How to grow a 22-23 week infant…

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Department of Pediatrics, UC Davis

Photo by SJ McElroy

FANNP's National Neonatal Nurse Practitioner Symposium: Clinical Update and Review, 2025 ©

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Disclosures

- Academic Advisory Board Member for NECSociety, Lactalogics, and Noveome
- Collaborations with Defensin Therapeutics (provides peptides)
- Funding through NIH/NIDDK
- All photos were obtained with parental permission

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Disclosures

Don't give up.
I believe in you all.
A person's a person
no matter how small.
– Dr. Seuss

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Disclosures/Early Acknowledgement

- Susan Carlson, dietitian at University of Iowa
- Jon Klein, Medical Director and Professor emeritus, University of Iowa
- Katy Wright, dietitian University of California, Davis

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Objectives

- A historical perspective on viability
- What defines viability
- Current national guidelines and outcomes
- Why the 22-23 week gut is unique
- How to grow a 22-23 week infant (at UC Davis)
  - Fluid management
  - PN
  - Feeding protocol
  - Monitoring

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vi·a·bil·i·ty

- **Definition of *viability*:** the quality or state of being viable: such as
  - **(1):** the ability to live, grow, and develop
  - **(2):** the capability of a fetus to survive outside the uterus

Merriam-Webster.com Dictionary, Merriam-Webster,

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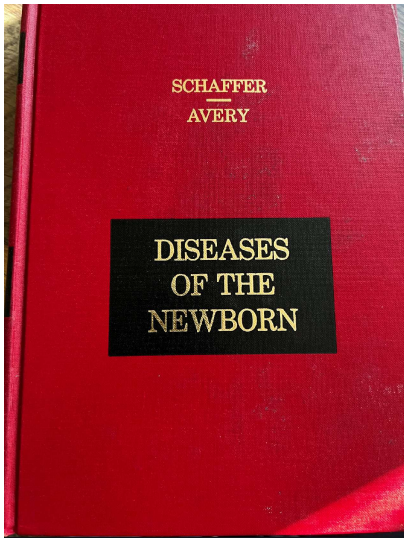
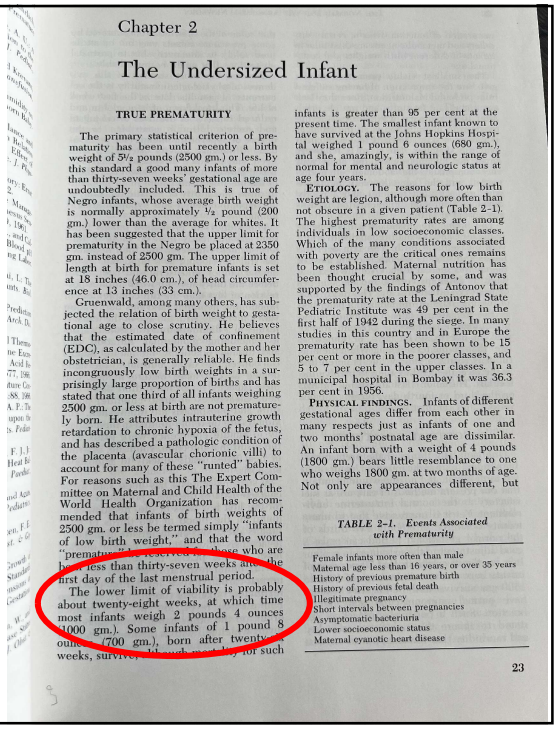


The limits of viability in 1971 (one year before I was born) was determined to be 28 weeks…



Chapter 2

The Undersized Infant

TRUE PREMATURITY

The primary statistical criterion of prematurity has been until recently a birth weight of 5½ pounds (2500 gm.) or less. By this standard a good many infants of more than thirty-seven weeks' gestational age are undoubtedly included. This is true of Negro infants, whose average birth weight is normally approximately ½ pound (200 gm.) lower than the average for whites. It has been suggested that the upper limit for prematurity in the Negro be placed at 2350 gm. instead of 2500 gm. The upper limit of length at birth for premature infants is set at 18 inches (46.0 cm.), of head circumference at 13 inches (33 cm.).

Gruenwald, among many others, has subjected the relation of birth weight to gestational age to close scrutiny. He believes that the estimated date of confinement (EDC), as calculated by the mother and her obstetrician, is generally reliable. He finds incongruously low birth weights in a surprisingly large proportion of births and has stated that one third of all infants weighing 2500 gm. or less at birth are not prematurely born. He attributes intrauterine growth retardation to chronic hypoxia of the fetus, and has described a pathologic condition of the placenta (avascular chorionic villi) to account for many of these "runted" babies. For reasons such as this The Expert Committee on Maternal and Child Health of the World Health Organization has recommended that infants of birth weights of 2500 gm. or less be termed simply "infants of low birth weight," and that the word "premature" be reserved for those who are born less than thirty-seven weeks after the first day of the last menstrual period.

The lower limit of viability is probably about twenty-eight weeks, at which time most infants weigh 2 pounds 4 ounces (1000 gm.). Some infants of 1 pound 8 ounces (700 gm.), born after twenty-six weeks, survive [illegible] for such infants is greater than 95 per cent at the present time. The smallest infant known to have survived at the Johns Hopkins Hospital weighed 1 pound 6 ounces (690 gm.), and she, amazingly, is within the range of normal for mental and neurologic status at age four years.

ETIOLOGY. The reasons for low birth weight are legion, although more often than not obscure in a given patient (Table 2-1). The highest prematurity rates are among individuals in low socioeconomic classes. Which of the many conditions associated with poverty are the critical ones remains to be established. Maternal nutrition has been thought crucial by some, and was supported by the findings of Antonov that the prematurity rate at the Leningrad State Pediatric Institute was 49 per cent in the first half of 1942 during the siege. In many studies in this country and in Europe the prematurity rate has been shown to be 15 per cent or more in the poorer classes, and 5 to 7 per cent in the upper classes. In a municipal hospital in Bombay it was 36.3 per cent in 1956.

PHYSICAL FINDINGS. Infants of different gestational ages differ from each other in many respects just as infants of one and two months' postnatal age are dissimilar. An infant born with a weight of 4 pounds (1800 gm.) bears little resemblance to one who weighs 1800 gm. at two months of age. Not only are appearances different, but

TABLE 2-1. Events Associated with Prematurity

Female infants more often than male
Maternal age less than 16 years, or over 35 years
History of previous premature birth
History of previous fetal death
Illegitimate pregnancy
Short intervals between pregnancies
Asymptomatic bacteriuria
Lower socioeconomic status
Maternal cyanotic heart disease

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Infant care before 1850 (Europe)

- Before the late 19th century, physicians essentially ignored infants.
- There were no hospitals for children. Church sponsored "foundling homes" were created for unwanted and sick infants.

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Infant care before 1850 (Europe)

- Before the late 19th century, physicians essentially ignored infants.
- There were no hospitals for children. Church sponsored "foundling homes" were created for unwanted and sick infants.
- The admission rate in Paris was >7000 infants per year. In Moscow it was > 14,000.
- Infant mortality rates at these centers were 85% to 95%.

