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45th National Conference on Pediatric Health Care

Corewell Health Helen DeVos Children's Hospital

To Feed or Not to Feed: A Review of the Literature

Ashley Eggleston DNP, APRN, CPNP-AC/PC
Abbie Woudwyk MSN, APRN, CPNP-AC

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Literature Review

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- Key terms
  - Enteral nutrition, feeds, acute care, critical care, pediatric, nasogastric, nasojejunal, transpyloric, vasopressor, vasoactive, compressed, gavage, bolus, continuous.
- Various databases
- Excluded articles related to patients in the NICU
- Excluded articles specific to:
  - Gastric residual feeding protocol
  - Single diagnosis (pancreatitis)
  - Summary of feeding practices of HLHS
- Reviewed clinical guidelines from ASPEN/SCCM

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Learning Objectives

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- Describe the importance of enteral nutrition in pediatric patients in acute care settings.
- Identify strategies to improve nutrition delivery to pediatric patients.
- Recognize clinical outcome differences between continuous versus bolus feedings.
- Review the literature related to patients receiving enteral nutrition while also on vasoactive medications.
- Identify areas for future research.

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What pediatric setting do you currently work in?

A) Inpatient general medicine
B) Inpatient subspeciality
C) Outpatient
D) Critical Care
E) My setting is not listed

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How long have you been practicing as a Nurse Practitioner?

A) I am a student
B) < 1 year
C) 1-5 years
D) 5-10 years
E) > 10 years

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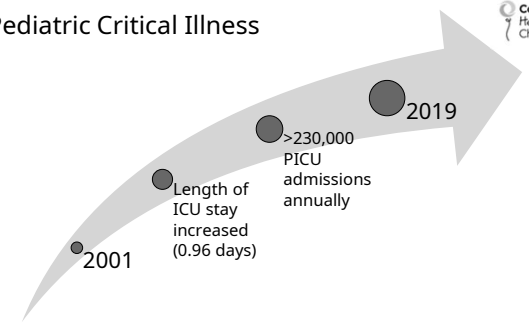
Pediatric Critical Illness



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Malnutrition

- A **deficient**, **excessive**, or **imbalanced** intake of nutrients that jeopardizes one's health status.



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Malnutrition vs. Undernutrition

- Malnutrition
  - A deficient, excessive, or imbalanced intake of nutrients.
- Undernutrition
  - Nutritional inadequacies in an individual's energy and nutrient intake absorption.
    1) Wasting
    2) Stunting
    3) Underweight
    4) Micronutrient deficiencies

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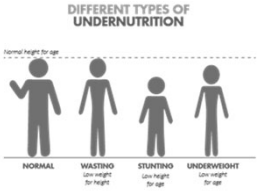
Undernutrition

- Wasting
  - Low weight for height
  - Rapid weight reduction
  - Decreased consumption of nutrition
  - Frequently ill

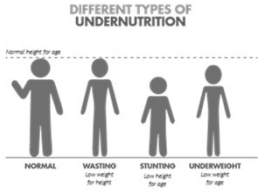


(Action Against Hunger, 2024)

9

Undernutrition

- Stunting
  - Short height for age
  - Chronic or repeated malnutrition
    - Poverty
    - Poor prenatal health
    - Frequent illness
    - Improper feeding/care early in life



(Action Against Hunger, 2024)

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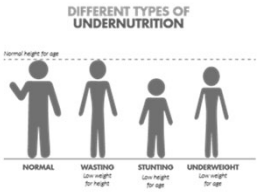
Undernutrition

- Underweight
  - Abnormally low weight for age.
  - These children may be stunted, wasted, or both.
- Micronutrient Deficiencies
  - Deficiency of vitamins and minerals.



(Action Against Hunger, 2024)

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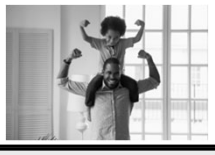
If left untreated…

- Wasting leads to increased mortality.
- Stunting limits children's physical and cognitive capabilities.
- Proper growth and development is restricted.



