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Nutritional management of the critically ill child

Nutritional management in the critically ill child and the barriers contributing to inadequate nutrition.

Zara Kerr – Advanced Dietetic Practitioner
PICU
Royal Belfast Hospital for Sick Children, Belfast
October 2025

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Objectives:

- To obtain an overview of the metabolic response during critical illness
- To discuss the nutritional recommendations and considerations for critically ill children
- To be familiar with the barriers to advancing nutrition in the intensive care setting

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KEY PRACTICE RESOURCES

Fundamental resources to support nutrition management in the PICU include -

- 2017 Society of Critical Care Medicine (SCCM)/American Society for Parenteral and Enteral Nutrition (ASPEN) guidelines
- European Society for Pediatric and Neonatal Intensive Care (ESPNIC) 2020 clinical recommendations

Guidelines

ESPNIC 2020
(European Society of Paediatric and Neonatology Intensive care)
ASPEN 2017
(American Society for Parenteral and Enteral Nutrition)

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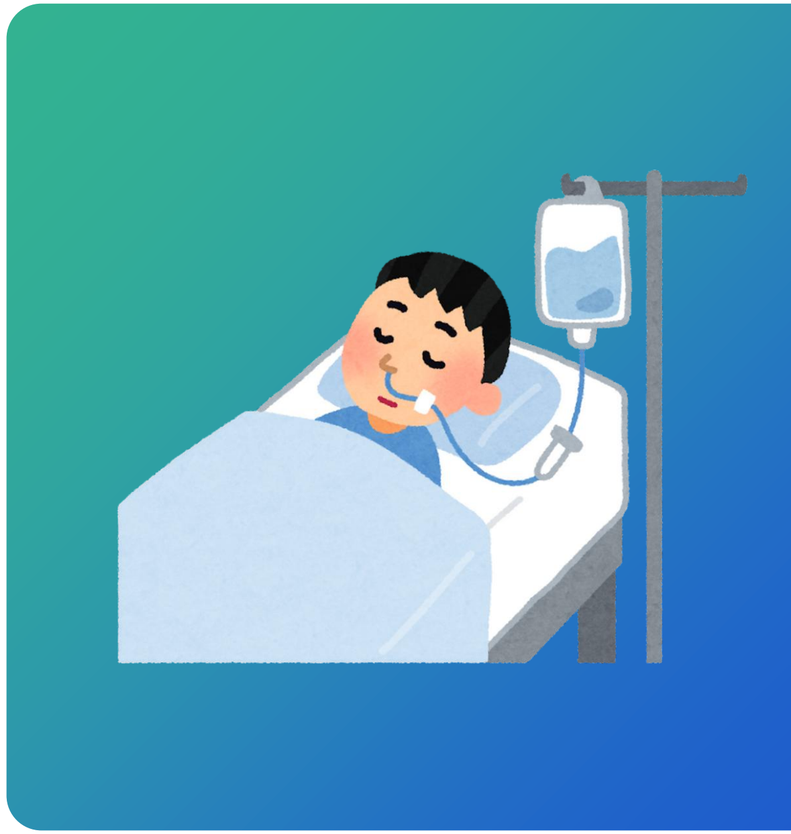
Background:

Nutritional support is considered essential for the outcome of paediatric critical illness.

It involves providing adequate calories, protein and nutrients through oral, enteral, or parenteral routes, tailored to the child's individual needs and the phase of illness.



Hulst J, Joosten K, Zimmermann L, Hop W, van Buuren S, Büller H, Tibboel D, van Goudoever J. Malnutrition in critically ill children: from admission to 6 months after discharge. Clin Nutr. 2004;23:223–232. doi: 10.1016/S0261-5614(03)00130-4.

Joosten, K.F.M.; Kerklaan, D.; Verbruggen, S.C.A.T. Nutritional Support and the Role of the Stress Response in Critically Ill Children. Curr. Opin. Clin. Nutr. Metab. Care 2016, 19, 226–233.

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Metabolism in critical illness

