ENTERAL Nutrition in PICU

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Why is Nutrition important?

under and over nutrition including obesity is associated with adverse clinical outcomes which include

longer lengths on mechanical ventilation

higher risk of nosocomial infection

longer length of stay and increased mortality

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P92 - Does Malnutrition affect Clinical Outcomes in Septic Patients in the Pediatric Intensive Care Unit

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Conclusion: Septic patients admitted to the PICU who were screened as malnourished or at risk of malnutrition displayed longer PICU and hospital LOS. Additionally, patients screened as malnourished or at risk of malnutrition were less likely to die if a caloric goal was recorded within the first 48 hours of admission in comparison to patients where no caloric goal was recorded. Screening of malnourishment and prompt interventional action is critical as sepsis/septic shock patients in the PICU are at higher risk of worsening clinical outcomes as a result.

Nutritional status

Anthropometric: Children should have their **weight, length/height** (also head circumference in children <2 years) measured and plotted on their appropriate growth chart within 24 hours of admission

It is important to note that weight can often be confounded by hydration status, catabolism, autophagy and inaccuracy of measurement.

Height is more of a long term measure not ideally suited to the acute nature of the majority of PIC admissions, and is fraught with inter-measurer error and skill of equipment use.

Protein catabolism and nitrogen loss are characteristic features of the metabolic stress response to critical illness,

resulting in net negative protein balance and loss of lean body mass**. Accurate measurement of muscle** mass and efforts to preserve it during critical illness may improve functional outcomes

laboratory data

TABLE 13.2 Nutritional Monitoring and Associated Limitations During Critical Illness

Methodology	Clinical Indication/Use	Considerations During Critical Illness
Weight	Standard growth reference	Falsely affected by fluid shifts, edema. Difficult to obtain.
Height/Length	Standard growth reference	Difficult to obtain.
Serum Albumin	Visceral protein stores. Useful for long-term nutrition monitoring/assessments.	Falsely low due to immobility, capillary leak syndrome, renal or GI losses, or hepatic disease.
Serum Prealbumin	Visceral protein stores. Useful to detect acute changes in nutritional status	Falsely low during periods of inflammation. Influenced by liver and renal disease.
Hemoglobin	Iron status	Falsely low with phlebotomy, anemia of chronic disease.
Transferrin	Reflects protein depletion	Influenced by liver disease and inflammation.
Serum Retinol-Binding Protein	Vitamin A status. Often low with malnutrition	Falsely low during periods of inflammation. Influenced by liver and renal disease.
Urinary Nitrogen Excretion	Protein metabolism, specifically daily protein losses	Affected by diuretics, renal function, protein intake.

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When should we initiate nutrition? Early or late?

Feed children in PICU enterally as soon as possible unless it is contraindicated (necrotising enterocolitis, bowel obstruction or significant gastro-intestinal haemorrhage.) Feed using 3-4 hourly boluses initially depending on the child's age as this is more physiological than continuous feeds.

early initiation of EN, within the first 24–48 h after admission to the PICU, in eligible patients

Expert consensus based upon observational cohort studies has suggested that the delivery of at least two thirds of the prescribed energy requirement by the end of the first week in PICU is a pragmatic target to achieve

Enteral Nutrition

EN is recommended as the preferred mode of nutrient delivery to the critically ill child. Observational studies support the feasibility of EN, which can be safely delivered to critically ill children with medical and surgical diagnoses and to those receiving vasoactive medications.

stepwise algorithmic approach to advance EN in children admitted to the PICU

the gastric route be the preferred site for EN in patients in the PICU. The postpyloric or small intestinal site for EN may be used in patients unable to tolerate gastric feeding or those at high

risk for aspiration.

Existing data are insufficient to make recommendations regarding the use of continuous vs intermittent gastric feeding.

PICU ENTERAL FEEDING GUIDELINES

- **Evaluate for risk of aspiration** (depressed cough/gag, altered mental status, delayed gastric emptying, significant reflux or vomiting, severe bronchospasm, prone positioning, unable to elevate HOB >30 degrees):
  +aspiration risk→ transpyloric (nasoduodenal or nasojejunal) feeding tube
  -aspiration risk→ nasogastric feeding tube or via G.T.T. (in place prior to admission)
- **Place nasogastric tube**, preferably at time of intubation, or transpyloric tube, then confirm placement
- **Elevate HOB >30 degrees** unless contraindicated
- **Obtain Nutrition Consult** for all patients starting enteral feeds; coordinate with dietitian to identify goal feeding volume, nutritional status/ risk of malnutrition, caloric needs

Clinical Nutrition

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Narrative Review

Intermittent fasting in paediatric critical illness: The properties and potential beneficial effects of an overnight fast in the PICU