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Undernutrition and Malnutrition

- More prevalent in women, infants, children, and adolescents.
  - Children with special healthcare needs
- Children more vulnerable to malnutrition.
  - Lower caloric reserve
  - High nutritional requirements
- Malnutrition should be routinely screened for in primary care settings.
  - Predisposes them to severe, acute illnesses
  - Exacerbate underlying diseases/conditions

(Albadi, 2022; Becker, 2014; McCarthy, 2019)

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On average, what percentage of patients will receive a malnutrition diagnosis upon admission to the PICU?

A) 5%

B) 10%

C) 30%

D) 70%

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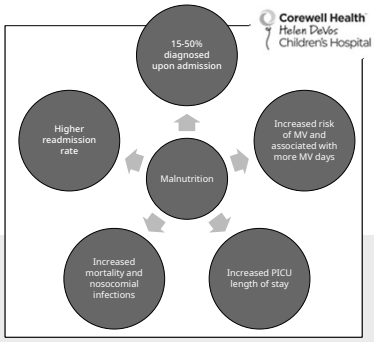
Malnutrition or Undernutrition in the PICU



Albadi, 2022; De Souza Menezes, 2012; Hoyer-Haro, 2022; Jouncastay, 2021)

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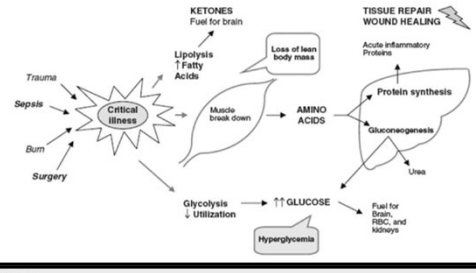

(Mehta, 2009)

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Pediatric Enteral Nutrition

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- Providing enteral nutrition may offset the metabolic burden of the stress response.
  - Improved wound healing
  - Decreased catabolic response to injury
  - Improved GI structure and function
- Optimizing protein intake to prevent lean body mass depletion is one of the most important goals of nutritional therapy in the PICU.

(Bechard, 2021; Mehta, 2012; Mikhailov, 2014)

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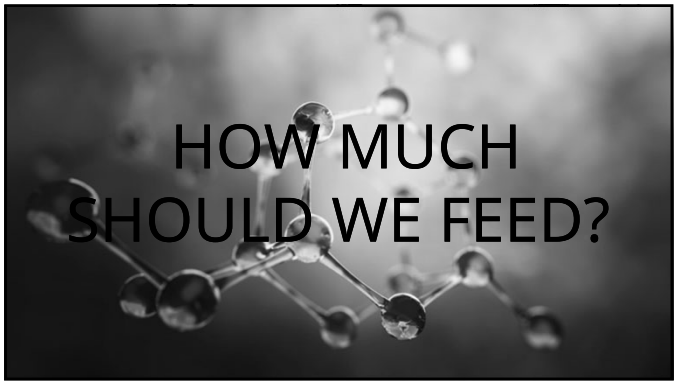

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Calculating Caloric Needs

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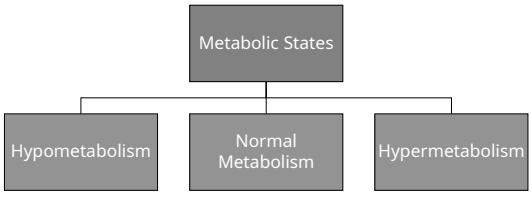

(Mehta, 2017)

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How much nutrition is recommended?

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According to a multicenter study by Mehta et al.

- 31 PICUs
- 500 intubated patients

Patients who received >66% of prescribed calories via EN over 10 days had a lower 60-day mortality compared with those who received <33% prescribed calories.

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Protein needs in critically ill children

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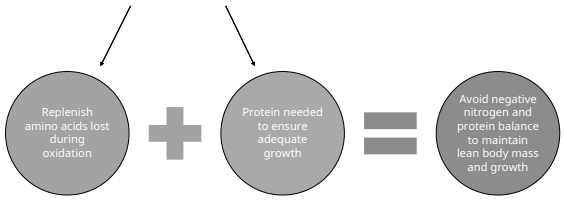

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Protein Requirements

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Prospective multicenter cohort study including 59 PICUs

- 1,245 children requiring mechanical ventilation >48hours
- Protein intake less than 1.5g/kg/day associated with negative protein balance.
- Muscle wasting in patients with acute lung injury has been associated with weakness and impaired quality of life.

