FRESENIUS KABI

The Nutrition Blueprint:

Enhancing Outcomes in Critical Care

The Power of Nutrition in Critical Care

How can tailored nutrition strategies transform outcomes for critically ill patients?

IMPORTANCE OF CLINICAL NUTRITION IN ICU

Malnutrition in ICU:

- Every critically ill patient staying for **more than 48 hours** in the ICU should be considered **at risk** for malnutrition.[1]
- Malnutrition can **influence major outcomes** such as mortality, length of stay, duration of mechanical ventilation and infection rates.[2]

Nutrition for Recovery:

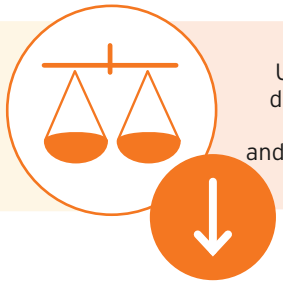
- Nutrition therapy plays a **vital role in the recovery process** by providing necessary energy and substrates.[3]
- In patients with malnutrition and/or muscle loss, nutrition plays a role in supporting muscle anabolism, reducing catabolism and improving outcomes.[4]
- Sufficient energy is required to spare muscle protein and provide substrates for muscle protein synthesis.[4]
- Protein and amino acids support muscle as substrates for muscle protein synthesis as well as modulating the immune system.[4]

Individualised Approach:

- Nutritional strategies should be **adjusted based on phases of critical illness** as well as **patient specific factors** including body composition and nutritional status.[5]

Both overfeeding and underfeeding can be deleterious[6, 7]

- Overfeeding during acute stress metabolism phases can impair respiratory function, increase infection risk, and lead to fat storage
- Overfeeding risk is increased by a progressive decrease in lean body mass over time when weight-based equations are used without accounting for weight changes



Underfeeding can result in calorie deficits, depleting energy reserves, reducing lean body mass, and increasing infectious complications

MALNUTRITION DIAGNOSIS

- Diagnosis and grading of malnutrition can be performed using the GLIM criteria.[8]

Phenotypic and Etiologic Criteria for the Diagnosis of Malnutrition

To diagnose malnutrition, at least one phenotypic criterion and one etiologic criterion should be present.

Phenotypic Criteria			Etiologic Criteria	
Weight Loss (%)	Low body mass index (kg/m²)	Reduced muscle mass	Reduced food intake or assimilation	Inflammation
> 5 % within past 6 months, or > 10 % beyond 6 months	*< 20 if < 70 years, or < 22 if > 70 years*	*Reduced by validated body composition measuring techniques*	*< 50 % of ER > 1 week, or any reduction for > 2 weeks, or any chronic GI condition that adversely impacts food assimilation or absorption*	*Acute disease/injury or chronic disease related*

Thresholds for Severity Grading of Malnutrition into Stage 1 (moderate) and Stage 2 (severe) Malnutrition[1]

