Ongoing access to real-time and accurate monitoring of urine output could improve management of critically ill patients

Summary

Oliguria (low urine output) is a valuable marker of kidney function and a standard criterion for diagnosing and staging Acute Kidney Injury (AKI). Episodes of oliguria occur frequently in ICU patients, and studies have shown that accurate, timely measurement of low urine output (UO) can identify a higher percentage of AKI patients than serum creatinine values. A major barrier to the application of UO criterion is that accurate, hourly urine measurements are difficult to obtain, and there is no standardized process for recording and assessing changes in UO. Increasing automation of vital signs monitoring and wireless transmission of patient data into hospital electronic medical record systems suggests an opportunity for accessing UO data as a continuous physiological variable, providing a valid criterion for early recognitionof kidney injury.

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Urine output: the sixth vital sign

Measuring patient vital signs is a fundamental and vitally important procedure providing a window into the patient's condition. Commonly measured and recorded vital signs include: temperature, respiratory rate, pulse, blood pressure, and oxygen saturation. Accurate and timely reading and recording of these values ensures that nurses and physicians can assess a patient's condition and make essential therapeutic interventions.

Urine output (UO) has frequently been termed the sixth vital sign since it often mirrors the patient's hemodynamic and physiologic condition. In critical care units, UO is recorded with the same frequency as the other five vital signs.

Timely, accurate UO measurement can provide early detection and aid prognosis of AKI

Acute kidney injury (AKI) is the abrupt loss of the kidney's ability to balance fluids and electrolytes. Beyond loss of kidney function, AKI is also responsible for increased length of stay, cost, readmission rates, and patient mortality in hospitals everywhere.[1,2,3,4]

Urine output and serum creatinine criteria are the key biomarkers in commonly used classification systems for AKI: RIFLE (Risk, Injury, Failure, Loss of kidney function, and End-stage) and AKIN (Acute Kidney Injury Network).[5]

In a prospective study of 317 critically ill patients, Macedo et al.[6] showed that UO alone was a sensitive and specific criterion for AKI, and that the diagnosis of AKI occurred earlier in oliguric than in non-oliguric patients.

In a retrospective cohort study of 14,524 patients, it was found that in patients who developed AKI, UO alone was a better mortality predictor than creatinine alone or the combination of both.[7] And in a study of 21,207 unselected ICU patients, it was found that UO obtained within the first 24 hours of critical care admittance was an independent predictor of mortality irrespective of diuretic use.[8]

"Prevention and effective treatment of hospital-acquired AKI should be a national priority." [9]

Acute kidney injury: mortality, length of stay, and costs in hospitalized patients

It is estimated that 7-18% of hospitalized patients acquire AKI,[10] and up to 50% of those patients admitted to critical care units develop AKI.[11] Among critical care patients, AKI is often associated with sepsis and non-renal organ system failure, resulting in a 40-80% mortality rate.[12] AKI has been documented to more than double hospital stay costs, resulting in annual U.S. healthcare expenditures estimated at over $10 Billion.[13,14]

In "Adding Insult to Injury," the National Confidential Enquiry into Patient Outcome and Death[15] investigated the management of 564 patients who died subsequent to a diagnosis of AKI. In this intensive review, they found that many cases of patients who died from hospital-contracted AKI either had avoidable AKI or a large recognition delay and/or an inadequate risk assessment of AKI.

"In clinical practice, UO has to be closely monitored in order to diagnose oliguria as soon as possible and to adapt therapeutics in a reactive manner." [16]

Current methods of UO measurement are manual, time-consuming, and error-prone

A major barrier to the application of UO criterion is that accurate hourly urine output measurements are difficult to obtain, and there is no standardized UO recording process.[17, 18, 19] There are three current methods of attaining UO measurement: estimating urine collection bag contents, draining the collection bag into a graduated beaker, or using an electronic monitor.

A urine collection bag is typically hung low on the patient's bed rail, below the level of the bladder to avoid urine reflux. The most common method of measuring the UO amount is bending down and "eye-balling" the urine collection bag (or a plastic "urine meter" incorporated into the bag), then recording the results. A secondary method is draining the collection bag into a measuring container, then recording the results.

Both of these methods are time-consuming and usually performed by highly-skilled nurses who may be busy with more visible patient care issues. The net result is that UO measurements may not be done in a consistent, timely fashion and are often estimated over a 12-hour shift.

The third method, electronic measurement via a monitor, currently requires the use of specialty catheters, tubing and/or containers. The digital monitor numbers are recorded by hand on flow sheets and/or manually into the EMR. The need for specialty catheters and tubing poses an issue for patients who arrive at the critical care unit already catheterized, as infection control protocol prohibits removing and replacing indwelling catheters except for specific clinical indications such as infection, obstruction, or compromise of closed system integrity.[20]

At this time, none of the above methods transmit data automatically to the hospital's electronic medical record (EMR) system. In practice, this can mean that the UO data is not entered into the EMR until the end of a shift, depriving off-site physicians of vital information for appropriately managing critically ill patients.

"For prevention and treatment of AKI, accurate hourly monitoring of urine flow would provide more opportunities for intervention." [21]

Electronic medical record (EMR) systems and vital signs documentation

The American Recovery and Reinvestment Act of 2009 (ARRA) instituted incentive payments to hospitals and physicians for adopting EMR systems under a meaningful use program designed to improve healthcare quality, safety, and efficacy. In 2016, Medicare will begin penalizing facilities for failing to meet these meaningful use requirements.