- Results show an association between higher enteral protein intake and lower 60-day mortality.

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ASPEN and SCCM Recommendations

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- The goal is to reach two-thirds of the prescribed energy requirements by the end of the first week.

Protein requirement is 1.5 g/kg/day (minimum)
0–2 years: 2–3 g/kg/day
2–13 years: 1.5–2 g/kg/day
13–18 years: 1.5 g/kg/day

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Enteral Nutrition

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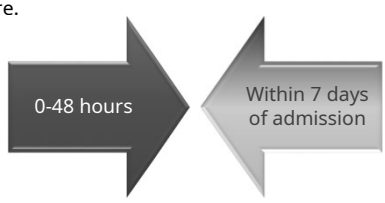
- Early enteral nutrition is defined differently throughout the literature.



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Early Enteral Nutrition Is Associated With Improved Clinical Outcomes in Critically Ill Children: A Secondary Analysis of Nutrition Support in the Heart and Lung Failure-Pediatric Insulin Titration Trial

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- Secondary analysis of the HALF-PINT trial including 35 PICUs.
  - Patients with hyperglycemia requiring vasoactive support and/or mechanical ventilation.
  - EN within 48 hours of randomization into the study associated with better clinical outcomes including:
    - Lower 90-day mortality
    - More ventilator free days
    - Decreased length of stay
    - Less organ dysfunction

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Effect of Early Nutritional Support on Intensive Care Unit Length of Stay and Neurological Status at Discharge in Children With Severe Traumatic Brain Injury

- Retrospective study
  - (n = 109)
- Early EN (average 1.49 days)
  - Decrease in PICU LOS
  - Improved functional outcomes at discharge

Initiating Nutritional Support Before 72 Hours is Associated with Favorable Outcome After Severe Traumatic Brain Injury in Children: A Secondary Analysis of a Randomized, Controlled Trial of Therapeutic Hypothermia

Elizabeth Meinert, MD[1], Michael J. Bell, MD[1,2,4], Sandra Buttram[3], Patrick M. Kochanek[1,4],

- Secondary analysis of *The Cool Kids Trial*
  - Multinational RCT
  - (n = 77)
- Early EN (within 72hrs following injury)
  - Decreased mortality
  - Improved outcomes (GOS-E Peds Score)

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The Pediatric Guideline Adherence and Outcomes Program in Severe Traumatic Brain Injury: *A Single Center Hybrid Implementation-Effectiveness Study*

Monica S. Vavilala, MD[1,2,3], Mary A. King, MD[2,3], Jen-Ting Yang, MD[1,2], Scott L. Erickson, BA[2,4], Brianna Mills, PhD[2], Rosemary M. Grant, RN[2], Carolyn Blayney, RN[2], Qian Qiu, MBA[2], Randall M. Chesnut, MD[2,5], Kenneth M. Jaffe, MD[2,7], Bryan J. Weiner, PhD[8], and Brian D. Johnston, MD[2,3]

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- PEGASUS study
- Determine acute care clinical indicators that are associated with outcomes following severe TBI in children.
- Five centers in the U.S. (n = 236)
- Early EN (within 72hrs following injury)
  - Decreased mortality
  - No difference in GOS score

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Time to achieve delivery of nutrition targets is associated with clinical outcomes in critically ill children

Lori J Bechard, Steven J Staffa, David Zurakowski, and Nilesh M Mehta

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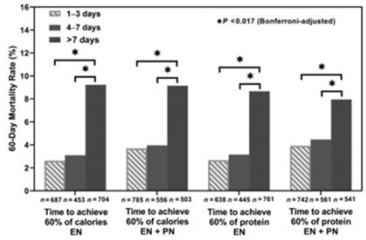
- Prospective observational cohort study
  - n= 1,844 mechanically ventilated children
  - 77 PICUs



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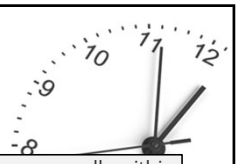
ASPEN Recommendation



Suggest early initiation of enteral nutrition, generally within the first 24-48 hours following admission to the PICU.