Grade the malnutrition based on one of the phenotypic criterion

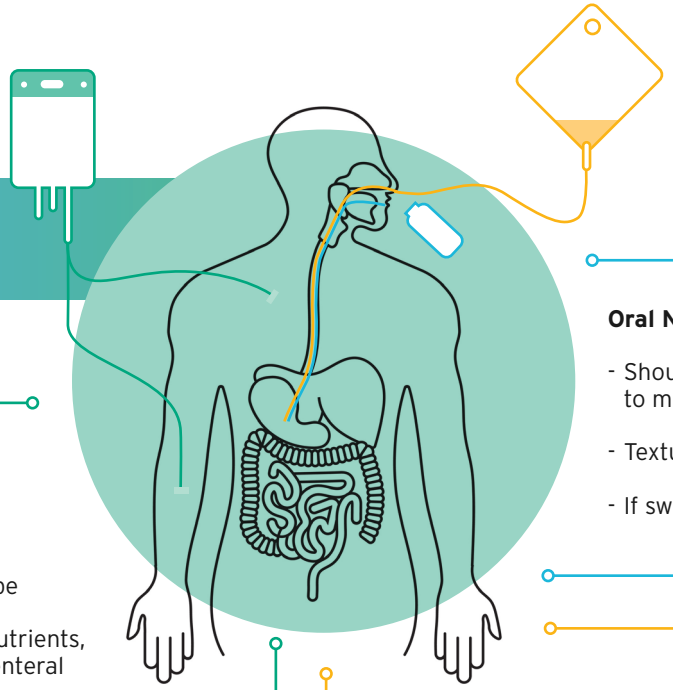
	Phenotypic Criteria		
	Weight Loss (%)	Low body mass index (kg/m²)	Reduced muscle mass
Stage 1 / Moderate malnutrition (Requires 1 phenotypic criterion that meets this grade)	*5 - 10 % within the past 6 months or 10 - 20 % beyond 6 months*	*< 20 if < 70 years, or < 22 if ≥ 70 years*	*Mild to moderate deficit (per validated assessment method)*
Stage 2 / Severe malnutrition (Requires 1 phenotypic criterion that meets this grade)	*> 10 % within the past 6 months or > 20 % beyond 6 months*	*< 18,5 if < 70 yr* *< 20 if ≥ 70 yr*	*Severe deficit (per validated assessment method)*

GLIM = Global Leadership Initiative on Malnutrition ER = Energy Requirements

Effective nutrition in the ICU, tailored to each patient's unique needs, is a balancing act that prevents malnutrition and supports recovery.

Nutritional Approach:
Enteral and Parenteral Solutions

How do we choose the right nutritional route for critically ill patients?



Parenteral Nutrition (PN)

- PN should be used when EN is contraindicated[7]
- PN, over short-term, is considered safe and effective and is not associated with increased risk of infection[9]
- The phase of critical illness, as well as nutritional status should be considered when deciding to use PN[10]
- Total parenteral nutrition (TPN), providing all macro and micronutrients, or supplemental parenteral nutrition (SPN) as a supplement to enteral or oral nutrition[10]
- SPN has been shown to reduce infection rate and antibiotic use[11]

Indications for TPN[10]

- Acute bowel obstruction
- Surgical conditions or complications preventing EN e.g. anastomotic leak or high output fistula
- Malignant bowel obstruction (death not imminent)
- Oncology associated complications e.g. graft vs host disease or severe mucositis
- Prolonged GI failure in ICU (when other strategies to improve tolerance has not been successful)
- Lack of access for EN
- Severe malabsorption

Indications for SPN[10]

- Insufficient EN that cannot be improved due to functional issues
- Hypermetabolic conditions where EN is unable to provide full calorie or protein requirements
- Prolonged GI failure in ICU (when other strategies to improve tolerance has not been successful)
- Malabsorption

GI = Gastrointestinal

Oral Nutrition Supplements (ONS)[7]

- Should be considered in non-intubated patients who are unable to maintain nutritional targets through oral intake
- Texture-adapted feeds can be used in patients with dysphagia
- If swallowing is unsafe EN should be administered