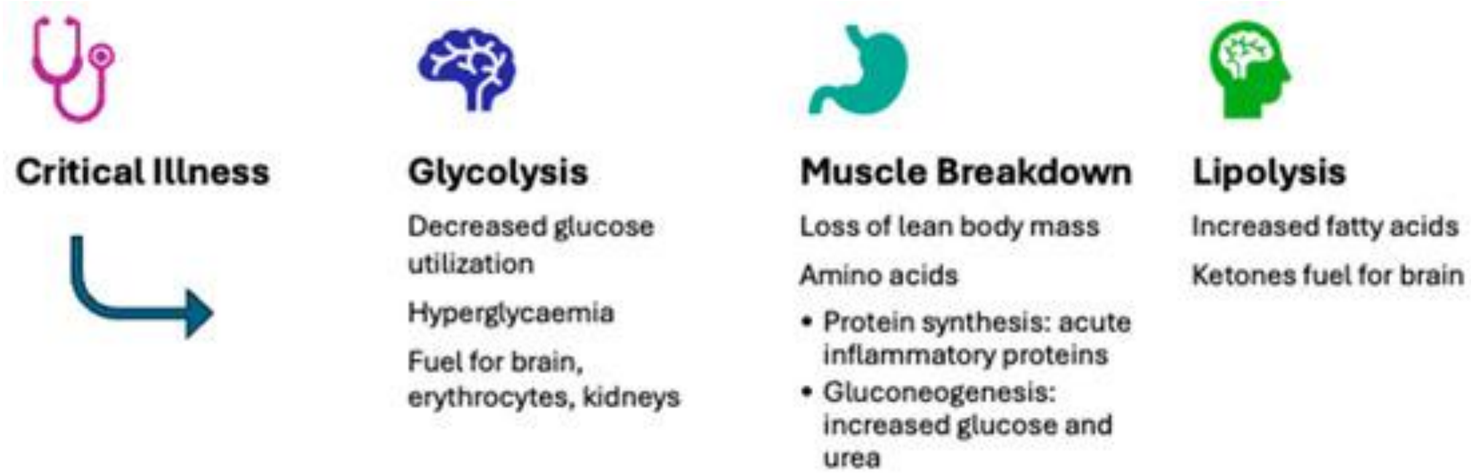

Figure 1. Typical metabolic adaptations during the acute phase of severe illness

Briassoulis, G., Ilia, S., & Briassouli, E. (2024). Personalized Nutrition in the Pediatric ICU: Steering the Shift from Acute Stress to Metabolic Recovery and Rehabilitation. *Nutrients*, *16*(20), 3523. https://doi.org/10.3390/nu16203523

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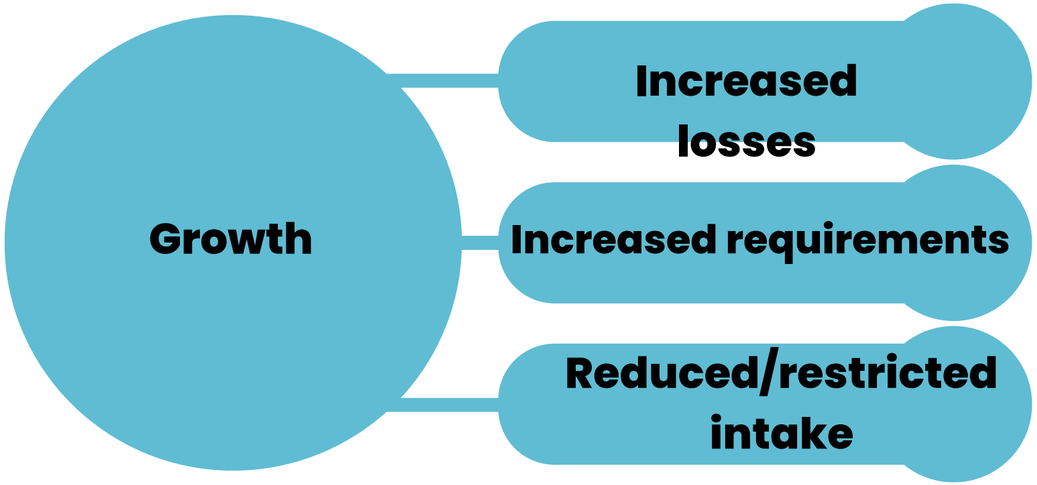
Growth may be effected by the following during PICU stay:

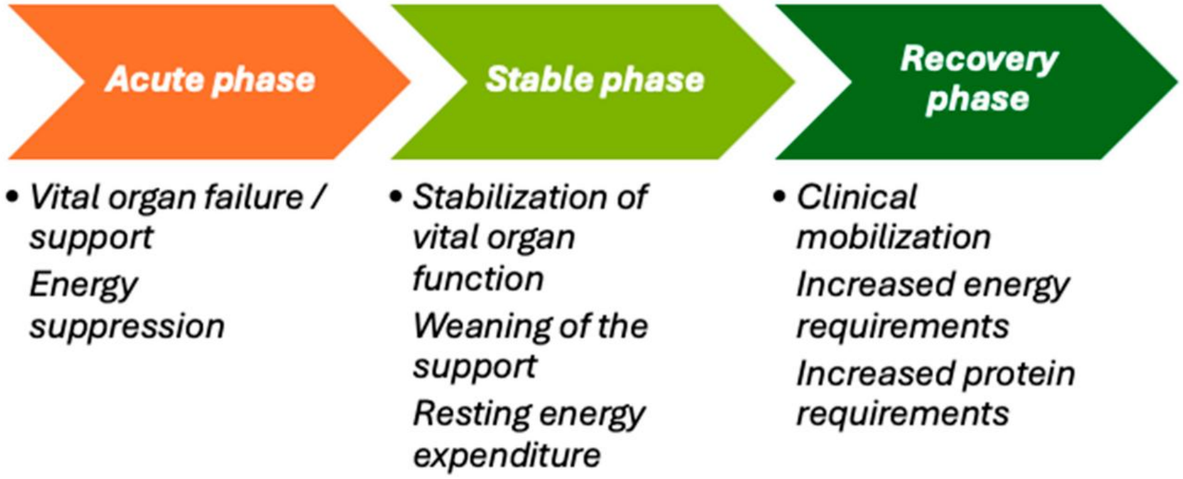


Phases of critical illness:

Acute
In the acute phase, energy intake provided to critically ill children should not exceed REE.

