

Nutrition in Critical Illness

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Outline

Importance of Nutrition in Critical Illness

Nutrition Therapy during ICU Stay

Enteral and Parenteral Nutrition



Reversing Pathology with Nutrition



- Advances in ICU care allow for prolonged survival
- An increasing number of patients who survive ICU are suffering from severe, prolonged functional disabilities
- many ICU “survivors” are not returning home to functional lives post-ICU, but instead to rehabilitation or nursing home

“are we creating survivors ... or victims?”

Reversing Pathology with Nutrition



- The post-intensive care syndrome (PICS) definition was agreed to describe new or worsening problems in physical, cognitive, or mental health status arising after a critical illness and persisting beyond acute care hospitalization
- To improve functional and QoL outcomes, one essential, low-cost therapeutic strategy that can be rapidly implemented the ICU stay and recovery period is:

Optimal Provision of Nutrition

Metabolic Derangements during Critical Illness



- Inflammation
- Increased energy expenditure
- Insulin resistance
- Catabolic response leading to generation of energy from stores such as hepatic glycogen (glucose), fat (free fatty acids), and muscle (amino acids)

What is Going on in ICUs?



In a recent retrospective observational study of 17,524 patients, the mean \pm standard deviation energy and protein received was 56 \pm 30% and 52 \pm 30% of the intended aim, respectively

The Importance of Proteins during Critical Illness



Beneficial outcomes of critical illness are positively associated with the patients' muscle mass on ICU admission, the predominant endogenous source of amino acids

The catabolic response leads to reductions in muscle mass up to 1 kg/day during the first 10 days of ICU stay in patients with MODS

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Phases of Critical Illness



The 'ebb' or early shock phase (day 1-2)	'flow' phase (day 3-7)	Anabolic recovery phase (>7 days)
<p>Hemodynamic instability and hormonal changes (insulin resistance),</p> <p>Prioritising the delivery of energy substrates to vital tissues,</p> <p>Resulting in endogenous glucose production as well as lower energy expenditure compared to pre-injury</p>	<p>Catabolic Phase: involves the breakdown of tissue (including lean muscle tissue)</p> <p>'fight or flight' response</p>	<p>Resynthesis of lost tissue can take place and the body may be more metabolically able to process delivered nutrients</p> <p><i>Lambell K, et al. 2020</i></p>

Nutrition Therapy during ICU Stay



When to Start Nutrition Support?

- Generally, early enteral nutrition (EEN) is recommended, as it is superior over delayed enteral nutrition (EN) and early parenteral nutrition (PN)
- When to start EEN in shock is the matter of debate
- EN can be commenced after the initial phase of hemodynamic stabilization and it is not necessary to delay EN until vasopressors have been stopped

Zanten, et al. Critical Care, 2019

Nutrition Therapy during ICU Stay



When to Start Nutrition Support?

- In the NUTRIREA-II trial among severe circulatory shock patients, an increased risk of splanchnic ischemia and gastrointestinal intolerance was observed induced by “forced” EEN
- Higher levels of citrulline were observed after 3 ICU days (reflecting enterocyte mass) in patients on EEN, suggesting EEN is beneficial for the gut mucosa even in severe circulatory shock patients

When to Start?



Indications of nutritional support in a critically ill patient:

At least one of the following criteria:

- Pre-existing severe malnutrition
- Intake matches <50% of the energy
- Expected delay before recovery of eating ≥ 3 days

Start Or Delay Early EN



Recommendations	Rationale
Start early EN in all critically ill patients within 48 h, preferably within 24 h when there is no reason to delay enteral nutrition	Early EN is associated with lower risk of infections and preserves the gut function, immunity, and absorptive capacity
Delay early EN in case of enteral obstruction	Feeding proximal of an obstruction will lead to blow-out or perforation

Singer, et al. Clinical Nutrition, 2019 (ESPEN Guideline)

Start Or Delay Early EN



Recommendations	Rationale
<p>Delay early EN in case of compromised splanchnic circulation such as uncontrolled shock, overt bowel ischemia, abdominal compartment syndrome, and during intra-abdominal hypertension when feeding increases abdominal pressures.</p>	<p>Absorption of nutrients demands energy and oxygen. In states of low flow or ischemia, forcing feeding into the ischemic gut may aggravate ischemia and lead to necrosis or perforation.</p>
<p><i>Singer, et al. Clinical Nutrition, 2019 (ESPEN Guideline)</i></p>	

