






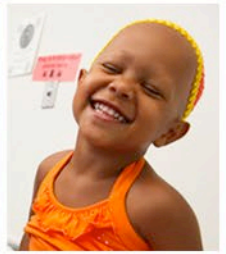


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Challenges in the Management of Intestinal Failure in Preterm Infants

Amy B. Hair, M.D.

Associate Professor of Pediatrics
Program Director of Neonatal Nutrition
Medical Director of TCH Milk Banks
Associate Director of NICU Intestinal Rehabilitation Team
Division of Neonatology
Department of Pediatrics
Baylor College of Medicine
Texas Children's Hospital

Disclosure

- I have no conflicts of interest to disclose.

- Funding sources: NIH- NIDDK, NIH-NICHD
  Chan Zuckerberg Initiative, Gerber Foundation

Texas Children's Hospital
Neonatal Intensive Care Unit

- 195 Total Beds
- 55 Level II
- 76 Level IV
- 44 Pavilion for Women

- 12 CICU (Neonatal beds)

Our Program

100+ Faculty

56 Medical Center Physicians
38 Community Initiatives Physicians
13 Mother-Baby Unit Physicians
7 Austin Physicians

54 Nurse Practitioners

600+ Neonatal Nurses

40 Respiratory Therapists

*Slide courtesy of Dr. Reber and Laura Gollins

TCH NICU Intestinal Rehabilitation Team

- Dr. Murali Premkumar- Director of NICU IR
- Dr. Amy Hair- Associate Director

- Dr. Elena Itriago and Dr. Emily Sabatini- NICU IR attendings
- Neonatal Dietitians
- Primary team attends IR rounds
- Fellows, NNPs and Care Coordinators
- Subspecialists – Pedi GI, Pedi Surgery

NEC Awareness Day 2025
Research Team

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Neonatal Dietitian Team

Elizabeth Brodine
MS,RD,LD

Allyson Camp
MS,RD,CSP, LD

Amy Carter
MS,RD,LD

Agnes Mandy
RD,LD

Nidia Delgado-Woldegiogis
MS,RD,CSPCC,LD

Laura Lucas
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Adriana Massieu
RD,LD,CNSC

Veronica Rubio
MS,RD,CSP,LD

*Slide courtesy of Dr. Reber and Laura Gollins

Disclaimer

- There is limited evidence in the literature to guide how to feed premature infants with gastrointestinal disease and intestinal failure.

- The protocols I share today are from our “NICU Intestinal Rehabilitation Guidelines” at Texas Children’s Hospital which have been approved by our NICU Intestinal Rehabilitation Team and Neonatology Section and are based on evidence when possible.

- Our goal is to practice in a similar manner and then research the outcomes of the protocols implemented.

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NICU Intestinal Rehabilitation Rounds

- Meet weekly for one hour
- Multi-disciplinary discussion and development of clinical plans including feeding plans, surgical scheduling, and discharge planning
- Neo IR attending, Neo Dietitians, Surgeons, Primary Neo team, Pedi GI representative, Care coordinator
- Discuss 10-12 patients

Murali Premkumar, MBBS
Program Director

Amy Hair, MD
Associate Director

Elena Itriago, MD
IR Attending

Emily Niemyjski, DO
IR Attending

Consults: High-Risk and Low-Risk Diagnoses

Infants with Intestinal Failure

High-Risk Group

- Short bowel syndrome (SBS) defined as <60cm of remaining intestine
- Ultra-short bowel syndrome defined as <30cm of remaining intesitine
- Surgical necrotizing enterocolitis
- Large abdominal wall defects: Complex gastroschisis or large omphalocele
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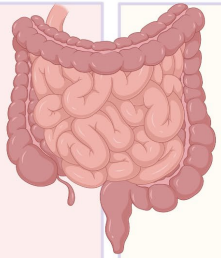
- Intestinal failure with multiple failed feeding attempts
- Presence of intestinal failure-associated liver disease (congugated bilirubin >2mg/dl) and PN dependence



Low-Risk Group

- NEC (medical, no surgical intervention)
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- Simple gastroschisis
- Small omphalocele
- Intestinal atresia
- Meconium ileus
- Spontaneous intestinal perforation
- Malrotation with volvulus
- Growth failure for >4 weeks on enteral nutrition

Fig. 1 High and low risk groups of infants at risk for Intestinal Failure (IF) and Morbidities. Parenteral nutrition (PN), necrotizing enterocolitis (NEC), intestinal failure-associated liver disease (IFALD). Figure created with BioRender.com. Adapted with permission from: Hair A and Premkumar M. Intestinal Failure and Intestinal Rehabilitation. In: Gastroenterology: Guidelines for Acute Care of the Neonate 30th edition (2022–2023), Fernandes CJ, Pammi M, Katakam L, et al. (Eds), Baylor College of Medicine, Section of Neonatology, Department of Pediatrics. Copyright © 2022.

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TCH Intestinal Rehabilitation Team Outcomes

- Surgical Short Bowel Syndrome (<60 cm small bowel)
  - -96% survival at last follow-up
  - -97% resolution of Intestinal Failure Associated Liver Disease (IFALD) with fish-oil based lipid emulsion
  - -63% enteral autonomy prior to discharge and 85% by last document follow-up
  - -Over 25 Ultra-Short Bowel Syndrome
    - Residual small bowel length 8-30 cm
  - -Zero intestinal transplants

Internal Data- TCH NICU Intestinal Rehabilitation Team. Baylor College of Medicine, Section of Neonatology, Department of Pediatrics.

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DOI: 10.1002/jpen.2124

ORIGINAL COMMUNICATION

In neonatal-onset surgical short bowel syndrome survival is high, and enteral autonomy is related to residual bowel length

Roxana Fatemizadeh MD[1] | Laura Gollins MBA, CNSC[2] | Joseph Hagan ScD, MSPH[3] | Anne Debuyserie MPA[3] | Kristi King RD[2] | Adam M. Vogel MD[4] | Kristin L. Van Buren MD[5] | Amy B. Hair MD[1] | Muralidhar H. Premkumar MBBS, MS[1]

Fatemizadeh R, Gollins L, Hagan J, Debuyserie A, King K, Vogel AM, Van Buren KL, Hair AB, Premkumar MH. In neonatal-onset surgical short bowel syndrome survival is high, and enteral autonomy is related to residual bowel length. JPEN J Parenter Enteral Nutr. 2022 Feb;46(2):339-347.