The implementation of EMR systems provides the avenue for immediate access to vital signs information. In practice, this is dependent on how vital signs data are entered into the patient's electronic record. The most seamless method is through the use of monitors and/or intermediate devices that transmit data wirelessly to the EMR. In these cases, the nurse simply verifies the information on a computer screen to populate the electronic record, making it available for any healthcare practitioner who has access to the system.

If wireless transmission is not available, entering vital signs into the EMR adds additional steps, such as a handwritten log or the use of a mobile device. These steps delay the availability of vita sign data to healthcare providers who are not at the patient's bedside, while increasing the likelihood of errors, such as: transposition of digits, missing digits, charting on the wrong patient, or simply failure to enter vital signs data into the patient's record at all.

Five studies evaluating the transmission of vital signs data found significantly higher error rates when using methods other than wireless transmission. (See table on following page.)

Vital Signs Documentation Error Using Various Techniques

Author	Vital Signs Sets Entered	Method of EMR Entry Comparison	Error Rate (%)
Fieler et al.[22]	64	Paper to EMR	18.75
	66	Wireless	0.00
Gearing et al.[23]	613	Paper to Paper	25.60
	623	Paper to EMR	14.90
Meccariello et al.[24]	52	Paper to EMR	13.50
	92	Wireless	3.30
Smith et al.[25]	1514 Total	Paper to Paper	10.00
		Paper to EMR	4.40
		PDA to EMR	0.08
Wager et al.[26]	113	Paper to Paper	16.80
	33	Paper to EMR	15.20
	124	Bedside Tablet to EMR	5.60

Indwelling catheter risk: catheter-associated urinary tract infection (CAUTI)

For accurate measurement of UO, a Foley or indwelling catheter must be placed in the patient's bladder to funnel urine into a collection bag. A potential complication of Foley catheter use is a urinary tract infection (UTI). Catheter-associated UTIs, or CAUTIs, are the most common healthcare-associated infection, estimated at nearly 450,000 annually, with an additional cost (in 2007) of $749-1,007 per admission. CAUTIs were among the first hospital-acquired conditions selected for non-payment by Medicare in 2008.[27]

With the increased awareness of indwelling catheter risks and Medicare penalties for CAUTIs, there has been a significant effort by hospitals to remove Foley catheters as soon as possible. This presents a quandry for practitioners using UO crtierion for early detection of AKI.[28]

HICPAC, the Centers for Disease Control (CDC) Healthcare Infection Control Practices Advisory Committee,[29] has published a "Guideline for Prevention of Catheter-Associated Urinary Tract Infections" which includes the following table of appropriate indications for Foley catheter use:

Examples of Appropriate Indications for Indwelling Catheter Use
Acute urinary retention or bladder outlet obstruction
Need for accurate measurements of UO in critically ill pts
Peri-operative use for selected surgical procedures: • Patients undergoing urologic surgery or other surgery on contiguous structures of the genitourinary tract • Anticipated prolonged duration of surgery • Patients anticipated to receive large-volume infusions or diuretics during surgery • Need for intra-operative monitoring of urinary output
To assist in healing of open sacral or perineal wounds in incontinent patients
Patient requires prolonged immobilization (e.g., potentially unstable thoracic or lumbar spine, multiple traumatic injuries such as pelvic fractures)
To improve comfort for end of life care, if needed
Examples of Inappropriate Uses of Indwelling Catheters
As a substitute for nursing care of the pt with incontinence
As a means of obtaining urine for culture or other diagnostic tests when the patient can voluntarily void
For prolonged post-operative duration without appropriate indications (e.g., structural repair of urethra or contiguous structures, prolonged effect of epidural anesthesia, etc.)

Electronic ICUs (eICUs)

An Electronic Intensive Care Unit (eICU) is a form of telemedicine that uses state of the art technology to provide an additional layer of critical care service, often 24/7 coverage. The eICU incorporates a two-way, audio-video technology that links remote practitioners to monitoring centers staffed by highly-trained critical care physicians (Intensivists) and critical care nurses. Studies over the past twelve years have demonstrated positive patient outcomes in hospital systems with eICU programs.[30]

In 2000, Sentara Hospital in Virginia was the first hospital to implement an eICU program. As of 2011, over 40 eICUs were being used throughout 249 hospitals, covering 5,789 ICU beds. Barriers to adoption include the start-up costs, unproven ROI, and technical difficulties.[31]

The ability of the eICU to provide up-to-the-minute, state-of-the-art care is dependent on timely and accurate data in the EMR. A commonly used system used by eICU staff to trigger a medical alert at covered hospitals is MEWS (Modified Early Warning Score).[32] One of the factored observations in MEWS is hourly urine output, which is often not available to critical care specialists in the eICU.

Conclusion

Urine output is a valuable criterion for early identification of kidney injury among critically ill patients. Studies have shown that UO criterion is more sensitive that creatinine values for assessing the morbitity of AKI. However, current methods of measuring and reporting UO are not standardized, which often means this data is not available or meaningful in assessing the patient's condition.

The automation of measuring and transmitting vital signs data directly into EMR systems has been demonstrated to show a significant reduction in transcription error, and offers a means for timely assessment and therapeutic intervention based on the patient's changing condition. Urine output, the sixth vital sign, is not currently included in data automatically transmitted to EMRs.

Ongoing access to real-time and accurate monitoring of urine output could improve management of critically ill patients by hospital providers and e-ICU staff. Earlier detection of kidney injury through proper application of UO critierion could save lives and reduce health care costs.

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