Stable
Stress response not resolved, increased energy expenditure with reduced sedation and early mobilisation.

Recovery and rehabilitation
Mobilisation and normilisation of metabolic function leads to additional energy, protein and micronutrient requirements to repair and replete body stores.



Energy Requirements

- Energy requirements are reduced in the critically ill patient due to the effects of paralytic agents, mode of ventilation and illness.
- Underfeeding and overfeeding of critically ill patients has been associated with adverse effects leading to significant morbidity and mortality.
- Overfeeding is associated with hyperglycaemia, increased CO2 production, prolonged mechanical ventilation and immune dysfunction.
- *If indirect calorimetry (gold standard) is not feasible then the schofield equation should be used with the addition of stress factors to calculate basal metabolic rate (BMR).*
- At least ⅔ of calculated resting energy expenditure should be achieved by the end of the first week of admission. Cumulative energy deficits during the first week are associated with morbidity and mortality.

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Table 1. Predictive equations for calculating BMR

Age (Years)	Female	Male	Worked example
<3	(58.317 x weight kg) – 31.1	(59.512 x weight kg) – 30.4	4kg female infant = 202kcals/day = 50kcals/kg
3-10	(22.706 x weight kg) + 485.9	(22.7 x weight kg) + 504.3	5 year old male 18kg = 913kcals/day = 51kcals/kg
10-18	(17.686 x weight kg) + 692.6	(17.5 x weight kg) + 651	14 year old female 53kg = 1230kcals/day = 30kcals/kg

Reference: Dr Graeme O'Connor, Practical Solutions to dietetic challenges on a paediatric intensive care unit (PICU).

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Protein requirements

A minimum protein intake of 1.5g/kg/day should be achieved. A protein intake higher than this threshold has been shown to prevent cumulative negative protein balance and provide positive clinical outcomes.

The protein reference nutrient intake (RNI) is not recommended in critical care as it underestimates protein need.

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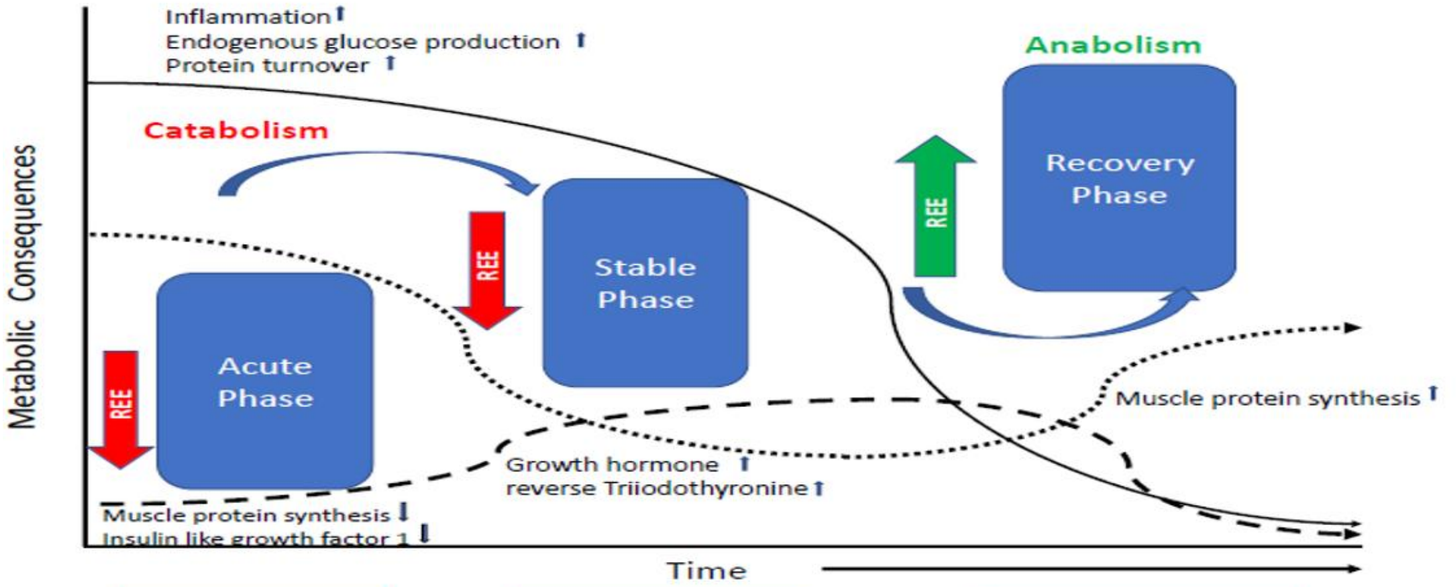
Phases of critical illness:

PHASES OF CRITICAL ILLNESS



<REE Protein 1–2 g/kg	REE x 1.3 – 1.5 Protein 1–2 g/kg	REE x 2 Protein 3–4 g/kg
Escalating organ support	**Stable or weaning** organ support	**Usually** occurs post-discharge from PICU

REE- Resting Energy Expenditure

Joosten KF, et al. *Curr Opin Clin Nutr Metab Care*. 2016;19(3):226-233.
Meyer R, Marino LV. Chapter 6: Nutrition in critically ill children. In: *Clinical Paediatric Dietetics*. 5th ed. John Wiley & Sons Ltd; 2020:80-96.

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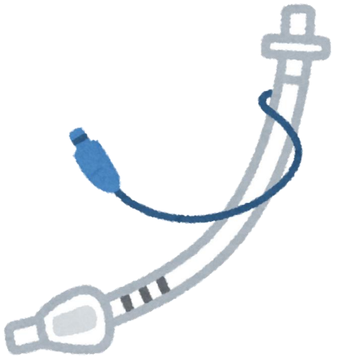

Enteral Nutrition

Enteral nutrition (EN) is the preferred method for feeding critically ill children.

EN helps preserve the integrity of the intestinal mucosa, preventing the translocation of toxins and microbes into the bloodstream—a key factor in reducing the risk of multiple organ failure Compared to parenteral nutrition, EN is also more cost-effective and associated with a lower risk of infection.

Solana, M.J.; Manrique, G.; Fernández, R.; Slocker, M.; García, M.; Redondo, S.; Yun, C.; Gil, R.; Balaguer, M.; Rodríguez, E.; et al. Nutritional Status and Nutrition Support in Critically Ill Children in Spain: Results of a Multicentric Study. Nutrition 2021, 84, 110993.

Solana, M.J.; Manrique, G.; Slocker, M.; Fernández, R.; Gil, R.; Yun, C.; García, M.; Redondo, S.; Balaguer, M.; Rodríguez, E.; et al. Early vs Late Enteral Nutrition in Pediatric Intensive Care Unit: Barriers, Benefits, and Complications. Nutr. Clin. Pract. 2023, 38, 442–448.

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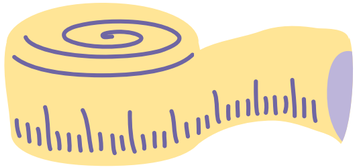
Anthropometric Measurements

- Weight - admission and at least weekly
- Length - on admission and alternate weeks
- Head circumference in children <2 years

Surrogate Measurements

- MUAC - This is a useful measurement in children under 5 years, as MUAC increases fairly rapidly up until this age
- Ulna length for height



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Micronutrient considerations

What we know:

- There are no evidence based micronutrient requirements during paediatric critical illness.

- Serum levels of micronutrients (vitamins and trace elements) may be affected by critical illness and inflammation.

- There is no evidence that supplementation of micronutrients improves clinical outcomes.

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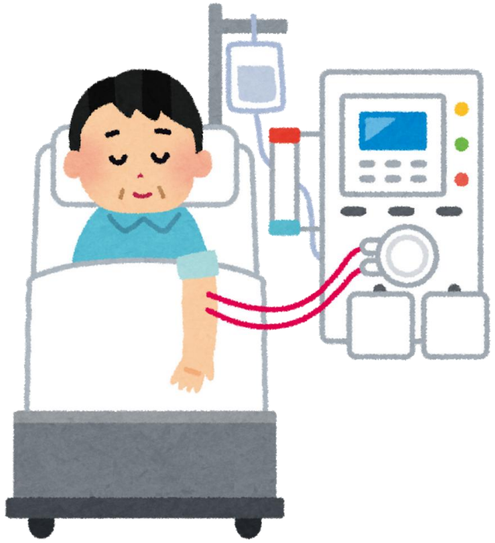
Therapeutic factors impacting on micronutrient uptake:

- Continuous renal replacement therapy (CRRT)
- Duodenal/jejunal feeding
- Parenteral nutrition
- Frequent blood letting
- Medications (PPI, steroids, diuretics)



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Gastric residual volume:

A practice associated with enteral feeding that is relatively common is the monitoring of gastric residual volumes (GRVs) as a measure of feed tolerance. A comparison study has demonstrated that not undertaking routine monitoring is not associated with increased vomits, aspiration pneumonia events or necrotising enterocolitis.

This practice is currently being explored via the GASTRIC-PICU trial, which is seeking to determine non-inferiority of no routine GRV monitoring compared to at least 6 hourly GRV monitoring in terms of health and economic outcomes.