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Of the different intermittent fasting strategies investigated, time-restricted feeding with a daily extended fasting period appears most feasible in the PICU. Moreover, planning the fasting period overnight could help maintain the circadian rhythm. Although not investigated, such an overnight intermittent fasting strategy might improve the metabolic profile, feeding tolerance and perhaps even have beneficial effects on tissue repair, reperfusion injury, muscle weakness, and the immune response

three predominant phases of illness in critically ill children admitted to PIC

These different phases require different macronutrient intakes

Acute phase (first phase after event, characterised by a need for escalating vital organ support)

Stable phase (stabilisation or weaning of vital organ support, where different aspects of the stress response are not completely resolved).

Recovery phase (clinical mobilisation with resumption of homeostasis).

How much nutrition should we provide?

indirect calorimetry

Schofield equation or Food Agriculture Organization / World Health Organization / United Nations University equations

Indirect Calorimetry

IC remains the gold standard when striving to accurately determine a patient's energy expenditure.10 IC should be utilized to measure **resting energy expenditure** (REE) in the PICU and inform energy goals of the nutrition regimen. IC is a non-invasive procedure that can be performed on ventilated and non-ventilated PICU patients. Results provide valuable data to guide nutrition prescriptions throughout a patient's illness and recovery process. The energy expenditure of a critically ill child does not remain constant; changes from hypometabolism to hypermetabolism may occur throughout a critical illness depending on the course of the individual patient. The calorimeter can capture the REE at that moment by measuring **oxygen consumed** (VO2) with **carbon dioxide exhaled** (VCO2); results are entered into the Weir equation in order to determine the resting energy equation.

Targeted Indirect Calorimetry

Children who are high risk for metabolic alterations are suggested candidates for targeted measurement of resting energy expenditure (MREE) in PICU.

Underweight, overweight or obese

Children with >10% weight change during ICU stay

Failure to consistently meet prescribed energy goals

Failure to wean or need to escalate respiratory support

Neurologic trauma (traumatic, hypoxic and or ischaemic)

Oncologic diagnoses (stem cell transplantation)

Children with thermal injuries or amputations

Children requiring mechanical ventilation for >3days

Children suspected to be severely hypermetabolic (status epilepticus, hyperthermia, SIRS, autonomic storms, etc) or hypometabolic (hypothermia, hypothyroidism, phenobarbitone or midazolam coma, etc).

Table 1. Schofield equation (12) – Used to calculate resting energy expenditure (REE) in kcal/day.

Age	Boys	Girls
0-3 years	59.5 x (weight in kg) - 30	58.3 x (weight in kg) - 31
3-10 years	22.7 x (weight in kg) + 504	20.3 x (weight in kg) + 486
10-18 years	17.7 x (weight in kg) + 658	13.4 x (weight in kg) + 692

Table 2. Suggested energy and macronutrient intake during different phases of critical illness (11).

	Acute phase	Stable phase	Recovery phase
Enteral Nutrition (preferred)			
Energy	Start as soon as possible to match REE and gradually increase if tolerated		2x REE and higher if necessary to enable growth
Protein (g/kg/day)	1 – 2	2 – 3	3 – 4
Parenteral nutrition			
Energy	<REE	1.3-1.5x REE	2x REE
Carbohydrates (mg/kg/min) Newborn 28d – 10kg 11 – 30kg 31 – 45kg >45kg	 2.5 – 5 2 – 4 1.5 – 2.5 1 – 1.5 0.5 – 1	 5 – 10 4 – 6 2 – 4 1.5 – 3 1 – 2	 5 – 10 6 – 10 3 – 6 3 – 4 2 – 3
Protein (g/kg/day)	0	1 – 2	2 – 3
Lipid (g/kg/day)	0	1 – 1.5	1.5 – 3

Increasing energy and protein delivery in infants

Rather than concentrating specific powdered feeds we advise changing the type of feed to provide adequate energy and protein delivery. Due to fluid restriction in PIC energy and protein delivery via enteral feeds may need to be optimised to meet their assessed energy targets, particularly in infants post cardiac bypass surgery. For example, in an infant being fed via nasogastric tube with expressed breast milk (EBM) we may introduce a combination of 25% feed volume of a high calorie (1.0kcal/ml) formula (e.g. Infatrini Peptisorb) and 75% EBM. This proportion can continue to be altered as the patient's nutritional status is monitored closely during their PICU and hospital stay. The decision to incorporate a high calorie formula must first be discussed with the child's parents to gain consensus.