TABLE 2 Outcomes of infants with neonatal-onset short bowel syndrome with documented residual bowel length (n = 48)

Variable	≤30 cm (n = 8)	31–60 cm (n = 19)	>60 cm (n = 21)	*P*
Residual bowel length, cm[1]	12 (10–22)	45 (37–47)	81 (70–91)	<.001
Residual bowel length, %[1,2]	9 (8–17)	35 (32–39)	70 (56–82)	<.001
Age at last follow-up, months[1]	44.5 (30.5–70.5)	30 (19–59)	38 (13–66)	.489
Survival to discharge,[3]	8 (100)	18 (95)	20 (95)	1.000
Survival at last follow-up,[3]	8 (100)	18 (95)	20 (95)	1.000
EA prior to discharge,[3]	0 (0)	6 (32)	14 (67)	.002
EA at last follow-up,[3]	4 (50)	13 (68)	20 (95)	.008
Highest CB,[1]	2.8 (2.1–5.2)	3.5 (2.4–7.1)	3.9 (1.9–5.7)	.852
IFALD,[3]	6 (75)	15 (79)	15 (71)	.824
Days to full EA,[1]	585.5 (502–834.5)	207 (121–320)	154 (137–403)	.032

Abbreviations: CB, conjugated bilirubin; EA, enteral autonomy; IFALD, intestinal failure–associated liver disease; IQR, interquartile range.

[1]Median (IQR), Kruskal-Wallis test *P*-value.

[2]Percentages based on mean normative values for corrected gestational age at time of first surgery.[15]

[3]Frequency (%), Fisher exact test *P*-value.

Fatemizadeh R, Gollins L, Hagan J, Debuyserie A, King K, Vogel AM, Van Buren KL, Hair AB, Premkumar MH. In neonatal-onset surgical short bowel syndrome survival is high, and enteral autonomy is related to residual bowel length. JPEN J Parenter Enteral Nutr. 2022 Feb;46(2):339-347.

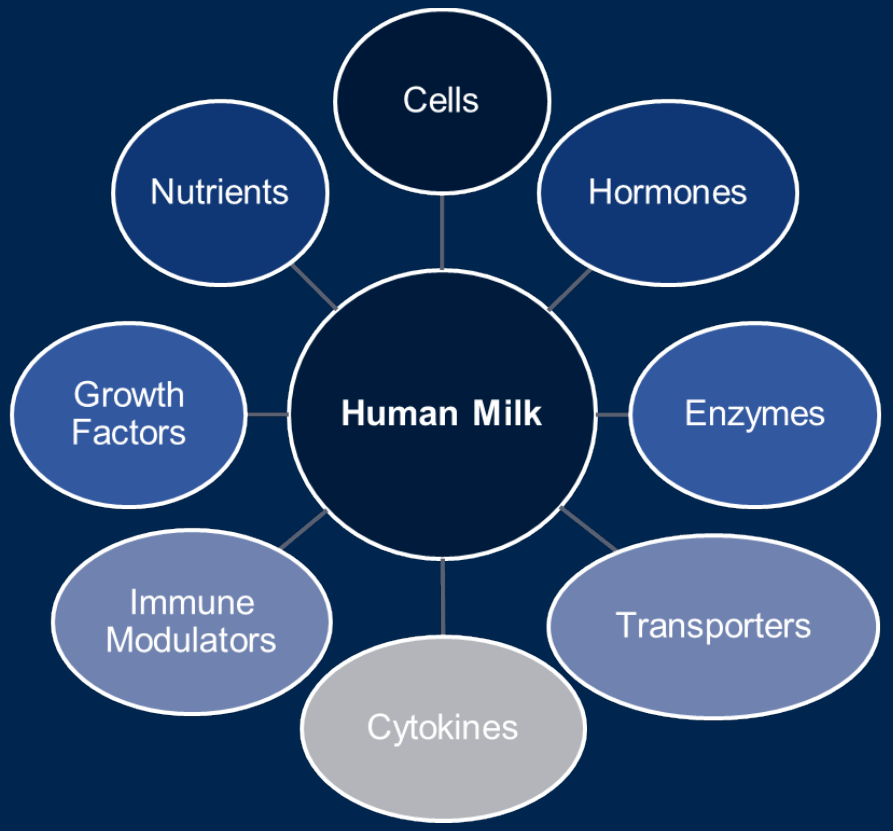
Early Enteral Nutrition in the Preterm Surgical Neonate

- Start enteral nutrition as early as possible, when there is return of bowel function

- Potential benefits
  - Promotes intestinal adaptation
  - Decreases the risk of IFALD
  - Reduction in the number of days with central venous catheters
  - Reduction in catheter related blood stream infections

What do we use if no Mother's milk?

- Mother's milk is always best
- Donor milk:
  - Concerns about growth and inadequate protein
  - Loss of immune factors due to pasteurization
- The preterm surgical neonate sometimes require different feeding strategies (elemental formula) especially post-surgery



Oral Immune Therapy (Oral care with colostrum)

- Contain various immunomodulatory agents[1]
  - Secretory immunoglobulin A [sIgA], Growth Factors, Lactoferrin, Anti-inflammatory cytokines
- Meta-Analysis of 8 RCT studies with over 1,000 preterm infants[2]
  - Decreased incidence of ventilator associated pneumonia, necrotizing enterocolitis, mechanical ventilator days however study data had high heterogeneity
- Recent Meta-Analysis showed with low to very low certainty that oral care with colostrum has a beneficial effect on NEC, sepsis, and time to full enteral feeds.[3]
  - Associated with an increase in mother's milk supply


Lee et al. *Pediatrics* 2015

1. Rodriguez, N.A., et al., Oropharyngeal administration of colostrum to extremely low birth weight infants: theoretical perspectives. *J Perinatol,* 2009. 29(1): p. 1-7.
2. Cai M, et al. Effect of Breast Milk Oral Care on Mechanically Ventilated Preterm Infants: A Systematic Review and Meta-Analysis of Randomized Controlled Trials. Front Pediatr. 2022 Jul
3. Kumar J, et al. Oropharyngeal application of colostrum or mother's own milk in preterm infants: a systematic review and meta-analysis. Nutr Rev. 2023 Sep 11;81(10):1254-1266.