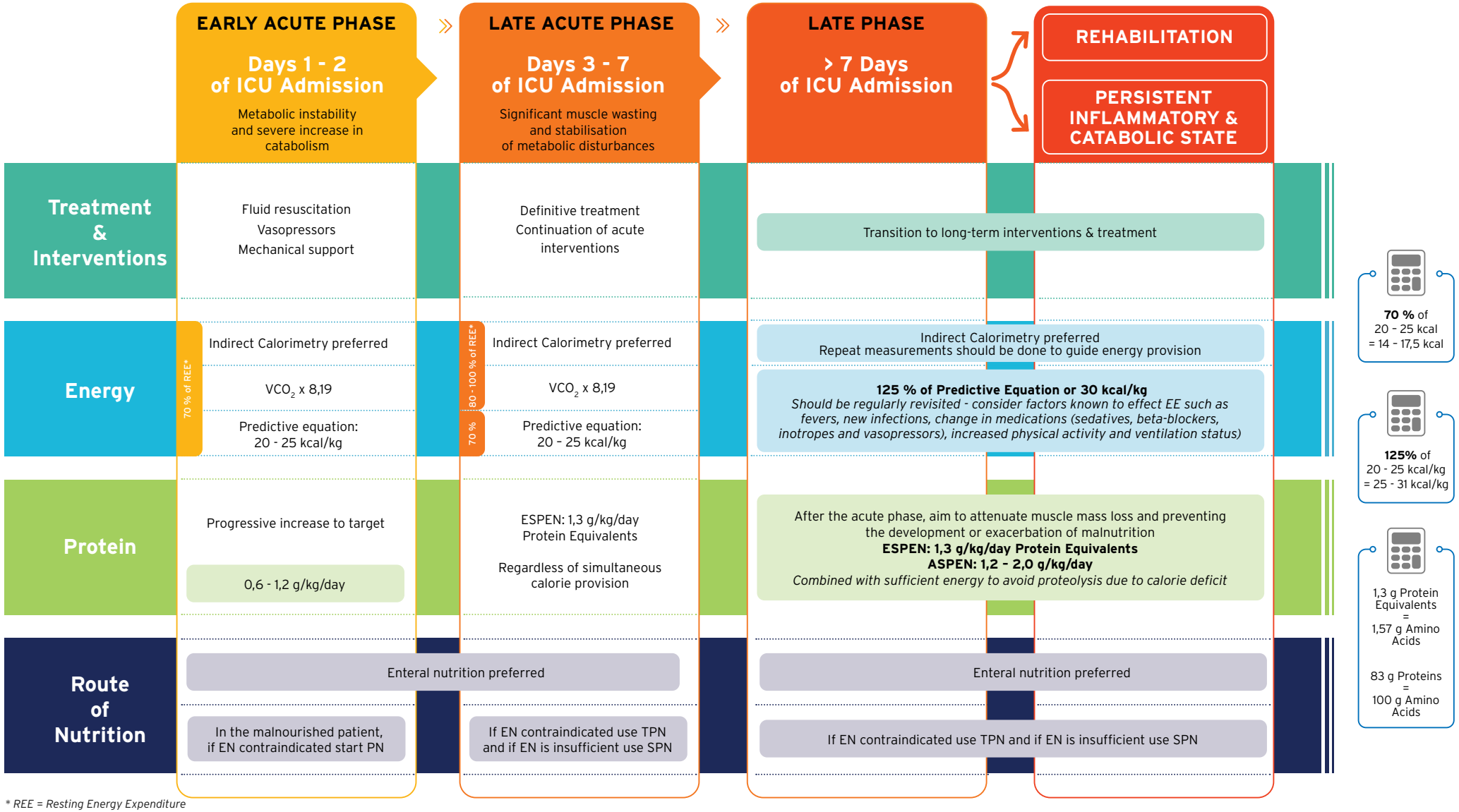
Enteral Nutrition (EN)

- Critically ill patients who cannot maintain adequate oral intake should receive enteral nutrition within 48 hours of ICU admission[7]
- Early EN
  - Prevents gut atrophy and enterocyte apoptosis[12]
  - Reduces infectious complications[7, 12]
- Trophic EN Feeding may have non-nutritional benefits such as gut barrier function[9]
- Gastric feeding is the initial route, postpyloric can be used in those with gastric feeding intolerance or at high risk of aspiration[7]
- Delayed EN may be necessary to prevent complications in unstable patients, including those with:[7]
  - Uncontrolled shock
  - Severe hypoxemia
  - Acidosis
  - Bowel ischaemia
  - High-output fistula
  - Upper gastrointestinal bleeding
  - Abdominal compartment syndrome
  - Gastric aspirate volume > 500 mL per 6 hours

Tailoring enteral and parenteral nutrition to patient needs ensures effective support and minimises complications.