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Time to achieve delivery of nutrition targets is associated with clinical outcomes in critically ill children

Lori J Bechard, Steven J Staffa, David Zurakowski, and Nilesh M Mehta

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- Bechard study showed PN initiation by day 4 was associated with improved outcomes compared with late (after 7 days).

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ASPEN and SCCM Recommendation

- PN should be delayed in patients with a normal baseline for at least 7 days.
- Patients that are severely malnourished or at risk of nutrition deterioration, PN may be supplemented in the first week.

(ASPEN, 2024; Mehta, 2017)

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Does your institution use a feeding protocol to guide the delivery of enteral nutrition?

A) Yes

B) No

C) I do not know

D) I do not work in an acute care setting

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Feeding Guidelines

According to a systematic review of 9 studies by Wong et. al, enteral nutrition guidelines in the PICU:

- Improves time to start feeds
- Improves time to goal feeds
- May decrease GI complications and reduce infective complications

(Wong et al., 2014)

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ASPEN suggests the use of institutional guidelines and stepwise algorithms.

(ASPEN, 2024; Mehta, 2017)

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• Research •

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Feeding Guideline implemented 2019

Primary Outcome: Do guidelines decrease time to start feeds, reach goal feeds and decrease interruptions to feeds?

Secondary Outcomes: MV days, PICU LOS, feeding intolerance requiring change to transpyloric feeds

Studied 146 patients pre and post-protocol (n=292)

Exclusion criteria: Patients on HFNC, Inotropes, PCICU, Post-op

Inclusion criteria: NIPPV or MV Admitted January-May 2019 and December 2019-March 2020

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National Association of Pediatric Nurse Practitioners

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Results

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Variable	Pre-Protocol Group (N=146)	Post-Protocol Group (N=146)	p-value
Time from admission to Initiation of Enteral Feedings (hours)	23 [12, 43]	19 [9, 30]	0.0334
Time from start of feedings to Goal feeding (hours)	N=138 19 [3, 29]	N=145 14 [0, 22]	0.0286
Times NPO Avoidable 0 1	N=108 106 (98.1) 2 (1.9)	N=124 123 (99.2) 1 (0.8)	0.5991*
PCCU LOS (days)	N=146 4 [3, 10]	N=145 5 [3, 9]	0.7971
Days on Mechanical Ventilation	N=96 4 [2, 8]	N=92 5 [3, 7]	0.2408
Feeding Intolerance requiring change to transpyloric feeding tube?	N=109 9 (8.3)	N=112 4 (3.6)	0.1389

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After implementing an EN guideline in the PICU, there was a statistically significant:

1) Decrease in the time from admission to starting EN.

2) Decrease in the time to reach goal feeds.

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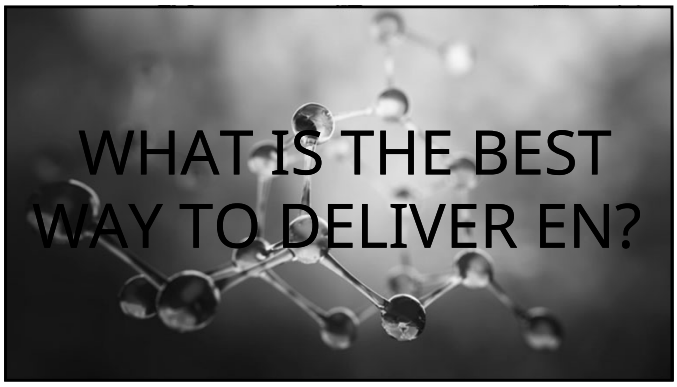
WHAT IS THE BEST WAY TO DELIVER EN?

