with some regulatory differences in living donation depending on the law of the country. In some cases a person may not be suitable to receive a kidney from a deceased donor due to increased frailty or complex surgical issues but may benefit from a planned operation with the kidney being donated from a living donor.

4.2 Tissue Typing and Blood Group Compatibility

Whether the recipient is receiving a kidney from a living donor or deceased donor, blood group compatibility and tissue matching form part of the initial assessment. The majority of kidney transplants will take place between blood group compatible pairs - and follow the same compatibility rules as a blood transfusion (though the Rhesus factor is only taken into account in select circumstances). Blood Group O donors are universal donors, and Blood Group AB can accept from any of the donor blood groups. In the circumstances of a living donor being blood group incompatible with their intended recipient, this can be overcome by entering a kidney sharing scheme or in some cases, depending on antibody levels, undergoing treatment to desensitize the recipient with intense immunosuppression to remove antibodies [25] (Fig. 3).

Tissue typing is important in transplantation as it allows the rejection risk of a donor-recipient pairing to be assessed through reviewing their Human leukocyte antigens (HLA) matching and whether any anti-HLA antibodies present in recipient serum would react with the donor. Closely matched pairs have a lower risk of rejection and improved long-term graft survival compared with poorly matched pairs. Additionally, avoidance of poor HLA matching reduces the risk of recipient sensitization to mismatched HLA which might affect their prospects for future repeat transplantation should it be required [27].

Fig. 3 Blood group compatibility [26]



Waiting on a Transplant – An European Perspective

All transplant “waiting” lists have the aim to ensure the most suitable organ is transplanted into the recipient who is going to benefit most.

Within Europe there are individual countries that facilitate their lists and allocation, such as France. France maintain an allocation system of one kidney allocated nationally and the other kept locally [28].

Spain is well known for the Spanish Model on Organ Donation and Transplantation which helped the country evolve from 14 donors pmp to >30 donors pmp in less than a decade. There is a national program in place to prioritize patients who are highly sensitized. Despite the high deceased organ donation rates there is still not enough kidneys to meet demand, and there is a current focus on facilitating pre-emptive living donor transplantation [28].

Eurotransplant acts as a mediator between donor and recipient for the optimal allocation of organs between Austria, Belgium, Croatia, Germany, Hungary, Luxembourg, the Netherlands, and Slovenia (total 137 million people) [29].

ScandiTransplant is the organ exchange program for Denmark, Finland, Iceland, Norway, Sweden, and Estonia which covers a population of 28.9 million people.

NHS Blood and Transplant (NHSBT) maintain the kidney transplant for the United Kingdom. In common with the other allocation organizations, a complex mathematical process calculates the best possible recipient for the offer of a deceased donor kidney. Factors which are taken into account include compatibility, length of time on list, tissue type matching, age, antibody sensitization, and difficulty in matching [8].

The European Organs Directive lays down the quality and safety standards for organs. It covers all steps in the transplant process from donation, through procurement, testing, handling to distribution [30].

5 Living Donation

Living donation starts and stops with the recipient – if the person with kidney failure is unsure about the benefits and risks of a living donor transplant and the impact on the donor they will not openly discuss it with family and friends. People considering living donor transplant report feeling uncomfortable asking others to donate, due to concerns about risks to the donor, thus ruling out the option of living donation even before fully understanding its advantages [31].

Renal teams require to address recipient concerns about living donation to allow potential donors to come forward. Early education and information are the keys to promoting pre-emptive living donor transplantation. People may often be overwhelmed with information about their kidney disease and treatment options when attending hospital clinic appointments [32]. They may not broach the subject of living donation due to difficulties in approaching the family and social networks due to reluctance to “ask” for a kidney [33].

It is recommended that donor and recipient have separate clinical teams, who work together to ensure effective communication and co-ordination of the transplant process without compromising the independence of either donor or recipient [16].

It is very important for potential donors approaching the living donor teams that they have correct contact details for the living donor team. Many donors will not have had any interaction with hospital services before (as they are often fit and healthy individuals). Even making the first initial contact with hospital services can be daunting; – donors report that a positive initial contact telephone conversation can reassure donors. In countries where altruistic donation is permitted signposting to the correct service requires a clear pathway, as they do not have a recipient to direct them to the living donation team.

Legal frameworks are in place in living kidney donation to protect both the donor and recipient. The donor is undergoing an operation they do not need on a clinical basis, so the sole aspects to be considered are the risks they are undertaking. When the risk–benefit has to be discussed, the analysis should focus on these risks (as direct benefits to the donor are marginal) compared to the potential benefits for the patient to be transplanted [4].

Living donor teams ensure that strict selection and thorough assessment minimize the risks for the donor and maximize the benefits for the recipient. Donor candidates undergo a thorough medical, surgical, and psychosocial evaluation by a multi-disciplinary team [34].

Informing potential donors about the risks of donation is an ongoing process, and often repeated by all the healthcare professionals that the donor meets. The risks to the living donor are both short and long term, with the risk of death being estimated at 1 in 3000. The longer term risk of living with a solitary kidney is quantified by large studies worldwide, with the lifetime risk of developing end stage renal disease low at 0.5%, however, donating a kidney does increase this risk. Genetics and immunologic factors were identified as increasing the risk factor [16]. It is important for living donor teams to ensure local complication data and outcomes are available for potential donors and recipients to assist with informed consent.

Table 1 Routine living donor investigations [16]

Urinalysis	Chest X-Ray
Blood tests – Hematology, biochemistry, blood glucose, blood group and tissue typing	Electrocardiogram
Virology and infection screen	Isotope Glomerular Filtration Rate (GFR)
Magnetic Resonance Imaging (MRA)/CT scan	Legal requirements of the governing bodies

There are a number of national and international guidelines which provide comprehensive guidance on the assessment and follow-up of living kidney donors [16] [34]. Countries will also follow their legal framework to ensure the integrity of programs. As previously discussed, trafficking of organs and transplant tourism is condemned by the transplant community. Legal frameworks also aim to ensure that donors are not coerced into donating and the donor is fully aware of the risks involved [34].

The table of routine donor investigations demonstrates routine screening as described in the British Transplant Society/Renal Association Guidelines in the UK, which will be similar to most European countries, however there will remain variation between local protocols (Table 1).

Living donor transplant is successful in the short and long term for a number of reasons - it can be planned to avoid the recipient requiring dialysis, a minimal cold ischemic time and the kidney comes from a fit and healthy individual with adequate renal function. To maximize these benefits, centers need to adapt their programs to ensure:

- Early education and referral to ensure recipient is a good transplant candidate.
- Early donor assessment to ensure donor is ready to donate before the recipient needs dialysis (donors may be excluded on medical, immunological or psychological grounds and another donor work up commenced).
- Theater access to minimize the time the kidney is without a blood supply (cold ischemic time). Ideally operations should happen simultaneously. In the case of a kidney sharing scheme when living donor kidneys are being transported round the country timing of surgery and transport are essential to minimize cold ischemic time.

6 Kidney Sharing Scheme

It is estimated that approximately 40% of living donors are incompatible with their intended recipient. Some countries have established Kidney Exchange Programmes (KEP) which aim to match donors to recipients in optimal combinations for kidney exchange within the pool. By optimizing the use of living donor kidneys, overall kidney transplantation rates could substantially increase in many European countries, yielding improved access to transplantation, better recipient outcomes, and reduced dialysis costs [35] (Fig. 4).

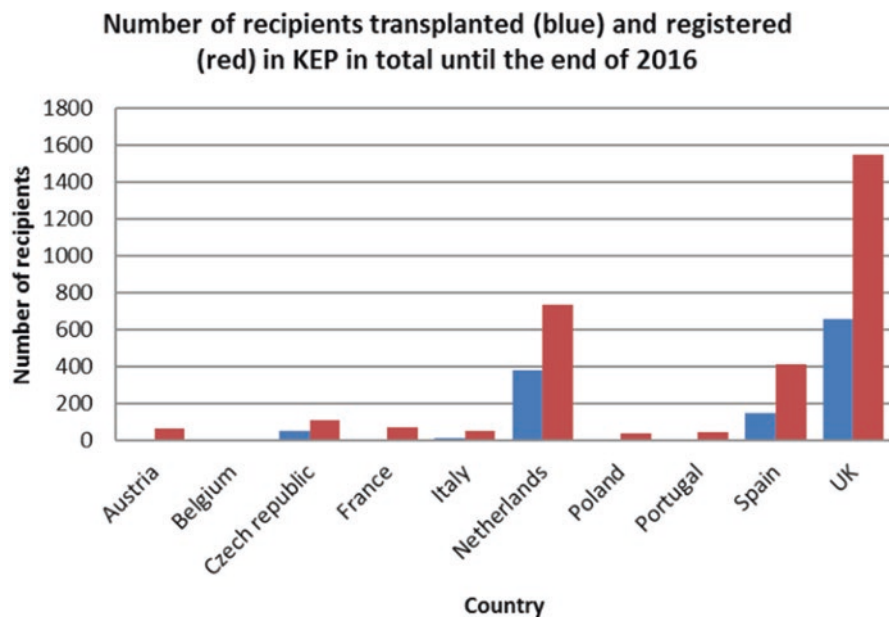


Fig. 4 Kidney Exchange Programmes in Europe [35]

7 Surgery and Complications

Whether the transplant is pre-planned from a living donor or allocated via a national scheme from a deceased donor, the recipient will require several tests to be done before the transplant proceeds, including ensuring the person is fit enough for surgery and the potential recipient does not have any antibodies toward the donor kidney (crossmatch). With living donation these tests can be pre-planned with time for multi-disciplinary review, when an offer comes from a deceased donor then time is critical. Deceased donor transplant centers have a well-rehearsed system to call the recipient in for pre-operative tests while the kidney is being transported by the quickest route. Often in the case of living donor transplantation the donor and recipient operations can be done simultaneously in adjoining operating theaters. In both situations keeping the cold ischemic time to a minimum is key.

The transplant operation usually takes around 2–4 h with the recipient receiving a general anesthetic. The donor kidney is placed in either the right or left iliac fossa, the donor artery connected to the iliac artery and vein connected to the iliac vein, with the ureter connected directly to the bladder. Unless indicated the recipient's own kidneys will be left in situ [8]. No surgery is without risk, and a transplant is a unique operation (Table 2).

Table 2 Post operative complications [8]

Early risks	Later risks
Bleeding/infection	Infection from the donor kidney (i.e., CMV)
Delayed graft function/rejection	Rejection
Urine leakage/nerve damage	Hernia
Damaged blood supply to the leg	Blood vessel narrowing
Blood clots inside the kidney transplant	Increased risk of some cancers
Deep vein thrombosis/stroke	Side effects of immunosuppressants

8 Follow-Up and Immunosuppression

As with the allocation and transplant operation, the focus of follow-up is to maximize the benefit of the transplant and preserve function. For the transplant recipient, immediately post-operative is an intense period of monitoring and adjustment. The success of transplantation has been widely due to the development of immunosuppressive therapy. In most cases the transplant recipient will be required to take immunosuppressants for as long as the kidney is functioning. Rejection will destroy renal tissue so the primary aim of immunosuppressive therapy is to avoid rejection [36].

During the early phase after the transplant, prevention of acute rejection and infection are the priority. After around 3–6 months, the priorities change to preservation of transplant function and avoiding the long-term complications of immunosuppressive medication. The potential complications include heart disease, infection, cancer, bone disease, and blood disorders [36]. Careful monitoring and education support the recipient to be alert for complications.

Immunosuppressive therapy aims to prevent acute rejection and optimize the function of the transplanted kidney, while minimizing the adverse effects of immunosuppression (such as increased risk of infection, cancer, diabetes, and cardiovascular disease). Immunosuppressive therapy can be categorized as induction therapy or maintenance therapy. Induction therapy is an intensive immunosuppression regimen that is used for up to 2 weeks around the time of transplant and may include polyclonal or monoclonal antibodies. Maintenance therapy starts immediately after transplant and continues for life.

NICE guidelines 2017 [37].

9 Living Donor Follow-Up

It is recommended that all living kidney donors receive an annual follow-up appointment. This should include measurement of blood pressure, serum creatinine, and urinary protein and general health check [34]. Referral options to specialists should be made if any concerns arise about blood pressure management or kidney function are present.

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Management of the Elderly Patient with Kidney Disease

Sofia Zyga and Victoria Alikari

Learning Objectives

- To describe the different symptoms that people who suffer from end stage kidney disease experience.
- To identify the palliative care needs of elderly people with end stage kidney disease.

1 Prevalence of ESKD in Elderly Patients

Aging is the progressive deterioration of the organism over the years and is usually measured by chronological age. A person aged ≥ 65 is often referred to as an “elderly.” The aging process differs between populations due to differences in genetic characteristics and lifestyle. Thus, there are no specific definitions of “elderly” that adequately characterize this patient population [1]. The changes that take place in the human body and lead to old age frighten people because they cannot reverse or avoid them. Morbidity and vulnerability increase significantly, survival curves show a rapid decline while the frequency of accidents increases. More important is the fact that significant changes are expected in human functions (functioning of vital organs, vision, hearing) [2].

Over the past years, profound demographic changes have caused the rapid aging of the world’s population. This phenomenon had an exponential rate, especially in advanced countries [3]. Until the late 1970s, people over the age of 55–60 were

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considered “elderly” and sometimes candidates for some form of kidney replacement therapy [4].

The prevalence of End Stage Kidney Disease (ESKD) has increased significantly in recent decades, and the diagnosis of ESKD is expected to be more common. Based on estimates provided by the Chronic Kidney Disease Surveillance System, in 2018 the point prevalence among U.S. residents adjusted by age was 7.232/million for >75 years old and 7.401/million for residents 65–74 years old. The corresponding results in the U.S. for 2008 were 6.098/million for >75 years old and 6.530/for 65–74 years old [5]. The reasons for the increase in the diagnosis of chronic kidney disease (CKD) can be traced essentially to longevity in industrialized countries. The analysis of epidemiological data reveals that most CKD diagnoses concern people of advanced age (>65 years) and are mainly diagnosed with stage III (mild to moderate kidney dysfunction) [6]. It is estimated that more than one-third of the general population aged >70 years suffer from CKD, defined by an estimated decline in GFR (eGFR) <60 ml/min/1.73m² [7].

2 Factors Increasing the Frequency of ESKD in the Elderly Patients

Several specific factors have played a particular role in the favorable increase in the number of elderly people starting kidney replacement therapy. Over the past decades, the most common causes of ESKD have changed. In addition to the “epidemic” increase of diabetic nephropathy, in the elderly population kidney failure is often secondary to vascular disease (nephrosclerosis, kidney disease) or endovascular procedures [8, 9]. Complications from the use of drugs such as angiotensin-converting enzyme inhibitors, angiotensin II Receptor blockers, nonsteroidal anti-inflammatory drugs, and nephrotoxic oncology treatments are also very common. In many of these cases, the diagnosis is acute kidney failure, but the prognosis is much worse as up to 30% of people eventually enter some type of kidney replacement therapy [10]. Ultimately, the increase in the number of elderly people on kidney replacement therapy seems to be the inevitable price of aggressive treatment of cardiovascular and cancer diseases.

It is still unclear whether the decline in kidney function that can occur in the elderly is due to an ongoing pathological process or whether it can be considered, at least in part, as a result of normal aging of the body [11]. Above all, it is important to investigate whether mild to moderate kidney dysfunction in an elderly person can lead to a worse prognosis compared to a healthy person. Recent studies [12, 13] have aimed to evaluate the characteristics of kidney disease in the elderly and to compare the effects resulting from a decrease in eGFR in different age groups, verifying whether the prognosis may be different between the young and the elderly.

3 Comorbidity

The very high incidence of major comorbidity in the population over 75 years of age is a common finding in people under dialysis. A 45% of these people are multimorbid with two or more serious illnesses such as diabetes, hypertension, and hyperlipidemia [14]. Mortality, both from cardiovascular causes and from other diseases, is very high in people on HD compared with the general population of the same age [15]. The gap between the incidence of cardiovascular disease in people on HD and the general population increases and exceeds 90–130% in the population over 75 years of age [16]. In a study of 139 people on HD over 75 years of age followed up for 3 years, less than one admission per year, (averaging 12 days/year), per patient was reported [17].

The problem of heart failure deserves special mention. In the last decades, heart failure has been increasingly added to the classic “metabolic” indications for starting kidney replacement therapy [18]. This group of people often starts kidney replacement therapy with relatively residual kidney function, either unplanned or emergently. The use of catheters for vascular access is almost universal in such cases.

Of particular importance in the elderly population are other medical problems such as cognitive decline [19], mental disorders, and motor problems [20] that make the elderly partially or completely dependent in daily activities. A frequent consequence of this condition is malnutrition, the prognostic importance of which in dialysis has been recognized [21].

4 Assessment of Kidney Function in the Elderly

According to a recent study [22], 11% of people over the age of 65 meet the diagnostic criteria of CKD stage III. Of these individuals, only a minority develop proteinuria and less than 0.1% per year will develop CKD and undergo dialysis [9]. This large proportion of individuals classified as ill must therefore be interpreted with extreme caution. First, prevalence studies conducted in the general population are often based on individual assessments of kidney function and do not take into account the criterion of at least three months of chronicity recommended by the guidelines. CKD prevalence estimates can be significantly changed by changing the observation period of people from the minimum 3 months recommended by the guidelines to 6 months for stage 3, 2.0 months for stage 4, and 1.2 months for stage 5 meaning that the lower the stage of CKD the longer the observational time. Therefore, observation of the patient over time and periodic monitoring of kidney function appears to more accurately select those who are truly suffering from the disease and would allow individuals with transient mild or acute changes in kidney function to be excluded from the diagnosis of CKD [23].

5 Structural and Functional Alterations in the Aging Kidney

Over the years, significant structural modifications occur in the kidneys that affect the thickness of the cortex. On average, at the age of 50–80 years, the kidney diameter can decrease up to 2 cm. In the elderly, the kidneys usually have a smooth or granular surface. In the glomeruli, the basement membrane thickens. The number of sclerosing glomeruli increases, especially the cortical ones. Glomerulosclerosis, interstitial fibrosis, tubular atrophy, arteriosclerosis, arteriolar hyalinosis, tubular diverticuli, and nephron hypertrophy are common in histological specimens. Simultaneously with alterations of the afferent and efferent glomerular arterioles, mainly in the medullary, shunts are established between the afferent and efferent arterioles. Interstitial fibrosis occurs widely, particularly in the medulla [11].

The structural changes lead to a decrease in glomerular filtration, on average from 130 to 80 ml/min between the ages of 30 and 80, with an emphasis after the age of 65. Despite the decrease in creatinine clearance values, creatinine levels tend to remain unchanged for a long time due to its lower production by muscle mass which, with aging, decreases. Kidney blood flow, particularly cortical blood flow, is reduced and vascular resistances are increased. Nocturia becomes frequent. Albuminuria increases with age. Kidney functional reserve, urine concentrating capacity, immediate elimination of water and sodium load, and sodium retention in acutely restrictive situations are reduced. Instead, the ability to retain it in conditions of chronic reduction of its intake is preserved [24].