Tume L. No routine measurement of gastric residual volume in paediatric critical care. 2024. Available at: https://www.isrctn.com/ISRCTN79668198. Accessed May 28, 2024.

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Parentral Nutrition

Nutritional support is an important part of the treatment of critical ill children and the phase of disease has to be taken into account.

The Pediatric 'Early versus Late Parenteral Nutrition' (PEPaNIC) trial showed that withholding supplemental parenteral nutrition (PN) during the first week in critically ill children, when enteral nutrition was not sufficient, prevented infections and shortened the stay in the pediatric intensive care unit (PICU) and the hospital.

Joosten K, Verbruggen S. PN Administration in Critically Ill Children in Different Phases of the Stress Response. Nutrients. 2022 Apr 27;14(9):1819. doi: 10.3390/nu14091819. PMID: 35565787; PMCID: PMC9104104.

Early versus Late Parenteral Nutrition in Critically Ill Children – PEPaNIC Trial, 2016

- This was a multicenter, randomized, controlled trial involving 1440 critically ill children to investigate whether withholding parenteral nutrition for 1 week in the pediatric intensive care unit was clinically superior to providing early parenteral nutrition.

- For the 723 patients receiving early parenteral nutrition, parenteral nutrition was initiated within 24 hours after ICU admission, whereas for the 717 patients receiving late parenteral nutrition, parenteral nutrition was not provided until the morning of the 8th day in the ICU.

Conclusion

- In critically ill children, withholding parenteral nutrition for 1 week in the ICU was clinically superior to providing early parenteral nutrition.

Fivez, Tom & Kerklaan, Dorian & Mesotten, Dieter & Verbruggen, Sascha & Wouters, Pieter & Vanhorebeek, Ilse & Debaveye, Yves & Vlasselaers, Dirk & Desmet, Lars & Casaer, Michael & Garcia Guerra, Gonzalo & Hanot, Jan & Joffe, Ari & Tibboel, Dick & Joosten, Koen & Berghe, Greet. (2016). Early versus Late Parenteral Nutrition in Critically Ill Children. The New England journal of medicine. 374. 10.1056/NEJMoa1514762.

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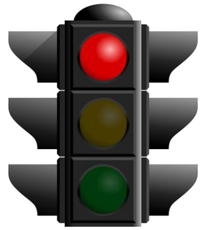
Barriers to nutrition -

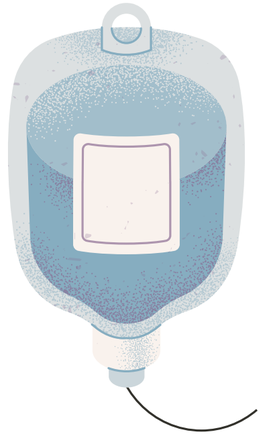


Fluid balance in critically ill children

- Fluid balance is imperative in maintaining homeostasis, particularly electrolytes and blood pressure.
- Aggressive fluid administration can lead to fluid overload, a condition where there is a positive fluid balance in the patient.
- A positive fluid balance in critically ill ventilated patients exerts hazard for major morbidity and mortality.

Complications associated with fluid overload (hypervolemia):

- Pulmonary oedema and subsequent oxygenation failure
- Prolonged mechanical ventilation
- Electrolyte imbalance



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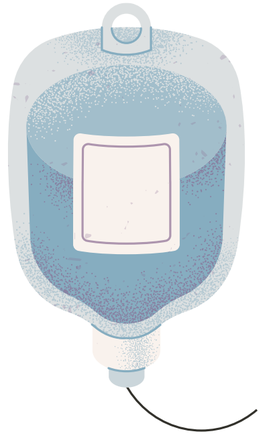
Fluid calculations used in PICU:

The fluid allowance on PICU is expressed as a percentage and is calculated cumulatively as below:

4ml/kg/hr for first 10kg in weight
2ml/kg/hr for the second 10kg in weight
1ml/kg/hr for every kg above 20kg



Example: Infant weighing 5kg with 100% fluid allowance
= 4ml x 5kg x 24 hours
= 480mls
= 96mls/kg/day = 100% fluid allowance

*As opposed to 150mls/kg

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Antibiotic Related Diarrhoea

The first line treatment for the management of sepsis is aggressive intravenous antiobiotic administration.

Antibiotics work by killing all bacteria and cannot distinguish between healthy and “bad” bacteria.

The gut flora is a complex community of bacteria, which if unbalanced can trigger loose stools and diahorrea.

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Antibiotic Related Diarrhoea - nutritional management

Fibre based formulas which contain fructo-oligosaccharides have been shown to decrease diarrhoea by increasing the concentration of faecal bifibacteria in patients with antibiotic related diaorrhoea.

Providing fibre can seem counterintuitive but fructo-oligosaccharides is a soluble fibre therefore will not exacerbate diarrhoea.

if diarrhoea persists, rule out microorganism involvement and consider ORS for 24 hours - introduce a fibre containing whole protein feeds mixed with ORS (50:50).