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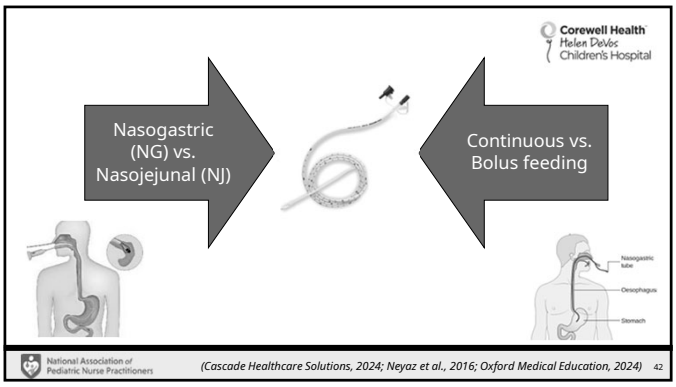
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Nasogastric (NG) vs. Nasojejunal (NJ)
Continuous vs. Bolus feeding
Nasogastric tube
Oesophagus
Stomach
National Association of Pediatric Nurse Practitioners
(Cascade Healthcare Solutions, 2024; Neyaz et al., 2016; Oxford Medical Education, 2024)
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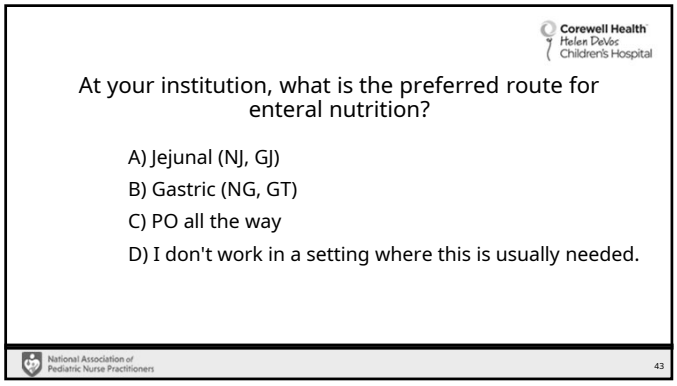
Corewell Health
Helen DeVos Children's Hospital
At your institution, what is the preferred route for enteral nutrition?
A) Jejunal (NJ, GJ)
B) Gastric (NG, GT)
C) PO all the way
D) I don't work in a setting where this is usually needed.
National Association of Pediatric Nurse Practitioners
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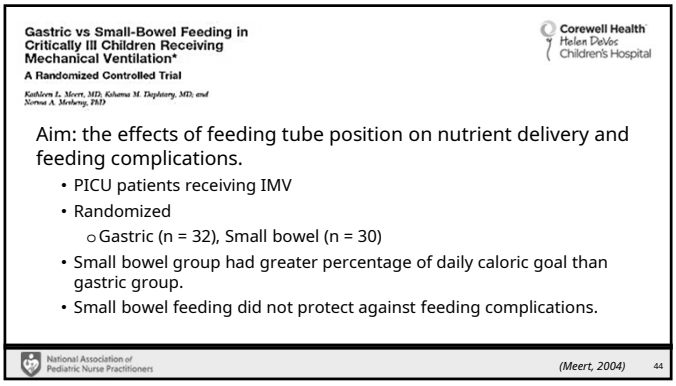
Gastric vs Small-Bowel Feeding in Critically Ill Children Receiving Mechanical Ventilation*
A Randomized Controlled Trial
Kathleen L. Meert, MD, Kihoma M. Taghavary, MD, and Norma A. Morkeny, PhD
Corewell Health
Helen DeVos Children's Hospital
Aim: the effects of feeding tube position on nutrient delivery and feeding complications.
• PICU patients receiving IMV
• Randomized
o Gastric (n = 32), Small bowel (n = 30)
• Small bowel group had greater percentage of daily caloric goal than gastric group.
• Small bowel feeding did not protect against feeding complications.
National Association of Pediatric Nurse Practitioners
(Meert, 2004)
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Contents lists available at ScienceDirect
Australian Critical Care
journal homepage: www.elsevier.com/locate/aucc

Research paper

Effect of two different feeding methods on preventing ventilator associated pneumonia in the paediatric intensive care unit (PICU): A randomised controlled study

Duygu Sönmez Düzkaya PhD, BSc, RN[a,*],
Suzan Yildiz PhD, BSc, RN[b,1]

Randomized controlled experiment from 2012-2013 in Turkey.

- PICU patients on IMV for at least 48hrs
  - 20 = continuous EN by nasoduodenal route
  - 20 = intermittent EN by nasogastric route
- No statistical difference found between feeding methods and VAP.