The pathological processes that are usually responsible for the chronic anatomic-functional changes in the elderly are as follows:

- (a) Vascular nephrosclerosis, atherosclerosis, arterial hypertension.
- (b) Dyslipidemia, hyperuricemia, obesity, metabolic syndrome, smoking, heart failure, diabetes, possibly undetected current or previous infections, and side effects of medications (especially anti-inflammatories and antibiotics).
- (c) Primary and secondary parenchymal vascular, glomerular, interstitial nephropathies, urinary tract obstruction, nephrolithiasis [11, 24].

6 The Elderly Patient on HD

Numerous physiological and psychological changes due to age can affect the success of the HD regimen. Of particular importance is the frequency with which hemodynamic changes occur resulting in hypotensive episodes during HD sessions [25]. Reduced secondary cardiovascular function, heart failure, arteriosclerosis, or dysfunction make elderly people particularly susceptible to complications [26]. When planning an HD regimen, it is especially important to reduce the ultrafiltration rate and/or use ultrafiltration techniques.

Changes in protein metabolism and a tendency to malnutrition are common in the elderly population. Psychosocial (apathy, tendency to depression, reduced mobility) and financial problems contribute to this situation. Anorexia, nausea, and fatigue that commonly occur after each HD session can significantly worsen the clinical condition. Ensuring adequate consumption of protein, calories, vitamins, and minerals is not easy [27].

Cognitive decline and mobility problems due to diseases of the musculoskeletal system or strokes make the patient often a partially or fully dependent elderly person. At the same time, the lack of a structured family unit or, in any case, the unavailability of family members requires the assistance of formal caregivers or admission to special facilities [28]. Ultimately, the success of an HD program in older adults is highly dependent on a well-organized multidisciplinary structure, ideally including nephrologists, nurses, dietitians, social workers, and psychologists [29].

7 Vascular Access

Common guidelines for establishing vascular access are primarily concerned with the type of access preferred and the ideal timing with respect to the progression of kidney disease. As is well known, the native radial-cephalic arteriovenous fistula (AVF, anastomosis of the radial artery and the cephalic vein) is preferred first, followed by the brachial-cephalic, the brachial-basilic and, finally, the synthetic grafts. When there is adequate preoperative planning, autogenous access patency rates in elderly people over 80 years of age are similar to younger people [30]. Creation of autogenous access in the elderly should ideally occur at least 4 months before the intended dialysis start date due to the low risk of sepsis and death. Permanent intra-vascular catheters should be avoided because of the risk of bloodstream infections [31].

The change of the modality in the elderly typically involves switching from peritoneal dialysis (PD) to hemodialysis (HD) and is mainly due to recurrent peritonitis, loss of ultrafiltration, or catheter malfunction [32]. Thus, a patient with ESKD who is older than 85 might initially benefit from PD by avoiding the infectious complications associated with the use of central venous catheters and potentially sparing vascular access sites, but the long-term benefits of this tactic are reduced due to a higher incidence of acute method loss and unplanned transition to a central catheter. One strategy to optimize the benefits of dialysis in the elderly would be to establish permanent vascular access before the loss of PD [33].

8 HD or Peritoneal Dialysis?

Elderly people undergo PD less often than HD, even in countries where PD is a relatively popular type of treatment. This is the case in many European countries [34] where the frequency of PD in people over 75 years of age is approximately only 12% [35]. These data are not surprising, since PD may have several advantages

(such as patient autonomy), but physical problems such as vision or hearing problems, poor mobility, and cognitive decline do not favor its application [35]. The Study Group on Geriatric Nephrology of the Italian Society of Nephrology showed no difference between people <65 years old and ≥ 65 in terms of quality of life, peritonitis rates, and hospitalizations [36].

9 Kidney Transplantation

At the beginning of 1990, the elderly was considered to be over 60 years old. In recent years, both in the USA and in Europe, the number of people on the waiting lists has been increasing mainly among people over 70 years old. If recipients older than 70 years old are well selected, kidney transplantation is a good option since elderly people present good outcomes after kidney transplantation. Therefore, the age of the donor or recipient alone should not exclude this option [37].

In the USA, kidneys are given according to the waiting time on the list, while in Europe they are given according to the donor-recipient age criteria, i.e., the transplants are given to people of the same age group (program “old for old”) [38]. The probability of a good outcome is increased if:

- It is the first transplant.
- The cold ischemia time is short.
- The kidney was not injured during the surgeries.
- The graft worked quickly postoperatively.

10 Functionality

The aging of people on HD is accompanied by an increasing proportion of people who are not just elderly but essentially “frail” and suffering from multiple comorbidities [39]. This “fragility” often leads to a significant loss of functional autonomy and compromises both quality of life and dialysis tolerance (frequent transports, hospitalizations, and psychological dependence on the lifesaving HD session). In this situation, nurses should reassess the risk-benefit relationship associated with kidney function replacement. Functional status declines significantly within 6 months of starting HD in a large amount of frail elderly people, with an increasing need for home nursing support. This loss is due to isolation from daily activities as for these people, more than half of the survival days gained by kidney replacement therapy were taken up by HD sessions or hospital admissions [20, 40].

Several criteria have been proposed to better classify elderly people on HD into “healthy,” “vulnerable,” or “frail” [41]. According to this classification, chronological age is combined with certain scales to quantify, for example, functional autonomy (Karnofsky Performance Scale), degree of comorbidity (Charlson Comorbidity Index), and geriatric syndrome so that it is more possible to identify people who are more suitable for HD compared to more fragile people [41].

11 Falls

CKD is an important risk factor for falls, attributed to progressive decline in both endocrine and exocrine kidney function. Elderly people >65 years old on dialysis have a higher incidence of falls than subjects with residual kidney function [42]. The highest incidence of falls was attributed to the deficiency of the activated form of vitamin D. In addition, several cytokines interfere with the process of muscle degeneration in the ESKD patients and therefore increases the risk of falls [43].

12 Palliative Care in Elderly Patients with CKD

There are three groups of people who are eligible for palliative care. The first group is the one that prefers to withdraw from dialysis to pursue conservative care. In this case, particular attention is paid to the relief of the symptoms and complications of the disease while slowing down the deterioration of the existing kidney function. This phase can last 1–2 years. The second group is those who start HD in good clinical condition but soon suffer from the burden of symptoms and are less able to tolerate HD. The focal point is the symptom control and may include reducing the frequency of HD sessions. The third group includes people with progressive diseases that cause CKD and for whom the prognosis is poor. The approach that combines symptom management and palliative care is in the right direction [44, 45].

Palliative care in ESKD includes clinical and psychological management and moral and spiritual care with skilled health professionals. The integration of palliative care into the care of people with CKD is influenced by the views, perceptions, and knowledge of healthcare professionals. Comorbidities, family and social support are significant factors in clinical decisions. However, family and/or patient indecisiveness can complicate and disrupt end of life care planning [46].

13 Health-Related Quality of Life in the Elderly

Regardless of the type of dialysis method used, the initiation of PD or HD has a significant impact on the quality of life of the elderly patient. The mandatory HD session, the numerous physical difficulties associated with the treatment (fistula puncture, muscle cramps, abdominal pain, itching), food restrictions, and the difficulty of restricting fluid intake affect not only personal habits, but also social and family relationships by changing the patient's role in the family and work. The family must adapt to the patient's changing living conditions and the rhythms imposed by the disease and treatment. The dependence on both the machine and the nephrology nurses, as well as the fear of death, are factors of psychological distress in elderly people on HD. Elderly people on HD experience feelings of helplessness, dependency, need for long-term care, loss of social roles, social isolation, loneliness, depression, and, sometimes, a lack of meaning in life [47, 48].

It is noteworthy that in several studies younger age is associated with lower health-related quality of life in the psychological domain but higher in the physical domain. More specifically, a study showed that age is inversely related to factors such as emotional problems which were more common in younger people on HD compared to older ones [49]. In another study, younger people experience more mental fatigue than elderly patients indicating more problems for young people in terms of the mental domain [50]. Also, elderly patients report that they use religious and spiritual coping strategies and feel more satisfied with their lives. More generally, it seems that elderly people on HD show better psychosocial adaptation to HD than younger people but experience more limitations in physical function [51].

14 Case Study

Mrs. Ana is an 81-year-old woman with CKD stage 4 who lives at home with her husband and daughter. She is cured by a nephrologist. Due to the Parkinson's disease, she suffers from, she cannot easily take care of herself and receives help from her daughter for basic daily needs such as cooking, toileting, and dressing. She presents with swelling in her lower limbs and blood pressure of 190/110 mmHg with respiratory distress. She has been informed about the possibility of an HD program but she refuses it. She has distended jugular veins and creatinine of 5 mg/dl. Despite the administration of furosemide in an increased dose, the blood pressure remained high and her creatinine was now approaching 6 mg/dl. The nephrologist again talked to her about HD. Ms. XXX insisted on not joining the HD program and she wanted to know what her options were.

15 Analysis

Ana is an elderly patient with CKD and Parkinson's disease. She is largely dependent on her daughter and husband for her basic daily needs. The increased dose of furosemide did not lead to the relief of symptoms. Taking into account the patient's right to participate in clinical decision-making, conservative nephrological care and an interdisciplinary approach (by a nephrologist, nurse, and psychologist) will be applied to Ana. Also, spiritual care through multidisciplinary team is a very relevant part of palliative care.

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Psychosocial Approach in People with CKD: Psychosocial Implications

Mike Kelly

Learning Objectives

- To understand the psychosocial factors that impact on quality of life in people with chronic kidney disease (CKD).
- To identify coping strategies for people with CKD.
- To describe nurse's role in a psychosocial approach.

1 Introduction

The psychosocial consequences for those diagnosed with chronic kidney disease (CKD) are well documented [1, 2]. Cameron in his review of the history of dialysis clearly links the physical symptoms associated with long-term dialysis with the psychological factors patients face as well [3]. Today the term quality of life (QoL) encompasses these and other factors that impact on the person with CKD. A study by Finnegan-John et al. (2013) showed that the psychological burden of the patients has to contend with impacts on their QoL [4]. Hence, quality of life is increasingly being considered as an important measure of how disease affects patients' lives, especially in long-term diseases like chronic kidney failure [5].

The World Health Organization defines QoL as an individual's perception of their position in life in the context of the culture and value systems in which they live and in relation to their goals, expectations, standards, and concerns [6]. While this definition is generally accepted, it is very broad and to a large degree dependent on the person's individual perception. It is necessary to take into consideration

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every individual's perception in order to assess and understand their personal QoL as it is unique to each one.

In this chapter we would like to look at some of the psychosocial factors that impact on the QoL of people with CKD as well as the influence on how they view their illness, themselves and the world of living with a chronic illness.

2 Psychosocial Reaction When Receiving the Diagnosis of CKD

The moment when a person is told he/she suffers from CKD is described in different terms. Some describe it as a shock, others describe it as feeling stunned. While many people appear to continue with life as normal, internally a profound change is taking place often accompanied by an overwhelming state of anxiety and panic. This marks the beginning of the psychological reaction to diagnosis, the beginning of a journey that may be long and distressing [7].

What people are experiencing is a sense of loss; that the life they have lived, the way they behaved, and the freedom that life gave them is now curtailed and that significant changes now had to be made in terms of lifestyle and behavior. Many describe it as the mind going numb and a loss that is akin to a grieving process which one person with CKD described as a strange and uncertain process, with no rules or guidelines or time limit to it [8].

3 Coping Strategies When Suffering from CKD

When confronted with different situations in life, people adopt different coping styles and mechanisms. For example, denial is employed if there is something to be avoided rather than faced. The fear of being overwhelmed can lead to depression or may provoke an angry response. People with CKD are no different. Some may use denial as a way of coping with their diagnosis. Denial may not always be negative but as Fitzgerald Miller says "denial might be helpful early in the chronic illness, however if this method of avoidance continues to such extremes that treatment is not sought or abandoned, then the denial is no longer effective" [9]. Depression is another common coping mechanism. A survey by Kidney Research UK found that 67% of respondents experienced symptoms of depression [10]. People with symptoms of depression should be monitored carefully.

Anger is another common response. Anger is an emotion that is both basic and necessary to human nature. It is often perceived as negative but the problem is not the emotion but the way it finds expression. Anger, which Bowlby notes has "habitually been underestimated, at least by clinicians, to whom it seems to have appeared out of place and irrational" [11]. In those diagnosed with CKD it is important that nurses acknowledge a person's anger as failure to do so may be "subtly telling the client that this expression is not appropriate" [12]. If this happens then the first nurses will know

there is a problem when something like a breakdown, however that may manifest itself, occurs.

4 Nurse's Role in People Suffering CKD: Psychosocial Approach

Nurses can play a pivotal role in both challenging and supporting the persons coping style. As Nichols rightly says, “a small amount of effort at inquiry will reveal sufficient concerning a patient’s psychological state to allow for a general impression” [13]. This should help identify what coping style and what coping strategy the person is employing. Fitzgerald Miller reminds us of the imperative of identifying the individual patient’s coping mechanisms. Two questions to keep in mind are: what coping mechanism is this patient employing to deal with the ups and downs of treatment? And are their coping mechanisms of benefit or not? [9] What is key, according to Nichols is that the basic psychological state should be noticed and action should be taken from there [13].

This is particularly true when it comes to imparting information, which often has to be given when the person with CKD is experiencing psychological trauma. Awareness of the patient’s psychological state and the coping mechanisms employed can inform nurses, enabling them to support their patient’s adjustment to their condition [14]. Therefore, knowledge of the person with CKD’s coping mechanisms can enable the nurse to tailor what information to give and how much of it to give in a way that supports the coping style of the person. If too much or too little information is given, the person’s psychological trauma may be exacerbated. Should this happen, it will impact on the patient’s ability to cope and adapt to their illness [4]. In this regard the nurse also needs to be conscious that they “may unwittingly style helpful client strategies, making judgments about what they themselves would do in similar circumstances instead of objectively evaluating the client selected strategies and supporting those that are effective” [9].

5 Behavioral Change When Suffering from CKD

It is at this turbulent time, when confusion and uncertainly reign, when people are feeling vulnerable, that people with CKD have to negotiate significant changes in their life. As Ryan observes patients are challenged to make significant behavioral change at a time of vulnerability [15]. And as Dr. Thomas remarked that while he understood his diagnosis his “brain just would not let me get there” [7]. Not only are people with CKD challenged to change behavior patterns but they also may have to make a number of significant behavioral changes shortly after diagnosis [15]. Making significant changes in behavior as a result of a diagnosis of CKD is difficult. The psychosocial impact often impedes change as is seen in the results of a survey carried out by Kidney Research UK. Thirty-six percent of respondents believed that because of the psychological problems they encountered, their ability to take care of

themselves was compromised, limiting their capacity to make the necessary behavioral changes [10].

6 Nurse's Role in Facilitating Behavioral Change

Nurses play a key role in supporting the person with CKD negotiate these changes. Nurses will often be the ones who will monitor these behavioral changes and need to be sensitive to how the person behaves, especially in the early stages when there may be some resistance to change. As Ryan notes “inability to change behavior can decrease one's sense of power” [15] leading to a feeling that one's personal freedom and control is limited with the knock-on effect this has on QoL [4]. For the nurse the skill is in bringing the person with CKD to the point where they see the value in making these behavioral changes and that the structure put in place to support them is achievable. To do this the nurse must make sure that behavior change must be tailored to the individual's lifestyle. New behaviors should fit with routines and preferences [15].

The ability to support people with CKD, particularly following diagnosis, is predicated on good communication. If quality and compassionate nursing care is central, then good communication skills are vital [16]. Good communication depends on the nurse acknowledging that each person with CKD is unique, that each one has different needs and abilities, and that the nurse has some understanding of the person with CKD's communicating style. The nurses' role therefore is to “establish the patients' linguistic and intellectual capabilities and then moderate content, language, visual aids and pace and cater for these” [13].

Information giving is an important feature following diagnosis. The nurse needs to be aware of the person with CKD's needs when it comes to imparting information. Part of good psychosocial care is keeping the person informed. However, for some people with CKD this is not essential. Some people with CKD can adopt a passive stance. They may do this fearing that information about their condition could overwhelm them. To protect themselves they seek as little information as possible. Some who do not want to receive information about their condition or treatment may not also give information. Following a review with a patient, a nurse expressed her frustration at the person's failure to communicate with her. The nurse had asked the person with CKD to weigh themselves each day between clinic appointments as the nurse wished to monitor the person's weight gain/loss. When the nurse asked for this information, the person informed her that they could not carry out the task as they had no weighing scales at home.

7 The Importance and Value of Providing Psychosocial Care to Patients with CKD

There is no doubt that providing psychosocial care has positive outcomes. The results of a study by Reiss and Sandborn showed that the provision of “satisfactory psychosocial care improves QoL and reduces the total economic strain on the health care system” [17]. In an era where there is an emphasis on cost effectiveness in health care, which in Nichol’s view moved the emphasis “from quality of patient care to money care” [13], note should be taken of the result of this study. As Han et al. rightly point out patients have to contend with not only physical and psychological symptoms but also significant social and behavioral change that impact on the patient’s QoL. Such momentous change calls for a robust, comprehensive, and integrated approach that offers the necessary support to patients [18]. Yet the reality is often quite different. The reality, as a study by Kelly et al. highlighted, that the provision of such services is “patchy rather than uniform” [19]. The result, as the study by Kidney Research UK showed; 68% of respondents, people with CKD, are not being offered mental health support [10]. This suggests there is a long way to go before a robust psychosocial structure is in place to support people with CKD in the psychosocial struggles, they face following diagnosis.

Nurses and health care professionals can and do a lot to support people with CKD and help them come to terms with their life changing condition. The end result for all this effort is, perhaps, summed up by a person with CKD who concluded that “sometimes, when an illness can’t be got rid of, then what can be cured is how we view it, deal with it and learn to live with it. Often acceptance is the best cure at the end of the day” [8]. Nurses and health care professionals are well placed to support those with CKD on this journey toward acceptance.

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Quality of Life in People Receiving Kidney Replacement Therapy

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Learning Objectives

- To Understand psychosocial aspects of people who are under chronic hemodialysis and peritoneal therapy.
- To examine the perception of pain in people who are on chronic hemodialysis therapy and analyze the relationships between their pain, anxiety, and depression.
- To identify emotional intelligence skills and its relationship to quality of life in patients undergoing chronic hemodialysis therapy.
- To detect indicators of quality of life in order to use specific health interventions.
- To identify therapeutic adherence factors in people with peritoneal dialysis.
- To distinguish the implications for nursing practice when caring for people with chronic hemodialysis and peritoneal dialysis.

1 Introduction

Chronic kidney disease (CKD) is a major incurable illness [1] and the most common therapy used worldwide is hemodialysis (HD) [2], which entails an absolute life dependency on an external blood filtering machine. Therefore, the life of patients undergoing chronic HD therapy is subject to different stressful and disturbing

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situations. Complications stemming from HD therapy, and which may interfere in different areas of quality of life, are physical (loss of normal body function, sleep disorders, HD complications); psychological (pain, anxiety, depression, fatigue, self-image disturbance, decreased quality of life); and social (role change, perception of the disease, time in dialysis unit) (Table 1). [3].

2 Quality of Life in HD Patients

Research into the regulation and management of emotions and its potential implications for quality of life has aroused great interest in all areas in the past years [4, 5]. Numerous studies show the impact that quality of life has toward physical and mental health [6]. Moreover, health-related quality of life is a concept that is closely influenced by an individual’s perception of their physical and psychological state, level of independence, social relations, and their relationship with the environment [7].