Start Or Delay Early EN



Recommendations	Rationale
Delay early EN in case of high-output fistula that cannot be bypassed.	Enteral feeding will be spilled into the peritoneal space or increase the fistula production.
Delay early EN in case of active gastrointestinal bleeding.	Enteral feeding will limit the visualization of the upper gastrointestinal tract during endoscopy

Singer, et al. Clinical Nutrition, 2019 (ESPEN Guideline)

Start Or Delay Early EN



Recommendations	Rationale
<p>Delay early enteral nutrition in case of high gastrointestinal residual volume (>500mL per 6h).</p>	<p>This threshold is associated with poor gastric emptying and may increase the risk of aspiration. Prokinetics and postpyloric feeding can circumvent this problem.</p>

Singer, et al. Clinical Nutrition, 2019 (ESPEN Guideline)

Nutrition Therapy during ICU Stay



Progressive Administration of Calories

- Early overfeeding should be prevented
- Hypocaloric or normocaloric feeding does not confer major differences in outcome when protein intake is similar.
- Aggressive early caloric intake leads to more episodes of hyperglycemia and need for high-dose insulin therapy
- To estimate the caloric target after the initial phase, indirect calorimetry is strongly recommended

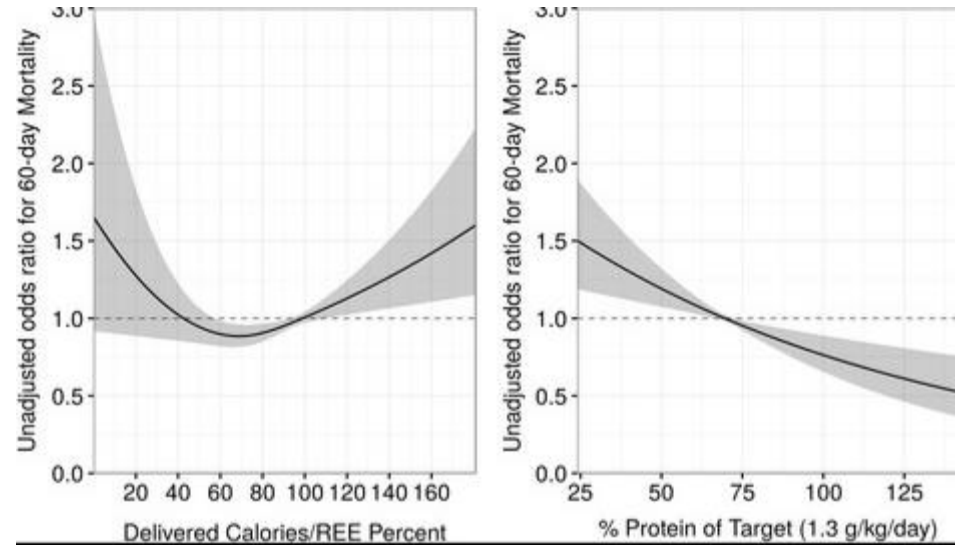
Zanten, et al. Critical Care, 2019

Nutrition Therapy during ICU Stay



Progressive Administration of Calories

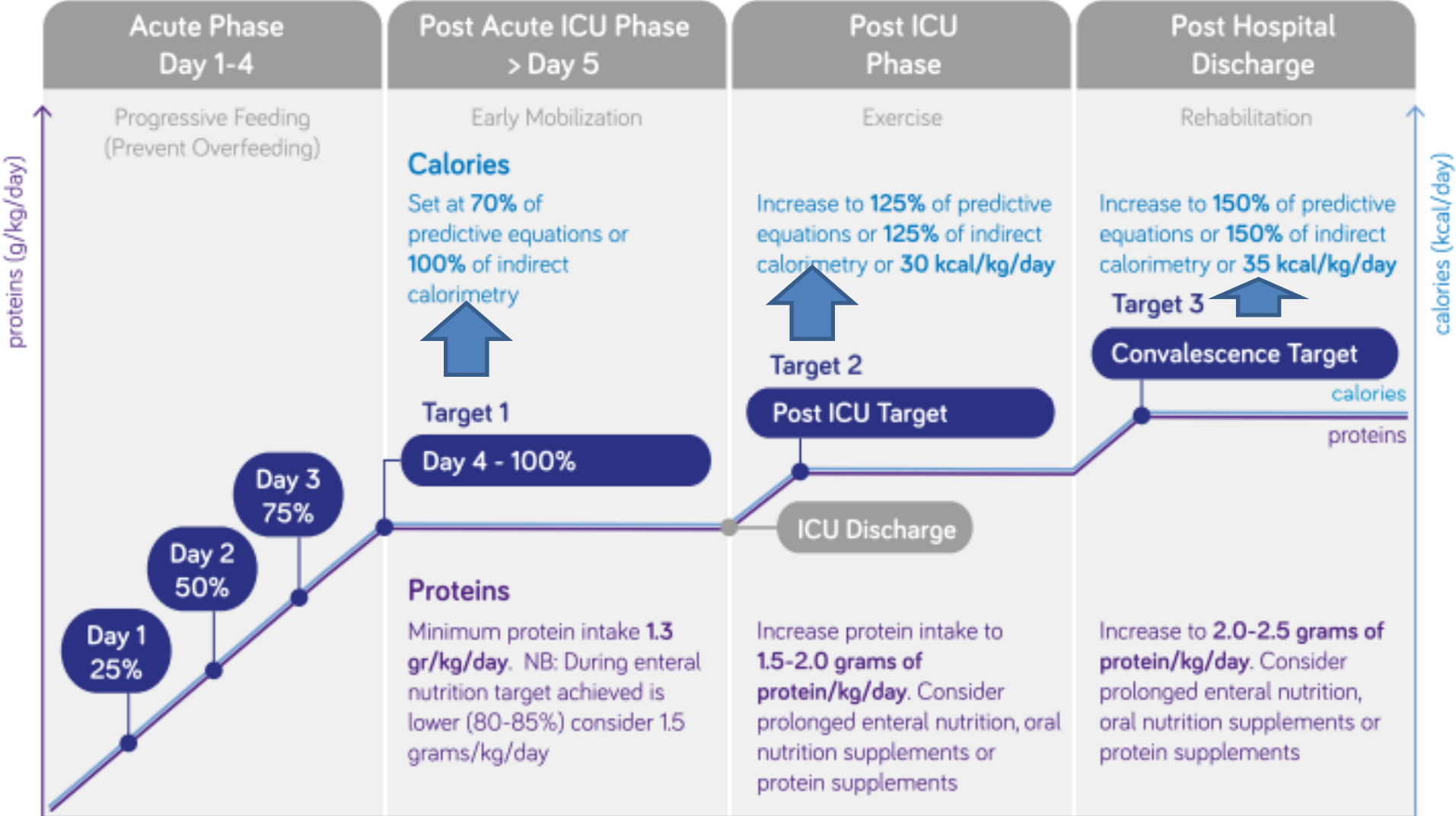
- As prolonged caloric deficits should be prevented, accepting a limited deficit (20–30% in the first ICU week) seems to be optimal (Permissive underfeeding)



Be Careful about Refeeding Syndrome



- Electrolyte shifts in response to reintroduction of nutrition after a period of starvation
- It can be best identified in ICU patients by refeeding hypophosphatemia (drop below 0.65 mmol/l) within 72 h after the start of nutrition therapy
- Caloric restriction to 500 kcal/day or less than 50% of target for 2–3 days is essential to prevent attributable mortality from RFS





Acute Phase
Day 1-4

Post Acute ICU Phase
> Day 5

Post ICU
Phase

Post Hospital
Discharge

Recommendations

Adjust caloric intake for non-nutritional calories from: glucose, propofol and citrate

Patients are at-risk for reductions in caloric intake after cessation of enteral

Patients are at-risk for prolonged reduced caloric intake consider the use of oral