Phases of Care: Adapting Nutrition Through Critical Illness

How does nutritional support evolve through the phases of critical illness?



** REE = Resting Energy Expenditure*

Figure developed based on content from: Singer et al. 2018[1]; Singer et al. 2014[6]; Singer et al. 2023[7]; Ridley et al. 2021[10]; Smith et al. 2024[13]; Oshima et al 2024[14]; Van Zanten et al. 2019[15]; Blaauw et al. 2024[16]

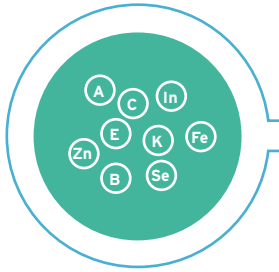
Understanding each phase of critical illness allows for precise nutritional interventions that align with changing metabolic needs.

Balancing Act: Other Nutrients in for Complete Nutrition

How do carbohydrates, lipids, and micronutrients contribute to effective ICU nutrition?

Glucose[7]

- A preferred source of energy.
- Excessive glucose is associated with hyperglycaemia, enhanced CO_2 production, enhanced lipogenesis and increased insulin requirement.
- The amount of glucose (PN) or carbohydrates (EN) should not exceed 5 mg/kg/min.



Micronutrients[7,17]

- Trace elements and vitamins are essential for human metabolism.
- All patients receiving medical nutrition should get sufficient essential trace elements and vitamins from the start of their nutritional support.
- Daily provision of vitamins and trace elements to enable substrate metabolism and prevent deficiencies.
- In patients receiving less than 1 500 kcal/day via enteral nutrition additional micronutrients (either enterally or parenterally may be considered).

Lipid Emulsions[7]

- Intravenous lipid emulsions (ILE) should generally be part of parenteral nutrition.
- Dosage of ILE should not exceed 1,5 g/kg/day and should be adapted to individual tolerance (monitoring of triglyceride levels and liver function tests can be used to guide dosing).
- Non-nutritional calories (e.g. from Propofol) should also be taken into account.
  1 mL Propofol 1 % & Propofol 2 % = 0,1 g fat and 1,1 kcal

Proper management of essential nutrients ensures balanced energy provision and prevents metabolic complications.

Nutritional Powerhouses: Omega-3 and Glutamine in Critical Care

How do omega-3 fatty acids and glutamine transform outcomes in critically ill

Omega-3 Fatty Acids in Critical Care Patients[18]

- The regulation of inflammation and oxidative stress is crucial for improving patient outcomes in critical illness.

- Long chain Omega-3 polyunsaturated fatty acids (PUFAs), specifically eicosapentanoic acid (**EPA**) and decosahexanoic acid (**DHA**), are known for their **anti-inflammatory effects** and are therefore used in parenteral nutrition (PN).

- The international Lipids in PN Summit concluded that including fish oil in ILEs leads to **significant clinical benefits without any indication of harm.**

Biological Role of Omega-3 PUFAs in Critical Illness

The body's ability to balance inflammation and the anti-inflammatory immune response influences clinical outcomes during critical illness

Omega-3 PUFAs, specifically **EPA** and **DHA** → are **precursors** → to **specialised pro-resolving mediators** (SPMs)

SPMs actively reduce inflammation and guide the immune response towards resolution and homeostasis, unlike traditional anti-inflammatory medicines that can suppress the immune system

Omega-3 PUFAs also potentially counteract muscle mass loss by enhancing muscle protein synthesis and/or reducing muscle protein breakdown

Evidence Supporting Omega-3 PUFAs in PN

Numerous clinical studies and meta-analyses indicate that ILEs containing fish oil positively affect the inflammatory response and improve clinical outcomes in critically ill patients

Benefits include:

- Decreased length of stay in ICU and in hospital
- Fewer infections
- Cost saving

Glutamine in Critical Illness[19]

Glutamine (Gln) is **crucial for nitrogen transport, amino acid metabolism**, and as a **fuel for rapidly proliferating cells**, but is usually considered dispensable for healthy individuals

In severe **disease states**, the body's **demand for Gln increases** due to stress-mediated hormonal changes, leading to **depletion and metabolic impairment**.