Measurement of quality of life is subjective to each individual and involves multidimensional areas including physical, emotional, social function, and treatment effectiveness from patients [8]. Many different instruments have been used to assess quality of life including generic and disease-specific instruments. The generic instruments (e.g., 36-Item Short Form Health Survey (SF-36) [9], European Quality of Life-5 Dimensions (EQ- 5D), the World Health Organization Quality of Life-BREF (WHOQOL-BREF), diabetes-specific quality of life) measure overall health and functions whereas the disease-specific instrument is used to focus on individual symptoms of a specific disease (e.g., Kidney Disease Quality of Life (KDQOL) [10], Quality of Life Index-Dialysis, and Transplantation). Nevertheless, there is no consensus about standard instrument to measure the quality of life. Using ideal tools and procedures for routine data collection of quality of life in the clinic setting will assist both clinicians and researchers by providing reliable information on quality of life.

HD therapy is not free of complications or changes in the lives of patients and their relatives. While technology has managed to decrease the mortality of patients with CKD and improve the replacement therapy modalities of renal function, morbidity risk for patients with CKD continues to increase due to the existence of negative mental and physical impacts that affect their health-related quality of life [9]. Additionally, quality of life of patients on HD is affected by emotion-focused coping strategies and cognitive processing, which can both be affected by

Table 1 Independent variables related to Quality of Life in patients under chronic HD therapy [3]

Physical	Psychological	Social
Sleep disorders	Anxiety	Role change
Loss of body function	Depression	Perception of the disease
HD complications	Self-image disturbance	
Pain	Fatigue	
Disease responsible for CKD		

socio-environmental and situational factors [10]. This way, the perception of quality of life is different to each individual and health care professionals need to take that into consideration when caring for these patients.

As the research improves and patients and family members are involved in the process of research, data demonstrates the psychological challenges that patients face, along with those that may be experienced by their partners, family, and carers when living with chronic kidney disease. There is a need to recognize that kidney failure is a family concern, as it can affect carers/family member's mental health, along with patients. It should be part of the care planning to provide support to all members [11].

2.1 Pain, Anxiety, and Depression as a Quality of Life Factor in Patients on HD

The International Association for the Study of Pain (IASP) defines pain as “An unpleasant sensory and emotional experience associated with, or resembling that associated with, actual or potential tissue damage” [12, 13]. The concept integrates biological and psychological aspects, and accordingly considers it a subjective experience. Patients can manifest a painful sensation even without tissue damage or any discernible pathophysiological cause. Lack of self-control over pain often leads to developing anxiety and worry, leading to a depressed mood, and complicating the clinical situation even further. It is also known that depressive and anxious patients experience more painful stimulation and a decrease in quality of life [14–16].

The studies performed in relation to pain in patients on chronic HD therapy show that pain management is such a complex concern that a multidisciplinary team should care for these patients in order to lessen not only the physical but also the psychological and social impact [17]. The remedy for pain suffering in these patients is difficult to apply or is insufficiently administered as the clinical efficacy and effects of most analgesic medicine is altered by impaired renal function [18]. There is limited information on the ability of dialysis to clear the medicines and their metabolites [19]. The degree to which analgesic medicine regimes require alteration for patients undergoing chronic HD therapy, depends among others, on many different variables, such as residual kidney function and the medicine active metabolites that are dependent on kidney excretion [20]. Pain in patients on HD is associated with high levels of uremia which can develop with renal bone disease, osteoarthritis, calcific uremic arteriolopathy and peripheral neuropathy. On the other hand, comorbidity of the underlying disease as well as the disease responsible for CKD has an impact on chronic pain [21].

Pain is a substantial and current factor for patients who are on chronic HD therapy [22, 23] and it has been shown to have a negative effect on their quality of life as well as their physical, emotional, and social condition [3]. Approximately 60% of people who are under chronic HD therapy report some kind of pain. Chronic pain and acute pain are also present in high percentages of patients in a large systematic review [24]. Musculoskeletal pain appears to be the most common pain symptom

among patients under chronic HD therapy. However, other types of pain are defined such as pain related to arteriovenous access, headaches, general pain, neuropathic, and ischemic pain [22].

Symptom burden in end-stage renal disease should be considered, as it is substantial and may have a remarkably negative impact on patients. In this way, pain is an independent predictor of both the mental and physical composite of health-related quality of life [25]. It is also relevant to consider gender differences when managing pain as women generally present a lower perception of pain than men [16].

Comprehensive pain assessments must rely on validated scales and health professionals should require specific skills and training as it is a complex task. The visual analogue scale (VAS) (Fig. 1) is one of the most widely used instruments to measure the intensity of pain. It consists of a straight line with the absence of pain represented at one endpoint (0) and extreme pain at the other [10]. The patient should mark the degree of pain he or she is suffering on the straight line between the two endpoints. When VAS is applied in different formats such as “face score” it is useful for population who do not have the capacity to express the level of pain such as children or adults with dementia, for example. This is a great advantage for VAS as it can be used for nearly all population. However, VAS has many limitations as it is a unidimensional measure of pain and only assesses the intensity of pain and leaves out other important aspects such as the type, characteristics of pain, the area of the body affecting, if it travels, time of the day that appears the pain, etc. Missing all of this data interrupt the specific evaluation and treatment of the patient who is suffering it. In the clinic settings, the multidimensional instrument most used for the

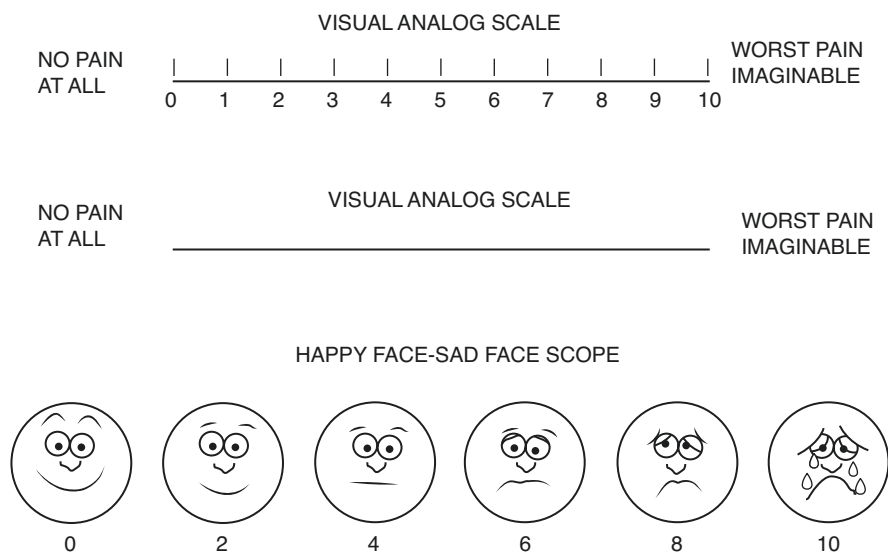


Fig. 1 Visual Analogue Scale (VAS) [27]

measurement of pain is Mc Gill Pain Questionnaire (MPQ) where it offers a variety of data that will help to understand what the patient is going through.

Uncontrolled pain can have consequences beyond the immediate perception of pain and can negatively affect patients' well-being on multiple levels. It is known that the presence of pain has a negative impact on the quality of life of patients on chronic HD therapy and may play an important role in the comorbidity of mental health symptoms such as depression and anxiety [23–25].

There is a high prevalence of patients undergoing chronic HD therapy who suffer from anxiety and depression [26]. In other words, one in five patients in both sexes meet the diagnostic criteria for clinical anxiety and one in six patients in both sexes suffer from clinical depression [27]. In addition, anxiety has been associated with a lower quality of life and is higher in patients who are on chronic HD therapy at an older age. It has also been observed that anxiety is more prevalent in the first months of HD therapy [28].

A greater awareness of this common symptom is vital to reduce its prevalence and prevent unnecessary suffering in a group of patients whose quality of life is already altered by CKD and the HD therapy.

2.2 Emotional Intelligence as a Protective Factor for Quality of Life in Patients on HD

Emotional Intelligence (EI) is composed of three dimensions and can be defined as the ability to attend (emotional attention), understand (emotional clarity), and modify (mood repair) emotional states [29], as well as the ability to regulate emotions to promote emotional and intellectual growth [30]. However, a high level of emotional attention interferes negatively with the positive effect of mood repair and personal growth if it is not complemented by a clear understanding of emotions [31].

Considering the risks and consequences of emotional disorders among patients on chronic HD, emotional intelligence can be an adequate tool to face stressful situations and achieve emotional well-being [10, 32].

Studies on emotional intelligence and quality of life in patients undergoing chronic HD are scarce. However, some authors observed a positive correlation between both variables. In other words, a high level of emotional intelligence has been related to a high level of quality of life among HD patients. Moreover, an educational program in emotional intelligence confirmed to be effective and increased quality of life in those patients [33].

Multiple aspects need to be precise when assessing emotional intelligence for the prediction of health outcomes and gender differences are present in the perception of emotions. When using self-report measures for emotional intelligence, such as TMMS- 24, sex differences in results are shown. Thus, males perceive themselves as more emotionally intelligent than females [27].

The relationship between emotional intelligence and some mental health indicators like anxiety and depression have been studied previously and high levels of emotional intelligence correlate to a better mental health. This way, emotional

intelligence skills can remain an indicator of health, emotional well-being, and vital satisfaction [34].

The ability to regulate emotions is an essential element, as individuals who have a high ability to perceive their own feelings, understand their implications and efficiently control them, they will cope better with the negative experiences using a regulatory process.

2.3 Implications for Nursing Practice when Caring for People on Chronic HD Therapy: Psychosocial Approach

Many studies reinforce the existing evidence that patients with CKD receiving HD therapy experience adverse mental health effects, which have an influence on their well-being and quality of life [16]. Effective measures need to be developed and implemented in nursing practice.

HD nurses who belong to the nephrology team have the capacity to assess and understand the needs of the patient who requires renal replacement therapy, and it is fundamental to prioritize treatment modalities for each patient according to their individual needs [35]. In other words, nurses should start caring for patients' quality of life by assisting patients and family to make a good decision in the treatment modality such as self-care in satellite units, home hemodialysis (HHD), continuous ambulatory peritoneal dialysis (PD), and pre-emptive transplantation, which provides patients with improved control over their lives and enhances overall quality of life, along with mental and physical well-being [34, 36].

Nurses have the ability to establish a supportive relationship with their patients and have at their disposal key resources to do so, for example, empowering patients on HD to enhance their coping strategies [37], active listening to support patients and sustain a respectful environment [38], and emotional Intelligence training [39, 40]. Moreover, nurses can accomplish a helping relationship and have access to key resolution resources [37, 41].

HD nurses should adopt a holistic view of patients with CKD in order to promptly recognize, consider, and care for multiple aspects of their suffering, involving the management of pain, mental health, and physical health. To this end, constant advanced care planning in nursing is considered fundamental to improve quality of life and respond to the changes experienced by patients on HD on an individual basis. This would include an emotional evaluation of the patient both in the first instance, and continuously throughout HD therapy, in order to provide the highest level of care and following Nephrology Nursing Scope and Standards of Practice) [31]. Likewise, renal association guidelines currently recommend health-related quality of life to be monitored in patients undergoing renal replacement therapy [42] and integrating patient-reported outcome measures (PROM) assessments into the patient centered care of persons receiving HD could provide consistency, reassurance, and enhance the care of those patients with the greatest symptom burden [11].

Clinical practitioners treating patients on HD should assess levels of emotional attention, especially in females. Dialysis nurses should also study the factors that

affect quality of life in order to minimize patients' negative effects. If instability is detected, a complete psycho-emotional intervention should be conducted. Assessment of emotional intelligence in patients undergoing chronic HD therapy can be an indicator of clinical outcomes and improve health interventions as well as being a tool for evaluating the therapy carried out. Improving quality of life and subsequently enhancing emotional intelligence may prevent irreversible complications in patients undergoing chronic HD therapy. A holistic and multidisciplinary approach to those high complex patients is necessary in order to achieve adequate outcomes.

3 Quality of Life in Peritoneal Dialysis Patients

3.1 Introduction

People's quality of life with chronic kidney disease undergoing dialysis treatment have been well documented recently, and the influence of these people's beliefs and personality have been observed to have an impact. In addition, the type of kidney replacement treatment contributes to their health and quality of life as well as the coping strategies they use in the management of their primary diagnosis [43–46].

3.2 Quality of Life and Peritoneal Dialysis

When assessing quality of life in relation to the renal replacement therapy modality, numerous studies describe that patients who are on peritoneal dialysis (PD) perceive a better quality of life compared to those who undergo HD therapy [47–49]. However, variant studies also appear to establish no differences in quality of life in relation to the dialysis modality [50] or even show better scores when receiving hemodialysis [51].

Other psychological aspects that have been analyzed in patients treated with PD show that they have a better life perception and satisfaction, particularly in relation to the increased flexibility they have managing the treatment and the ability to continue engaging in their daily activities. Moreover, people undergoing chronic PD present lower scores of anxiety and depression related to the lower perception of fatigue and symptoms of illness, as well as higher adaptation and coping strategies at different ages than people undergoing chronic HD treatment [48, 52]. Conversely, PD patients have also been reported to have a poorer perception of physical health and suffering symptoms of deeper depression [53, 54].

Other benefits of PD treatment have been described as obtaining greater clinical, psychosocial, and financial benefits, maintaining hemodynamic stability during treatment, experiencing no sudden metabolic changes and it allows a gradual management of blood volume, and maintaining stable hematocrit levels.

Enhanced autonomy and empowerment of the treatment allows greater flexibility of time to carry out the dialysis session, consequently it is more compatible with

work, gives greater ease of travel, and decreases hospital admissions and duration [55, 56].

Recently, research has begun on the effects of dialysis on certain blood cells, specifically on circulating regulatory Treg (T), the function of these cells is to preserve patients' immune response and tolerance while maintaining the ability to fight infectious agents, and it seems that PD compared to HD was more effective in increasing T levels and be able to contribute to the improvement of inflammatory status. Thus, PD may contribute to better outcomes for patients with renal dysfunction while also maintaining homeostasis of peritoneal and renal tissues [57].

On the other hand, the daily dedication required to PD treatment demands constant attention and decision-making by the patient and family members, which can lead to exhaustion, cause limitations in social activities and increase social isolation. Autonomy in decisions and intermittent contact with health professionals can increase emotional distress, increase depression, and lower perceptions of physical function [58, 59].

3.3 Therapeutic Adherence and PD

People's therapeutic compliance with PD is crucial since the responsibility for kidney treatment through dialysis falls directly to the patient, and this depends on the physical well-being that is directly related to the perceived quality of life [60].

Research on therapeutic adherence to PD began to be explored at the beginning of the century. Different studies provide high percentages of adherence to the dialytic and medicinal technique, but less so to the adherence of liquid and dietary restrictions [61]. The systematic review by Griva (2014) [62] concluded that the levels of non-adherence to the technique itself were between 2.6% and 53%, those of therapeutic non-compliance between 3.9% and 85% and those of dietary non-compliance between 14.4% and 67%. Following the same trend, different publications have shown that non-adherence levels are still high in these particular patients [63, 64].

Implications for nursing practice when caring for people undergoing chronic PD: psychosocial approach.

Communication and education should be understood as a training process that promotes healthy lifestyles that provide opportunities for the promotion of healthy environments suitable for people with kidney problems. [65, 66] To achieve successful results in PD, the role of the nurse is key to establish links and interpersonal

relationships in the communication process between the patient and/or their relatives, and this relationship should be promoted in a continuous and dynamic way. According to Watson's theory (2012) fostering a helping-trust relationship is conclusive to the expression of feelings, it affects therapeutic adherence, quality of life and continuity of care. This relationship allows through coherence, empathy, non-possession, effective and assertive communication, increasing the participation of the patient and their immediate environment, as well as creating realistic expectations according to their clinical situation [67].

The function carried out by the nurse has an impact on the actions of the patient's performance on PD, and influences knowledge about the needs of their disease and activities for their own care and in dialytic therapy sessions. All these actions allow a good adaptation to the technique since they acquire skills to successfully cope with the treatment. [68].

However, the fact of having to take responsibility for one's own care, managing the different therapeutic procedures, the dialysis solutions, the maintenance of aseptic technique during the treatment, in addition to their personal demands, can generate states of anxiety and excessive burden that can contribute to the failure of the treatment. Nursing professionals should promote health literacy, which is understood as the degree to which individuals have the capacity to obtain, process, and understand health information and make appropriate health decisions. By empowering the patient with the technique and with the possible risks as well as health education of the initial signs and symptoms can help to reduce complications, reduce psychological discomfort, and the stress level of those who are responsible for home dialysis. [46, 60, 66].

The periodic monitoring of the quality of life allows health professionals to identify the aspects in which it is necessary to intervene in order to maintain, recover, and/or improve their well-being. In addition, guaranteeing the success of PD during the time that the person needs renal replacement treatment. [60, 69].

Symptom burdens must be assessed and should be a significant component in the holistic evaluation of the dialysis patient. Recognizing mental aspects in a dialysis patient consequently can impinge upon overall treatment and quality of life with physical symptoms to dialysis care [62].

The role of the nurse in the care of people with PD should be based on effective communication between the patient and their immediate environment. Throughout the process, healthy lifestyles, health education, and technical empowerment should be promoted, as this relationship will have a positive impact on activities for self-care and on knowledge about the needs of their disease (Fig. 2) [63].

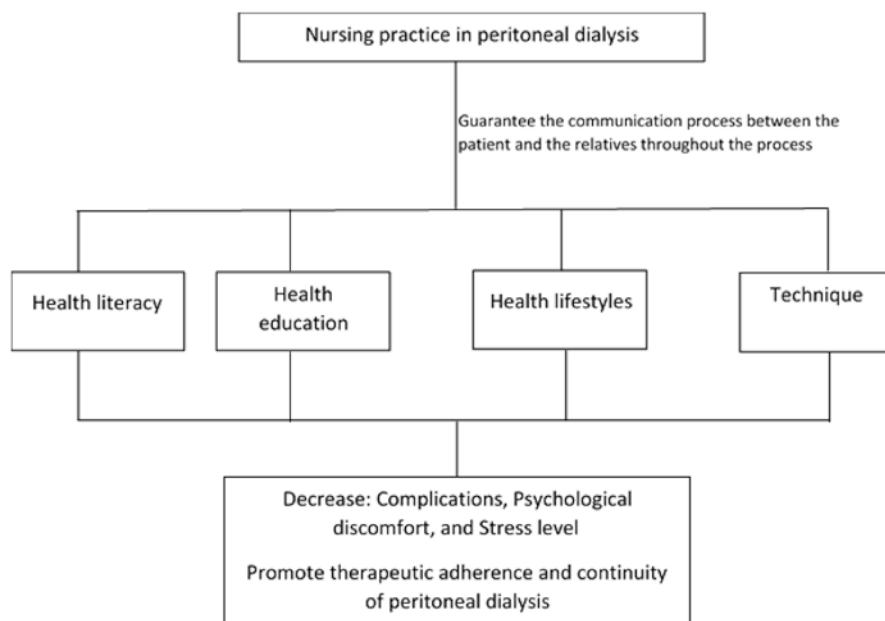


Fig. 2 The role of nursing in PD [63]

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Sexual Health and Kidney Failure

Clare McKeaveney and Sandra M. Dumanski

Learning Objectives

- To explore the concept of sexual function as it relates to individuals living with kidney failure.
- To understand the key kidney disease-specific factors that are related to sexual function.
- To describe strategies for treatment and management of sexual dysfunction in people living with kidney failure.