Monitoring

Monitor Phosphate. Stay at 25% of caloric target for 48h when phosphate drops

Prevent very early high protein intake

Indirect Calorimetry (every 48h) and adjust target accordingly

Consider to monitor Nitrogen balance

Monitor oral intake, do not remove feeding tube early

Consider use of muscle ultrasound, BIA, DEXA or CT for body composition

Monitor oral intake and oral nutrition supplement intake

Consider functional muscle tests and follow-up of body composition

Strategy	Evidenced-based feeding protocol	GRV (minimum 500 ml cut-off)	Appropriate and timely use of prokinetics for EN intolerance	Post-pyloric tubes for EN intolerance
ASPEN/SCCM (2016)	Use an EN protocol (designed and implemented to increase the overall percentage of goal energy delivered)	Do not use GRVs as part of routine care to monitor ICU patients on EN If GRVs are used, use 500ml cut-off	Use metoclopramide or erythromycin where indicated	nil

Strategy	Evidenced-based feeding protocol	GRV (minimum 500 ml cut-off)	Appropriate and timely use of prokinetics for EN intolerance	Post-pyloric tubes for EN intolerance
Canadian Clinical Practice Guidelines (2015)	Use an EN protocol (that details strategies to improve delivery of EN) (based on 2 level 2 studies and 3 cluster RCTs)	Use GRV of 250–500 ml every 4–6 h (based on 3 level 2 studies)	Use metoclopramide where indicated (based on 1 level 1 study and 5 level 2 studies)	Use post-pyloric tubes for patients at high risk for intolerance to EN or aspiration (based on 16 level 2 studies)

Strategy	Evidenced-based feeding protocol	GRV (minimum 500 ml cut-off)	Appropriate and timely use of prokinetics for EN intolerance	Post-pyloric tubes for EN intolerance
ESPEN (2019)	nil	EN should only be delayed when GRV is > 500 ml/6 h	Use IV erythromycin as a first line therapy or use IV metaclopramide or combination therapy Alternatively, combination therapy (IV metoclopramide and erythromycin)	Use post-pyloric feeding for EN intolerance not resolved with prokinetics

Nutrition Therapy during ICU Stay



Administration of Proteins

- In non-septic critically ill patients, early high protein intake was associated with lower mortality and early energy overfeeding with higher mortality.
- In septic patients early high protein intake had no beneficial effect on mortality.

Administration of Protein



- Gradual progression to the protein target can be recommended
- Step-wise increase to target in a few days can be performed using enteral nutrition. Following the ESPEN guidelines, the protein target after progression should be at least 1.3 g/kg/day
- Clinical guidelines recommend protein delivery of between 1.2 and 2 g/kg/day. Higher protein provision is recommended in specific clinical conditions (i.e. burns, obesity, and multi-trauma)

Zanten, et al. Critical Care, 2019

Lambell K, et al. Critical Care, 2020

Administration of Protein



How to Reach the Protein Target?

Stepwise approach to achieve a high-protein intake without overfeeding

Step 1: Calculate the caloric need by your preferred equation and target 70% (first week) or measure energy expenditure by indirect calorimetry (after day 3) and set this as the 100% target.

Step 2: Subtract the amount of non-nutritional calories provided from propofol, glucose, or citrate.

Administration of Protein



Step 3: Calculate the daily limit for overfeeding (maximum calories allowed for feeding).

Step 4: Select a very high-protein-to-energy ratio enteral feed or the highest protein-energy ratio feed available and calculate the maximum acceptable dose based on step 3 without overfeeding. (protein ratio of total calories should reach to 30%)

Step 5: Monitor the actual intake during the day and progress to higher than calculated infusion rates for limited time in case of previous interruptions of administration (stoppages), and use volume-based strategies.

Administration of Protein



Step 6: Add enteral protein supplements in case more enteral feeding will lead to overfeeding when increasing the administration dose. Use no protein supplements during the very early phase (day 1–day 3).

Step 7: Add parenteral amino acid supplementation in case of contraindications to enteral feeding or inadequate enteral feeding/ enteral protein supplementation at 4–7 day post-ICU admission (likely sooner in malnourished patients)

Administration of Protein



- Two observational studies have reported increased survival with early increased protein delivery (day 3–4).
- A single-centre retrospective cohort study (n = 455) reported a lower protein intake (< 0.8 g/kg/day) before day 3 and high protein intake (> 0.8 g/kg/day) after day 3 was associated with lower 6-month mortality compared to patients with overall high protein intake.