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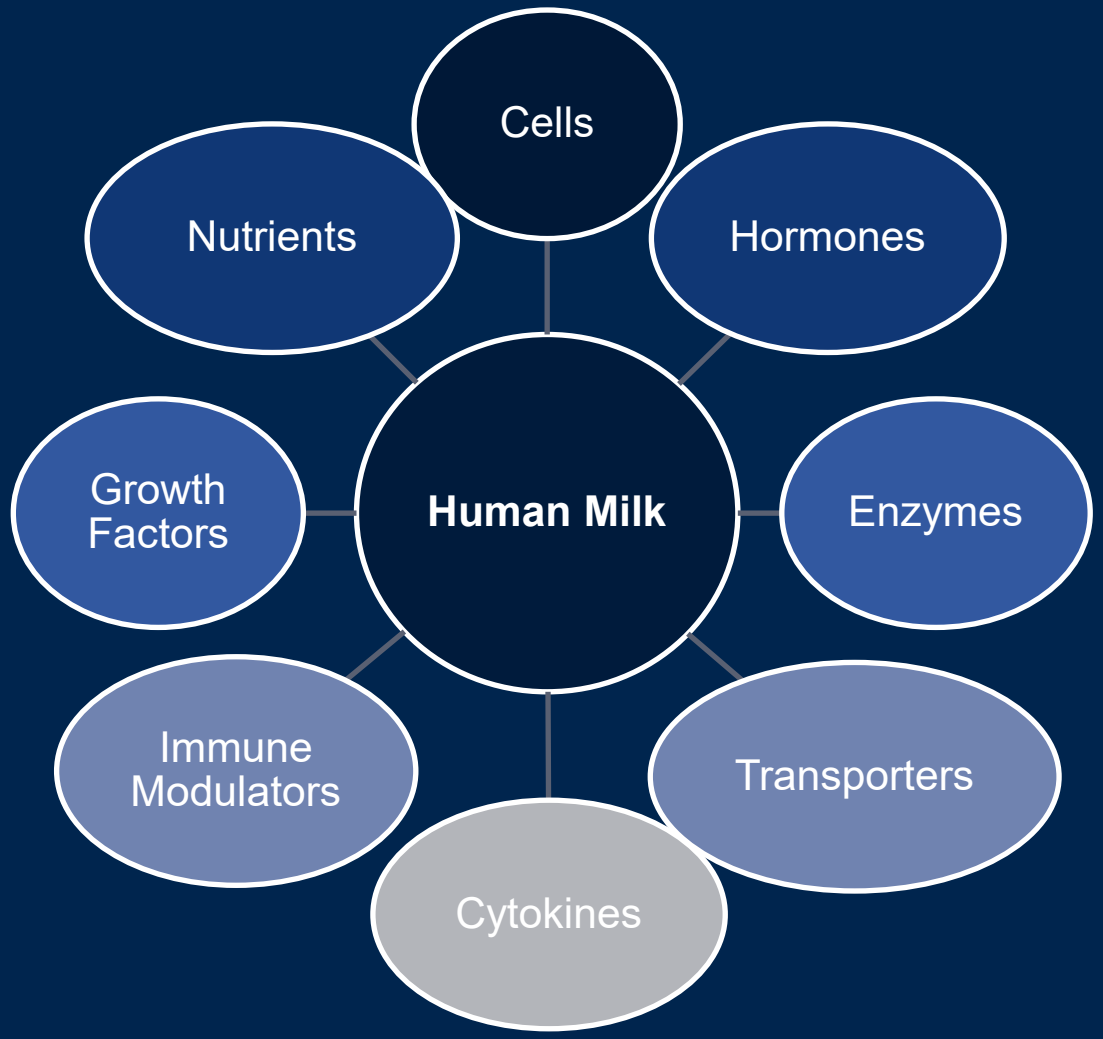
Goals of Feeding- Preterm Infants

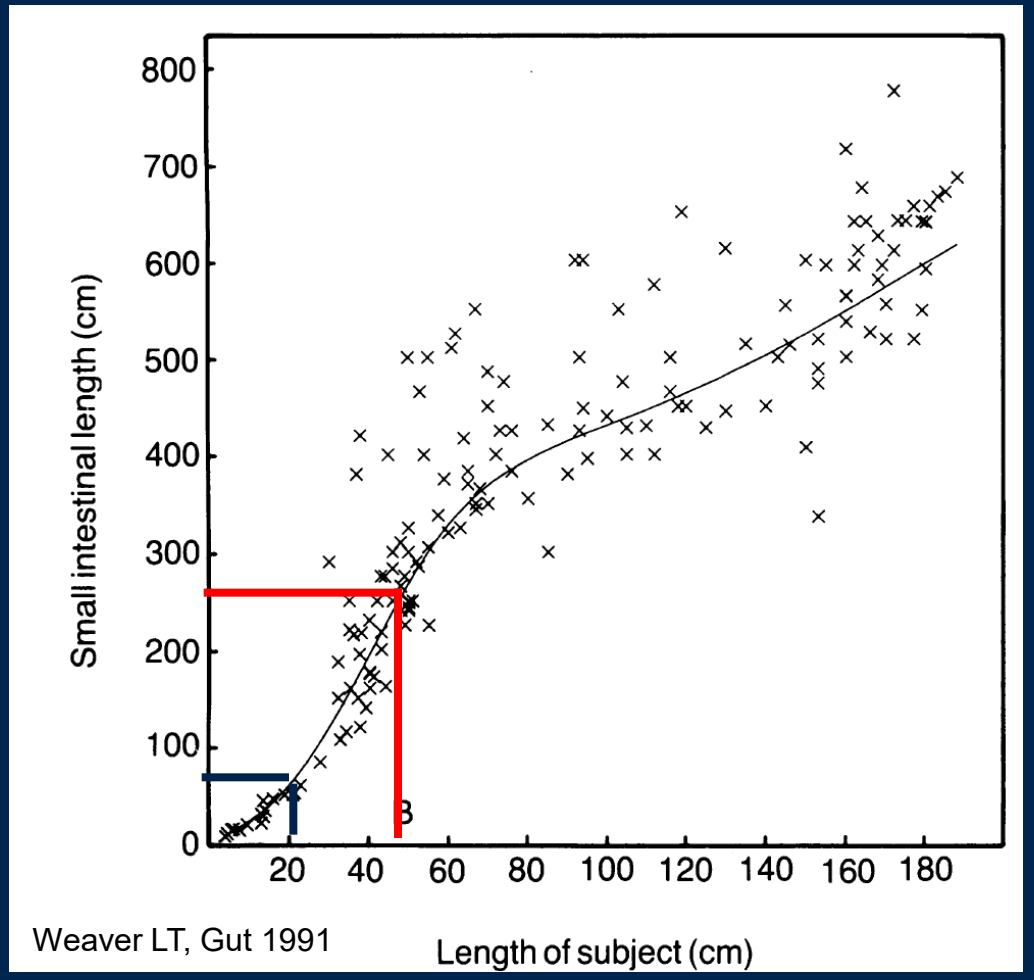
- Promote intestinal adaptation and intestinal growth
- Improve nutrition and promote growth
  - Meet nutritional needs to promote growth with Parenteral Nutrition and Enteral Nutrition
  - Prevent nutrient deficiencies and growth failure
- Avoid Complications
  - Minimize IFALD, blood stream infections
- Transition from parenteral nutrition to all enteral feeds
- Transition to all oral feeds

Intestinal Adaptation

- Recovery of intestinal function
- Compensatory changes
  - Mucosal architecture & Function
- Increase in absorptive surface area
  - Lengthening of villi
  - Deepening of crypts
- Increased enterocyte proliferation
- Enhanced enterocyte function



Longitudinal Intestinal Growth



Weaver LT, Gut 1991

Role of Pasteurized Donor Human Milk?

- Should we give pasteurized donor human milk to infants with intestinal failure to promote intestinal adaptation?

- Should we give oral care with pasteurized donor human milk if mom's milk is unavailable?
  - If infant is a premature infant?