1 Introduction

Sexual health is defined by the World Health Organization as “a state of physical, emotional, mental and social well-being in relation to sexuality; it is not merely the absence of disease, dysfunction or infirmity.” Sexual health is a critical component of the overall health and well-being of an individual, and in part, relies on an individual’s sexual function [1, 2].

Sexual dysfunction is a very common complication of kidney disease [3–5] and may be linked to the degree of kidney dysfunction [4, 6–11]. In individuals living with kidney failure, it is estimated that sexual dysfunction affects >75% of the population, females and males alike [4, 7, 11]. In females with kidney failure, sexual dysfunction may present as impaired sexual desire, abnormal vaginal lubrication, anorgasmia, or dyspareunia, while in males sexual dysfunction may

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encompass reduced sexual desire, erectile dysfunction, anorgasmia, or abnormal ejaculation [5, 8, 12]. Additionally, females living with kidney disease treated with dialysis can also experience complications of menstruation and premature menopause, alongside an increased likelihood of abstaining from sexual intercourse [4, 13, 14].

Despite its high prevalence and large burden on physical, mental, and emotional health, sexual dysfunction in kidney failure continues to be under-recognized and under-treated by healthcare professionals and remains a vital unmet need in kidney disease [15].

2 Causes of Sexual Dysfunction in Individuals Living with Kidney Failure

The causes of sexual dysfunction in kidney failure are multifactorial and may involve both physical and psychosocial factors (Fig. 1) [16]. From a pathophysiological perspective, impairment of the hypothalamic-pituitary-gonadal axis is a common complication in kidney failure and the resultant hormonal abnormalities



Fig. 1 Contributors to sexual dysfunction in people with kidney failure Harrison et al. [16]

may have a direct impact on sexual function in both females and males (Figs. 2 and 3) [8]. Specifically, females with kidney failure commonly demonstrate elevated prolactin and reduced estradiol, which may result in diminished sexual desire and impaired vaginal lubrication, respectively [9, 17]. Similarly, sexual desire disorder and erectile dysfunction in males with kidney failure may be related to elevated prolactin and/or reduced testosterone [10]. In addition to an abnormal reproductive hormone balance, kidney disease disrupts the vascular, neuronal, and sexual structures creating unique sexual function concerns for people living with kidney disease [18]. Finally, comorbid conditions such as diabetes, obesity, and hypertension are also associated with sexual dysfunction and are highly prevalent co-morbidities in kidney disease [19].

In addition to the pathophysiologic factors that impair sexual function in individuals living with kidney failure, a multitude of other factors have the potential to impact sexual health. As an example, chronic kidney disease (CKD) symptoms (e.g., fatigue, anemia, or chronic pain) and treatment (e.g., side effects of medication and dialysis) may further magnify sexual dysfunction. Moreover, psychological diagnoses including depression and anxiety, which are highly prevalent in kidney

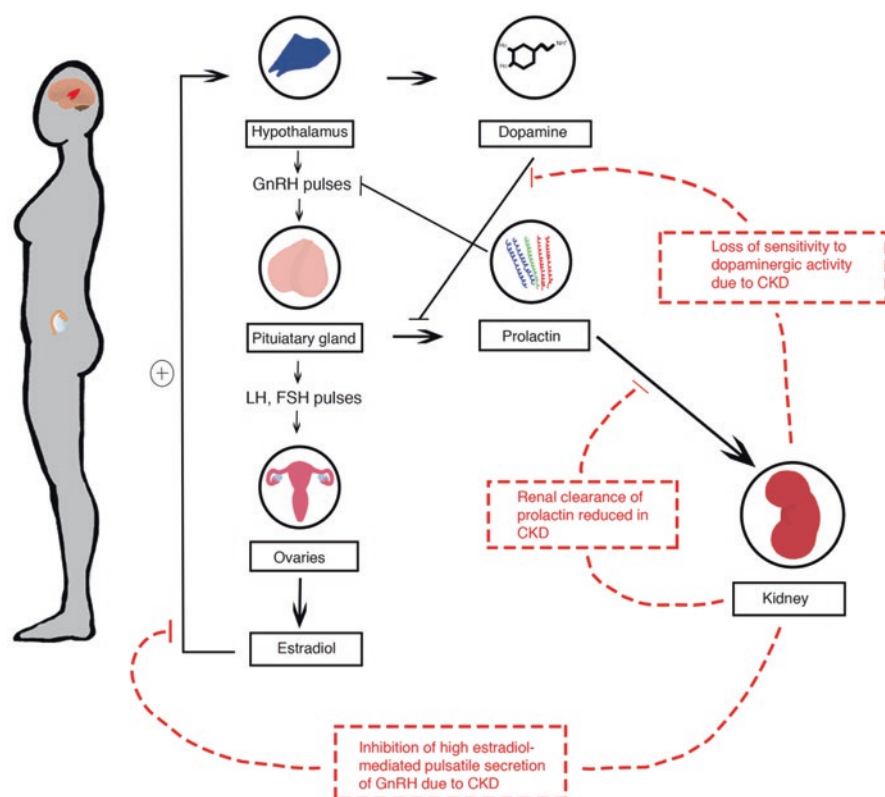


Fig. 2 The effect of kidney failure on the hypothalamic-pituitary-ovarian axis. Dumanski and Ahmed [6]

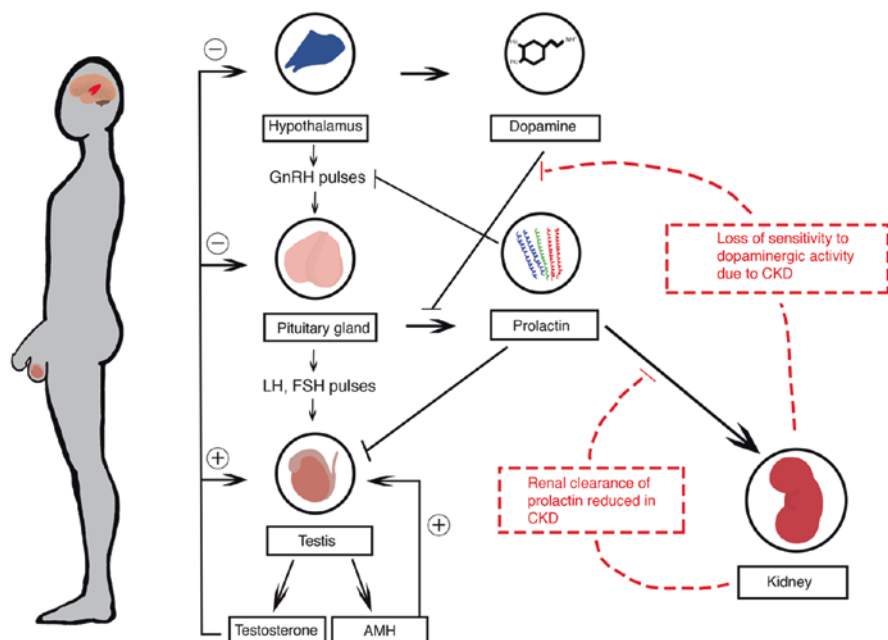


Fig. 3 The effect of kidney failure on the hypothalamic-pituitary-testicular axis. Dumanski et al. [8]

disease [20], can also affect sexual function [12]. An individual's body image (e.g., dialysis catheters, surgical scars, weight gain following transplantation) and the medicalization of their intimate spaces (e.g., dialysis machines or medical supplies in the bedroom) may also impact their sexual desire and function [12, 21, 22]. Body image and reduced feelings of attractiveness can lead to dramatic effects on self-esteem and impact on sexual relations and activity [23]. Finally, individuals living with kidney failure report difficulty accessing social networks to find intimate partnerships, as well as a pronounced fear of rejection [21]. It is well-established that age is associated with reduced sexual function; however, it is important to remember older people are not "asexual beings" [24].

3 Treatment and Management of Sexual Dysfunction in Kidney Failure

There is little research available to guide clinicians on the treatment and management of sexual dysfunction in people living with kidney failure. However, literature suggests that the following management strategies may provide benefit:

Environmental Strategies Healthcare professionals should consider providing novel guidance on sex, including "...varying the sexual position, timing sexual

activity, timing medication administration, and reducing or eliminating the use of offending agents..." including limiting alcohol and tobacco (p. 349) [25].

Psychological Strategies Lack of sexual fulfillment can create a significant emotional crisis for patients and their partners which may require more intensive guidance (e.g., cognitive behavioral therapy) [26, 27]. Alternative strategies might also include encouraging direct verbal communication of sexual needs with partner(s), as well as novel strategies such as self-stimulation (e.g., masturbation), initiating non-sexual contact with intimate partner(s) (e.g., massage) and introducing a self-help book [25]. People living with kidney failure can also experience body image disturbances affecting self-esteem [28, 29] and may benefit from practical solutions (e.g., lingerie, support wear).

Medication Review It is important for healthcare professionals to understand the potential for drug-induced sexual dysfunction. Multiple medications commonly prescribed to individuals living with kidney failure, such as anti-hypertensive medications, medications for depression, and immunosuppressive agents may negatively impact sexual function. Although it may not be possible to stop all medications that interfere with sexual function, a conscious effort to review culprit medications and transition patients to more sexual function-friendly options may provide benefits [12].

Treatment of Anemia Anemia is associated with increased fatigue, as well as impaired sexual function. Literature to date demonstrates that appropriate treatment of anemia in chronic kidney disease, including repletion of iron stores and maintenance of an appropriate hemoglobin level, can significantly improve sexual functioning [10, 30].

Treatment with an Increased Hemodialysis (HD) Dose Although many individuals living with kidney failure treated with dialysis receive ~12 h of HD each week, those treated with intensive HD (>20 h of dialysis each week) appear to have further normalization of their reproductive hormones, which may positively impact their sexual function [31]. Consideration of home HD or an intensified HD prescription may be beneficial for individuals with kidney failure-associated sexual dysfunction.

Pharmacological Therapies A Cochrane review published in 2010 identified several studies assessing the pharmacologic treatment of sexual dysfunction in individuals with kidney disease with varying degrees of success. The most frequently studied treatment was phosphodiesterase-5 inhibition for erectile dysfunction, which consistently demonstrated improvement in erectile function. Other treatments for limited types of sexual dysfunction included zinc, bromocriptine, vitamin D and E, but mixed results were demonstrated. Importantly, this review has not been updated, and few studies have followed its publication. There is an urgent need for

further clinical trials to evaluate the safety and efficacy of interventions for sexual dysfunction for males and females with CKD [12]

Transplantation Evidence suggests that both females and males can experience improvement in sexual function and activity after a successful kidney transplant [4, 32, 33]. Conversely, some patients can continue to experience sexual dysfunction following kidney transplantation [4] requiring support and intervention.

Raising Awareness of Kidney Failure-Associated Sexual Dysfunction Healthcare professionals have identified several challenges in recognizing and treating sexual dysfunction in CKD, including a fear of embarrassment for themselves and their patients [15]. There is also confusion over role responsibility when dealing with sexual dysfunction. Some nurses believe that it is the role of the nephrologist, but some nephrologists believe it is the role of the general practitioner [34]. Healthcare professionals should be encouraged to discuss sexual health and function with their kidney failure patients, regardless of personal or perceived challenges and delegate where necessary.

Professional Sexual Education There is a lack of tailored sexual health education for renal healthcare professionals [15]; however, several models of sexual counseling do exist (e.g., ALARM [35], PLISSIT [36], EX-PLISSIT [37], and BETTER [38]) and are effective in nursing assessment and intervention of sexual problems [39–41]. The PLISSIT (P-LI-SS-IT) framework is the most commonly used model [42] which aids dialogue about sexual function between healthcare professionals and people living with chronic illness and/or disabilities. The PLISSIT is a four-level intervention starting with Permission, Limited Information, Specific Suggestions, and Intensive Therapy. The PLISSIT model involves a progressive approach to addressing sexual issues in healthcare. It begins with granting patients permission to discuss their concerns openly and without judgment. Then, basic sexual health information is provided to address any misconceptions. Specific suggestions are offered to tackle individual concerns, and in more complex cases, intensive therapy involving specialized professionals may be necessary. Van Ek [34] suggests customizing a tool like the PLISSIT for the context of kidney care could potentially benefit people living with kidney failure and their partners.

4 Impact on Partners

Despite limited research on the impact on partners of individuals living with kidney disease, the impact of illness and caring can be damaging to a relationship which can include negatively affecting sexual relations [43]. Healthcare professionals should encourage open communication between patients and their partners about the associated challenges of CKD and sexuality. Healthcare professionals have suggested that the provision of tailored support and resources for partners would be helpful to address sexual health concerns in kidney disease [34].

5 Conclusion

Sexual dysfunction and impaired sexual health are common among people living with kidney failure; however, sexual dysfunction is often overlooked by healthcare professionals [13]. Treatments for sexual dysfunction in kidney failure have been identified by both patients and healthcare professionals as an important area for research which will help inform tailored management and support strategies [44]. However, professional sexual education and raising awareness among healthcare professionals are vital aspects to improving the overall care and well-being of individuals (and their partners) living with kidney failure.

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CKD Care for Pediatric and Adolescent Patients

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Learning Objectives

- To identify the specific needs of pediatric and adolescent patients who suffer from chronic kidney disease (CKD).
- To develop an appreciation of the psychosocial impact of CKD on children, adolescents, and their families.
- To gain an understanding of the challenges encountered during the transition from pediatric to adult CKD care.

1 Introduction

Children cannot be seen as small adults. However, pediatric chronic kidney care is often overlooked in the literature that focuses more on adults, despite the unique medical and psychosocial needs of children and adolescents.

The prevalence of end-stage kidney disease (ESKD) in children and adolescents is 55–60 per million of age-related population [3], but it is rising, due to an increase in congenital anomalies of the kidneys and urinary tract (CAKUT) and cancer survival [4], as well as the advancements in medicine that allow increasing numbers of

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CKD pediatric patients to survive into adulthood. With that arises an increased need for appropriate transition from pediatric care to adult care.

Unlike adult-patient care, which is patient-centered, autonomous and requires independent decision making, pediatric-care is family-oriented and requires parenteral involvement. Both healthcare professionals' and caregivers' have their unique roles that need to be properly coordinated to reach the best possible outcome.

Some of the known comorbidities resulting from CKD that can be generalized to all populations are cardiovascular complications, mineral bone disorders, anemia, and the need for dietary and fluid restrictions, polypharmacy, and social constraints [2]. However, being in the younger population adds more difficulty in controlling those comorbidities. This becomes more evident when looking at the need of intensive caregiver involvement, the importance of preventing renal osteodystrophy in the critical phase of skeletal growth and trying to balance providing essential nutrients and caloric intake in the face of the needed dietary restrictions related to CKD [21].

2 Caregivers for Pediatric and Adolescent Patients with CKD

The caregivers play a major role in the care of the pediatric patients with CKD. Most of the times the figure of a caregiver in the pediatric environment is the parents. Parents contribute to the management as much as the patients and attend to issues, such as medication administration, special diet preparation, clinic attendance, hospital admissions, and dialysis treatments [16].

In addition to the standard disease management, their parenting skills also influence the patient's ability to self-manage their disease in the future. According to Bagley et al., parenting style is significant: liberal or indulgent education leads to failure in the adult setting, whereas authoritarian education fosters resilience in a competitive work environment and the greatest transition preparedness [7].

The burden of CKD disease affects the caregivers as well. Multiple studies have reported deteriorating caregivers' quality of life, leading to psychological problems, and even increased mortality. There is a potential risk of stress, depression, and anxiety related to the role of being a caregiver for these patients, as well as an impact on the entire family's quality of life [17]. The awareness of the caregivers' involvement in the management plan, parenting techniques, and the resulting psychosocial stress should direct both healthcare professionals and caregivers to seek appropriate psychosocial support as needed [17].

3 CKD-Bone Mineral Disease

CKD is associated with specific abnormalities of skeletal homeostasis, known as renal osteodystrophy (ROD). While the management guidelines are similar to the ones of the adult population, the consequences can be detrimental. If not treated

appropriately during the critical phases of skeletal growth can result in bone deformities and a disturbed growth pattern [11]. Chronic kidney disease-bone mineral disease (CKD-BMD) is first seen at stage 2 CKD and diagnosed based on laboratory results of serum calcium, phosphorus, parathormone, and vitamin D levels. However, as the CKD progresses to stages 3–5, children begin to experience bone pain, skeletal abnormalities, and difficulty in ambulation [18].

The goals of therapy are to prevent secondary hyperparathyroidism, without overcorrection which may lead to adynamic bone disease. The European CKD-MBD and Dialysis working group recommends target PTH levels near normal levels for children with stage 2–5 CKD and two to three times the upper limit of normal for those on dialysis [11]. There are some interventions established in order to prevent renal osteodystrophy, according to different European Guidelines which include [22–24]:

- Close monitoring of clinical, biochemical, and radiological markers of renal bone disease.
- Correct metabolic acidosis.
- Maintain plasma-phosphate as per age-range.
- Monitor phosphate intake and offer dietary counseling.
- If hyperphosphatemia persists, adjust dialysis and phosphate binders accordingly.
- Maintain normal levels of cholecalciferol.
- Monitor PTH levels and administer active vitamin D metabolites or calcimimetics if needed.
- Monitor calcium phosphorus product.

4 Diet in Children with CKD

Nutritional management of children with (CKD) should focus on the efficient growth development of the child and management of the specialized metabolic needs. The balance between energy intake, protein needs, and fluid and electrolyte restrictions that need to be addressed according to the child's needs is essential. Continuous education to parents and children who suffer CKD is key to maintain balance between intake and assessment of specific needs of each child. Moreover all members of the care plan need to be flexible to modify the plan at any time according to the growth needs, the disease course, and the treatment options [12].

4.1 Nutritional Assessment

As nutritional needs of the children are individualized, nutritional assessment is essential to analyze these needs. Assessment of the growth status by the evaluation of height, weight, head circumference, and body mass index (BMI) should be a part of the baseline evaluation and the estimated needs will be then based on the anthropometric data of each child. Because children with CKD frequently experience growth

retardation and low stature as a result of metabolic acidosis, poor nutritional intake, and problems with growth hormone metabolism, efficient nutrient intake, particularly during infancy, appears to have the greatest positive influence on infant length [13].

4.2 Nutritional Needs

4.2.1 Energy

According to the available guidelines for the nutritional management of the child with CKD by the Kidney Disease Outcomes Quality Initiative (KDOQI) energy needs do not differ from healthy children of the same age but should be adjusted to the growth level and weight trends. Furthermore, symptoms that have a negative impact on nutritional intake, i.e., nausea, vomiting, gastroesophageal reflux, anorexia, and taste alterations should be managed to facilitate efficient energy intake by the child [12, 13].

For infants, breast milk with close monitoring of potassium and phosphate levels is the preferable feeding choice. If this is not possible, whether due to lack of availability or being complicated by hyperkalemia or hyperphosphatemia, then standard. Energy needs can be enhanced with fortification with carbohydrates and fats to increase energy density. For children >2 year old in need of energy supplementation, pediatric oral nutritional supplements (ONS) can be used and in case of specific nutritional needs due to the course of the disease, ONS specific for CKD for adults can also be provided [14].