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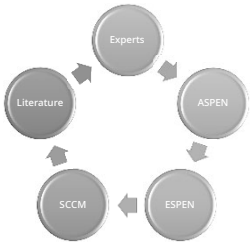
A guide to enteral nutrition in intensive care units: 10 expert tips for the daily practice

Jean-Charles Preiser[1*], Yaseen M. Arabi[2], Mette M. Berger[3], Michael Casaer[4], Stephen McClave[5], Juan C. Montejo-González[6], Sandra Peake[7,8], Annika Reintam Blaser[9,10], Greet Van den Berghe[4], Arthur van Zanten[11], Jan Wernerman[12] and Paul Wischmeyer[13]

- Guidelines based on adult literature from 2013-2015.
  - RCTs have shown post pyloric feeding reduces pneumonia, but no other benefits have been observed.
  - Provider's decision to switch from gastric to post pyloric is generally subjective based on perceived intolerance or delayed gastric emptying.



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Routine gastric residual volume measurement and energy target achievement in the PICU: a comparison study

Lyvonne N. Tume[1] · Anna Bickerdike[2] · Lynne Latten[3] · Simon Davies[4] · Madeleine H. Lefèvre[5] · Gaëlle W. Nicolas[5] · Frédéric V. Valla[6]

According to this study by Tume et. al, 87 children were compared between two PICUs: one that measures GRV and one that does not.

- No significant difference between the two groups in median % of energy target achieved in the first 4 days.
- In the patients that GRVs were measured, there were more EN interruptions.
- No difference in rates of VAP and NEC between the two groups.

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ASPEN Recommendation

- There is limited evidence to make universal recommendations regarding the optimal site to deliver EN.
  - Gastric is the preferred primary route for EN.
  - Post pyloric EN should be considered in patients unable to tolerate gastric feeding or those at high risk for aspiration.

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What is your feeding practice with patients receiving respiratory support?

A) Start continuous feeds.

B) Start bolus/intermittent feeds.

C) It depends on the patient.

D) I don't order enteral feeds.

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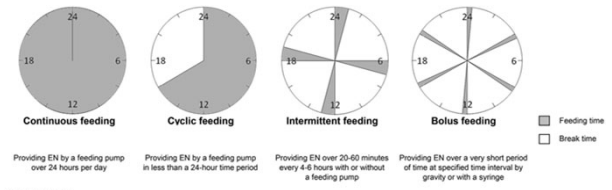
Methods of Enteral Nutrition



EN, enteral nutrition.

(Ichimaru, 2018)

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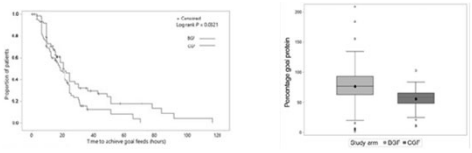
COntinuous vs. BOlus Multicenter Trial

Multicenter, prospective, unblinded, randomized comparative effectiveness trial.

- 7 PICUs in the US from 2015-2018.
- 151 patients on MV, randomized to bolus feeds or continuous feeds.



Bolus feeds shortened the time to attain goal feeds compared with continuous feeds and increased the percentage of target protein and energy delivered.

(Brown, 2022)

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Is bolus or continuous enteral feeding better in critically ill children: An evidence-based review

Hayley Littler RNC, BSc, Staff Nurse[1] |
Lyvonne N. Tume RN, PhD, Associate Professor in Child Health[2]

- Specific outcome measures:
  - Time to achieve goal feeds
  - Feeding intolerance
- Four studies:
  - 2 RCTs (Fayazi et al. 2016 & Brown et al. 2022)
  - Systematic review (Brown et al. 2020)
  - Randomized comparative effectiveness intervention (Brown et al. 2018)
- Overall, current evidence isn't strong enough to make a recommendation on which is superior.

(Littler & Tume, 2023)

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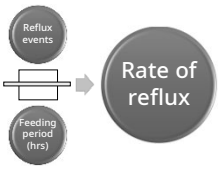
Continuous Feedings Are Not Associated With Lower Rates of Gastroesophageal Reflux When Compared With Bolus Feedings

*Lisa B. Mahoney, [1]Enju Liu, and *Rachel Rosen

- Retrospective (n = 18)
- Utilized 24-hr multichannel intraluminal impedance with pH study.
- Results:
  - No differences in reflux
  - No differences in risk of reflux
- Continuous feedings may not offer a significant advantage in reducing reflux.