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A new emphasis on infant care

- France realized it would run out of soldiers and workers if infant mortality rates continued
- An increase in infant welfare began

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A new emphasis on infant care

- France realized it would run out of soldiers and workers if infant mortality rates continued
- An increase in infant welfare began
- The discipline of obstetrics was established on October 18, 1881
- The first infant incubators were developed by modifying poultry incubators from the Paris zoo
  - Stephane Tarnier

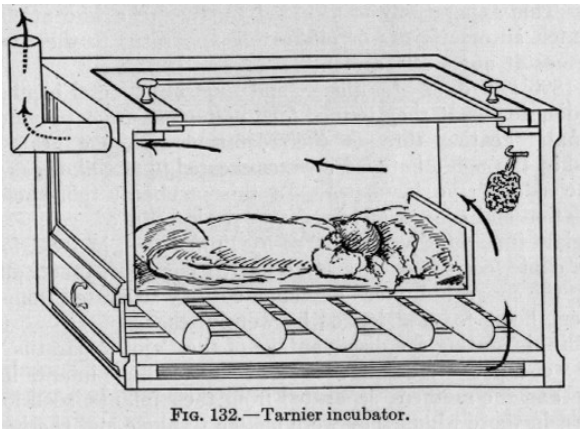

FIG. 132.—Tarnier incubator.

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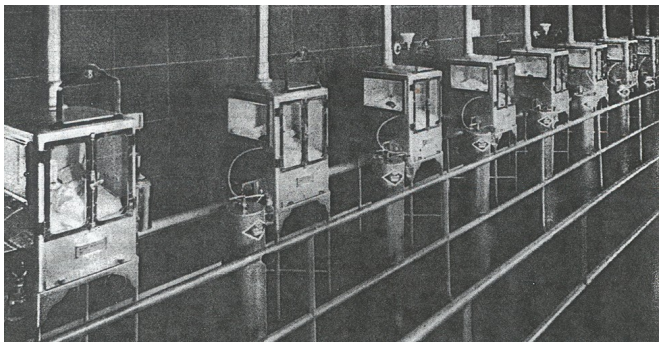
US Infant care in the early 1900's

- In 1915, the US infant mortality rate (all newborns) was 99.6/1,000 live births (~10%)
- In the early 1900's, Dr. Martin A. Couney emigrated to the US and opened an exhibit of incubators for premature infants on Coney Island



1930's Chicago World's Fair:
"Science Finds, Industry Applies, Man Conforms"

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The spark that lit a fire

- Born at 12:52 PM on Aug 7, 1963 at Otis Air Force Base
- **34 weeks gestation 4lb 10.5 oz**
- Diagnosed with Idiopathic respiratory distress syndrome (RDS)
- He was flown to Boston Children's Hospital.
  - His blood had to be run across the street to be run on a blood gas machine—one of only a few in existence nationwide.
- At the time, there was no surfactant and no ventilators. He was placed in a hyperbaric chamber at 27 hours of life


The Boston Globe
MORNING EDITION
BABY SPED TO BOSTON
Has Trouble Breathing; Kennedy Stands by Here
Whole World Taken By Littlest Kennedy
They Helped — And Hoped
After Visiting Baby
King Names FBI Agent Powers to Head N.H. Sweeps
'He's a Kennedy --He'll Make It'

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The spark that lit a fire

Pronounced dead at 4:04 AM on Aug 9 (39 hours)

Kennedy Baby Dies At Boston Hospital; President at Hand
By The Associated Press
BOSTON, Friday, Aug. 9— The new baby boy of President and Mrs. Kennedy died

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Since Patrick Kennedy

- The NICHD was founded in 1962 and further funded by the government following the Kennedy death in Oct of 1963
- "*The Surfactant System of the Lung*" (published 1968)
- The first mass produced infant ventilator "the baby bird" (1971)
- The first surfactants were developed and brought to market (1990)

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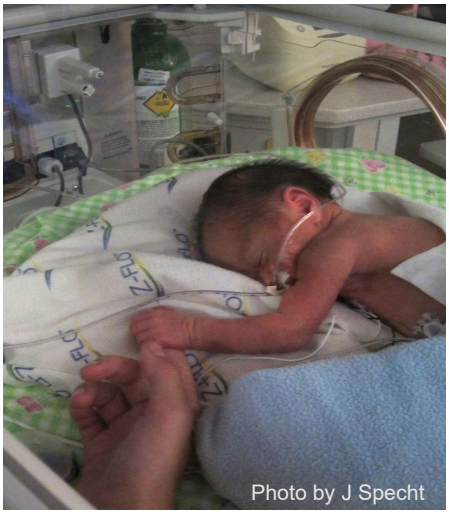
So how early is too early?

- Gestation at which 50% of infants survive
  - 1960's 30-31 weeks
  - 1970's Limit of viability defined at 28 weeks
  - 1980's 26-27 weeks
  - 2000's 24 weeks
- 0.5% of births are before the third trimester and account for >40% of infant mortality



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So how early is too early?

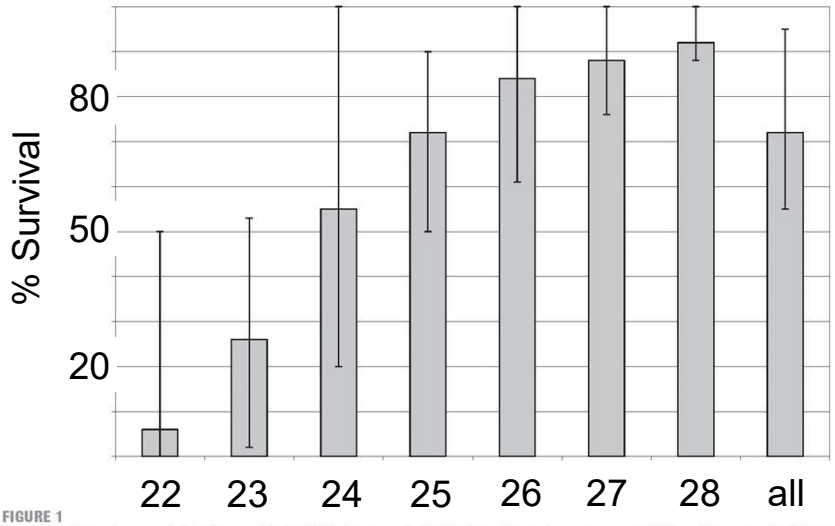

FIGURE 1
Survival to discharge according to GA among 9575 VLBW infants born in NICHD NRN centers between January 1, 2003, and December 31, 2007. The thin lines indicate ranges across centers.

Stoll BJ, et al. Pediatrics 2010

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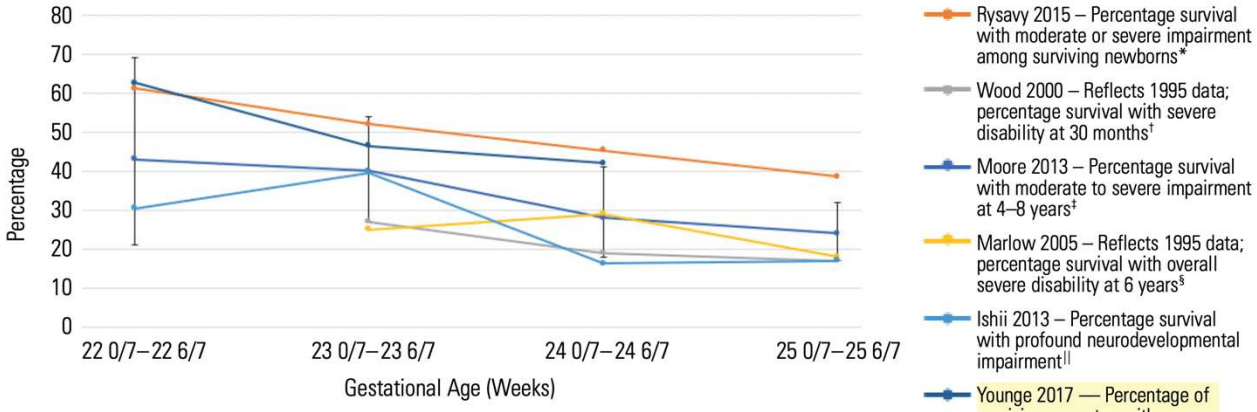
So how early is too early?