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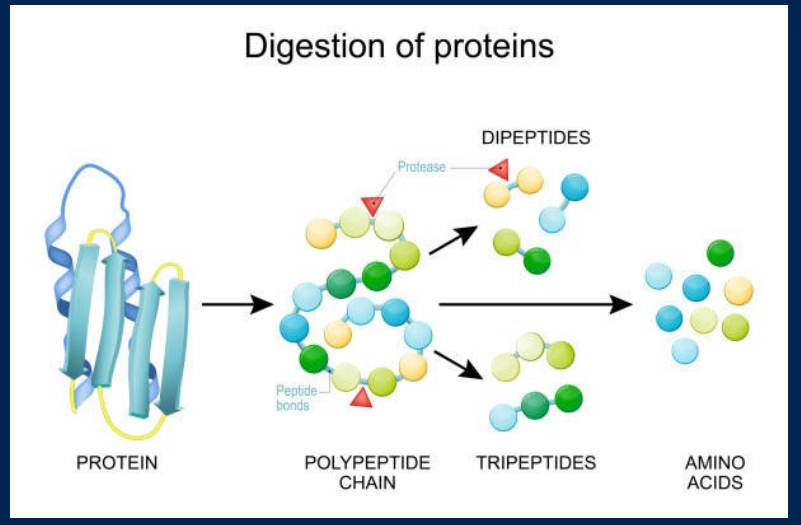
What to feed for post-surgery in preterm infants?

- Breast milk is the preferred feed
  - Trophic factors (EGF, GH), Immunoglobulins, effect on microbiome
  - Shorter duration of PN
- Amino acid-based formulas:
  - Use when there are concerns for protein allergy, or feeding intolerance
  - If baby is term or > 36 weeks postmenstrual age and no mother's milk, it can be used to fortify human milk



Andorsky DJ, J Peds 2001

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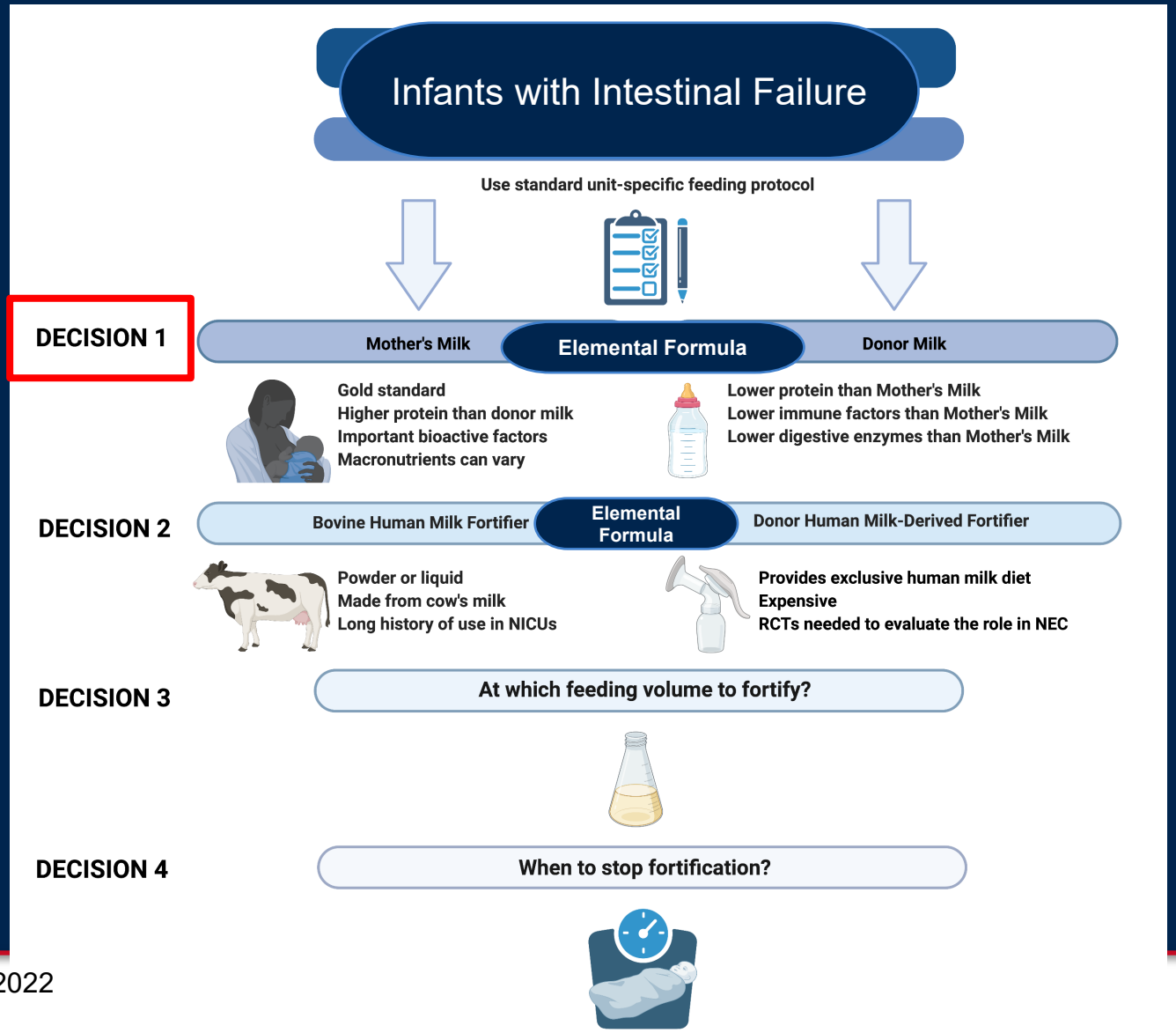
Fortification- Intestinal Failure and post-NEC



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Feeding Post-surgery

Infants with Intestinal Failure

High-Risk Group

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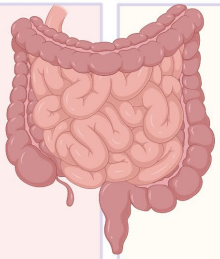

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- Growth failure for >4 weeks on enteral nutrition