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Intermittent versus continuous enteral nutrition in critically ill children: a pre-planned secondary analysis of an international prospective cohort study

Enid E. Martinez, MD[1,2], Lori J. Bechard, PhD, MEd, RD[1,2,4], Ann-Marie Brown, PhD, CPNP-AC/PC, CCRN, CNE, FCCM, FAANP[3], Jorge A. Coss-Bu, MD[5], Sapna R. Kudchadkar, MD, PhD[6], Theresa A. Mikhailov, MD, PhD, FAAP[7], Vijay Srinivasan, MD[8], Steven J. Staffa, MS[2,3], S. (Sascha) C.A.T. Verbruggen, MD, PhD[1,9], David Zurakowski, PhD[2,3], Nilesh M. Mehta, MD, FASPEN[1,2,4]

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- Secondary analysis of an international prospective cohort study.
  - 1,375 mechanically ventilated patients from 66 PICUs
  - Primary aim: evaluate if there are infection differences between continuous and intermittent fed children.
    - No statistical difference in frequency of infection between the groups.
    - No difference in reaching energy target and EN interruptions between the two groups.
  - According to this study, until further evidence is available, individualized EN strategies rather than a universal strategy may be appropriate.

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Protein synthesis in skeletal muscle of neonatal pigs

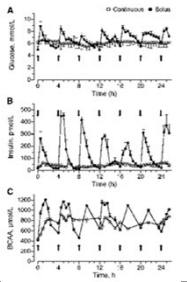
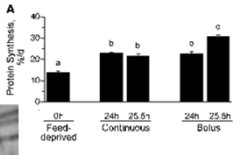


Photo from istock



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Adult Literature

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Intermittent/bolus feeds

- Pulsatile CCK release which leads to gallbladder emptying *(Patel, 2018).*
- Lower blood glucose levels *(Patel, 2018).*
- No increase in diarrhea or aspiration compared to continuous *(Ichimaru, 2018).*
- Bolus feeds resulted in greater nutritional delivery for protein and energy. Also resulted in peak leucine concentrations *(McNelly, 2020).*
- Increases splanchnic blood flow, pulsatile changes in ghrelin, insulin, peptide YY, further stimulating muscle protein synthesis *(McNelly, 2020).*

Continuous Feeds

- Blunts the CCK release leading to gall bladder distention *(Patel, 2018).*
- Increased interruption to feeds *(Ichimaru, 2018).*
- One RCT in adults found higher rates of achieving goal nutrition; however, there are studies that oppose this finding *(Theodoridis, 2023).*
- May impair autophagy *(Patel, 2018).*

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Pediatric Conclusions

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Intermittent/Bolus Feeds

- Increased protein synthesis *(Gazzaneo, 2011).*
- Time to goal feeds shorter *(Brown, 2022).*
- Labor intensive for nursing staff *(Martinez, 2022).*

Both EN methods

- No statistical difference in acquired infections between the two groups *(Martinez, 2022).*
- No difference in the rate of reflux *(Mahoney, 2019).*
- No difference in time to goal energy target (*Martinez, 2022).*
- No difference in interruptions to feeds *(Martinez, 2022).*
- No difference in GI complications/LOS *(Fayazi, 2016).*

Continuous Feeds

- Increased interruption to feeds *(Brown, 2022).*
- Small single center study found higher proportion of patients achieved adequate protein with continuous feeds *(Wong, 2017).*

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When do you start EN on a patient receiving vasoactive medications?

A) Right away… why are we waiting?

B) When the epinephrine or norepinephrine is ≤ 0.05 mcg/kg/min.

C) When the epinephrine or norepinephrine is ≤ 0.1 mcg/kg/min.

D) When the patient is hemodynamically stable regardless of vasopressor dose.

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Enteral Nutrition and Vasoactive Medications

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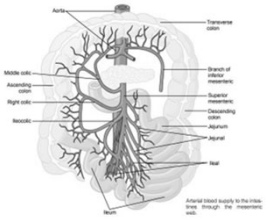
- Hypoperfusion to the GI tract and splanchnic bed is a physiologic phenomenon with hemodynamic instability.
- Vasoactive (VA) medications→ increased splanchnic vasoconstriction.
- EN in hemodynamically unstable patients with or without VAs is controversial.