Rates of moderate or severe disability

ACOG Consensus. Obstet Gynecol 2017

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So we are all speaking the same language…

- Death and survival are very different
- No/Mild NDI
  - Normal hearing/vision
  - No CP
  - Cognitive > 85 (>70 for BSID II)
- Moderate NDI
  - Mild or moderate CP, GMFCS 2-3
  - Cognitive 70-84
- Severe NDI
  - Blind or deaf
  - Severe CP, GMFCS >3
  - Cognitive < 70

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So how early is too early?

Systematic Reviews ajog.org

Proactive neonatal treatment at 22 weeks of gestation: a systematic review and meta-analysis

Carl H. Backes, MD; Brian K. Rivera, MS; Leanne Pavlek, MD; Lindsey J. Beer, M
Charles V. Smith, PhD; Jeffrey A. Bridge, PhD; Edward F. Bell, MD; Heather A.

- Meta-analysis of 31 studies, 2226 infants born at 22 weeks and were provided proactive treatment
- Pooled survival of 29%
- Prenatal steroid use doubled survival from 19.5% to 39%

TABLE 8
Morbidity among survivors

Morbidity	Pooled prevalence, %
BPD (any)	78.0
Severe BPD	61.1
IVH (any)	31.7
Severe IVH or PVL	25.2
Severe NEC	12.0
Severe ROP	39.0

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ACOG Consensus Update 2021

	20 0/7 weeks to 21 6/7 weeks	22 0/7 weeks to 22 6/7 weeks	23 0/7 weeks to 23 6/7 weeks	24 0/7 weeks to 24 6/7 weeks	25 0/7 weeks to 25 6/7 weeks
Antenatal corticosteroids	Not recommended 1A	Consider 2C	Consider 2B	Recommended 1B	Recommended 1B

- For 20 and 21 week infants, consider antibiotics but nothing else
- For 22 week infants, consider steroids antibiotics and resuscitation
- For 23 week infants, consider everything

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But then there is the Iowa data…

ORIGINAL ARTICLES

www.jpeds.com • THE JOURNAL OF PEDIATRICS

Check for updates

Outcomes at 18 to 22 Months of Corrected Age for Infants Born at 22 to 25 Weeks of Gestation in a Center Practicing Active Management

Patricia L. Watkins, MD, MS, John M. Dagle, MD, PhD, Edward F. Bell, MD, and Tarah T. Colaizy, MD, MPH

University of Iowa, 2020

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But then there is the Iowa data…

	22 wk	23 wk	24 wk	25 wk
• Total infants	20	50	79	99
• Survived	70%	82%	89%	90%

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But then there is the Iowa data…

	22 wk	23 wk	24 wk	25 wk
• Total infants	20	50	79	99
• Survived	70%	82%	89%	90%
• At 18-22 mo • Follow up rate 79%				
• severe NDI	18%	9%	4%	4%
• No/mild MDI	55%	68%	79%	73%

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But then there is the Iowa data…

	22 wk	23 wk	24 wk	25 wk
• Total infants	20	50	79	99
• Survived	70%	82%	89%	90%
• At 18-22 mo • Follow up rate 79%		None of these are statistically different		
• severe NDI	18%	9%	4%	4%
• No/mild MDI	55%	68%	79%	73%

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Most recent data

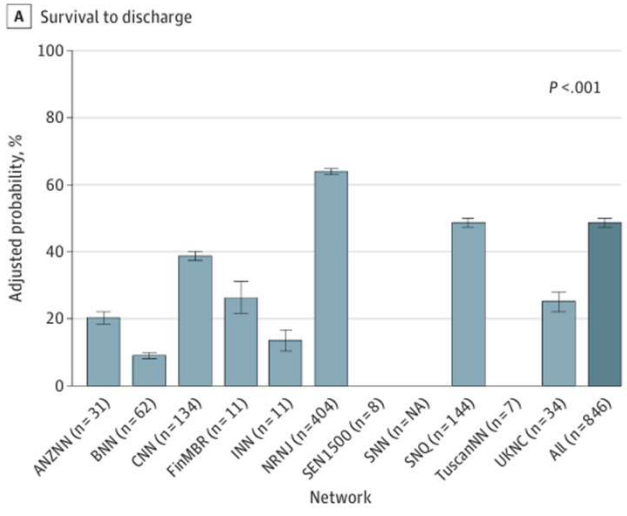
JAMA Pediatrics | Original Investigation

Outcomes of Preterm Infants Born at 22 to 23 Weeks' Gestation in 11 International Neonatal Networks

Tetsuya Isayama, MD, PhD; Mikael Norman, MD, PhD; Satoshi Kusuda, MD; Brian Reichman, MBChB; Liisa Lehtonen, MD, PhD; Kei Lui, MD; Mark Adams, PhD; Max Vento Torres, MD, PhD; Luca Filippi, MD, PhD; Malcolm Battin, MD; Ruth Guinsburg, MD, PhD; Neena Modi, MD; Stellan Håkansson, MD; Gil Klinger, MD; Maria Fernanda de Almeida, MD, PhD; Kjell Helenius, MD; Dirk Bassler, MD; Yi-Chen Su, MSc; Prakesh S. Shah, MD; for the International Network for Evaluation of Outcomes (iNeo) Investigators

ANZNN: Australia/New Zealand
BNN: Brazil
CNN: Canada
FinMBR: Finland
INN: Isreal
NRJN: Japan
SEN1500: Spain
SNN: Switzerland
SNQ: Sweden
Tuscan: Italy
UKNC: United Kingdom

USA: Around 25-30%



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UC Davis approach

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Two lessons we can apply from Ted Lasso

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Complex ideas are difficult to exactly replicate

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The intestinal tract is the largest part of our bodies that interact with the external environment.

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Relative surface areas of human tissue.

Skin
$2m^2$

Gut
$300m^2$

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All that separates us from the "outside" is a single epithelial layer of cells

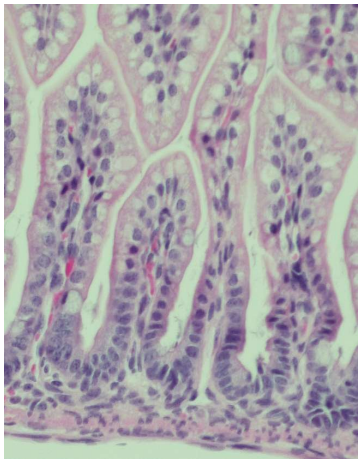
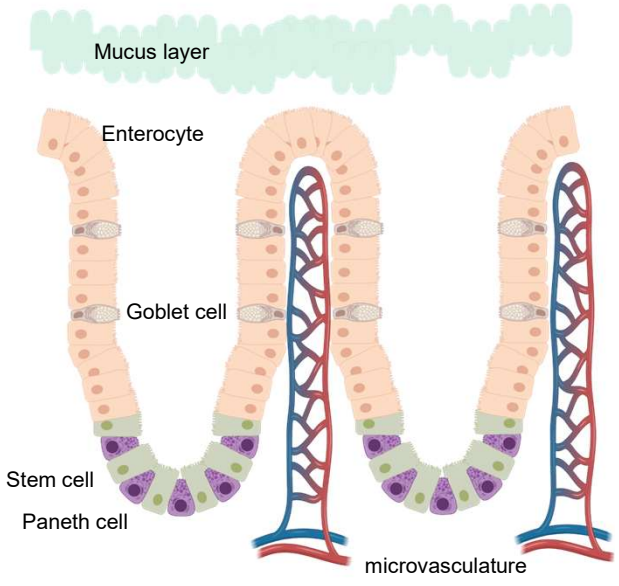