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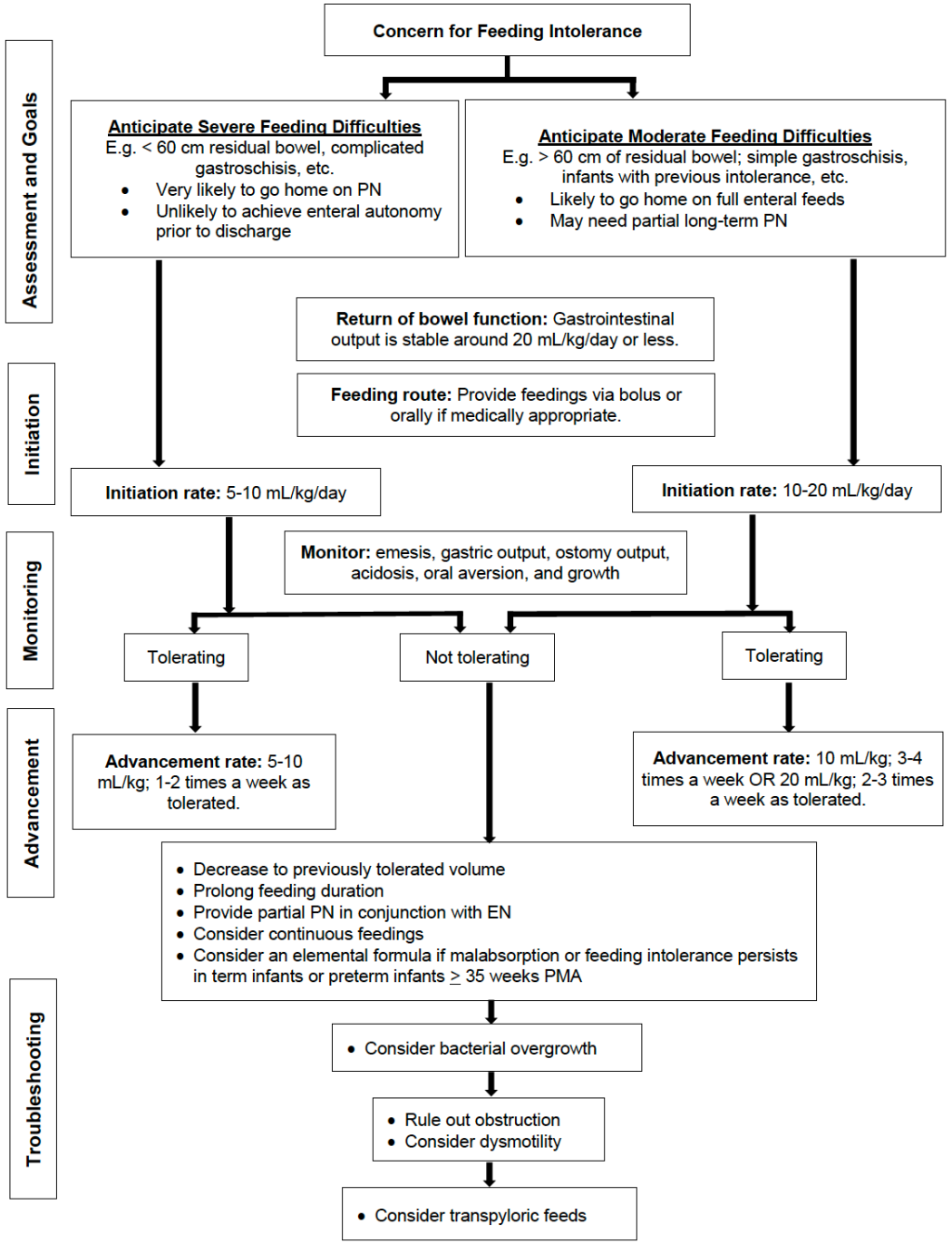
Feeding Preterm Infants post-surgery

- Medical or surgical NEC?
- How much bowel removed?
- Ostomy?
- How preterm is the infant and what is birth weight?
- Standardized Feeding Protocol- at TCH we have the Intestinal Failure Team

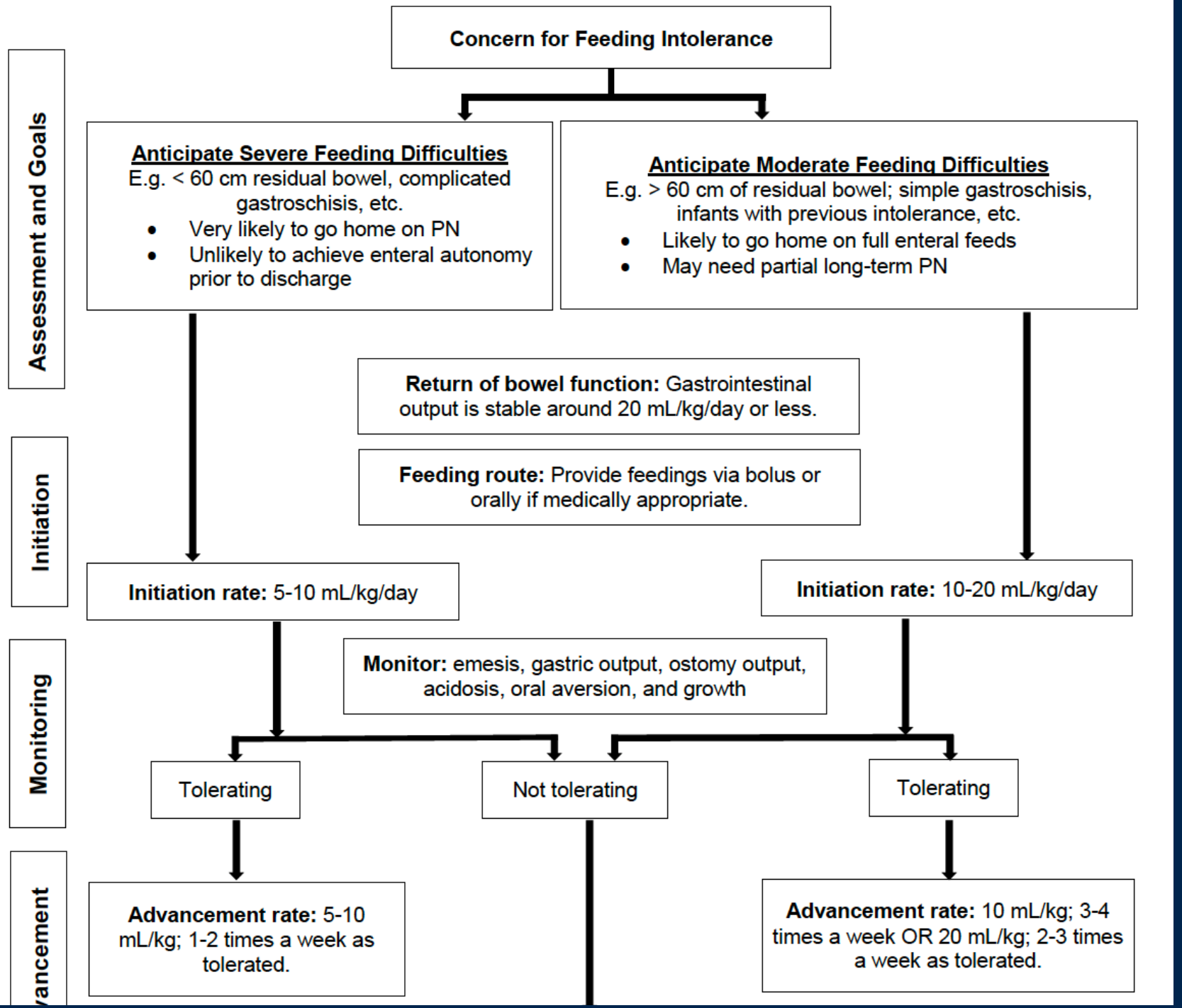
Feeding Protocol for Post-surgery and Intestinal Failure