Standard amino acid solutions for parenteral nutrition lack Gln, making it difficult to prevent Gln depletion in critically ill patients.

When IV glutamine is supplemented, according to clinical guidelines, in line with professional information. (0,5 g/kg Dipeptide / 0,34 g/kg Glutamine) **benefits include**:

- Reduced risk of hospital mortality
- Reduction in risk of infectious complications
- Reduction of hospital and ICU length of stay
- Reduction in duration of mechanical ventilation

Integrating omega-3 PUFAs and glutamine into nutrition plans offers significant benefits including reducing inflammation and improving recovery.

Precision Care: Monitoring Nutrition in the ICU

How can effective monitoring enhance nutritional support in critically ill

Effective monitoring and timely adjustments are crucial components of nutritional management in the ICU, ensuring that the nutritional support provided aligns with the patient's evolving clinical status and metabolic needs.

Monitor for tolerance, overfeeding and underfeeding

Blood glucose levels

- Measure initially and every 4 hours for at least the first 2 days.
- Insulin to be provided when glucose levels exceed 10 mmol/L to maintain glycaemic control.

Gastric Residual Volumes (GRV)

- Monitoring GRV can help assess gastrointestinal tolerance to enteral nutrition during initiation and progression.
- Enteral feeding should be delayed if GRV is greater than 500 mL/6 hours, and prokinetic agents may be used to improve tolerance.
- May not be necessary to monitor established enteral nutrition with continued measurements of GRV.

Monitor for refeeding

Electrolytes

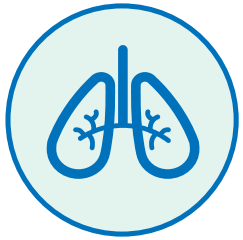
- Potassium, magnesium and phosphate should be measured at least once daily for the first week.

- In patients with refeeding hypophosphataemia (< 0,65 mmol/L or a drop of > 0,16 mmol/L):
  - *Energy supply should be restricted for 48 hours and then gradually increased.*
  - *Electrolytes should be closely monitored (2 - 3 times a day) and supplemented as needed.*

Implementing these monitoring and adjustment strategies,healthcare providers can optimise nutritional therapy in the ICU, enhancing patient outcomes and minimising the risk of complications.

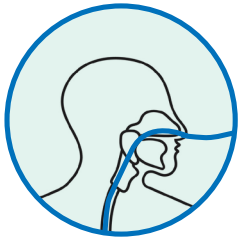
Pathways to Recovery:
Nutrition Beyond the Acute Phase and the ICU

How do nutritional needs change as a patient transitions from the acute phase in the ICU, and when discharged to the ward?



Post Extubation[20]

- Patients often experience low energy and protein intake.
- More than 25 % of patients may have dysphagia following extubation and swallowing should be evaluated by a speech therapist.
- Modified diets or enteral/parenteral nutrition may be required until swallowing is restored.
- Non-invasive respiratory support (high flow nasal cannula (HFNC) and non-invasive ventilation (NIV)) can reduce oral intake.



Removal of Nasogastric Tube[20]

- Has shown to decrease nutritional intake:
  22 – 44 % drop in calorie intake
  27 – 51 % drop in protein intake
- Prolonged tube feeding should be considered until oral nutrition intake is sufficient.

Patients that survive the acute phase in ICU
may have additional nutritional challenges

Persistent Critically ill Syndrome with chronic inflammation[13]

Patients with prolonged ICU stays (> 10 days) face unique nutritional challenges.