Image Source: McElroy Lab



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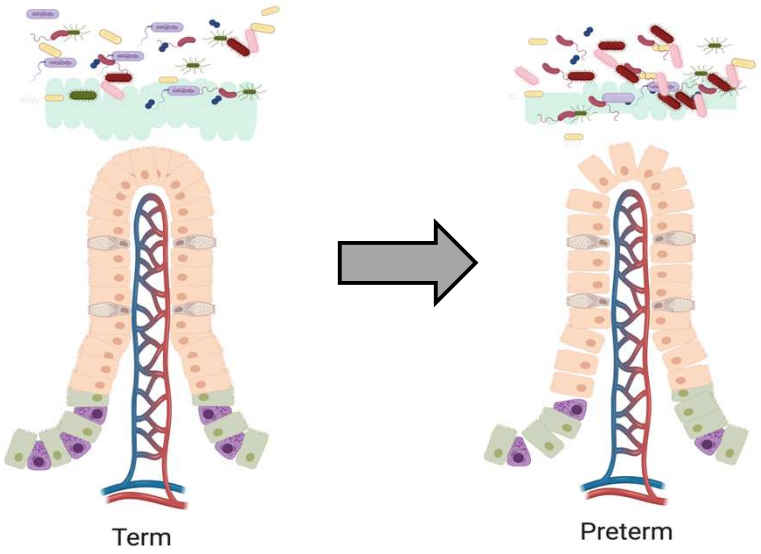
Term vs Preterm intestine



- Less diverse biome
- More inflammatory biome
- Less mucus

- Looser tight junctions
- Fewer epithelial cells
- Fewer immunoactive cells

- Hypoxic environment
- Frequent antibiotics
- Hyperosmotic feeds
- Exposure to ICU flora
- Frequent blood flow changes

Image Source: McElroy Lab

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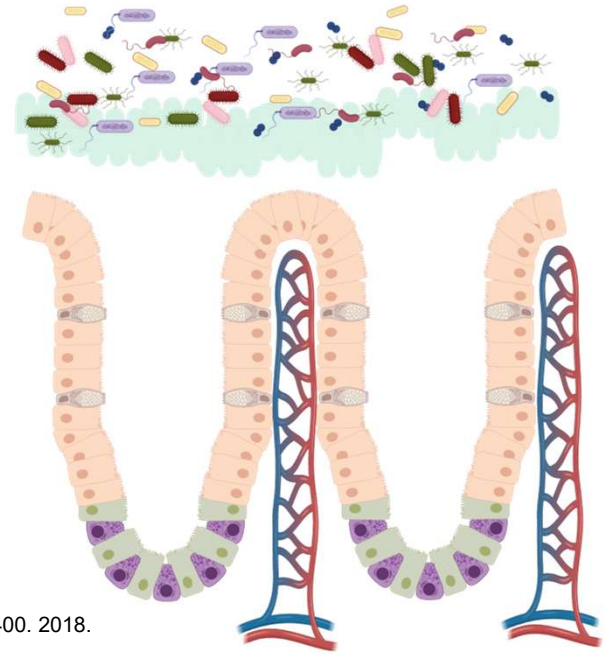
Remember that we have 1.5-10 times the bacteria in our intestine than we have cells in our body



Gilbert J *et al*. *Nat Med.* 24, 392-400. 2018.

Image Source: McElroy Lab

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Electron microscope picture of the Small Intestinal Lumen

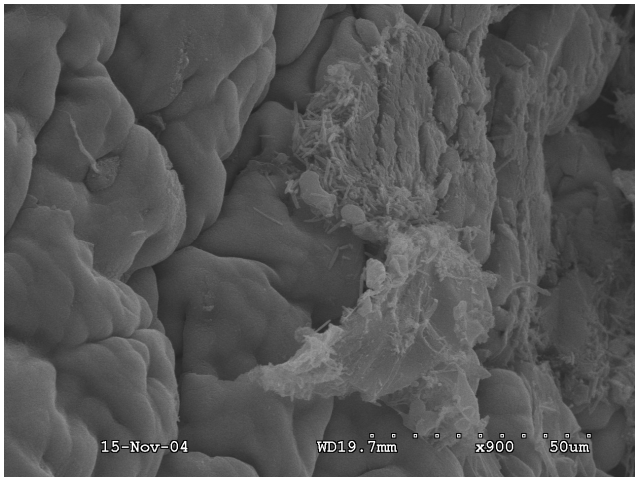

Image Source: Thaddeus S. Stappenbeck, Washington University School of Medicine

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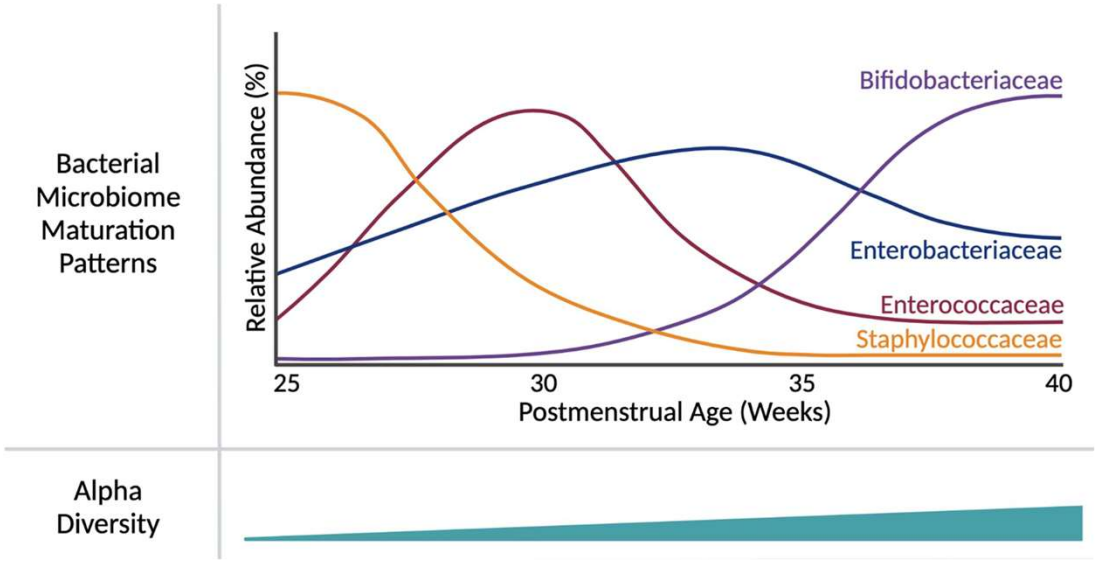
But the microbiome is also "immature"