Intact or Hydrolyzed Protein?



- At present, recommendations are against the routine use of these semi-elemental formulations
- Whether semi-elemental formulations are superior in specific groups of patients at risk of enterocyte mass reduction and gut dysfunction

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Principles of Enteral Nutrition



When to Start?

- Early provision of EN (within 48 h of ICU admission) in patients who are mechanically ventilated

Principles of Enteral Nutrition



How Should EN be Delivered?

- The most common method of delivering EN in ICU is via a gastric tube, with a continuous hourly infusion.
- Recently, it has been proposed that bolus (intermittent) feeding may be more physiologic and therefore superior to continuous feeding (*Patel JJ, et al. Curr Opin Clin Nutr Metab Care, 2018*)
- Continuous vs Bolus feeding: less diarrhea no difference in GRV and aspiration (*Singer p, et al. Clin Nutr, 2019*)

Principles of Parenteral Nutrition



When to start?

Due to the potential harm with early PN, it is the opinion of the authors that if oral intake or EN is contraindicated, then PN should only be considered between ICU days 3 and 7 and that supplemental PN be considered on an individual case-by-case basis

Timing of Supplemental PN



- Early initiation of supplemental parenteral nutrition (SPN), before days 3–7, is not recommended

What is the patient's nutritional status?^a

Well-nourished or moderately malnourished

Severely malnourished

Acute early phase

(ICU day 1-2)

- Consider EN
- Do not use PN
- Energy target: <70% estimated or measured requirements^b
- Protein target: accept protein dose provided by delivering energy targets

- Follow management for well-nourished patients, and:
- Watch closely for signs of refeeding syndrome, specifically hypophosphatemia
- If phosphate low, replace and keep energy target at ~50% requirements for 2-3 days before gradually increasing

Acute late phase

(ICU day 3-7)

- Give EN
- Consider PN if EN contraindicated or insufficient (case-by-case basis)
- Energy target: 70% estimated or 80-100% measured requirements^b
- Protein target: gradual increase to 1.3g/kg/day^c

- Give EN
- Start low and progressive PN if EN contraindicated or insufficient
- Energy target: 70% estimated or 80-100% measured requirements^b
- Protein target: gradual increase to 1.3g/kg/day^c
- Continue to watch for signs of refeeding syndrome

Recovery phase

(ICU >7 days)

- Give EN
- Commence PN if EN contraindicated or insufficient (case-by-case basis)
- Energy target: 80-100% estimated or measured requirements by IC; Protein target: at least 1.3g/kg/day^c

Approach to Nutrition Support

- ✓ How much of Requirements? Energy, Macro- and Micronutrients
- ✓ Which Route?
- ✓ Which Substrate/Formula?
- ✓ How to Administer?
- ✓ How to Monitor?



How much of Requirements



Energy Requirement:

In the acute and initial phase of critical illness:

- ✓ 20-25 kcal.kg⁻¹.d⁻¹ (ideal body weight)

In the anabolic recovery phase:

- ✓ 25-30 kcal.kg⁻¹.d⁻¹ (ideal body weight)

How much of Requirements



Energy Requirement:

- Estimating energy expenditure via VO_2 and VCO_2 (carbon dioxide production from the ventilator)

Weir formula ($REE = VCO_2 \times 8.19$)

- Measuring energy expenditure in the critically ill—indirect calorimetry: gold standard method for measuring REE in critical illness (especially for obese or underweight patients)
- Estimating by predictive equations (25 kcal/kg)

How much of Requirements



Energy Requirement:

If BMI > 25 or sarcopenic:

- ✓ Ideal BW: (height-100) + (0.25 x (actual BW - (height-100)))

How much of Requirements



Protein Requirement:

- ✓ 1-1.5 g.kg⁻¹.d⁻¹
- ✓ In morbidly obese ICU patients: 1,2 g/kg/d actual BW or 2-2,5 g/kg/d ideal body weight with a lower relative energy supply

When to Start?



Timing of Implementation

- Early (<48 hours) enteral nutrition

Which Route?



Oral

Enteral

Enteral + Supplemental Parenteral

Total Parenteral

Thank You

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