4.2.2 Protein

According to the available guidelines children with CKD stage 3 should be provided with 100–140% of protein dietary reference intake (DRI) for ideal body weight (IBW) and in stages 4–5 children should receive 100–120% of protein DRI for IBW. For children in dialysis extra protein should be provided to cover the losses during dialysis. Therefore, an additional 0.1 g/kg/day of protein should be provided for children in hemodialysis and 0.2–0.3 g/kg/day for children in peritoneal dialysis. The recommendations according to the stage of the disease and the age of the child is presented in Table 1 [13].

Table 1 Protein needs in children with CKD

Age	DRI				
	DRI (g/kg/d)	CKD stage 3 (g/kg/d) 100–140% DRI	CKD stage 4–5 (g/kg/day) 100–120% DRI	HD	PD
0–6 months	1.5	1.5–2.1	1.5–1.8	1.6	1.8
7–12 months	1.2	1.2–1.7	1.2–1.5	1.3	1.5
1–3 years	1.05	1.05–1.5	1.05–1.25	1.15	1.3
4–13 years	0.95	0.95–1.35	0.95–1.15	1.05	1.1
14–18 years	0.85	0.85–1.2	0.85–1.05	0.95	1.0

Font: [2]

4.2.3 Sodium

Families with children with CKD should be advised to limit salt intake. At baseline a recommendation of “no added salt” should be provided. More specifically, for children requiring sodium restriction, KDOQI guidelines recommend <1500 to 2400 mg/day. Conversely, in children with salt wasting additional salt should be provided. Thorough education of family members to identify “hidden sources” of sodium is essential and advice should be provided for the enhancement of taste without adding salt [12, 13].

Fluid intake should be restricted in children with CKD with lower urine output to prevent fluid overload. To achieve this, children should limit intake of beverages and liquid or semiliquid food items in room temperature (ice cream, jelly, yogurt, soups). Fluid restrictions should be accompanied with sodium restriction to control thirst and increase adherence [13].

4.2.4 Potassium

Hyperkalemia is common in children and raises the risk of arrhythmias and cardiac arrest. KDOQI recommendations suggest an intake of 40–120 mg/kg/day for infants and younger children and 30–40 mg/kg/day for older children. Breast milk is low in potassium, therefore preferable for feeding infants. Potassium lowering techniques should be provided to families to ensure the higher possible variety and safety for children. Salt alternatives are strongly discouraged as they contain potassium and are not recommended in a low potassium diet [13].

4.2.5 Phosphorus and Calcium

Disturbed bone metabolism is one of the main concerns in children with CKD, as it also affects growth and bone health. The management of potassium and parathormone levels is a great challenge and an important parameter for the improved clinical outcomes for these children.

KDOQI guidelines suggest the provision of 100% of DRI for age for phosphorus if PTH is elevated but phosphorus is within normal levels and provision of 80% of DRI for age in case of hyperphosphatemia and hyperparathyroidism [13].

Calcium balance is also of great importance. Provision of 100–200% of DRI for age with a maximum of 2500 mg/day should be considered, calculating the calcium intake from phosphate binders as well. Supplemental provision of calcium could be considered if dietary intake is insufficient [15].

5 Adolescent Patient Education

One of the biggest challenges for adolescent patients is the adherence to treatment. Being an adolescent on its own it is already a challenge but being a CKD adolescent is a greater test. Bell et al. (2011) mention that adolescents and emerging adults with CKD/ESDK have complex medical and dietary regimes, and therapeutic adherence is important for optimizing their health, quality of life, and longevity [1]. Healthcare providers play an important role in patient and family education by providing

literacy-accessible learning tools so they can become successful disease self-managers [1].

Adolescent patients with CKD are more likely to have cognitive deficits and learning disabilities [2] so it is essential to understand their difficulties and provide mitigation plans to overcome the challenges.

Moreover, anxiety and depression are highly prevalent among pediatric patients with CKD. When compared to their peers, the young patients with CKD often suffer from short stature due to multiple etiologies including genetic/syndromic factors, delayed puberty, abnormalities in the insulin-like growth factor, poor response to natural growth hormone, water and electrolyte abnormalities (particularly sodium), prescribed steroids, and anemia [6].

These complications increase their risk for depression. A study published in 2013 [20] revealed that 30% of the patients, age 9–18 years with CKD stages 3–5, met criteria for depression, compared to the reported rate of 0.4–8.3% in the general child and adolescent population [19]. This seems providing the clinical community with screening tools and management strategies of depression of utmost importance.

6 The Transition to Adult CKD Care

Providing chronic kidney care to pediatric, adolescent, and adult patients is quite different. Deciding when an adolescent is ready for transition to adult healthcare services is challenging, as it does not exclusively depend on the age of the patient, but also on their cognition and developmental readiness. In addition to the later, external factors such as family dynamics and availability of community services also play a crucial role in determining the best time for transition. In order to ensure clear communication between patient and health professionals it is necessary an interdisciplinary collaboration between pediatric and adult-focused health care teams and the services of a dedicated services of a dedicated transition coordinator [1].

The transition to adult CKD care should take into consideration that the brain maturation and self-management skills continue to grow until mid-twenties [2]. Majority of patients who transit from pediatric to adult health care service, they have shown that feel attached to the pediatric unit as they have been working together for many years. Once in adult care, data shows that adolescents feel out of place among the older patients, overwhelmed by the new environment and the perceived lack of attention from the healthcare staff [5].

An interesting fact about the transition to adult CKD care is described in a study published in 2016 describing the preferred health learning method by youths with chronic conditions and their effect on transition. The results showed that patients who preferred to learn from their parents had a better adherence. However, in the same study, those patients who preferred to learn about their health from health providers had better self-efficacy and HCT (healthcare transition) preparation scores [8]. Raising awareness to such deficiency can help create a smoother transition where both health care providers and patients feel more comfortable.

The outcomes of the HCT are still very poor. A successful HCT involves a complete, developmentally appropriate, and coordinated change from pediatric treatment to adult treatment, which involves a substantial amount of patient education. “Its goal is to achieve a continuum of care for chronically ill young adults that includes social and emotional development and the acquisition of independent living skills” [9].

This needs to be carefully planned and continued in the adult-oriented health-care systems. Communication and close collaboration between the patients, caregivers, and primary care/specialty health providers is paramount [2]. There is an important role to be played by the clinical team in the adult setting for the transition patients, especially by the internal medicine/pediatrics specialists who are particularly qualified to serve transitioning patients with chronic condition. The biggest challenge is that those specialists are rarely available in the adult setting. Raising awareness to such deficiency can help create a smoother transition where both health care providers and patients feel more comfortable.

7 The Consensus Statement

The International Society of Nephrology (ISN) and the International Pediatric Nephrology Association (IPNA) recommended a consensus statement describing the ideal care of young people with kidney disease during this critical phase of their lives [10].

The consensus statement is transcribed as follows:

1. “Transition to transfer

Transfer should occur from pediatric to adult nephrology services only after efforts to assess and prepare the adolescent/young adult have occurred and necessary patient care information has been delivered to the receiving adult service

2. Transfer from pediatric to adult nephrology should:

- be individualized for each patient after he/she has completed a transition plan; this will depend upon completion of physical growth and, where possible, educational, social and psychological attainment;
- be agreed upon jointly by the patient and his/her family/caregiver in conjunction with the pediatric and adult renal care teams;
- take place during a period without crises, especially if there is unstable social support;
- take place after completing school education;
- take into account treatment plans by other subspecialties, with particular reference to urological supervision;
- Take place with due consideration of financial factors and not be done abruptly without adequate preparation as a result of financial pressures.

3. Transition process

The most effective time to transfer an adolescent/ young adult from a pediatric to adult renal service occurs after a transition process. Hence, young people should be:

- introduced to the concept of transition in early adolescence (12–14 years);
- given information about transition in a gradual manner appropriate to his/her developmental stage and intellectual ability;
- directed by identified lead clinicians in pediatric and adult units to coordinate and educate on transition issues;
- assigned to a nominated key worker responsible for coordinating transition from both the pediatric and adult renal service;
- provided with a generic transition plan that then can be individualized for each patient;
- include parents, other family members and even partners (if the young person agrees), as more information lessens anxiety;
- be offered the opportunity of an informal visit to the nominated adult service before transfer occurs;
- be given the opportunity to participate in group sessions with other young people who are about to transition for peer-support experience;
- be able to receive tools to aid in the acquisition of disease self-management skills.

4. Transition or transfer clinic

- a transfer clinic in either the adult or pediatric renal unit with both adult and pediatric nephrologist in attendance is the optimal minimum standard;
- an internal medicine specialist or nephrologist in each adult service should take a special interest and be trained in managing young people with CKD 4–5;
- specialist nurses for adult patients who liaise with specialist nurses from the pediatric unit can ensure continuity of care;
- transfer to adult renal care should include a comprehensive written and verbal summary of all the multidisciplinary aspects of the young person's care; this should include medical, nursing, dietary, social, and educational information;
- the young person should be prepared through a transition pathway to assert their autonomy and help provide the relevant information about themselves.

5. Continuity of care

A recurring point raised by young people who have transferred is the lack of continuity of care and build-up of trust that they experienced in the pediatric unit. It is appreciated that many transition issues raised in these statements are aspirational, but two options could be considered:

- Option 1: An ideal method to promote successful transition is to preserve continuity of care through the efforts of a small team of specific professionals responsible for assuring the care of the transferred young person. This may involve an adult nephrologist, nurse specialist, and one or more support staff (youth worker, social worker, etc.) in the adult service. This dedicated team should have training in managing teenagers and young adults and have knowledge of pediatric renal diseases. The potential availability of such a team will vary according to country and facilities resourced.

- Option 2: Adult renal centres could establish young adult clinics that would incorporate both patients transferred from pediatric care and adolescents and young adults (aged <24) who may have presented with CKD 4–5 directly to the adult renal unit. A recent survey of US internists found that many felt the need for better training in congenital and childhood-onset conditions and expressed concerns about psychosocial and financial issues. Training of junior doctors on transition issues needs to be included in the training of adult specialists. This training is more imperative for lead clinicians in the adult centre” [10].

8 Conclusion

Pediatric patients with CKD transitioning to adult health care are not only going through a difficult phase of their development but may face substantial physical and psychological challenges.

It is paramount to support the caregivers for their heavy role with the invaluable support they provide in the care of young patients with CKD.

The psychosocial and dietary aspects of patients with CKD make this population unique in its treatment and only knowledgeable and specialized staff such as nurses and dietitians can ultimately provide and improve the quality of life of these patients.

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Patient Education in Kidney Care

Jeanette Finderup

Learning Objectives

- To consider relevant factors in people with kidney disease when planning their education.
- To gain knowledge about how to improve the learning situation when providing education to people with kidney disease.
- To understand the influence of the situation and content within the learning process.
- To recognize different teaching skills to improve learning outcomes.

1 Clinical Cases

Case I: A person with polycystic kidney disease initiating sub-acute, on center hemodialysis (HD) treatment. This person, compared to other people starting dialysis sub-acute, may know a lot about dialysis and polycystic kidney disease, if he has a whole family history of this disease. But maybe he is the first in his family to experience the disease. Maybe he has already had some children, and he needs to know how the disease will affect his children.

Case II: A person with thrombotic thrombocytopenic purpura stage four. Thrombocytopenic purpura is a rare serious blood disease. The disease can cause small clots in the smallest arteries, which may explain why this person will also experience kidney failure. Maybe the focus for this person is mainly on the blood disease and therefore not able to consume information about kidney disease. On the other hand, this person is mainly focused on his kidney disease, because it

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gives him symptoms, that affect his life, and he also needs to learn a lot about his blood disease.

However, kidney professionals may have a relatively limited knowledge of hematological conditions.

Case III: A person on HD with a high serum-phosphate level. The person has been prescribed phosphate restrictions and needs to be taught about these restrictions, as well as the other options about how to lower his se-phosphate level and the reason why lowering the phosphate level is important.

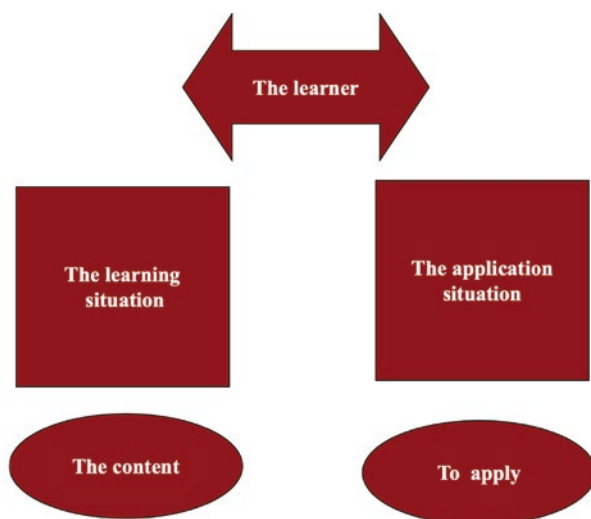
Case IV: A person on HD with fluid restrictions. This person comes to the HD unit thrice a week, every time with a fluid overload of 3.2 L. He has been taught about fluid restrictions several times, but need to be taught how to apply, this information in practice.

These four cases show how broad the spectrum is in education and kidney care. The four cases show different challenges, and that each person is in need of developing new competences, either knowledge, or skills, and the cases also show different challenges for the health professional responsible for the person and having the task of teaching the person. This chapter has its starting point in these cases. This may be suitable for the one who is able to process new information analytically best and may not be as suitable for the one who processes new information globally best. Read more about learning styles later on in this chapter. By using cases, it is a way of using examples, which may support the learning process. Read also more about how to use examples later on in this chapter.

2 The Learning Process

The purpose of learning is to subsequently use the learning outcome. The learning process includes five different components which are important to achieve a transformation of new knowledge (Fig. 1). According to Vibe Aarkrog, the learning

Fig. 1 The learning process as a transformation [2]



process is complex as different factors need to be considered to achieve some results [1]. Someone needs to learn something—*the learner*. When the person learns it, it is *the learning situation*. What the person must learn is *the content*. What a person learns, he can choose to *apply* in different ways, and he will do so in a specific situation—*the application situation* [2].

2.1 The Learner

In a nephrology setting the learner is either a person with chronic kidney disease or their relatives or close friends. Usually when a person must learn something, he has chosen the subject of his own choice and he will be taught the subject for some years. A person with chronic kidney disease has not chosen to have his disease and he will have his disease for life. Often the teacher is an expert, but when a person with a disease is taught, he is the expert, as he knows unquestionably how it is to live with chronic kidney disease and deal daily with, for example, phosphate restrictions. When we choose to teach a person with chronic kidney disease, e.g., about phosphate restrictions, he may not understand the need for this learning process and therefore is not ready to be taught. Perhaps he is focusing on other areas of his life. When a person in general is taught a subject, the subject is the center for the learning process. When teaching a person with a disease, the person becomes the center and not the content of the learning situation. The learner is more than a person with chronic kidney disease; It is a specific person, and what may be good for people in general is not necessarily good for every person with chronic kidney disease that you are going to teach [3].

Studies have been carried out describing which factors are important for the person with chronic kidney disease as to whether they learn what they need to or not. Young people, immigrants, women, the unemployed, a lack of network, being unmarried, highly educated, and poorly educated are factors that contribute to a peoples' ability to adhere to recommendations. Other factors that are more significant are the healthcare system and the relationship with the health professionals. Large hemodialysis units and busy health professionals have an impact on the person's ability to adhere to recommendations, but also impact the relationship with the health professional [4]. If people with chronic kidney disease could receive dialysis where and when it suited them and as often as they wanted to, it would be easier for them to adhere to fluid restrictions.

Cognitive impairment can be among the uremic symptoms, which is an important factor that also needs to be considered for the learner [5], although it appears that it is especially the short memory which is influenced. This does not mean that the person with chronic kidney disease is not able to learn something new, but it is more difficult to memorize information and there is more necessity for written instruction and support from relatives. You also have to consider learning by doing, as actions are easier to memorize than just listening.

2.2 Learning Styles

Learning styles differ between people and each individual uses different strategies in order to retain new and complex information. Dunn and Dunn have determined six different learning styles: Perceptual, psychological, environmental, emotional, social, and physical. Each element contains several influencing elements (Table 1) [6].

Table 1 Overview of elements influencing learning styles [6]

Perceptual The person prefers to sense learning new materials Auditory: The person remembers best by listening Visual pictures: The person remember best by seeing pictures Visual text: The person remembers best by reading text Tactile and/or kinesthetic: The person remembers best by doing Verbal: The person remembers best by discussing	Psychological The person prefers to process new and difficult information, make decisions, and solve problems this way Global: The person processes new information best, when it is presented in steps Analytic: The person processes new information best, when the whole concept is presented before the details Reflective: The person considers options before making a decision Impulsive: The person prefers to receive a few details before making a decision	Environmental How the physical environment influences the persons capability to concentrate Sound: The person either concentrates best with sound in the background or needs peace of mind Light: The person either works best in good light or prefers dim or indirect lighting Temperature: The person either concentrates best when sitting in a warm room or when sitting in a cooler room Working position: The person either concentrates best when sitting at a table on a chair or prefers a more relaxed working position	Emotional Preferences important for the person to take on challenging and difficult tasks Motivation: The person prefers either positive feedback from others or from himself Endurance: The person prefers either to finish a task before taking on a new one or to work on several tasks at the same time Conformity: The person prefers to work on a task either in his own way or the way defined by others Structural: The person prefers either to have the procedures given by others or to create his own procedures	Social The groups in which the person learn and collaborate best Teamwork: The person is most productive working together with others Authority: The person works better together with an expert subject, or work less effectively, when someone is looking over his shoulder Variety: The person prefers routine based work with well-known methods, or get bored when having to do the same thing over and over again	Physical Biologically based preferences that are decisive for his ability to maintain focus in learning Timing: The person works best during the daytime Eating and drinking: The person concentrates best when eating and drinking, or not Mobility: The person becomes restless if sitting quietly for a long time

2.3 Reflective Question

- Think about which learning style is most suitable for you when you learn.
- Think about which learning style you most often choose when you teach a person with chronic kidney disease.
- Do you use the same learning style, when you teach, that you prefer when learning yourself?

2.4 The Learning Situation

There are various factors in the learning situation that enhance the learning process; learning by using examples, learning by doing, learning together, learning at the right time, learning through instruction, counseling, supervision, or coaching, and learning through leaflets.

2.5 Learning by Using Examples

Using examples lower the level of abstraction. To lower the level of abstraction relates to a higher learning outcome. For example: a person on assisted automated peritoneal dialysis (PD) was told that he could drink a maximum of 1 L per day. *“That means 5 of these bottles’ but he pointed to 0.5 L bottles.”* This person had mistakenly converted 2 dl into a bottle and drank more than 2,5 liters per day [7].

2.6 Learning by Doing

Andragogy is the science of how adults learn, and one component in adult learning is experiential learning, learning by doing [8]. To remember what has been taught, the person needs real experiences with the task. They need to have it *“in their hands.”* We need to rethink the learning situation, so it is less learning “about” and more learning by “doing.” A person with a newly kidney transplant before discharge needs to learn how he should take his medication. Perhaps he should administer his medication himself during admission, and not just after discharge. An example of learning *“by doing”* is at a youth clinic in Denmark [9]. The clinic provides informal learning about being active and eating healthy food by offering the young people different opportunities by, e.g., participating in preparing the dinner. The learning pyramid shows how important learning by doing is for the learning outcome (Fig. 2) [10]. Although the learning pyramid is not evidence based and the percentage is not accurate, it is a visual image of the relationship between learning by doing and the learning outcome.