Nutritional Implications

- Increased use and longer duration of mechanical ventilation
- More prone to multiorgan failure
- Higher need for vasoactive support and renal replacement therapy
- Greater risk of infection and skin breakdown
- High rates of renal replacement therapy, skin breakdown, and lack of sunlight can worsen micronutrient deficiencies in ICU patients
- Hormonal changes in persistent critical illness that negatively affect metabolism and muscle mass
- Persistent critical illness is closely associated with muscle loss and is linked to severity of illness
- Muscle loss is significant in the first week and continues for 2 - 3 weeks necessitating prolonged mechanical ventilation

Nutritional Considerations and Strategies:

- Prevent underfeeding and cumulative deficits
- Assess barriers to intake
- Use indirect calorimetry to guide intake or if using predictive equations revise regularly
- Minimise fasting periods
- Monitor biochemistry and anthropometry

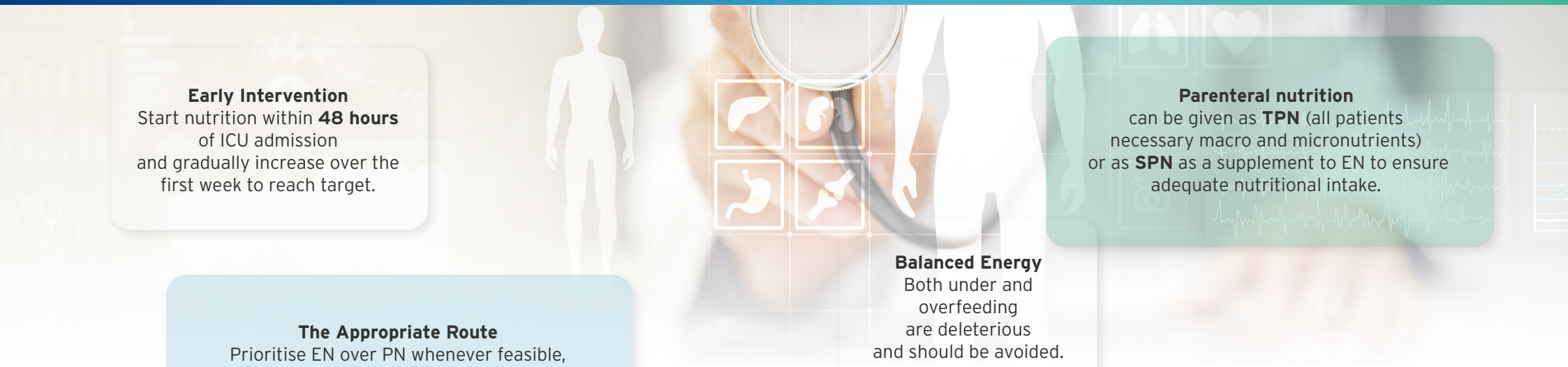
Discharged to the Ward[21]

Nutritional Therapy and Rehabilitation:

- Nutrition is often underprioritised in ICU rehabilitation strategies.
- Most patients who were mechanically ventilated will be malnourished when discharged from the ICU.
- Patients face various barriers to adequate intake that are physiological, functional and psychological as well as organisational barriers and those related to healthcare provider knowledge
- Practical strategies to enhance nutritional recovery:
  - Patient centered approach
  - Family engagement
  - Clear plans for transition to ward and to home
  - Involvement of dietitians as experts in the field of nutrition

A multidisciplinary approach to management, tailored to the needs of individual patients, supports recovery and enhances quality of life.

Overview: Blueprint



Early Intervention
Start nutrition within **48 hours** of ICU admission and gradually increase over the first week to reach target.

Parenteral nutrition
can be given as **TPN** (all patients necessary macro and micronutrients) or as **SPN** as a supplement to EN to ensure adequate nutritional intake.

Balanced Energy
Both under and overfeeding are deleterious and should be avoided.

The Appropriate Route
Prioritise EN over PN whenever feasible, as it helps maintain gut function and lowers infection risk.

Use PN when EN is not possible or insufficient, especially in high-risk or severely malnourished patients.