Ensure to monitor Na levels when on ORS.

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Role of the multidisciplinary team within PICU

All members of the PICU multidisciplinary team can influence a child's nutrition by optimizing opportunities for adequate provision and minimizing instances where delivery is reduced or delayed.

Research is increasingly demonstrating the benefits of such collaborative nutrition care in the critical care setting.

Multidisciplinary nutrition management models have been shown to improve nutritional indices and reduce intensive care unit (ICU) length-of-stay when compared to a traditional management model, and improve nutrition provision in PICU.

Jacinta Winderlich, Georgia Brown, Andrew A. Udy, Emma J. Ridley, Critical Care Nutrition for Children – Where are we now?, Critical Care Clinics,
Volume 41, Issue 2, 2025

Specialist Groups

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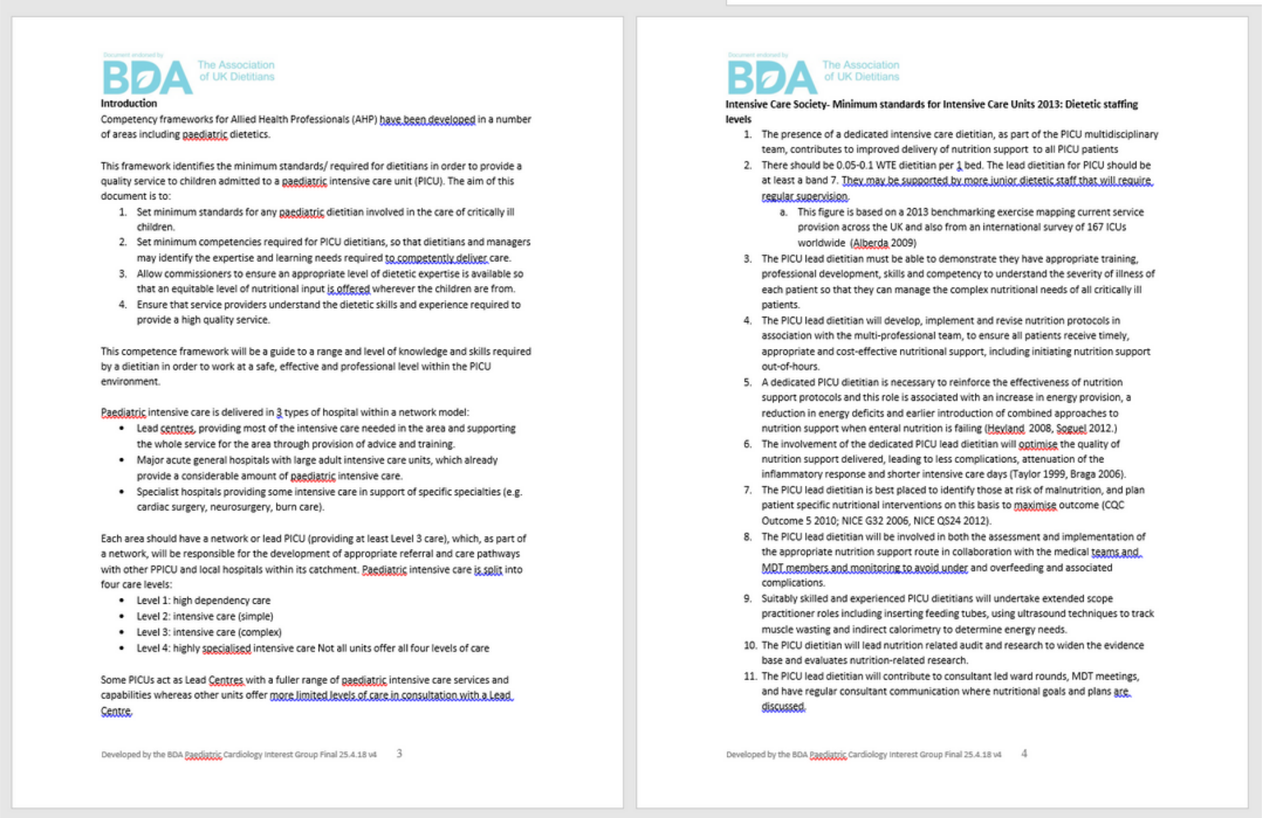
PCCS – Paediatric Critical Care Society sub group

Current work:

- Review of PICU competencies
- Review of cardiac competencies
- Obesity working group



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Introduction

Competency frameworks for Allied Health Professionals (AHP) have been developed in a number of areas including paediatric dietetics.