What is the minimum recommended protein requirement for critically ill children?

a minimum protein intake of 1.5g/kg/day as evidence has demonstrated at least this intake is required to prevent cumulative negative protein balance, loss of lean muscle mass and may be associated a lower mortality in mechanically ventilated children

The optimal protein intake threshold for infants and young children is likely to be higher than this value. For example, infants and young children admitted with bronchiolitis or other causes of respiratory failure requiring mechanical ventilation, require 2.5-3g/kg/day protein to improve protein balance

do not recommend the use of RDA values to guide protein prescription in critically ill children. These values were developed for healthy children and often underestimate the protein needs during critical illness.

RDA, recommended daily allowance

What is the target energy intake in critically ill children?

On the basis of observational cohort studies, we suggest achieving delivery of at least two-thirds of the prescribed daily energy requirement by the end of the first week in the PICU. Cumulative energy deficits during the first week of critical illness may be associated with poor clinical and nutrition outcomes. On the basis of expert consensus, we suggest attentiveness to individualized energy requirements, timely initiation and attainment of energy targets, and energy balance to prevent unintended cumulative caloric deficit or excesses.

Quality of evidence: low

GRADE recommendation: weak

If NG bolus feeds are poorly tolerated

First assess whether this is just milky nasogastric aspirates without other concerns such as vomiting, diarrhoea and/or a distended, tender abdomen. There is no strong evidence to support the measurement of gastric residual volumes (19). Holding feeds in this situation to prevent aspiration is unproven and may even prevent the achievement of caloric and protein targets. A planned UK randomised trial will provide some evidence on which to base these current recommendations.

If there are persistent high aspirates, bilious aspirates, vomiting, or clinical concerns initiate the following:

1. Consider reducing feed volumes to 2 hourly or continuous feeds.

2. Stop muscle relaxation and reduce opioids if able.

3. Make sure the patient is prescribed regular laxative therapy if it is safe to do so according to the guideline 'Constipation and bowel management in the critically ill child'.

4. Consider insertion of a nasojejunal tube for continuous post-pyloric feeding, see guideline 'Nasojejunal tube insertion on Seahorse PICU'.

5. Existing data is insufficient to make universal recommendations regarding the optimal site to deliver enteral nutrition (EN) to critically ill children (20). Postpyloric EN may be used in patients unable to tolerate gastric feeding or those at high risk for aspiration.

6. Consider prokinetic therapy erythromycin 3mg/kg IV QDS. However, the evidence for prokinetics is not proven in a randomised trial. Make sure a baseline ECG with documentation of a normal correct QT interval given the risk of QT prolongation. Always check interactions in the latest British National Formulary for Children.

TABLE 10.4 Complications of Enteral Feeding

Complication	Possible Causes	Treatment/Prevention
Gastrointestinal		
Abdominal distention, bloating, gas	Rapid formula infusion Constipation Lactose intolerance Malabsorption Bacterial overgrowth Aerophagia (swallowing air) Air in tubing Gastrointestinal obstruction	Reduce or regulate infusion rate Treat constipation Use low lactose or lactose-free formula Use lower fat formula or formula with MCT oil Treat bacterial overgrowth Use a Farrell bag or manually vent the stomach Prime tubing with formula Stop enteral feeds and address obstruction
Aspiration, aspiration pneumonia	Dysphagia Gastrointestinal reflux Emesis Delayed gastric emptying Tube displaced or migrates out of position	Speech therapy feeding evaluation and/or modified barium swallow to evaluate safety of oral feedings Treat reflux Elevate head of bed by at least 30 degrees Address cause of emesis Transition from gastric to post-pyloric feeding tube Confirm correct tube placement before use
Constipation	Inadequate fluid provision Inadequate fiber provision Electrolyte abnormalities Medication side-effect Physical inactivity Obstruction	Increase fluid provision Increase fiber provision Treat electrolyte abnormalities Modify or decrease medication causing constipation, if able Increase activity or physical/occupational therapy Rule out ileus Use laxative, stool softener, enema, and/or manual disimpaction

(*continues*)