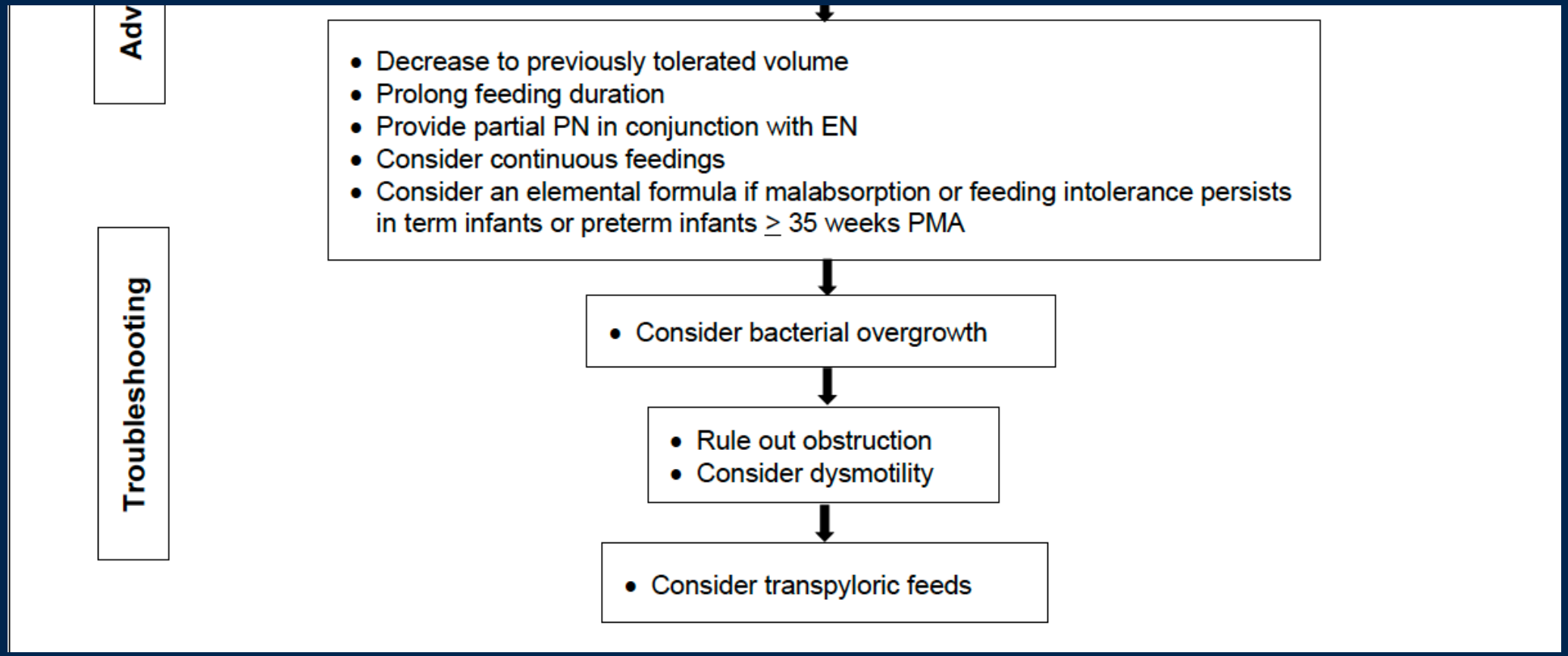
Figure 6-1. Feeding advancement flowchart



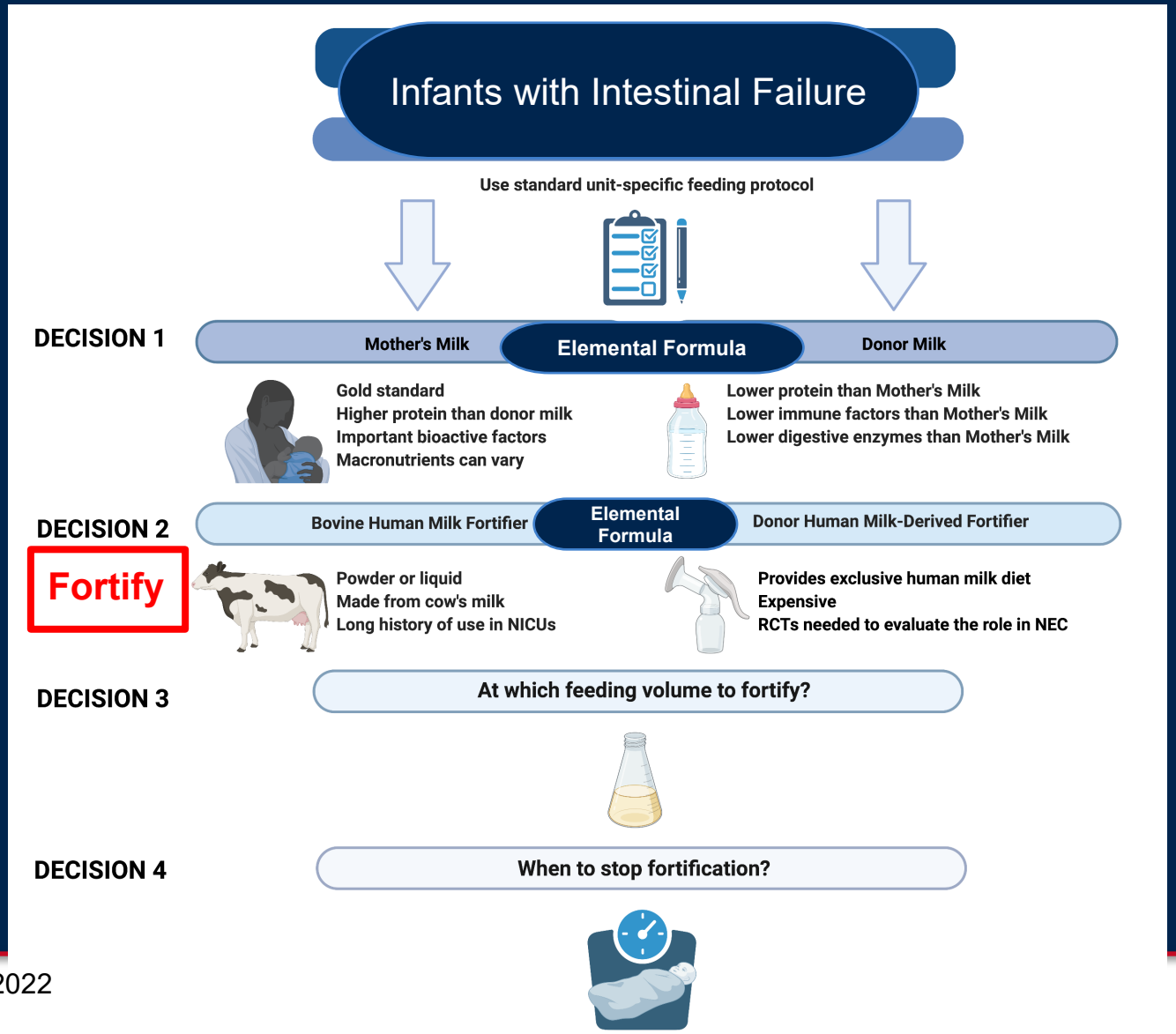
Hair A and M Premkumar. Nutrition Chapter. Guidelines for Acute Care of the Neonate 33rd edition (2025-2026), Fernandes CJ, Pammi M (Eds), Baylor College of Medicine, Section of Neonatology, Department of Pediatrics. Copyright © 2025.