This framework identifies the minimum standards/ required for dietitians in order to provide a quality service to children admitted to a paediatric intensive care unit (PICU). The aim of this document is to:

1. Set minimum standards for any paediatric dietitian involved in the care of critically ill children.
2. Set minimum competencies required for PICU dietitians, so that dietitians and managers may identify the expertise and learning needs required to competently deliver care.
3. Allow commissioners to ensure an appropriate level of dietetic expertise is available so that an equitable level of nutritional input is offered wherever the children are from.
4. Ensure that service providers understand the dietetic skills and experience required to provide a high quality service.

This competence framework will be a guide to a range and level of knowledge and skills required by a dietitian in order to work at a safe, effective and professional level within the PICU environment.

Paediatric intensive care is delivered in 3 types of hospital within a network model:

- Lead centres, providing most of the intensive care needed in the area and supporting the whole service for the area through provision of advice and training.
- Major acute general hospitals with large adult intensive care units, which already provide a considerable amount of paediatric intensive care.
- Specialist hospitals providing some intensive care in support of specific specialties (e.g. cardiac surgery, neurosurgery, burn care).

Each area should have a network or lead PICU (providing at least Level 3 care), which, as part of a network, will be responsible for the development of appropriate referral and care pathways with other PPICU and local hospitals within its catchment. Paediatric intensive care is split into four care levels:

- Level 1: high dependency care
- Level 2: intensive care (simple)
- Level 3: intensive care (complex)
- Level 4: highly specialised intensive care Not all units offer all four levels of care

Some PICUs act as Lead Centres with a fuller range of paediatric intensive care services and capabilities whereas other units offer more limited levels of care in consultation with a Lead Centre.

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Intensive Care Society- Minimum standards for Intensive Care Units 2013: Dietetic staffing levels

1. The presence of a dedicated intensive care dietitian, as part of the PICU multidisciplinary team, contributes to improved delivery of nutrition support to all PICU patients
2. There should be 0.05-0.1 WTE dietitian per 1 bed. The lead dietitian for PICU should be at least a band 7. They may be supported by more junior dietetic staff that will require regular supervision.
    a. This figure is based on a 2013 benchmarking exercise mapping current service provision across the UK and also from an international survey of 167 ICUs worldwide (Alberda 2009)
3. The PICU lead dietitian must be able to demonstrate they have appropriate training, professional development, skills and competency to understand the severity of illness of each patient so that they can manage the complex nutritional needs of all critically ill patients.
4. The PICU lead dietitian will develop, implement and revise nutrition protocols in association with the multi-professional team, to ensure all patients receive timely, appropriate and cost-effective nutritional support, including initiating nutrition support out-of-hours.
5. A dedicated PICU dietitian is necessary to reinforce the effectiveness of nutrition support protocols and this role is associated with an increase in energy provision, a reduction in energy deficits and earlier introduction of combined approaches to nutrition support when enteral nutrition is failing (Heyland 2008, Soguel 2012.)
6. The involvement of the dedicated PICU lead dietitian will optimise the quality of nutrition support delivered, leading to less complications, attenuation of the inflammatory response and shorter intensive care days (Taylor 1999, Braga 2006).
7. The PICU lead dietitian is best placed to identify those at risk of malnutrition, and plan patient specific nutritional interventions on this basis to maximise outcome (CQC Outcome 5 2010; NICE G32 2006, NICE QS24 2012).
8. The PICU lead dietitian will be involved in both the assessment and implementation of the appropriate nutrition support route in collaboration with the medical teams and MDT members and monitoring to avoid under and overfeeding and associated complications.
9. Suitably skilled and experienced PICU dietitians will undertake extended scope practitioner roles including inserting feeding tubes, using ultrasound techniques to track muscle wasting and indirect calorimetry to determine energy needs.
10. The PICU dietitian will lead nutrition related audit and research to widen the evidence base and evaluates nutrition-related research.
11. The PICU lead dietitian will contribute to consultant led ward rounds, MDT meetings, and have regular consultant communication where nutritional goals and plans are discussed.

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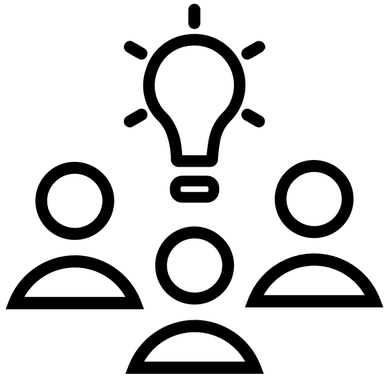
Summary of recommendations for nutritional support for children during critical illness:

- It is recommended to perform anthropometric measurements on admission and regularly during admission, and to express these measurements in z-scores, including weight, height/length mid upper arm circumference and head circumference in young children.
- It is recommended to commence early enteral nutrition within 24 h of admission unless contraindicated.
- In the acute phase, energy intake provided to critically ill children should not exceed resting energy expenditure.
- Routine measurement of GRV in critically ill children is not recommended.
- It can be considered appropriate to delay starting PN for up to 7 days in some patients.

Conclusion

There are numerous barriers to meeting energy, protein and micronutrient requirements in the critically ill child.