In the learning pyramid, teaching others has the highest learning outcome. Teach-back is an often-used method of having people with a disease teaching other. Teach-back is defined as:

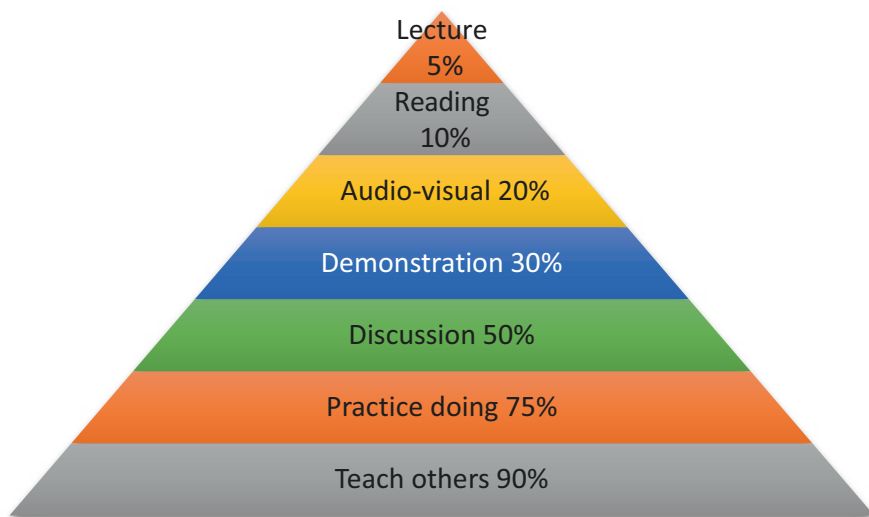


Fig. 2 The learning pyramid [10]

Teach-back is a way of checking understanding by asking people to state in their own words what they need to know or do about their health [11].

An example of the teach-back method used with a person who has just received a kidney transplantation. “*I want to check that I explained how to take this medicine clearly. Can you please explain it back to me so that I can be sure I did?*” It is important to use these open-ended questions and not closed questions which could be answered with a “yes” or “no.” Teach-back has been shown in people with chronic kidney disease to be an effective learning method [11].

Learning by doing is about acting in and influencing situations and that promotes self-efficacy. Self-efficacy refers to an individual’s belief in his capacity to execute behavior necessary to produce specific performance attainments and it is developed by four different methods: mastery experience, modeling, social persuasion, and bodily self-perception [12] (Table 2).

2.7 Learning Together

Collaborative learning or learning together with others is important and also possible for people with chronic kidney disease. People with chronic kidney disease give each other advice and tips and they learn from each other. Kidney schools are common in many places, but these are mostly for people with chronic kidney disease stage four or five, who need to decide on dialysis modality. Often relatives also participate in this type of kidney school. Alternatively, why not also gather people with a kidney transplant or people who have recently initiated dialysis. The recommendations for training people for home HD [13] and PD [14] are both to provide

Table 2 Overview of self-efficacy [12]

Mastery experience A personal feeling of success	Modeling Good examples or role modeling, vicarious experiences	Social persuasion Encouragement in the social community	Bodily self-perception Changing bodily self-interpretation
If every time a person comes to dialysis, the person is told that he has gained more weight than he should. Instead of 0.8 l, he drinks 2 l. The person does not experience a sense of success. Perhaps the goal should be made more manageable. For the next 3 weeks, he must try to get his fluid intake down to 1.8 l. If he succeeds, a new achievable goal will be set	If a person on dialysis succeeds with his fluid restriction, he can use this experience to believe that he will also succeed with his phosphate restrictions. When one person on dialysis has had success with fluid restriction, others may choose to follow the same regime	You could encourage a person on dialysis to succeed with his fluid restriction. The relative of the person on dialysis could also encourage the person to succeed and other people on dialysis in the unit could encourage the person too	The person on dialysis can feel the thirst and takes it as an expression that he cannot manage to comply with the fluid restrictions. They must learn to interpret bodily signals in a different way and specially to act on them in a new way

the training one to one, one health professional to train one person. While some places have tried group training with success for both home hemodialysis and PD. As shown in Fig. 2, the learning pyramid, teaching others is the learning activity which achieves the highest outcome. So, when including people with chronic kidney disease as educator at a kidney school, it is not just people participating in the kidney school who learn, but also the people with chronic kidney disease who teach. It could also be implemented in a HD unit, by inviting another person on HD to be a mentor of a new person in the unit.

2.8 Learning at the Right Time

The teaching must be relevant for the person with chronic kidney disease and provided to the person at the right time. As health professionals we often provide the entire palette and explain everything we know to the person with chronic kidney disease leaving it up to them to sort out the information. An example is that perhaps we spend a lot of time talking about milk in relation to phosphate restrictions and at the end the person says that he has a milk allergy or just does not like milk at all. We should always go through what we want to tell the person and consider what is necessary to know and what is nice to know. In a study among people with diabetes, they found that structured and intensive education maximized engagement, motivation, and long-term change [15].

2.9 Learning Through Instruction, Counseling, Supervision, or Coaching

When teaching people something, we use different learning methods, but usually we alternate between instruction, counseling, supervision, and coaching. These four different learning methods have all different purposes and different characteristics (Table 3). Therefore, we must be conscious of which learning methods we choose. The four different learning methods could also be used in a combination.

2.10 Learning Through Leaflets

We often use leaflets to support learning. It is a good supplement, but at the same time only a supplement. A leaflet cannot stand alone. An older study showed [16] that the outcome of individual learning without a leaflet had a learning outcome of 70%. Group learning without a leaflet had a learning outcome of 50% and learning only with a leaflet had a learning outcome of 0%. When developing a leaflet for people with chronic kidney disease, one should consider the literacy level of the population. In Australia they have measured the literacy level of their population with chronic kidney disease and discovered that their leaflets contained a higher literacy level than that of their population with chronic kidney disease. Tools to measure literacy level exist for free online and aim to reach a literacy level equal to that in magazines [7]. A way to ensure the right literacy level is to ask people with chronic kidney disease to provide feedback to the leaflet. When developing a leaflet

Table 3 Different learning methods [8]

Instruction	Counseling	Supervision	Coaching
A clear order Only content	Good advice Mostly content and less process	A frame for action Less content and mostly process	Good questions Only process
The instructor: Has maximum control Has full responsibility for the action	The counselor: Has control Has responsibility for action	The supervisor: Has minimal control Has minimal responsibility for action	The coach:
Typically says: You must... Remember to... You may not...	Typically says: You can... My advice is to...	Typically says: It seems to me... You could consider...	Typically says: What can you... How do you know... What different...
The person with chronic kidney disease: No ownership	The person with chronic kidney disease: A little ownership	The person with chronic kidney disease: Greater ownership	The person with chronic kidney disease: Total ownership
Typically says: Yes... I'll do that...	Typically says: I will try that...	Typically says: You have given me... It sounds like...	Typically says: Aha... Now I know what I...

for people with CKD, one should consider involving them in all aspects of the development process allowing them to determine its content [17]. Another way to reduce the literacy level is using pictures in leaflets, which also reduces the abstraction level. Pictures are also a way to use different examples or cases. However, if the person shown in the picture does not look like the person with chronic kidney disease, perhaps they look older, have another gender, etc. then the picture does not work. Using pictures without being age specific or gender specific could be an option. Figure 3 shows an example of drawings which is neither age nor gender specific. The pictures are used in a patient decision aid to learn the person with chronic kidney disease about uremic symptoms.



Fig. 3 An example of neither age nor gender specific drawings [18]

2.11 The Content of the Learning Situation

A systematic approach is needed to find out what the person with chronic kidney disease needs to be taught. You must use the same system in this process that you always apply when you decide the nursing care of a person. You should use the nursing process [19] and conduct a nursing diagnosis to guide you in choosing the content of the learning process. The nursing diagnosis is based on an overall assessment of the person. Next step in the nursing diagnosis is to set up goals with the person and decide some learning activities. It is important to take into account the learning classification that Bloom, Krathwohl, and Simpson provide when setting up the learning outcome and activities. These three different classifications show the relationship between what to learn, how to learn it, and the learning outcome (Table 4). [20].

2.12 Learning Activity

Based on the below case regarding a person on HD, decide what the nursing diagnosis is and which goals to achieve:

What are the characteristics of the person?

What may these characteristics be related to?

What is the problem?

Case:

It's the weekend. And we get an extra day free. It's really nice when you have visitors to our garden house. We like to stay in our garden house at the weekend, and we have a pretty garden, but it's a lot when I have visitors in the garden house. Then someone comes who wants a beer, but I shouldn't do that now. I don't mean to drink too much. I'll have a cup of coffee or something. But I drink more than usual. In the past, I would have a pint or so. My wife tries to give me what I am allowed to drink. It's more my wife who cares about what I am allowed to drink. She gives me the amount of ice cubes I am allowed to have. I'm not really into that. She wants me to comply. If I'm just sitting alone at home, I don't drink. It is particularly at the weekend that I drink a little too much.

2.13 To Apply What Has Been Learned

When the person with chronic kidney disease applies what he has learned it could either be by repetition, adaptation, interpretation, or no application at all [21]. Often when we teach a person with chronic kidney disease, we expect the person to repeat what we have taught him. When the person repeats exactly what we have taught, we believe that we have really succeeded. But repetition is not always applicable. For

Table 4 Description of cognitive (Bloom), affective (Krathwohl), and psychomotor (Simpson) taxonomy in learning process [20]

Taxonomy levels	Cognitive (Bloom)	Affective (Krathwohl)	Psychomotor (Simpson)
V	Assessment: Refers to the ability to determine the total value of a collected amount of information. The learner can separate the bad from the good	Personality: Does not change from day to day. It is the persons learned behavior and reaction pattern and cannot be easily changed	Complex skills: The learner can keep several balls in the air. For example, two or three tasks are performed in parallel with each other
IV	Synthesis: Means that the learner can combine subsets of factual knowledge	To organize: Getting control of ones' own life, a task or similar. Being able and willing to organize is often outside our possibilities, even though we seem to influence them	Execution with routine: The learner has the competence as an automatic skill
III	Analysis: Means that the learner can break down factual knowledge into its basic components	To appreciate: The basis for forming an attitude—once you have reached this point, the change in attitude is a personal matter	Controlled execution: The learners use of knowledge and where the learner can perform a skill under guidance
II	Using: Intersects slightly with understanding but must be understood as being able to use in other contexts. The learner goes from step 1 to step 2 here	To react: The learner reacts to what he received—however, the level of reaction can be very different, from winking with the eye to showing signs of wanting to participate in a debate	To show readiness: The learner's ability to show readiness to carry out a possible task or message
I	Understanding: Refers to a goal where the learner shows that he can apply the knowledge that was learned in the first step Knowledge: The concept is an achievement where the learner is expected to be able to reproduce or recognize	To receive: A prerequisite for being able to receive learning	To observe: The learner being able to receive information. This can be learned through all senses—listening, seeing, hearing, etc.

example, it is not appropriate if a person on HD complies with fluid restrictions when he has diarrhea. The person needs to adapt what they have learned into their lives and sometimes our framework of understanding is so far from theirs that not only an adaptation is needed, but rather an interpretation. Consequently, it is not certain that we can recognize what we have taught the person. We may think that the person has learned nothing at all but in reality, he may have actually learned something. Sometimes the person may learn something but does not apply it. We just

teach them bit by bit. For example, a person on hemodialysis did not comply with the fluid restrictions. Despite continually and repeatedly teaching him, eventually we gave up. When he had been transplanted, he came to see us, and said: *“Now I understand where I drank too much.”* He thought he was following the fluid restrictions, but this was not the case when he got on the scales. He realized that it was when he was brushing his teeth. That he unconsciously swallowed a quantity of water, enough to make quite a difference to his fluid intake.

2.14 The Application Situation

Some elements to the application situation can influence the person in applying what he has learned. These attributes could be, for example, the relatives, the person being an in-patient or out-patient, feedback, and conflicting goals.

2.15 The Relatives

The relatives influence the persons with chronic kidney disease ability to apply what he has learned, both positively and negatively. The relatives can both be the spouse or the wider network. In the above case, the wife has a positive influence on whether the person applies what he has learned. She encourages him to use a cup. But the friends do not, they encourage him to have one more glass of beer.

2.16 People with Chronic Kidney Disease Both as an In-Patient or an Out-Patient

We meet people with chronic kidney disease both as in-patients and out-patients. Both options have some advantages and disadvantages. If the person is an out-patient, we can follow up on the learning process and hear how it is going at their next appointment. But we are not able to support the person in the application situation, to support the person at home. However, it is usual practice for people on PD and home HD to have a health professional at home for the first treatment and in addition to have the ability to make a phone call, if and when they experience problems with their treatment [13, 14]. During hospitalization we have the option to support the person in the application situation and we can practice the learned skills together. Hospitalization also presents an opportunity to focus on other issues such as fluid restrictions or phosphate restrictions, if the person is not at risk nutritionally. It is important to provide careful and meticulous care, so that the person learns the importance of carrying out the procedures carefully. If we do not teach them this, they could think that it is not important to be careful. An example of this would be taking the immunosuppressive medication at the exact time.

2.17 Feedback

Feedback in the application improves the person's ability to apply what has been learned [1]. People with chronic kidney disease receive sparse feedback to applying what they have learned. When a person on HD does not apply the fluid recommendation, he may experience breathing problems or breathlessness. This is a type of negative feedback. When the person complies to the recommendations, he experiences an absence of symptoms. However, with phosphate recommendations, the person may or may not experience itching, as a high phosphate level does not give the person any symptoms; therefore, the person does not receive any feedback in the application situation, but only when he has his blood test results [22]. When we as health professionals provide feedback to a person with chronic kidney disease, it is important not just to focus on the result but equally on the process. Providing feedback to a person on fluid recommendations should not just be about the number of surplus kilo's but also the reasons why it has happened that the recommendations were not applied.

2.18 Conflicting Goals

Conflicting goals could be a reason why some people with chronic kidney disease are not able to apply what they have learnt [23, 24]. For example, a person on hemodialysis who has received a transplant is suddenly allowed to drink freely and encouraged to drink a lot. People with diabetes who suddenly have kidney failure experience a lot of conflicting goals between recommendation for diabetes and recommendations for kidney failure. What may apply to one disease may not apply to the other.

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Patient Partnership in Kidney Care

Jeanette Finderup, Henning Søndergaard,
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Learning Objectives

- To gain knowledge about developing and researching kidney care in partnership with patients.
- To describe how to involve patients in decision making regarding their kidney care.
- To understand what aspects are relevant to patients with kidney disease and his or her relatives.
- To be able to integrate patient partnership in kidney care nursing practice.

1 Involving Patients in Development and Research in Kidney Care

Involving patients in development and research in the medical field has become more common in the last few years however, this is not the case in chronic kidney disease. A literature review from 2020 revealed only 22 studies using patient involvement in research and these studies were conducted in only five different countries [1]. Only ten of the studies showed a high degree of participation. Involving patients in development and research in kidney care is defined as:

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The meaningful involvement of patients, caregivers, clinicians, and other healthcare stakeholders throughout the research process, from topic selection through design and conduct of research to dissemination of results. [2]

Involvement has to be meaningful for both the patient, the researcher, and the project, and it can be considered in any or all of the steps included in the project. Figure 1 shows different levels of involvement. The arrows in the figure between the dots represent the direction of communication, where the dot at the bottom represents the professional and all other dots represent the patients (or other stakeholders) [3].

Some may argue that only “expert” patients are capable of being involved in developing and researching care and that it calls on specific skills among the patients. However, all patients are “experts” on being a patient because they have lived experience with chronic kidney disease and can share this experience with the project team. A study from the UK showed that very frail patients with chronic kidney disease were also able to contribute a lot to a research project and even be able to collect and analyze data [4]. When the aim is to involve patients in development and research in kidney care, some recommendations have recently been published [1]:

- 1. Write a role description for the patients.
- 2. At the first meeting, develop ground rules for collaboration, including confidentiality.
- 3. Hold meetings at a place with opportunities for patients to rest, and with catering, considering patients have chronic kidney disease dietary restrictions and uremic symptoms.
- 4. Involve patients multiple times throughout a project, allowing them to be a part of the whole research process.
- 5. Work together as a team, with all participants contributing equally.
- 6. Evaluate each meeting and adjust the next meeting to the needs of all participants.
- 7. Create a plan for evaluation of the impact of involving patients in the project.

Some national initiatives give guidance on how to involve patients overall in development and research projects [3], but there is only one initiative (from the UK) that shows how to guide health professionals and researchers in involving patients in developing and researching kidney care. The initiative is named “Kidney Patient



Fig. 1 Different levels of involvement

Involvement Network” [5], the target group of this initiative includes patients, relatives, and professionals, and it provides a network and resources for use.

The Standardised Outcomes in Nephrology (SONG), an international initiative from Australia that aims to establish core outcomes in chronic kidney disease, has involved patients in the decision making for the research outcome in kidney care [6]. Research outcomes have been determined for patients on HD, peritoneal dialysis, kidney transplant recipients, children and adolescents with chronic kidney disease, and patients suffering from polycystic kidney disease. These projects do not only provide information about research outcomes but also provide knowledge about what is important and relevant to patients in kidney care. This way, patients can give a different point of view that health care professionals cannot visualize and can give a positive progression to the whole research project.

1.1 A Reflective Question

Think about a development project or a research project that you are a part of.

- If you have involved patients and/or relatives in this project, think about how you either could increase the level of involvement or increase the number of processes to be involved in (use Fig. 1 for your reflection).
- If you have not involved patients and/or relatives in your project, think about how you could involve patients and/or relatives in a meaningful way and decide what your next step should be.

The highest level of involvement is not necessarily the best, it still has to be meaningful for the people involved.