Mercer EM, Gut Microbes, Vol 15, 2023 Issue 1

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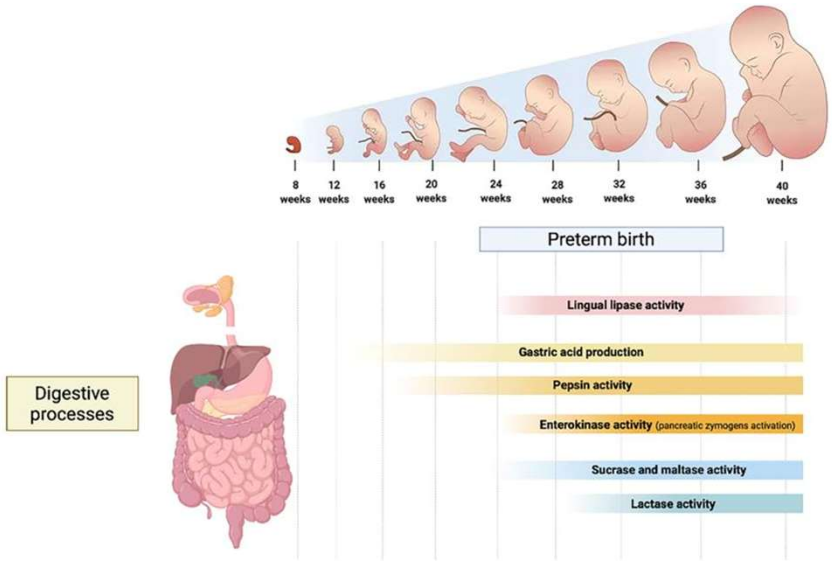
Intestinal ability to digest "food" is immature



Indrio F, Nutrients **2022**, *14*(7), 1405, **28 March 2022**

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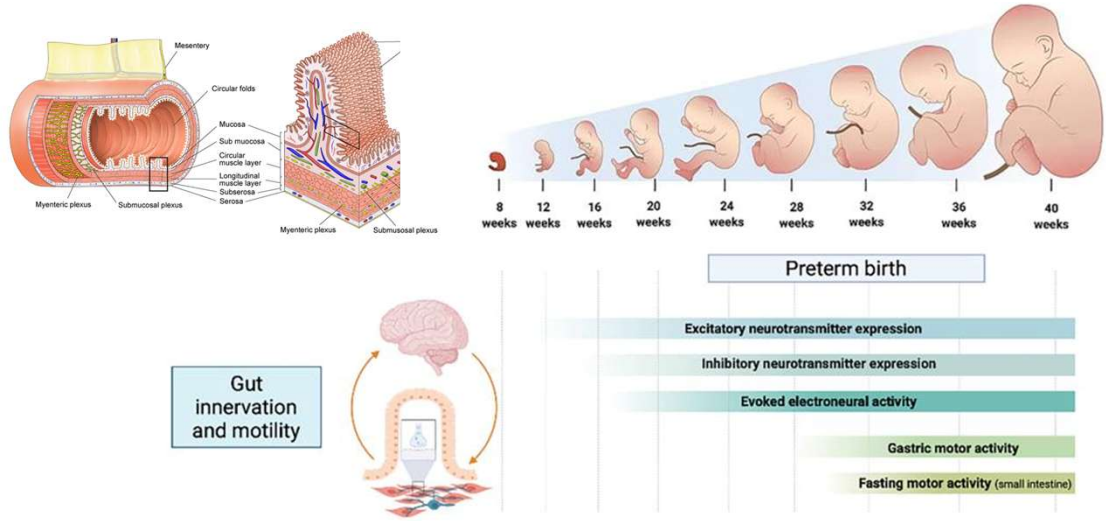
Intestinal motility system is underdeveloped



Indrio F, Nutrients **2022**, *14*(7), 1405, **28 March 2022**
Endo R, Regenerative Therapy, December 2023, Pages 64-73

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- Hypoxia or mild inflammation may induce mucosal damage

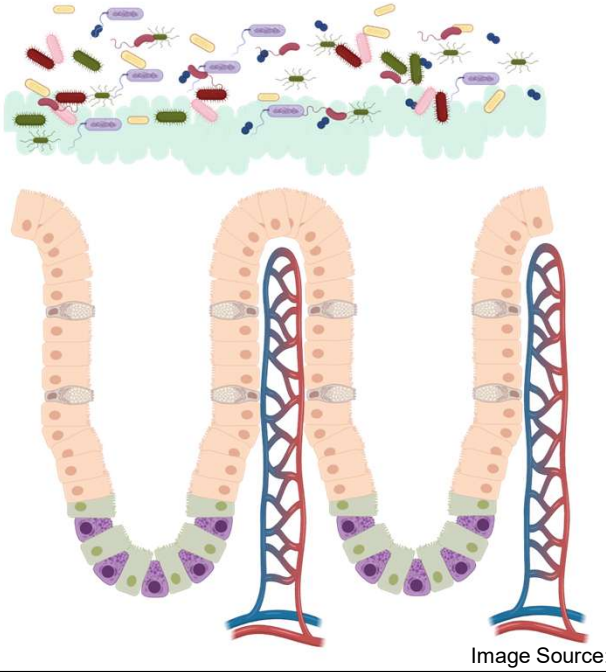

Image Source: McElroy Lab

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- This allows bacteria to invade the innate immunity barrier and make contact with the epithelial surface

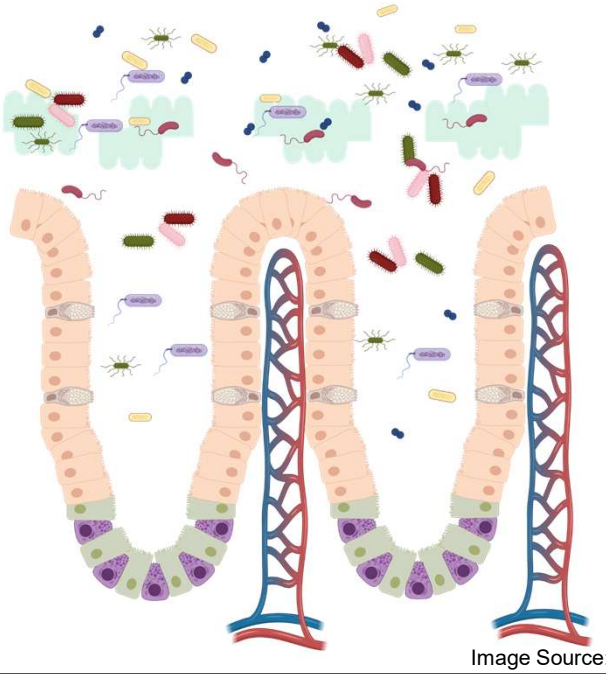

Image Source: McElroy Lab

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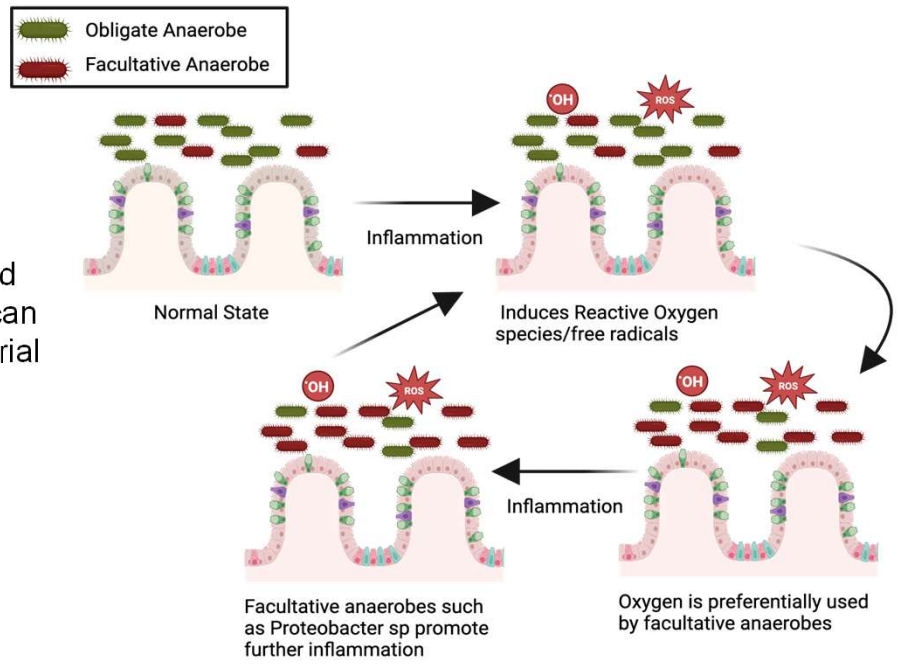
- Hypoxia or mild inflammation can alter the bacterial composition



Adapted from Elgin TG, *Clin Ther* 38(4) 706-15, 2016.