Dietetic interventions must navigate these obstacles by working cohesively with the multidisciplinary team to minimise malnutrition and ultimately improve patient outcomes.



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References

1. Lee P, Eisman JA, Center JR. Vitamin D deficiency in critically ill patients. N Engl J Med. 2009;360(18):1912–4.
2. Braun AB, Gibbons FK, Litonjua AA, Giovannucci E, Christopher KB. Low serum 25-hydroxyvitamin D at critical care initiation is associated with increased mortality*. Crit Care Med. 2012;40(1):63–72.
3. Braun A, Chang D, Mahadevappa K, Gibbons FK, Liu Y, Giovannucci E, Christopher KB. Association of low serum 25-hydroxyvitamin D levels and mortality in the critically ill*. Crit Care Med. 2011;39(4):671–7.
4. Hulst J, Joosten K, Zimmermann L, Hop W, van Buuren S, Büller H, Tibboel D, van Goudoever J. Malnutrition in critically ill children: from admission to 6 months after discharge. Clin Nutr. 2004;23:223–232. doi: 10.1016/S0261-5614(03)00130-4.
5. Marino LV et al., Micronutrient status during paediatric critical illness: A scoping review, Clinical Nutrition, https://doi.org/10.1016/j.clnu.2020.04.015
6. Tume L. No routine measurement of gastric residual volume in paediatric critical care. 2024. Available at: https://www.isrctn.com/ISRCTN79668198. Accessed May 28, 2024.
7. Joosten K, Verbruggen S. PN Administration in Critically Ill Children in Different Phases of the Stress Response. Nutrients. 2022 Apr 27;14(9):1819. doi: 10.3390/nu14091819. PMID: 35565787; PMCID: PMC9104104.
8. Joosten, K.F.M.; Kerklaan, D.; Verbruggen, S.C.A.T. Nutritional Support and the Role of the Stress Response in Critically Ill Children. Curr. Opin. Clin. Nutr. Metab. Care 2016, 19, 226–233.
9. Briassoulis, G., Ilia, S., & Briassouli, E. (2024). Personalized Nutrition in the Pediatric ICU: Steering the Shift from Acute Stress to Metabolic Recovery and Rehabilitation. Nutrients, 16(20), 3523. https://doi.org/10.3390/nu16203523

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References

10. Tavladaki, T.; Spanaki, A.M.; Dimitriou, H.; Kondili, E.; Choulaki, C.; Georgopoulos, D.; Briassoulis, G. Similar Metabolic, Innate Immunity, and Adipokine Profiles in Adult and Pediatric Sepsis Versus Systemic Inflammatory Response Syndrome-A Pilot Study. *Pediatr. Crit. Care Med.* 2017, *18*, e494–e505.
11. Spanaki, A.M.; Tavladaki, T.; Dimitriou, H.; Kozlov, A.V.; Duvigneau, J.C.; Meleti, E.; Weidinger, A.; Papakonstantinou, E.; Briassoulis, G. Longitudinal Profiles of Metabolism and Bioenergetics Associated with Innate Immune Hormonal Inflammatory Responses and Amino-Acid Kinetics in Severe Sepsis and Systemic Inflammatory Response Syndrome in Children. *JPEN J. Parenter. Enteral Nutr.* 2018, *42*, 1061–1074.
12. Fivez, T.; Kerklaan, D.; Mesotten, D.; Verbruggen, S.; Wouters, P.J.; Vanhorebeek, I.; Debaveye, Y.; Vlasselaers, D.; Desmet, L.; Casaer, M.P.; et al. Early versus Late Parenteral Nutrition in Critically Ill Children. N. Engl. J. Med. 2016, 374, 1111–1122.
13. Coss-Bu, J.A.; Hamilton-Reeves, J.; Patel, J.J.; Morris, C.R.; Hurt, R.T. Protein Requirements of the Critically Ill Pediatric Patient. Nutr. Clin. Pract. 2017, 32, 128S–141S.
14. Solana, M.J.; Manrique, G.; Fernández, R.; Slocker, M.; García, M.; Redondo, S.; Yun, C.; Gil, R.; Balaguer, M.; Rodríguez, E.; et al. Nutritional Status and Nutrition Support in Critically Ill Children in Spain: Results of a Multicentric Study. Nutrition 2021, 84, 110993.
15. Solana, M.J.; Manrique, G.; Slocker, M.; Fernández, R.; Gil, R.; Yun, C.; García, M.; Redondo, S.; Balaguer, M.; Rodríguez, E.; et al. Early vs Late Enteral Nutrition in Pediatric Intensive Care Unit: Barriers, Benefits, and Complications. Nutr. Clin. Pract. 2023, 38, 442–448.
16. Mesotten, D, Gielen, M, Sterken, C, et al. Neurocognitive development of children 4 years after critical illness and treatment with tight glucose control: a randomized controlled trial. JAMA 2012;308:1641-1650

Thank you!

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Acknowledgments

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