Specialised Nutrients
Nutrients such as fish oils and glutamine have shown a beneficial effect on patient outcomes in the ICU.

Comprehensive Monitoring and Continuous Reassessment
Monitoring and adjustment of nutritional strategies are important to make timely adjustments to meet the evolving needs of critically ill patients, ensuring optimal outcomes.

Protein Prioritisation
Ensure adequate protein intake to support muscle synthesis and prevent wasting.

Continuum of Care from ICU to Ward
The transition from ICU to the ward and subsequent changes in medical management e.g. extubation and removal of the nasogastric tube, can affect nutritional intake and should be monitored carefully to ensure patients' requirements are met.

Micro but Mighty
Ensure daily provision of essential micronutrients (vitamins and trace elements) to support metabolic processes and prevent deficiencies.

Tailored Nutrition
Develop personalised nutrition plans tailored to the specific needs and metabolic responses of critically ill patients.

Innovative Solutions:
Meeting Critical Care Needs

How can Fresenius Kabi products enhance nutritional support for critically ill patients?

Intravenous Total Nutrition:
The compounding unit produces and delivers a variety of intravenous par-enteral nutrition to meet patients' macro AND micronutrient requirements with one bag.

Dipeptiven:
An IV glutamine supplement containing 13,46 g IV glutamine per 100 mL

SMOFlipid:
A unique lipid emulsion containing Soybean, MCT, Olive and Fish Oil. Providing 15 g Fish Oil per 100 g of lipids

Micronutrients:
With a complete range of micronutrients, which are also included in the compounded bags the patient's daily requirements for trace elements, water soluble and fat soluble vitamins can be met.

A range of specialised and standard enteral tube feed formulas
to provide various options based on patients' specific requirements and tolerance.

A range of specialised and standard oral nutritional supplements,
including texture modified options, to provide various options based on patients' needs, oral intake and tolerance.

Fresenius Kabi offers a range of tailored solutions to optimise nutrition
and improve outcomes in critical care settings.

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S3 Addaven®. Each 1 ml concentrate contains 5,33 µg chromic chloride hexahydrate; 0,10 mg cupric chloride dihydrate; 0,54 mg ferric chloride hexahydrate; 19,80 µg manganese chloride tetrahydrate; 4,85 µg sodium molybdate dihydrate; 17,3 µg sodium selenite anhydrous; 1,05 mg zinc chloride; 16,6 µg potassium iodide; 0,21 mg sodium flouride. Reg. No.: 49/24/0996.

S3 Dipeptiven. Each 1 000 ml concentrate contains 200,0 g N(2)-L-alanyl-L-glutamine (82,0 g L-alanine & 134,6 g L-glutamine). Reg. No.: 33/23/0210.

S3 SMOFlipid® 20 %. Each 1 000 ml emulsion contains 60,0 g soybean oil; 50,0 g olive oil; 30,0 g fish oil; 60,0 g medium chain triglycerides. Reg. No.: 41/25.2/0060.

S3 Soluvit® Novum. Each 10 ml vial contains 3,2 mg thiamine HCl (as thiamine mononitrate); 3,6 mg riboflavin (as sodium riboflavin phosphate); 40,0 mg nicotinamide; 4,0 mg pyridoxine (as pyridoxine HCl); 15,0 mg pantothenic acid (as sodium pantothenate); 100,0 mg ascorbic acid (as sodium ascorbate); 60,0 µg biotin; 0,4 mg folic acid; 5,0 µg cyanocobalamin. Reg. No.: U/22.1.4/200.

S3 Vitalipid® Novum Adult. Each 1 ml concentrate contains 99 µg (330 IU) Vitamin A; 0,5 µg (20 IU) Vitamin D2; 0,91 mg (1 IU) Vitamin E; 15 µg Vitamin K1. Reg. No.: Z/22.1/236.

For full prescribing information refer to the latest professional information approved by the South African Health Products Regulatory Authority.

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