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To grow a fetus outside the uterus you must consider…

- Developmental biology (pt is still a fetus)
- Underdeveloped defense systems (barrier and immune)
- Underdeveloped enzyme production
- Poor motility
- Risk for injury (NEC and SIP)

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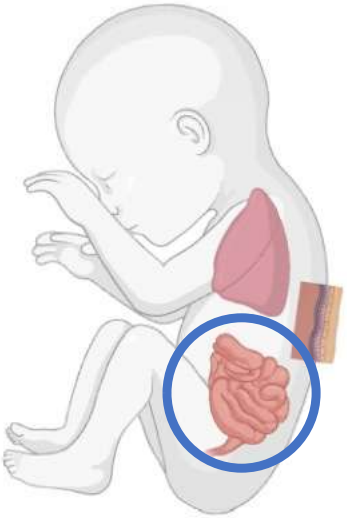

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Developing the UC Davis "Cub" nutritional guidelines

- Initial planning session (Mar '23)
- Jon Klein visits UCDH (Apr '23)
- Team trip to University of Iowa (Jan '24)
- Small Baby Admission Guidelines updated (Feb'24)
- Cub Room opens (Feb '24)
- RD presentation on 3-IVF method (Apr '24)
- NICU Enteral Nutrition Guidelines updated (Apr '24)
- Availability of D3.5W in NICU (Sep '24)
- Full NICU Nutrition Guidelines go-live (Oct '24)

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UC Davis goals

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"Our clinical guidelines aim to incorporate evidence, best practice, and local expert consensus into easily accessible, shared models...Our clinical guidelines aim to incorporate evidence, best practice, and local expert consensus into easily accessible, shared models."

-E Stieren MD, PhD

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UC Davis approach to nutrition

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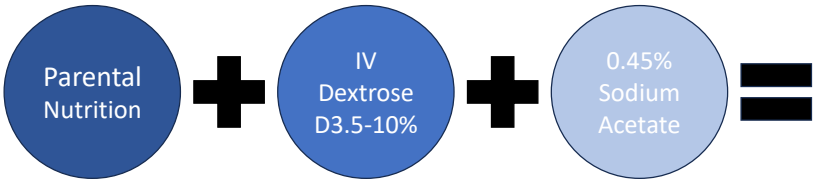
- We use a three-fluid approach for IVF and TPN during the "stabilization phase"



- Fluid needs during the "stabilization phase" are dynamic
- Initial PN orders are often made "blindly" and are time sensitive

https://health.ucdavis.edu/pediatrics/clinical-guidelines/

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UC Davis approach to nutrition

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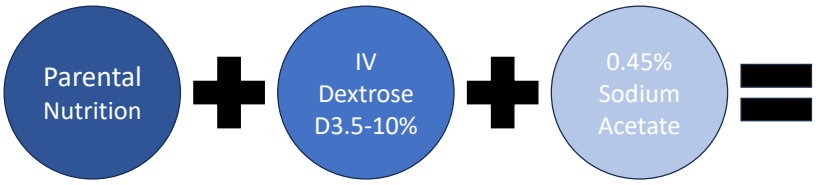
- We use a three-fluid approach for IVF and TPN during the "stabilization phase"



- This allows for concentration of PN, improved nutrition, and the flexibility to tighter control blood glucose control

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UC Davis approach to nutrition

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- PN is a complex, multi-component fluid
- Adjusting rates during the day is not an "easy fix" and can have many unintended consequences
- Titration of 3 IVF allows for flexibility & tighter BG control

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Overview of preterm PN requirements

	Calorie Requirement	GIR Requirement	Protein Requirement
Initial (prevent catabolism)	30-40 kcal/kg	3.5-4 minimum	1.5-2.5 gm/kg (3 gm/kg max)
Early PN	45-60 kcal/kg	Increase by 0.5-1 if BG <150 mg/dL	3-3.5 gm/kg
Goal PN	90-100 kcal/kg	11-12 goal	3-3.5 gm/kg

https://health.ucdavis.edu/pediatrics/clinical-guidelines/

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UC Davis approach to nutrition

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- Initial total fluid goal ~ 100-130 mL/kg using the following IVF.

1. Starter PN (D10% AA3%) at 50 mL/kg
   - Meets minimum protein & GIR goals to prevent catabolism with 23 kcal/kg, 1.5 gm/kg protein, 3.5 GIR
2. 0.45% Na Acetate at 0.5 mL/hr
3. IV dextrose (D3.5% - D10%) to make up remaining volume

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Glucose management

Target GIR for custom TPN order based on BG values

Blood Glucose Value	Recommended GIR adjustment
<120 mg/dL	If term/late preterm: increase by 2-3 mg/kg/min If VLBW/stable preterm: increase by 1-2 mg/kg/min If ELBW or <24 weeks, consider more cautious advance 0.5-1 mg/kg/min
120-150 mg/dL	If term/late preterm: may increase by 1-2 mg/kg/min or maintain GIR If VLBW/stable preterm: may increase by 0.5-1 mg/kg/min or maintain GIR If ELBW: increase by no more than 0.5 mg/kg/min or maintain GIR
150-180 mg/dL	Maintain same GIR or reduce GIR by 1-2 mg/kg/min; goal to maintain minimum 3.5-4 mg/kg/min GIR
>180 mg/dL	Reduce GIR by 1-2 mg/kg/min; goal to maintain minimum 3.5-4 mg/kg/min GIR

https://health.ucdavis.edu/pediatrics/clinical-guidelines/

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Tri-fluid method in action

”Baby A" is a 22w5d infant with BW 600 gm who is now 4 hours old. Initial total fluid goal (TFG) is 120 mL/kg/d.

One-fluid approach

1. Starter PN (D10% AA3%) @ 120 mL/kg

Total: 120 ml/kg, 55 kcal/kg, 3.6 gm/kg protein, 8.3 GIR

Three-fluid approach

1. Starter PN (D10% AA3%) @ 50 mL/kg
2. 0.45% Na Acetate @ 0.5 mL/hr (20 mL/kg)
3. D3.5W @ 1.2 mL/hr (50 mL/kg)

Total: 120 mL/kg, 29 kcal/kg, 1.5 gm/kg protein, 4.7 GIR

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Tri-fluid method in action

”Baby A" is a 22w5d infant with BW 600 gm who is now 4 hours old.
Now develops hyperglycemia with glucose >200

One-fluid approach

1. TPN rate reduced to 60 mL/kg & D3.5W y'in added at 60 mL/kg

Total: 120 ml/kg, 35 kcal/kg, 1.8 gm/kg protein, 5.6 GIR

Three-fluid approach

1. Starter PN (D10% AA3%) @ 50 mL/kg
2. 0.45% Na Acetate @ 0.5 mL/hr (20 mL/kg)
3. D3.5W @ 1.2 mL/hr (50 mL/kg)

Total: 120 mL/kg, 29 kcal/kg, 1.5 gm/kg protein, 4.7 GIR

In this system, you replace D3.5 with Na Acetate to maintain PN but decrease GIR

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Tri-fluid method in action

”Baby A" is a 22w5d infant with BW 600 gm who is now 4 hours old.
Remains hyperglycemia with glucose >200

One-fluid approach

1. TPN rate reduced to 60 mL/kg & D3.5W y'in added at 60 mL/kg

Total: 120 ml/kg, 35 kcal/kg, 1.8 gm/kg protein, 5.6 GIR

Now what? Reduce vs D/C starter PN to lower GIR?