Feeding Protocol for Post-surgery and Intestinal Failure





Dilemmas in Fortification- Intestinal Failure



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Feeding Preterm Infants with Ostomies

- Location of ostomy?

- Fortify at 80 ml/kg/day before weaning off PN, May need partial PN and partial feeds

- Achievement of full enteral nutrition (enteral autonomy) prior to re-anastomosis for infants with IF due to SBS and ostomy with or without a mucous fistula:
  - Reduction in parenteral nutrition days and lower peak conjugated bilirubin levels
  - Sustained enteral autonomy prior to re-anastomosis may be influenced by post-menstrual age at time of ostomy creation, location of ostomy, and presence of mucus fistula

Small Proportion of Low-Birth-Weight Infants With Ostomy and Intestinal Failure Due to Short-Bowel Syndrome Achieve Enteral Autonomy Prior to Reanastomosis

Anne L. Smazal, MD, MS[1]; L. Adriana Massieu, RD, LD[2]; Laura Gollins, MBA, RD[2]; Joseph L. Hagan, ScD[1]; Amy B. Hair, MD[1]; and Muralidhar H. Premkumar, MBBS, MS[1]

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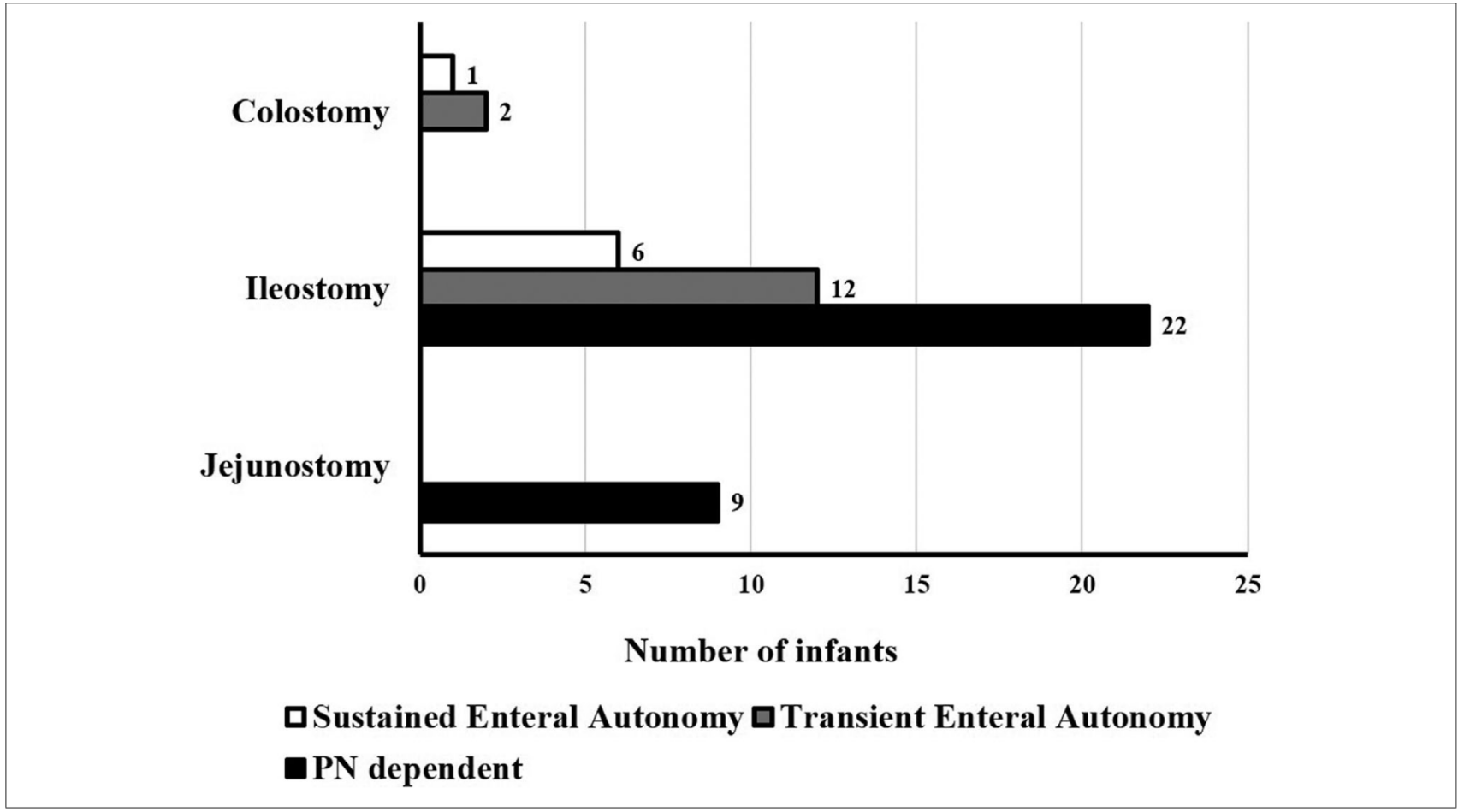

Figure 1. Comparison of the location of ostomy among infants who remained PN dependent, those who failed enteral autonomy (Transient Enteral Autonomy), and those who sustained enteral autonomy (Sustained Enteral Autonomy). PN, parenteral nutrition.

Smazal AL, Massieu LA, Gollins L, Hagan JL, Hair AB, Premkumar MH. Small Proportion of Low-Birth-Weight Infants With Ostomy and Intestinal Failure Due to Short-Bowel Syndrome Achieve Enteral Autonomy Prior to Reanastomosis. JPEN J Parenter Enteral Nutr. 2021 Feb;45(2):331-338.

Fortification Strategies

- Individualized and dependent on:
  - gestational age, weight, gastrointestinal history, previous feeding history, and presence of cholestasis
- Strategies utilized may include:
  - Donor human milk-based fortifier, Bovine HMF, Elemental Formula, Transitional or Term Formulas when appropriate
- If fortification is indicated, this typically occurs when enteral nutrition volume is at 80 ml/kg/day

Weaning of Parenteral Nutrition

- If infants are advancing well on EN and tolerating fortified feeds, central lines may be removed when infant is receiving ~100-120 mL/kg/day of EN

- These at-risk infants should demonstrate adequate growth and tolerance to enteral nutrition and fortification prior to removing central lines as they can exhibit inadequate growth and might require PN in conjunction with EN for additional caloric intake.