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Vasopressors and Enteral Nutrition in the Survival Rate of Children During Extracorporeal Membrane Oxygenation

*Erin Alexander, DO, *Imad Absah, MD, *Dana B. Steien, MD, *Rayna Grothe MD, and †Sheri Crow, MD

- Retrospective review
  - Pediatric patients (n=76) on VA ECMO
- Early EN and lower VIS associated with higher survival rate.
- VIS score
  - Less than 5.9 may be safe for EN

VIS = dopamine dose (µg/kg/min) + dobutamine dose (µg/kg/min) + 100 x epinephrine dose (µg/kg/min) + 10 x milrinone dose (µg/kg/min) + 10,000 x vasopressin dose (U/kg/min) + 100 x norepinephrine dose (µg/kg/min)

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Enteral Nutrition and Cardiovascular Medications in the Pediatric Intensive Care Unit

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- Retrospective chart review
  - n = 55 PICU patients
- No significant complications reported with EN and VAs.
  - The most common reported reason for interrupting EN was vomiting and constipation.

TABLE I
Vasopressor combinations used

Vasopressor(s) used	Number (%) of patients (total 55)
"Low-dose" dopamine (<6 µg/kg/min)	3 (5.4)
"High-dose" dopamine (≥6 µg/kg/min)	17 (30.9)
Dopamine + norepinephrine	23 (41.8)
Dopamine + norepinephrine + epinephrine	2 (3.6)
Dopamine + epinephrine	2 (3.6)
Dopamine + dobutamine	1 (1.8)
Dopamine + dobutamine + norepinephrine	1 (1.8)
Dopamine + phenylephrine	1 (1.8)
Dobutamine	3 (5.4)
Dobutamine + epinephrine	1 (1.8)
Phenylephrine	1 (1.8)

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Safety of Enteral Feedings in Critically Ill Children Receiving Vasoactive Agents

Apurva K. Panchal, MD[1]; Jennifer Manzi, CPNP-AC[2]; Susan Connolly, CPNP-AC[2]; Melissa Christensen, BS[3]; Martin Wakeham, MD[4]; Praveen S. Goday, MBBS, CNSC[5]; and Theresa A. Mikhailov, MD, PhD[1]

- Multicenter, retrospective chart review
  - Two groups: Fed (188) and Not fed (151)
  - VIS was utilized
- Fed group
  - Younger, less VA, lower PRISM/LOS
- No significant differences in GI outcomes between the two groups.
- EN is safe in patients receiving vasoactives.

Table 3. Comparison of the VIS Between the Fed and Nonfed Groups.

VIS	Fed	Nonfed	*P* Value*
Day 1	10.0 (5.0–25.0)	15.0 (5.0–30.0)	.017
Day 2	10.0 (5.0–15.0)	10.0 (5.0–25.0)	.34
Day 3	5.0 (5.0–10.0)	5.0 (0–20.0)	.48
Day 4	5.0 (0–9.4)	5.0 (0–12.5)	.99

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In Conclusion…

- Limited research in pediatrics.
- Adult studies have showed EN intolerance is associated with VA trajectory and dose.

Surviving Sepsis	ASPEN/ESPNIC
• Hold EN for pediatrics patients in active shock. • Consider in patients who are hemodynamically stable and no further escalation of VAs.	• No official recommendation for pediatrics. • EN should be considered in children who are stable on hemodynamic support.

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Opportunities for Future Research

- Tume et al. (2019) reviewed the literature related to pediatric nutrition and identified areas for future research:
  - Impact of malnutrition during critical illness, how critical illness induces lean muscle wasting
  - Accurate assessment of energy requirements during critical illness
  - Role of protein intake related to muscle wasting
  - Delivery of EN
  - Define feeding intolerance
  - Role and timing of PN
  - Nutrition therapies for specific populations

- Consider whether specific patient cohorts would benefit more from intermittent vs. continuous feedings and the cost, time and labor associated with each strategy of feeding.
- Determine the safety and appropriate delivery of EN for patients receiving vasoactive medications.

(Brown, 2022; Martinez, 2022; Tume et al., 2019)

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