Three-fluid approach

1. Starter PN (D10% AA3%) @ 50 mL/kg
2. 0.45% Na Acetate @ 0.5 mL/hr (20 mL/kg)
3. D3.5W @ 1.2 mL/hr (50 mL/kg)

Total: 120 mL/kg, 29 kcal/kg, 1.5 gm/kg protein, 4.7 GIR

In this system, you replace D3.5 with Na Acetate to maintain PN but decrease GIR

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Tri-fluid method in action

"Baby A" is now 5 days old, on 150-160 ml/kg/day.

One-fluid approach	Three-fluid approach
1. Custom TPN ordered @ 150 mL/kg • Contains: D5% AA2% • IL ordered at 1 gm/kg (5 mL/kg)	1. Custom TPN ordered @ 50 mL/kg • Contains: D10% AA6% • IL ordered at 1 gm/kg (5 mL/kg) 2. 0.45% Na Acetate @ 20 mL/kg 3. D3.5W at 75 mL/kg
Provides: 155 mL/kg, 48 kcal/kg, 3 gm/kg protein, 5.2 mg/kg/min GIR	*Provides: 150 mL/kg, 48 kcal/kg, 3 gm/kg protein, 5.3 mg/kg/min GIR*

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Tri-fluid method in action

"Baby A" is now 5 days old, on 150-160 ml/kg/day.
Now develops hyperglycemia with glucose >200

One-fluid approach	Three-fluid approach
1. Reduce TPN (D5% AA2%) to 50 mL/kg 2. Continue 1 gm/kg IL (5 mL/kg) 3. Y'in D3.5W to 95 mL/kg	1. Custom TPN ordered @ 50 mL/kg • Contains: D10% AA6% • IL ordered at 1 gm/kg (5 mL/kg) 2. 0.45% Na Acetate @ 75 mL/kg 3. D3.5W at 20 mL/kg
Provides: 155 mL/kg, 34 kcal/kg, 1 gm/kg protein, 4 mg/kg/min GIR	*Provides: 150 mL/kg, 41 kcal/kg, 3 gm/kg protein, 4 mg/kg/min GIR*

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Other key aspects

- Avoid adjustment of TPN rate unless clinically essential
- As status stabilizes, consolidate IVF as clinically appropriate
- Maintain minimum D10% concentration in TPN – allows for optimal Ca/PO4 solubility
- Hypernatremia and rising BUN most likely indicative of dehydration in this population rather than excessive sodium and/or protein load
- Goal to maintain BG <150-180 mg/dL
  - Minimize GIR ~ 3.5-4 mg/kg/min if hyperglycemic as first line management
  - Administration of insulin in BG remains >220

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Lipid management

- Intralipid® (100% soybean oil)
- SMOFlipid® (30% soybean oil, 30% MCT oil, 25% olive oil, 15% fish oil)
- Omegaven® (100% fish oil)

- At UCD, we use Intralipid as the lipid of choice for ELBW
  - Limited data that SMOF is better than Intralipid at equivalent doses
  - SMOF has lower levels of essential fatty acids which may be problematic in growth and development
  - Intralipid has the most drug compatibility data
- We target 2g/kg/day
  - Lower dose, but hepatoprotective and we are able to achieve good growth

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Lipid management

NICU Lipid Dosing Guidelines

	Initial Dose	Advancement	Maximum Dose^	Minimum Dose to Prevent EFAD
Intralipid	<750 gm: 0.5 gm/kg 750-1000 gm or SGA, IUGR, or septic: 1 gm/kg >1000 gm: 2 gm/kg/d	<750 gm: 0.5 gm/kg/d* 750-1000 gm or SGA, IUGR, sepsis: 1 gm/kg/d >1000 gm: 1 gm/kg/d	3 gm/kg	0.5-1 gm/kg (2.5-5 mL/kg)
SMOFlipid	2-2.5 gm/kg**	0.5-1 gm/kg	3 gm/kg	2.5-3 gm/kg ** (12.5-15 mL/kg)
Omegaven	1 gm/kg	N/A	1 gm/kg *May consider up to 1.5 gm/kg if IFALD + growth failure (off-label)*	1 gm/kg (10 mL/kg)

** Consider holding advancement if hyperglycemic with BG persistently > 150 mg/dL*
***SMOFlipid dose restriction can result in EFAD and is discouraged. Goal to start at 2-2.5 gm/kg and advance to goal dose within 24-48 hr. Infants who develop IFALD/PNAC should be transitioned to Omegaven for rescue treatment*
^Do not exceed 60% of total kcal due to risk of ketosis. Do not exceed infusion rate >0.15 gm/kg/hr.

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Lipid management

Triglyceride Value	Recommended IL adjustment
<250 mg/dL	Continue to advance as scheduled or maintain goal dose
250-400 mg/dL	Reduce dose by 0.5-1 gm/kg Ensure levocarnitine in PN (starting dose 10 mg/kg/d)
>400 mg/dL	Consider holding up to 24-48 hr Optimize levocarnitine in PN (up to 20 mg/kg/d) Do not withhold IL for >3 days in preterm infants due to risk of EFAD. If TG remains grossly elevated, provide minimum 0.5-1 gm/kg IL.

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UCD NICU Trace Element Dosing Guidelines

NICU TPN Trace Element Requirements

Trace Elements	Preterm Requirements (*from birth to term*) (mcg/kg/d)	Term Requirements (mcg/kg/d)
Zinc	400-500	<3 months: 250 >3 months: 50
Copper (cupric chloride)	20-40	20
Selenium	2-7	2

UCD Children's Hospital Standard Pediatric PN Trace Elements Guide (2022)

Multrys®	Patient weight (kg)	Zinc	Copper	Selenium	Manganese
Standard dose: 0.35 mL/kg	2.5-3 kg	350 mcg/kg	21 mcg/kg	2.1 mcg/kg	1 mcg/kg
1 mL/d (max dose)	3+ kg	1000 mcg	60 mcg	6 mcg	3 mcg

- Preterm infants <2.5 kg will receive individually dosed TE (400 mcg/kg Zn, 3 mcg/kg Se, 20 mcg/kg Cu)
- Preterm infants that are 2.5-3 kg will need an additional 50 mcg/kg zinc added to meet needs.
- For infants >3 kg who require TPN >7-14 days, assess if actual TE intake is appropriate to meet requirements for gestation & clinical status. Consult RD for assistance.