- Enteral Nutrition should provide 100-130 kcal/kg/day energy and 3.5-4.5 g/kg/day of protein for preterm infants.

Mucous Fistula Refeeding

- Infants at risk for fluid and electrolyte imbalances, malabsorption, nutrient deficiencies, growth failure, and IFALD may benefit from mucous fistula refeeding:
  - Collecting ostomy output and infusing into distal small bowel through mucous fistula
  - Helps mimic digestion that would happen if bowel were in continuity including resorption of bile salts and other nutrients
  - Goal is to refeed ostomy output volume via mucous fistula in 1:1 ratio
  - Monitor stool output from rectum and other clinical symptoms for signs of feeding intolerance

Figure 6-2. Mucous fistula refeeding

Eligibility Criteria

- Age 0-12 months
- Weight ≥ 1000 g
- Jejunostomy or ileostomy
- Mucous fistula
- On enteral/oral feeds

Preparation

- Shared decision between Intestinal Rehabilitation, Neonatology, Surgery, Nursing teams
- Ensure patency of the distal bowel with a contrast study
- Consensus on:
  - type and depth of insertion of feeding tube/device used
  - frequency of and quantity of refeeding

Procedure

- Insert feeding tube and secure 4-5 cm into mucous fistula
- Collect ostomy output once every 3-4 hours
- Feed ostomy output into mucous fistula over 1-2 hours (or less depending on volume) using a syringe pump
- Maintain patency of feeding tube

Monitoring

- Rectal stool output for signs of intolerance (i.e. loose stools, diarrhea)
  - In conjunction with ostomy output and growth will guide enteral/oral feeding advancement
- Complications

Premature Infants < 1000 g BW with Intestinal Failure

- When feeds are started:
  - Start with trophic feeds at 20 mL/kg/day
    - Bolus feeds are more physiologic
  - Fortify at 60 mL/kg/day with +6 donor human milk-derived fortifier
  - Once feeds at 100 mL/kg/day with +6 donor human milk-derived fortifier, start to wean off parenteral nutrition
    - If infant advances to full volume feeds and demonstrates adequate growth (10-20 g/kg/day) then PN is discontinued
  - Continue until 34 weeks PMA or until full feeds are reached for 2 weeks post-operatively

Premature Infants < 1000g Birth Weight

- Mother's own milk or Donor Human Milk + donor human milk-derived fortifier
  - Early fortification
  - Well tolerated pre- and post-operatively
  - No concerns about increased osmolarity with increased fortification
  - Can give increased enteral calories with donor human milk-derived fortifier

Enteral Nutrition: Establishing feeds <1000 g BW

- Feeding Advancement every 2-3 days
- Monitor tolerance
- Watch of ostomy output (<20-30 ml/kg/day)
- Bolus feeds over continuous feeds
- Infants should demonstrate adequate growth and tolerance of enteral nutrition and fortification prior to removing central line
- Attempt PO feeds if > 33 weeks PMA and showing cues

Take Home Points

- Nutritional Challenges for Post-intestinal Surgery Preterm Infant
  - Provide optimal enteral nutrition to prevent postnatal growth failure
  - Preterm infants can be at high or low risk for feeding intolerance post-surgery depending on the type of surgery and intestinal disease.
  - Optimize the use of mother's own milk with donor milk and elemental formula as secondary choices
  - Bolus feeds over continuous feeds

Better Nutrition= Better Long-term Outcomes

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Thank you!

Dr. Murali Premkumar – Associate Professor, Co-Director of NICU Intestinal Rehabilitation Team

NICU Intestinal Rehabilitation Attendings:

- Dr. Elena Itriago
- Dr. Emily Niemyjski

Neonatal Nutrition Program and Research Team:

- Laura Gollins – Clinical Program Coordinator
- Nora Abu-Hamdan- Research Coordinator
- Wen-Wen Wu- Research Coordinator
- Priscilla Vasquez- Senior Research Coordinator
- Jessica Nguyen- Clinical Research Manager
- Joe Hagan- Statistician

Neonatal Dietitians:

- Allyson Camp, Amy Carter, Nidia Delgado, Laura Lucas, Agnes Mandy, Adriana Massieu, Veronica Rubio

•Collaborators:

- Dr. Preidis, Dr. Misty Good, Dr. Cami Martin, Dr. Burrin, Dr. Roddy, Dr. Greg Valentine

NIH National Institute of Diabetes and Digestive and Kidney Diseases

NIH *Eunice Kennedy Shriver* National Institute of Child Health and Human Development

NEC SOCIETY
Building a World Without NEC

Chan Zuckerberg Initiative

Dr. Diane Anderson NEONATAL NUTRITION CONFERENCE
March 3 – 5, 2026
Texas Children's Hospital | Baylor College of Medicine

Resilient
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NEONATAL NUTRITION COLLABORATIVE

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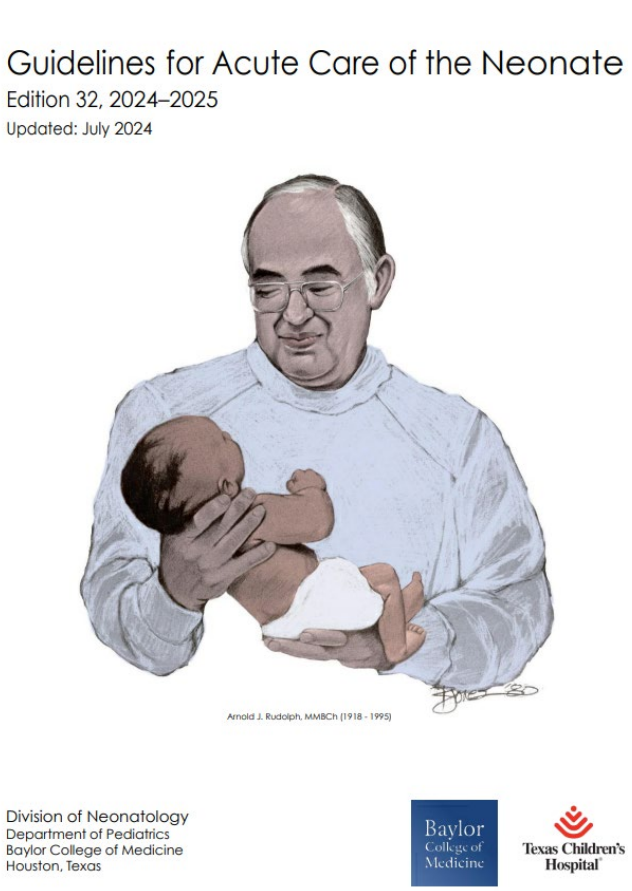
Translating Evidence Into Practice



- Evidenced-based
- Clinical practical guideline
- Revised annually for 33 years
- Downloaded around the world over 2,400 times in more than 67 different countries

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*Slide courtesy of Dr. Reber and Laura Gollins

Questions?

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