2 Involving Patients in Their Own Kidney Care

Involving patients in their own kidney care is the key concept of patient centered approach or person centered approach, by putting the person in the center. Person centered approach means involving patients in decisions about kidney care but also involving patients in their kidney health and care [7], see Fig. 2. The figure shows how involving people in health decisions relates to the involvement of patients in their health and healthcare, but it also shows the aims and interventions related to this involvement. The model is based on a literature review by L’hussier et al. [7]. Studies in kidney care have shown that patients being involved in decision making become more involved in their kidney care and health over time [8]. A patient expressed it this way: *“it is like a three-stage rocket. And I imagine the best way to get aboard this rocket is to get on from the start.”*

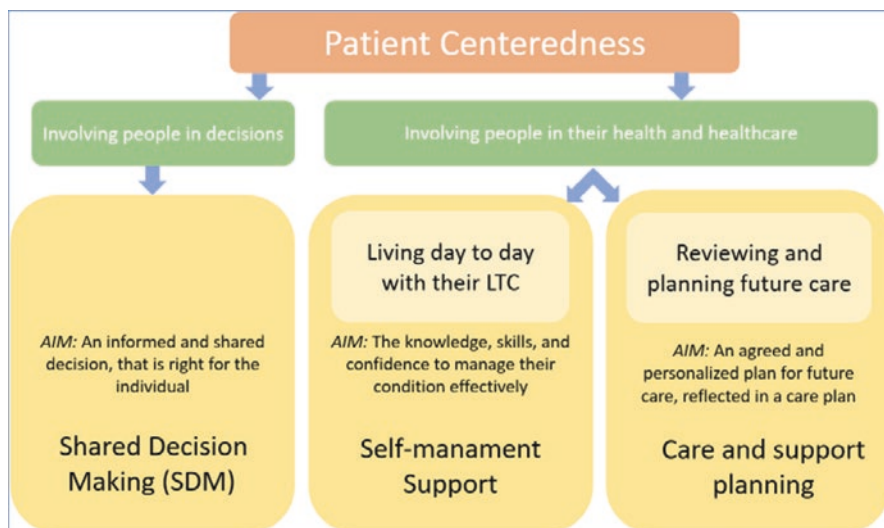


Fig. 2 A model of patient centeredness

3 Involving Patient in the Decision-Making Process Regarding Kidney Care

In a review from 2020, a total of 17 shared decision-making interventions were identified in kidney care, focusing on different decision points along the illness pathway [9]. Studies in kidney care have shown that shared decision making involves patients in their decision-making process [10] and that most patients made an informed decision based on their preferences [11]. Furthermore, based on research on decision making in kidney care, the MIND_IT (Making Informed Decisions Individually and Together) model as developed by Bekker shows what shared decision making is in general [12]. The role or decision frame of the patient is to make an informed decision about his/her life with kidney disease. The role or decision frame of the health professional is to make evidence-based decisions about delivery of care for their patient with kidney disease. Both patients and health professionals draw on their experiences, skills, knowledge, motivation, cultural beliefs, and viewpoints when making their decisions. The patient is influenced by other stakeholders in their lives such as their family, friends, other patients, and media; the health professional is influenced by other stakeholders within their health-care system such as their clinical team, clinical guidance, and scientific advances in treatment and care. Within consultations, patients and health professionals share information from their perspectives about the health problem, treatments and health-care management, and relevance to everyday life. This communication can be part of a shared decision-making process about health-care options, an exchange of understanding about how the patient and the health professional make sense of the health problem, frame the decision(s), talk about the benefits and harms of

different treatments, the reasons and trade-offs between options. In addition, also being aware of the patient’s preferences for options, agreeing upon an option that best meets the patient’s need(s), and working out issues about the care pathway for the agreed upon choice (Fig. 3).

3.1 A Reflective Question

Think about a patient you know very well or the patient in the case below. Try to make this calculation:

[The time (days) spent at the hospital in relation to chronic kidney disease a year] /
365 × 100 =?

Then you have the percentage of the patient’s life that he or she spend together with a health professional or close to a health professional. Think too about how much time the patient spends at the hospital. Using the above calculation patients on in-center HD spend too much time at the hospital, probably around 30% of their time. That is one reason, why it is so important to involve the patients in their own kidney health.

Self-management support is the term used for involving the patient in kidney care. The most common definition of self-management is:

The active participation of people in their own treatment, undertaking related tasks and activities with the collaboration and guidance of the individuals’ physician and other healthcare providers [13].

And self-management support is:

Strengthening people’s capacity to self-manage their health [14].

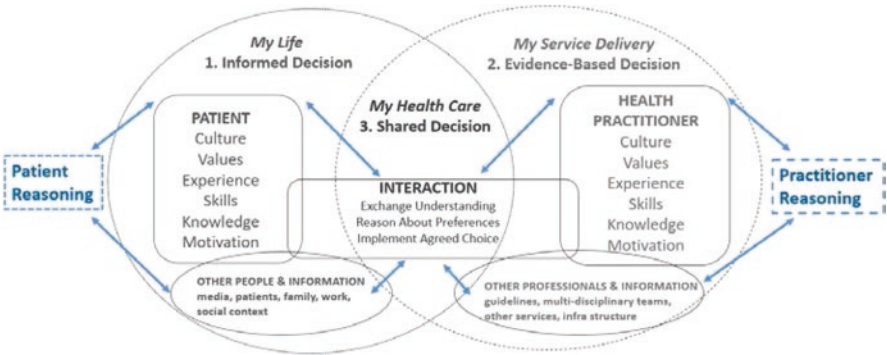


Fig. 3 A model of shared decision makingFigure legend: A shared decision-making framework developed by Bekker. [12] The framework: MIND_IT (Making Informed Decisions Individually and Together)

Three tasks are required by the patients with chronic disease for self-management: (1) the medical management of the condition, such as taking medication, adhering to a special diet, or having dialysis; (2) maintaining, changing, and creating new behavior or life roles, such as learning to cook in another way and buying different types of food, or reduce working hours to enable time for the dialysis treatment; (3) dealing with emotions such as anger, fear, frustration, and depression related to having a chronic condition, which will most certainly change the patients' view of the future [13]. The skills the patients need to self-manage these three tasks are: problem solving, decision making, resource utilization, forming of a patient/health professional partnership, and taking action [13].

4 Involving Patients in Their Own Kidney Care and Treatment

Post-transplant management and conservative kidney management are both treatment options which take place in the patient's home, and where the patient has to manage on their own. It is now possible for the patients to have both HD and peritoneal dialysis at home and be able to self-manage these treatments. For the patients having in-center HD, there is ample opportunity for involving them in their treatment. A concept mainly developed in the UK, called shared care, is based on the patient and the health professional sharing the care when performing in-center HD treatment [15]. Shared HD care allows the patients to choose which aspects of their care that they want to undertake. It could be small tasks such as taking their own blood pressure and weight measurements or preparing their chair before and after treatment. But it could also be bigger tasks such as setting up the machine or self-cannulation. Making the patient able to see the screen of their dialysis machine or asking the patient about the best place to put in the needle are also ways to involve the patients in their treatment.

4.1 A Learning Activity

- Go for a walk in your in-center HD unit.
- Count how many patients can see the screen of their dialysis machine.
- Observe how many patients are asked about the best place for needle placement.

5 Involving the Perspective of the Patient in Providing Kidney Care

The SONG-initiative has revealed what is important to patients with chronic kidney disease in different stages of their kidney disease trajectory [6]. The SONG-initiative included more than 9000 patients, relatives, and health professionals from over 70 countries, which is why it is a very strong indicator of what is important to patients

in kidney care and shows why it is important to involve the patient perspective when providing kidney care [16]. What matters most to patients with chronic kidney disease is “Living well with kidney disease” which is why the focus for kidney care should be on life participation, empowering the patients and managing symptoms [16].

Kleinman divides the illness experience into three parts [17], his three perspectives on illness are shown in Fig. 4. It is common practice for the health care professionals to focus on the patient with the disease from a nursing or medical perspective using the term disease. The patient’s subjective experience of living with chronic kidney disease may use the term “illness,” whereas a third perspective, termed “sickness” is how the disease appears from the outside perspective in the person’s life. Sickness is what makes a person believe that something is wrong. His personal experience of the situation is illness, which makes him to go to the nephrologist, who may give him the diagnosis of chronic kidney disease. Sickness is the consequence of the disease in the community. Sickness combines illness and disease together, because sickness combines the personal experience and the cultural belief in a community along with the medical understanding of a condition. Sickness may also give the patients some rights in the community, based on what that society has chosen, for example, whether to cover certain costs to medication and/or treatment or not [17].

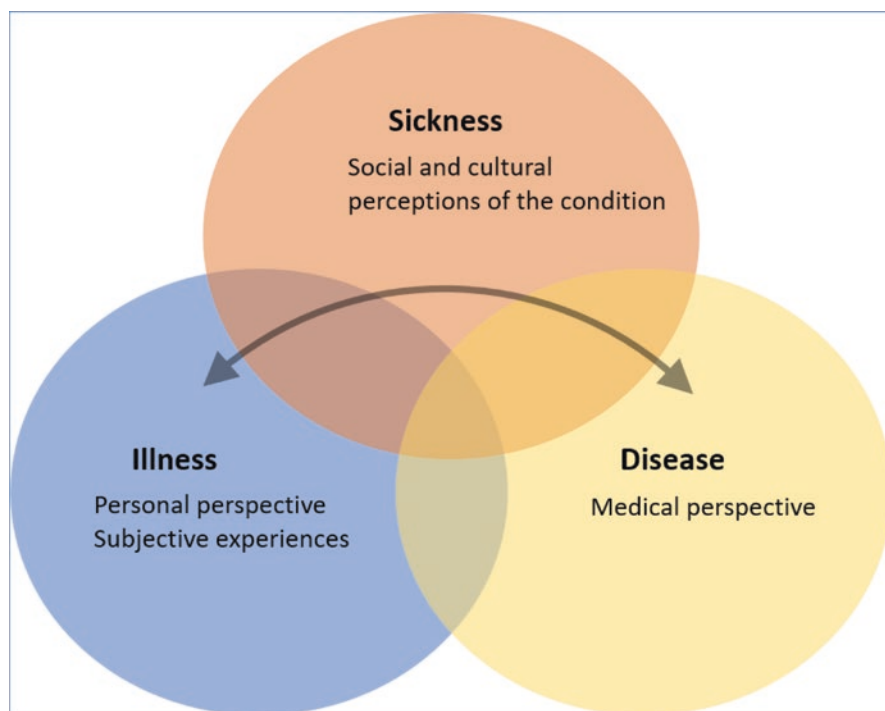


Fig. 4 Disease, illness, and sickness model

6 A Patient Case

Kristine has kidney disease and is currently on dialysis. Kristine has made a New Year's speech. In her speech, Kristine tells how she experiences her situation.

Here is an excerpt from the speech:

This year has been characterized by a life situation where my quality of life has been significantly reduced. When my friends meet and watch movies, go out to eat or just enjoy themselves together, I have not been able to be part of their community on Monday, Wednesday, and Friday between 14.30 and 20.30. That's when I am in the hospital busy preparing my machine for use, setting up the filter, stabbing myself, hooking up to the machine and letting all my blood flow out and into my body 10 times through my artificial kidney in order to remove all the waste materials that I cannot remove myself. This year I have spent well over 1,000 hours chained to my machine. Every single day I've been thinking about what I've been eating and drinking, and I can't get too many minerals that my body can't flush out on its own. I have had to make small choices all the time. I have had to choose between eating an apple or drinking a cup of coffee. This year has been a year where I have tried to accept my situation. It has been a year where I have cried a lot. It has also been a year in which I have grown incredibly as a person. I've turned myself inside out, and I've found the strength I didn't even think I had. So, in many ways I have managed to have a fantastic year ... Happy New Year.

Try to think how Kristine expresses her experience of her illness in her speech and how she expresses the three different perspectives: disease, illness, and sickness.

6.1 A Learning Activity

In order to reveal the patient perspective, Kleinman and his colleagues have suggested some questions to use in the dialogue with the patients [18]:

- What do you think has caused the problem you are struggling with right now?
- Why do you think this problem started at this point of your disease trajectory?
- What do you think the problem, or your disease does to you?
- How serious do you think this problem, or your disease is?
- Do you think you will suffer from this problem or your disease for a long or a short time?
- Which type of treatment do you think you need just now to solve your problem?

When interacting with a patient in the future, the kidney care professional should try and pose some of the above questions before diving into any further inquiries, and then think about how by doing so has affected the interaction with the patient and the quality of kidney care provided. The patient's reaction to these inquiries can also be elicited.

7 Involving Patients in Other Patient's Kidney Care

Peer-to-peer (P2P) support is a useful resource in kidney care [19] and offers information, appraisal, and emotional support for other patients with chronic kidney disease. P2P support is defined as:

An activity in which those with shared characteristics, conditions or circumstances support each other [20].

P2P support is underutilized in most clinics despite evidence showing P2P support to be an effective method when it comes to improving health outcomes as well as treatment decisions [21]. There is no official definition of P2P support, how it is done or what it entails. But generally P2P support and education can be divided into two different categories.

The First Category

Clinics establish formal P2P programs involving clinic staff to set up and often run the P2P program. The staff will usually act as a gatekeeper and identify patients and relatives who might gain insights from participating in a P2P program, both those who need help from fellow patients and experienced patients deemed able to help others [22]. It requires health professionals who are dedicated and passionate, as well as dedicated patient volunteers and support from the leadership in the organization to run such a P2P program. Some hospitals have used patient councils or advisory boards where patients and relatives can engage in support and education of their peers [23].

The Second Category

Informal P2P support which often occurs naturally such as when dialysis patients talk to each other in the clinic or when patients with kidney disease share stories and experiences via patient organizations or online forums. Informal P2P support can also be utilized by health professionals without a formal program. This can be done by encouraging patients to talk to other patients having overcome the same issues as themselves, or to seek out the organizations or forums that seem appropriate to the individual patient or their relatives.

Health professionals working with P2P support acknowledge that patients and relatives know and are able to share health related information and practice that health professionals are inherently unable to know or share. That means there is a fundamental difference between P2P conversation and interaction, and the conversation and interactions which happen between patient and a health professional. Many issues appear to be easier to talk to a peer about. It might be embarrassing things like gastro-intestinal problems or psycho-social issues, such as sadness, anxiety, fear of death, etc. Implicitly there is a different level of trust between peers that can be difficult to transfer to the conversation and interaction with a health professional regardless of what we do to break down that barrier. A multitude of psychological studies of “in-group–out-group dynamics” strongly support this idea [24].

8 Involving Relatives in the Patient's Kidney Care

Having a family member with a chronic disease impacts the relative's quality of life [25]. Especially in chronic kidney disease stage five there is a profound loss of energy affecting the ability to participate in everyday life which not only affects the patient, but it also creates additional responsibilities for relatives. A relational responsibility has been found among patients with kidney disease and their relatives, including protecting others from grief, and demonstrating loyalty [26]. Feelings of burden among relatives have been found to be related to the perceived burden of additional tasks handed over to caregivers [27]. Conversely, relatives may also find it rewarding to undertake caring activities [28]. Relatives have described a need for understanding the emotional and physical changes in patients, to receive advice from other relatives and health professionals to be able to provide adequate care and support, to reduce feelings of inability in helping the patient, and feelings of helplessness [29, 30]. This is why it is important to not just involve the patient in decisions, health and care, but we as health professionals also need to consider how we involve relatives in these aims, so that the relatives are able to provide the right support for the patient.

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Multidisciplinary Approach of Care and Management of Kidney Disease. Evidence-Based Nursing Practice and Different Nursing Roles in the Management of Kidney Care

Ann Bonner and Leanne Brown

Learning Objectives

- To understand and differentiate between multidisciplinary and transdisciplinary kidney care teams.
- To identify the domains of nursing and apply them to kidney care nursing.
- To explore the differences between nurses, advanced practice nurses, and nurse practitioners.
- To consider the role of nurse practitioners in the management of kidney disease.

1 Introduction

Chronic kidney disease (CKD) has been defined in chapter “[Management of Chronic Kidney Disease](#)” as the presence of impaired or reduced kidney function that occurs for longer than 3 months, and it is one of the fastest growing non-communicable diseases in the world largely due to diabetes, hypertension, and the aging population [1]. The progression of CKD can be prevented or slowed through early screening of

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people at risk particularly in primary healthcare settings. Testing involves measuring of blood pressure, urine albumin/creatinine ratio, and determining estimated glomerular filtration rate (eGFR) through a blood test. Unfortunately, this screening does not occur frequently enough even in high income countries where there is easy access to these resources [2].

Screening and interventions require a multidisciplinary approach to ensure CKD is detected early and progression to kidney failure is delayed or ceased. The presence of CKD generally occurs alongside other chronic diseases and the management of people with CKD often requires a care co-ordination approach with health providers from primary, secondary, and tertiary care. These providers are from a variety of disciplines and provide a multidisciplinary approach. Kidney care nurses work in or lead multidisciplinary teams in primary (e.g., general practice, community centers), secondary (e.g., small hospitals, outpatient departments), and tertiary care (e.g., nephrology wards, dialysis units).

This chapter will explore the concept of multidisciplinary and transdisciplinary care and will provide a case study to illustrate how effective these team models can provide a holistic patient-centered approach. The principles of kidney care provided through the nursing discipline will be outlined with discussion identifying the key domains of kidney care nursing and competencies needed for this. The next section will identify and define the nursing roles in terms of skills and experience of registered nurses, advanced practice nurses and nurse practitioners, and explore the difference between the skills and competencies. A case study will be used to demonstrate the role the nurse practitioner has within the transdisciplinary team.

2 Multidisciplinary Kidney Care

There is an increasing emphasis in teamwork in healthcare that involves multiple disciplines, and making teams work effectively is a core skill for all health professionals [4]. A team is “a group organised to work together” and teamwork is “cooperative effort by the members of a group or team to achieve a common goal.” It is generally assumed that efforts to involve more than one discipline are valuable and beneficial. A multiple disciplinary approach is emphasized in healthcare services, health research, and health policy. Most importantly, effective teamwork is about “collective capability,” i.e., “what professionals know and what they do collectively” [3] with a patient and the patient’s supporters to meet the patients’ needs.

The key attributes and processes for clinical team effectiveness are shared goals, interdependence, co-operation, co-ordination of activities, task specialization, division of effort, and mutual respect. The team needs operational guidelines that outline the process of team activity, a mechanism for decision-making, clear lines of communication and clearly defined roles, responsibilities, and accountability for team members. In the clinical team the uniqueness of the patient and their illness experience is frequently overshadowed by emphasis on standardized processes.

Multidisciplinary care is patient-centered and integrates independent disciplines to provide comprehensive care. It is collaborative to ensure optimal care for the person with a complex illness. Multidisciplinary care is important to help with CKD and multimorbidity to support patients and family members to make lifestyle changes, appropriately manage medications, improve dietary adherence, improve self-management, manage problems, and to make decisions about whether to commence kidney replacement therapy or not.

In kidney care, multidisciplinary teams are common. The team could comprise any or all of the following: nephrologist, nurse, dietician, pharmacist, social worker, psychologist, occupational therapist, exercise physiologist, and podiatrist. As people with CKD typically have multiple chronic diseases, additional team members are becoming more common in kidney care services. These team members may also come from other disciplines such as palliative care, geriatrics, primary care (e.g., general practitioner), community nurses, and diabetes educator. Table 1 summarizes some examples multidisciplinary teams used in kidney care. A systematic review [5] found that when the membership of the multidisciplinary team was only nephrologists and nurses there was no significant difference in all-cause mortality, however, when the team also contained additional team members such as dietitians, pharmacists or social workers as well as nephrologist and nurses, there was significantly lower risk of all-cause mortality.

2.1 Case Study

Chu Chun is a 50-year-old woman who lives in an apartment with her partner, grandparents, and three children (ages 10, 12, and 14 years). She works as a ground crew supervisor at a nearby international airport. She is the sole income earner; her partner is on disability pension. She has had type 2 diabetes for the last 15 years. Other comorbidities are hypertension, coronary artery disease (previous coronary artery bypass graft in 2020), peripheral neuropathy, diabetic retinopathy, CKD Grade 3B [9], and osteoarthritis. She smokes 25 cigarettes a day and has been smoking for 35 years. She has struggled with managing her blood glucose levels over the last few years and her HbA1C has increased to 10.4%.

She has been referred by her general practitioner to the nephrology multidisciplinary team for support and management.