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Enteral feeding

- Buccal swabs on admission with EBM/DBM - up to 0.1 mL q 2-6 hr with cares
- Goal is to start trophic feeds (10-20 mL/kg) within 48 hr of life if clinically appropriate
- EBM > DBM > Formula
- Early IBCLC consult – goal to initiate pumping within 6 hr of delivery

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Enteral feeding

- Maintain trophic feeds during initial stabilization phase (up to DOL 5)
- Slow advances ~ 10-15 mL/kg usually tolerated best
- Extend feeds empirically over 1 hr due to poor motility
- 3-day course glycerin slivers if no stool by 72 hr
- Fortify feeds to 24 kcal/oz once tolerating at least 40 mL/kg

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Enteral feeding

NICU Enteral Feeding Advancement Guidelines

BW (gm)	Initial Feeding	Duration of trophic feeds	Advancement	Fortification
<750	10 mL/kg	3-5 days	10-20 mL/kg daily	• When tolerating 40 mL/kg x 24hr, fortify to 24 kcal/oz w/HMF • Ensure fortified feeds tolerated x 24 hr prior to further advances.
750-1000	10-20 mL/kg	Up to 3 days	20 mL/kg daily	
1000-1500	20 mL/kg	24-48 hr	30 mL/kg daily	
1500-2000	20 mL/kg	At least 24 hr	15-20 mL/kg BID	Likely needed pending GA & clinical status: • May fortify w/HMF if majority of feeds via NG. • If progressing toward discharge, may add supplemental feeds of PDF 22-24 kcal/oz.
2000-2500	20-30 mL/kg	Up to 24 hr	20 mL/kg BID	Likely need supplemental feeds of PDF 22-24 kcal/oz at least 1-2x/d.
>2500	40-60 mL/kg/d or ad lib with minimum	Up to 24 hr	20 mL/kg BID	Only if needed. Evaluate need after tolerating goal volumes.

HMF = human milk fortifier (product used: Similac HMF Hydrolyzed Protein Concentrated Liquid)
PDF = preterm discharge formula (i.e. Similac Neosure or Enfamil Enfacare)

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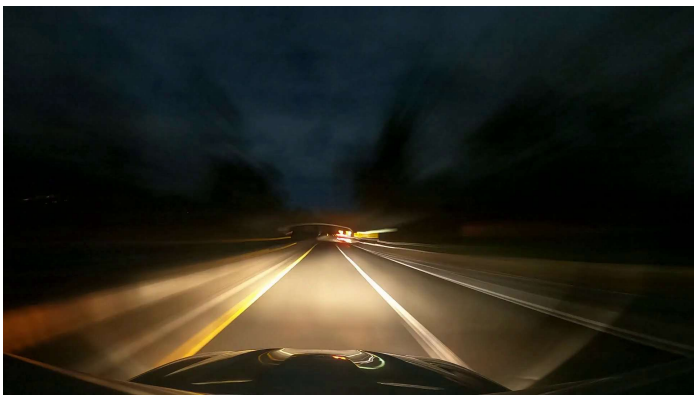
Monitoring



- Extreme prematurity leads to constant dynamic fluctuations.
- You need a standard, robust monitoring structure to not miss changes
- This will increase blood loss (risk/benefit)

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UC Davis Outcomes

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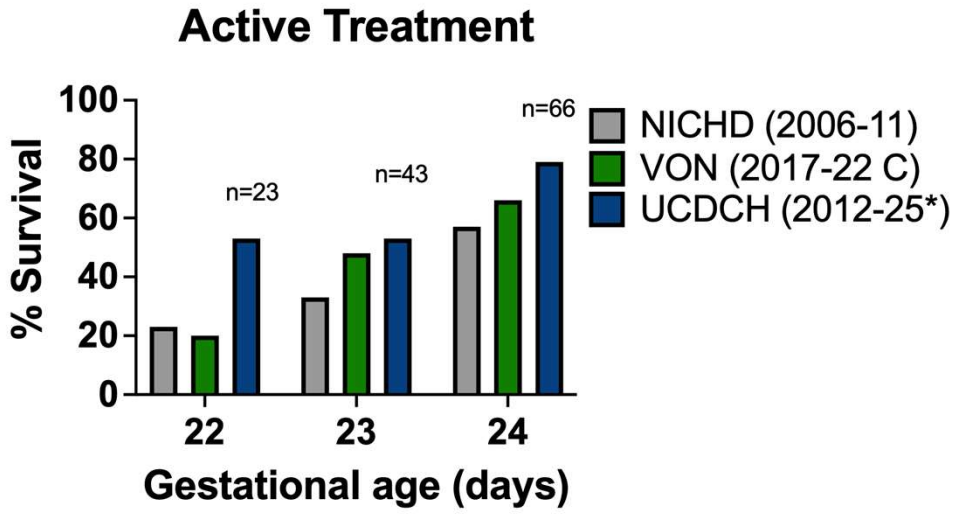
Outcomes at the limits of viability



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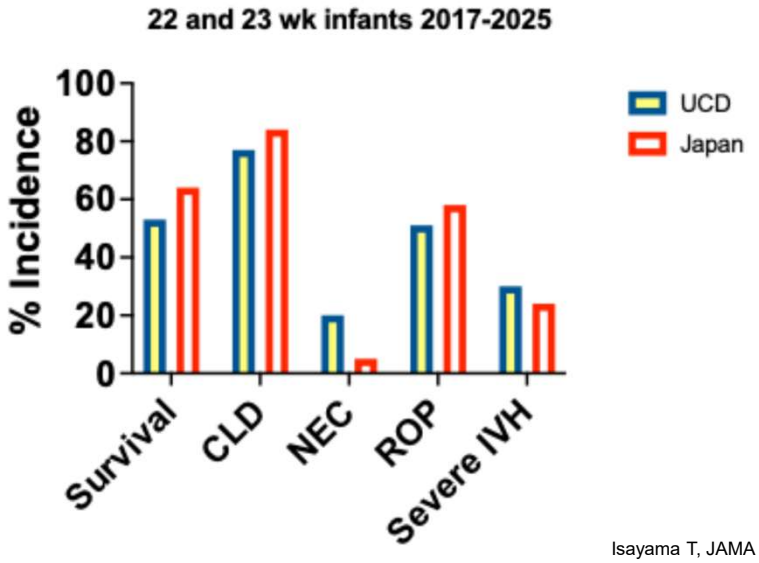
Outcomes at the limits of viability



Isayama T, JAMA Pediatrics, 2023

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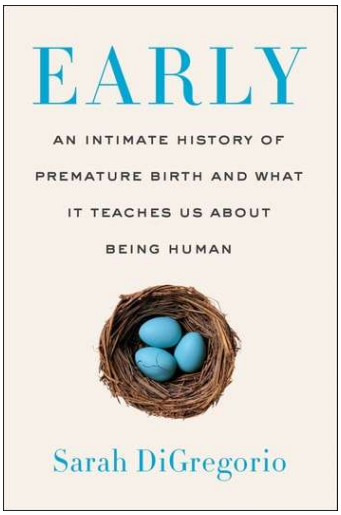

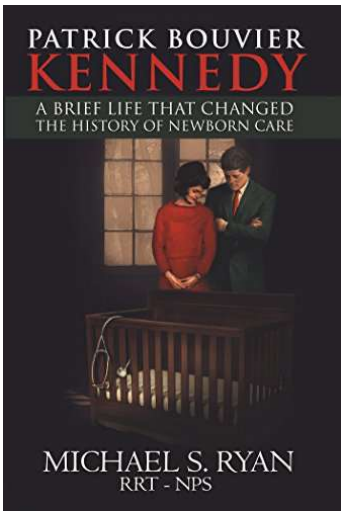

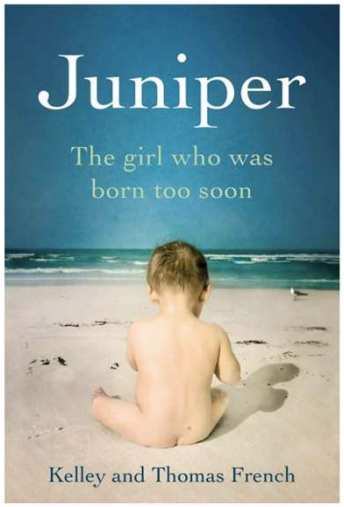

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UCDAVIS HEALTH | CHILDREN'S HOSPITAL

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- Jess Forster (PharmD)

- And many many others!

Photos by V Hopkins

22 week infant

Same 22 week infant

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Questions?
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