TABLE 10.4 Complications of Enteral Feeding *(continued)*

Complication	Possible Causes	Treatment/Prevention
Gastrointestinal		
Diarrhea	High osmotic load from formula/medications Rapid infusion rate Inadequate or excessive fiber provision Malabsorption Food allergies or intolerances Infection Bacterial contamination of formula Medication side effect Aggressive bowel regimen	Consider changing formula to an isotonic formula Reduce infusion rate Increase or decrease fiber provision Consider changing to a MCT-containing, semi-elemental, or elemental formula Change formula to avoid allergen or offending substance Test for and treat infection, if present Ensure proper storage, handling, and administration of feeds Change feeding bag daily Limit prepared formula to a maximum of 4 hours Use undiluted ready-to-feed products to reduce risk Note medications which may cause diarrhea, avoid or reduce, if able Reduce frequency or dosage of laxatives and stool softeners Consider anti-diarrheal if appropriate and troubleshooting is ineffective
Nausea and vomiting	Formula intolerance Too rapid advancement of volume Too high of a concentration Gastroesophageal reflux Delayed gastric emptying Post-operative nausea and vomiting Incorrect tube position Gastrointestinal obstruction	Consider changing formula to an isotonic or semi-elemental product Advance volume more gradually Consider continuous infusion if using bolus or cycled feeds Reduce concentration of formula Elevate head of bed by at least 30 degrees Transition from gastric to post-pyloric feeding tube Use anti-emetics, hold feeds temporarily Replace or reposition feeding tube and confirm placement Hold feeds if obstruction is suspected or confirmed

Overhydration	Excessive fluid intake Fluid retention/inadequate urine output Medical status	Evaluate fluid intake from all sources including formula, food and beverage, intravenous fluids, and medications Reduce fluid provision Determine medical plan to diurese excess fluid, if needed Reevaluate fluid plan and increase, when appropriate, to avoid developing dehydration
Electrolyte imbalance	Inadequate or excessive electrolyte intake Fluid or formula composition Medical condition or diagnosis Increased electrolyte losses or inadequate electrolyte output Electrolyte supplementation Medication side effect	Evaluate electrolyte intake from all sources including formula, food and beverage, intravenous fluids, and supplements Note medications which may impact electrolytes Supplement for low electrolyte levels Select a modified nutrition plan when reduced electrolyte provision is needed to prevent excess provision
Weight loss or inadequate weight gain	Inadequate calorie intake Decrease in supplemental oral intake Estimated needs are less than actual needs Energy needs have increased due to increased activity or change in health Inadequate provision of EN Intolerance of EN Inability to afford formula	Evaluate adequacy of calorie intake and increase calorie provision, if appropriate Obtain indirect calorimetry, if possible Establish plan for regular nutrition assessment in inpatient, outpatient, and home care settings Verify home feeding plan and adequate support Identify cause of intolerance and alternate plan Help patient identify resources for financial support
Excessive weight gain	Excessive calorie intake Supplemental oral intake has improved Estimated needs are less than actual intake Energy needs have increased due to decrease in activity or change in health Excessive provision of EN	Evaluate calorie intake and decrease calorie provision, if appropriate Obtain indirect calorimetry, if possible Establish plan for regular nutrition assessment in inpatient, outpatient, and home care settings Re-educate patient and family/caregivers on appropriate nutrition plan if overfeeding is a concern

(*continues*)

Parenteral nutrition (PN):

On the basis of a single, large randomised trial starting PN within 24 hours of PICU admission is not recommended because of the risk of infection. For children tolerating EN, we suggest that supplemental PN commencement be delayed for at least a week after admission for patients with normal baseline nutritional status and low risk of nutritional decline. However, we suggest you exert caution in holding PN for a week in those patients receiving no EN.

For example, vulnerable groups – malnourished child who may not tolerate a week of cumulative nutritional deficit by a late PN approach and those admitted with contraindications to EN, intestinal failure or those requiring ECMO often rely on PN to meet nutrient needs.

We therefore recommend the initiation of PN if EN is not possible for:

>3 days in a neonate

>4 days in a malnourished patient

>6 days in a nourished patient

What is the role of PN as a supplement to inadequate EN?

the role of supplemental PN to reach a specific goal for energy delivery is not known.

The time when PN should be initiated to supplement insufficient EN is also unknown.

The threshold for and timing of PN initiation should be individualized. Based on a single RCT, supplemental PN should be delayed until 1 wk after PICU admission for patients with normal baseline nutrition state and low risk of nutrition deterioration.

On the basis of expert consensus, we suggest PN supplementation for children who are unable to receive any EN during the first week in the PICU.

For patients who are severely malnourished or at risk of nutrition deterioration, PN may be supplemented in the first week if they are unable to advance past low volumes of EN.

Refeeding syndrome

At risk after >7 days of fasting, malnourished, recent weight loss (>10% body weight over last 2 months), baseline low potassium, phosphate, magnesium. Manifests as low phosphate, potassium, magnesium, and thiamine deficiency. Observe for confusion, weakness, resting tachycardia and arrhythmias. Monitor electrolytes 12 hourly initially and replace as required. Give thiamine and reduce energy intake if phosphate is <0.6mmol/L. Slowly grade up nutrition over 3 days and slower if signs of refeeding occur.

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Thanks for your attention