Discussion Questions

1. What team members do you think need to be involved? What would be the priority? If they are not available in the multidisciplinary team, what would you do?
2. How do the team members communicate their plan? How would you set the goals of care?
3. What benefits does the multidisciplinary team offer compared with management by only a nephrologist?

Table 1 Examples of multidisciplinary kidney care teams

	Nephrologist	Nurse	General Practitioner	Pharmacist	Dietitian	Social worker	Endocrinologist	Palliative Care
Garg et al. [6]	✓			✓	✓	✓		
Chen et al. [7]	✓	✓	✓	✓	✓			
Imamura et al. [5]	✓	✓		✓	✓		✓	
Purtell, Sowa [8]	✓	✓		✓		✓		✓

2.2 Transdisciplinary Care

As identified previously the multidisciplinary team consists of health professionals that work independently to provide comprehensive care. In CKD, this can improve outcomes such as mortality, delay the commencement of kidney replacement therapies, and be used to support people to make difficult decisions. However, multidisciplinary members tend to have their own professional agenda and do not share skills, knowledge, and decision-making. Typically, the nephrologist is the health professional “in-charge” of the team, but this situation is changing which we will discuss below.

For more than 10 years, transdisciplinary teams are occurring in healthcare due to the evolving relationships within teams [10]. The differences between multidisciplinary and transdisciplinary teams are along a continuum with multidisciplinary at one end and transdisciplinary at the other (see Table 2). The change to transdisciplinary is in how team members from different health disciplines work together and has come about due to the additive, interactive and holistic shift in focus of healthcare needed particularly by people with complex multiple chronic diseases. There are key enablers and barriers of multidisciplinary care, and that internal and external configurations of the multidisciplinary meetings need to be reviewed and strengthened and formal referral pathways developed [11]. Here these authors are using the term multidisciplinary but implicitly mean transdisciplinary because these authors

Table 2 Differences between multidisciplinary and transdisciplinary health teams

Team	Differing features
Multidisciplinary	• Provides disciplinary specific management to address mutual issues. • Skills and experience of individuals from different disciplines, with each discipline approaching the patient from its own perspective. • Often, this approach involves separate individual consultations. These may occur in a “one-stop-shop” fashion with all consultations occurring as part of a single appointment on a single day. • It is common for this team to meet regularly, in the absence of the patient, to “case conference” findings and discuss future directions for the patient’s care. • Multidisciplinary teams provide more knowledge and experience than disciplines operating in isolation.
Transdisciplinary	• More than two health disciplines in a single consultation, i.e., the patient-history taking. • Involves shared knowledge and skills with a shared purpose and goal that is directed by the patient. • The team, together with the patient, conducts assessment, diagnosis, intervention and short- and long-term management goals at one time. • The patient is intimately involved in any discussions regarding their condition or prognosis and the plans about their care. • Individuals from different disciplines, as well as the patient themselves, are encouraged to question each other and explore alternate avenues, stepping out of discipline silos to work towards the best outcome for the patient. • In these processes, family members and partners will also be involved in the plans about the care of their family member.

are describing the healthcare team as being dependent on all team members who collaborate collegially together to provide good quality care [11].

The implementation of transdisciplinary care is designed to facilitate disciplines to work together and share their expertise with the common goal established by the person with the complex care needs. That is, transdisciplinary teams have moved from providing patient-centered care to person-centered care. In transdisciplinary teams, the disciplinary boundaries (and hierarchies) disappear. An example of the effectiveness of transdisciplinary care can often be found in palliative care settings where the transdisciplinary team comprising many different health disciplines working together to provide healthcare which is focused on the individual (i.e., person-centered). For instance, a transdisciplinary team approach was able to reduce hospital bed days and improve well-being and quality of life in people with end-stage chronic diseases [12].

However, transdisciplinary teamwork has yet to be implemented widely in kidney care as the health care community need to foster an environment where more than two disciplines work closely together with effective and frequent communication facilitating the development of knowledge and skills between each discipline. Purtell et al. [8] describes in kidney supportive care, a transdisciplinary approach in which any member of the team can take the lead depending on patient need has been useful in managing complex care needs. In this team, symptom management may need non-pharmacological nursing interventions and involvement of a social worker rather than a medical practitioner and pharmacist.

2.3 Reflective Questions

1. Explore the differences between multidisciplinary and transdisciplinary care and reflect on models of care that you have observed in your work environment. What health professionals were involved and how did they interact with each other?
2. Did you notice an improvement in patient outcomes or satisfaction? What strategies need to occur to implement transdisciplinary model of care into your workplace?
3. How could the traditional approach to taking care of people with CKD (i.e., medical-led model) be changed?

3 Kidney Care Nursing Practice

Kidney nursing care principles are the foundation by which we care for people with CKD including those receiving kidney replacement therapy and those who have chosen to have conservative care. It is essential for the kidney nurse to provide appropriate holistic care to ensure the people that are being cared for have their physical, social and psychological aspects of life addressed. To provide this care,

kidney nursing practice must consider a multitude of domains. Here we identify common domains of practice recommended by the International Council of Nurses [13] which would suit kidney care nurses working in any country.

3.1 Professional Regulation

This domain ensures that kidney nurses understand their legal and ethical responsibilities and practice within this framework to protect the rights of the patient and protect themselves against litigations. The fundamental requirement of provision of kidney nursing care is that a nurse's primary professional responsibility is to the people requiring the care and services, whether they are individual, family members, communities, or population wide. Kidney care nurses must understand the legislation relevant to kidney care, for example consent, confidentiality, and negligence. The nurses providing kidney care must ensure they fulfill their duty of care and educate other nurses who are less experienced in kidney care as to how these responsibilities are applied in the context of nephrology. An element of duty of care is ensuring adequate staff to provide safe and effective care while adhering to the nephrology unit's policies and procedures. The kidney care nurse must understand the nursing interventions required, anticipate any adverse outcomes and question inappropriate orders or actions. Accurate documentation of the care provided is essential. The provision of easy-to-understand information for patients that is timely and accurate and delivered in a manner appropriate to patient's culture, language, cognition, and physical needs is a core component of professional ethical practice [13].

3.2 Practice

To continue to maintain and improve clinical speciality knowledge, continuing critical self-analysis needs to occur [13]. Through this critical self-analysis professional development opportunities and academic progression can occur which can then lead to the nurse becoming an expert clinician in the speciality practice of kidney care nursing. The practice domain is continuously informed by regulation, education, and research to ensure that practice is contemporary, and that patient care is based on evidence and safety [13]. Assessment and understanding of one's own ability and areas needed to develop, ensures safe clinical care and ongoing professional development. Areas identified for improvement might be the use of ultrasound to cannulate complicated arteriovenous fistula or assessment of a patient with advanced kidney disease and prioritizing care needs. Through seeking peer review of skills and reflecting on the day's activities, ongoing self-improvement can occur. For example, review of a clinical scenario such as intradialytic hypotension or poor drainage from a peritoneal catheter, and then critically discussing management strategies with other kidney care nurses. When developing a management plan for reflective practice,

consultation with other staff members such as nursing, allied health and medical can further enhance critical reflection and knowledge progression. The overall intent of kidney care nursing practice should be person-centered [14].

3.3 Education

The standard of education the kidney care nurse has undertaken will have a direct impact on patient outcomes. Kidney care nurses must undertake ongoing professional development to ensure improvement of skills and knowledge throughout their career [13]. Increasingly this is through formal university study at the post-graduate level. The intent is to provide evidence-based best practice care and to also support the development of less experienced nursing staff. Education for kidney care nurses should be designed and delivered by those who have reached an expert level in the provision of kidney care. Education also includes that which needs to be provided to those with kidney disease and can include health promotion and disease prevention counseling, health maintenance strategies, and facilitation of shared decision-making.

3.4 Research

The kidney care nurse must incorporate evidence-based research into clinical practice. This ensures the provision of optimal care for those with kidney disease. The implementation of research into practice can be undertaken in a variety of ways. The kidney care nurse can be directly involved in the process of nurse-led research or by collaborating with other healthcare team members. Alternatively, participation in monitoring or data collection for national or international studies, e.g., Dialysis Outcome and Practice Pattern Study (DOPPS) or national kidney registries. However, kidney care nurses if doing research-related work such as collecting data (e.g., blood results) for another researcher (or research team) should be compensated for their involvement or time away from core nursing work. Kidney care nurse's ought to expect that their contribution to research is acknowledged according to international research guidelines. The incorporation of research findings into clinical practice is an important element of the role of the kidney care nurse. For instance, Kidney Disease Improving Global Outcomes (KDIGO; see <https://kdigo.org/guidelines/>) has numerous guidelines to inform kidney nursing policies and procedures.

3.5 Leadership

This domain focusses on the kidney care nurse's role as a key leader and change agent within the kidney team. Leadership must incorporate role-modeling, evidence-based practice, supporting education and professional development of other nurses,

and using interpersonal skills and appropriate management techniques [13]. The kidney care nurse can undertake these activities by helping to identify and support professional development opportunities either by contributing individually to learning opportunities for others or encouraging attendance of colleagues to education events such as webinars, workshops, or conferences. Monitoring of standards of care must be undertaken and identification of variation of care with subsequent change of practice occurring. Kidney care nurses should establish and follow quality improvement processes. In addition, the kidney care nurse leader must also be an advocate for colleagues and people with kidney disease, and influence health services strategies and government policies.

4 Kidney Care Nursing Roles

According to the ICN, nursing encompasses autonomous and collaborative care of people of any age, including families, groups, and communities in all settings [15]. A nurse is a person who has completed basic, generic nursing education and is registered through a governing authority to practice in their country [13]. In many countries, a bachelor's degree is the minimum level of education to become a registered nurse [13]. A registered nurse caring for people with kidney disease is a beginner nurse who is developing specialist skills to manage the complex needs of adults or children with CKD.

Regardless of country, there are nursing career pathways in most countries, however, these pathways vary between (and often within) countries. Advanced practice roles have emerged in many countries although in some countries the advanced practice nurse (APN) role has existed for decades. APN are registered nurses but according to the International Council of Nursing, the APN has acquired further graduate education (usually at a minimum of a Master's degree), has an expert knowledge base, demonstrates complex decision-making skills, and also clinical competencies at the advanced practice levels [16]. These registered nurses practice at a more advanced level and may hold positions which are given titles such as clinical nurse specialist, clinical nurse consultant, nurse practitioner amongst many others. However, the title of these positions does not always reflect the ICN definition. Table 3 compares the differences between those of an APN and a nurse practitioner.

Despite the acquisition and application of advanced skills and knowledge, APNs provide care that is based within the context of nursing and undertake nursing practice, but the role has developed on a "as needs basis." This ad-hoc development has often resulted in confusion around the role and what advanced practice nursing entails. The Strong Model of Advance Practice [17] was developed to identify the level of practice in (i) direct comprehensive care, (ii) support of systems, (iii) education, (iv) research, and (v) publication and professional leadership (see Table 4). This model has been used internationally to understand the role of the APN, to differentiate the levels of nursing practice, and to identify these roles and positions more clearly [18].

Table 3 Characteristics of clinical nurse specialists and nurse practitioners

Clinical nurse specialists	Nurse practitioners
Defined scope of practice in an identified specialty	Comprehensive scope of practice specific to the NP with activities that include prescribing, diagnosis and treatment management
Provides direct and indirect care usually to patients with an established diagnosis	Commonly provides direct clinical care to patients with un-diagnosed conditions in addition to providing ongoing care for those with an already established diagnosis
Works within a specialist field of practice	Works generically within a variety of fields of practice and settings
Works in defined practice populations (e.g., oncology, pain management, cardiology)	Works with multiple diverse practice populations
Works autonomously and collaboratively in a team, using a systems approach, with nursing personnel or other healthcare providers and healthcare organizations	Works autonomously and in collaboration with other healthcare professionals
Frequent shared clinical responsibility with other health care professionals	Assumes full clinical responsibility and management of their patient population
Works as a consultant to nurses and other health care professionals in managing complex patient care problems	Conducts comprehensive advanced health assessments and investigations in order to make differential diagnoses
Provides clinical care related to an established differentiated diagnosis	Initiates and evaluates a treatment management plan following an advanced health assessment and investigation based on conduct of differential diagnoses
Influences specialist clinical and nursing practice through leadership, education, and research	Engages in clinical leadership, education, and research
Provides evidence-based care and supports nurses and other healthcare professionals to provide evidence-based care	Provides evidence-based care
Evaluates patient outcomes to identify and influence system clinical improvements	Frequently has the authority to refer and admit patients
May or may not have some level of prescribing authority in a specialty	Commonly has presenting authority

Source: International council of nursing guidelines on advanced practice nursing [16]

4.1 Kidney Care Advanced Practice Nurse

While APN roles exist in kidney care in many countries, it is the nephrology nurse practitioner position which is emerging in healthcare teams to help address the increasing burden of CKD and multimorbidity. Nephrology nurse practitioners are highly qualified, experienced registered nurses who have an expanded scope of practice beyond that of other nurses. According to the ICN, a nurse practitioner is a type of advanced practice nurse who can undertake comprehensive health assessment, diagnose, and prepare treatment plans, and in some jurisdictions prescribe medications and/or treatments [16].

Nephrology nurse practitioners work across the health continuum from primary to tertiary care. They practice in adult and pediatric nephrology settings including home therapies, hemodialysis (HD), peritoneal dialysis, acute kidney injury (AKI),

Table 4 Strong model of advanced practice role delineation

Domains	Attributes
Direct comprehensive care	Activities carried out on behalf of patients and their specific needs. These are “hands on” activities such as procedures, assessments, interpretation of data, providing physical care, and counseling.
Support of systems	Activities that promote innovative patient care and facilitate the optimal progression of patients through the healthcare system. Role advocacy is an important component of this domain.
Education	Dissemination of current scientific knowledge to caregivers and students. Also, the provision of information to the public enabling them to cope with illness, and to promote wellness.
Research	Supporting generation of knowledge and the integration of research findings into clinical practice. Such activities support a culture of practice that challenges the norm and strives to find better ways to give care.
Publication and professional leadership	Activities involve sharing and dissemination of knowledge in an area of expertise that is beyond the individual’s institutional setting. It requires commitment to the profession and to the profession’s public.

Reference: Gardner et al. [18]

CKD, transplantation, supportive care, and end-of-life care [19]. Several countries have had nephrology nurse practitioners for decades such as the United States (US), Canada, Australia, and the Netherlands. Other countries have nurses with titles of nurse practitioner (e.g., United Kingdom), however, these nurses have different roles and may not function at the same level. In the US, for instance, nephrology nurse practitioners perform kidney biopsies, and in Australia, they undertake complete episodes of care (i.e., assessment, diagnosis, prescribing medications, and dialysis treatment plans, etc.).

An integral part of the nurse practitioner role is the focus on the whole person and facilitating integrated care and support of self-management for people with CKD. Nurse practitioners who work in community or outpatient settings can achieve health outcomes for patients that are as good as those who received care from medical practitioners [20]. The Netherlands have incorporated nurse practitioners into the care for people with CKD and have demonstrated improved health outcomes [21, 22].

A systematic review found that by including nephrology nurse practitioner within the kidney care team, there was improved blood pressure, glycemic control, and cholesterol management for people with CKD [23]. Nephrology nurse practitioners have also demonstrated high levels of patient satisfaction [24] and improvement in self-management behaviors [25].

Recently a study used the Strong Model of Advanced Practice Roles, finding that Australian nephrology nurse practitioners were highly qualified, experienced nurses who spent most of the working time providing direct comprehensive care each week caring for people with CKD or in dialysis units [26]. Nephrology nurse practitioners are an additional model of health service delivery which can meet the growing global CKD burden. Having a clinical career pathway is also a useful workforce strategy to keep highly qualified and experienced nurses working in direct patient care roles rather than moving into other non-clinical leadership positions.

4.2 Case Study

Anastasia Pond, a 55-year-old woman, was referred to the nephrology nurse practitioner-led CKD transdisciplinary clinic by the general practitioner (local family medical doctor). The transdisciplinary team consists of a nurse practitioner, pharmacist, and dietitian. At this clinic, there is no nephrologist.

4.2.1 Medical History

- Grade 3b A3 kidney disease – nephrotic screening tests negative. History of post streptococcus glomerular nephritis as a child and repeated skin infections treated with penicillin during her adolescent period.
- Type 2 diabetes diagnosed 2 years ago.
- Posttraumatic stress disorder (PTSD) from trauma as a child.
- Smoker occasionally on pay day – packet lasts 3 days, smoked for 30 years, denies intake of alcohol or recreational drugs.

4.2.2 Social History

- Partner of 20 years (history of domestic violence and several years in jail), 5 children (last two delivered early due to preeclampsia).
- She lives in 3-bedroom house with her partner, children, two grandchildren, and her mother-in-law.

4.2.3 Family History

- Father had kidney disease and was on HD for 10 years and died 2 years ago.
- Mother had type 2 diabetes and cardiovascular disease and died 10 years ago from a myocardial infarction.

4.3 Medications

- Metformin XR 2 grams (2 tablets)
- Insulin glargine 20 units mane
- Perindopril 5 mg
- Escitalopram (SSRI) 10 mg

4.4 Investigations

- Sodium – 135 mmol/L
- Creatinine – 210 μ mol/L
- eGFR – 42 mL/min/1.73m²
- Potassium – 4.3 mmol/l
- Sodium bicarbonate – 25 mmol/l
- Albumin – 24 g/L

- Liver enzyme tests – normal
- Full Blood Count – Hb 112 g/L
- Transferrin saturation – 12%
- Ferritin – 210 ug/L
- HbA1C – 8.2%
- Total cholesterol – 5.0 mmol/L
- Urine albumin/creatinine ratio – 450 g/mol
- Vital signs – weight 75 kg, height 172 cm, waist circumference 105 cm, BP 160/80 mmHg, pulse 72 bpm, spot blood glucose level – 10.5 mmol/L (non-fasting)

At the transdisciplinary team meeting prior to seeing the patient at her first appointment, the team identified the clinical high-priority areas to be discussed in collaboration with Anastasia. It was agreed that to reduce the time-burden on Anastasia, a combined appointment involving the nurse practitioner and pharmacist would initially occur then the nurse practitioner would, alone, seek to gather from Anastasia the reasons that she had for being referred to the clinic. Also, during the first appointment, it is crucial to establish rapport with Anastasia, to identify her goals, and to also explain the role of each member of the transdisciplinary team.

For Anastasia, her goals were:

- Not to die from a heart attack like her mother.
- Remember to take her medications.
- To feel less anxious.

4.5 Reflective Questions

1. Identify and explore the strengths and weaknesses of the transdisciplinary team in addressing Anastasia's goals?
2. What expanded scope of practice could a nurse practitioner bring to the team?

5 Chapters Summary

In this chapter, the practice of kidney care nurses has been explored, and largely this practice is in multidisciplinary teams although there is a shift to transdisciplinary teamwork where any health discipline can lead the team. This shift is also occurring alongside the move from medical-dominated healthcare delivery to that of person-centered care. The reforms and redesign of kidney care is also occurring with the increasing recognition of the advanced practice roles that nurses have. In several countries these advanced practice roles enable nurses to have an expanded scope of practice. Nephrology nurse practitioners in these countries can lead multidisciplinary or transdisciplinary teams and can provide complete episodes of care

without the need to have direct involvement of the nephrologist or other medical practitioners. It is these reforms which are needed in kidney care due the increasing burden of CKD in every country.

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