CLINICAL

NUTRITION GUIDELINE

NUTRITIONAL MANAGEMENT *of* CRITICALLY ILL PATIENTS

MINISTRY OF HEALTH
IN COLLABORATION WITH

SRI LANKA MEDICAL NUTRITION ASSOCIATION

&

COLLEGE OF ANAESTHESIOLOGISTS
& INTENSIVISTS OF SRI LANKA

2021

Contents

Message from **DGHS**

The Ministry of Health spends a huge portion of its annual budget on providing care for critically ill patients. Though the capacity in providing care for such patients is limited, we always serve our best for optimizing the care. To achieve a better outcome in a critically ill patient, adequate nutritional care plays a vital role. Due to the increased risk of developing malnutrition, the nutrition provision in critically ill patients is of utmost importance. Prevention, timely diagnosis and treatment of impaired nutritional status shown to reduce the length of ICU and hospital stay, hence the health care cost spend on the patient.

An updated nutritional care guideline for critically ill patients is a great initiative in uplifting the level of care for the patients who are being managed in intensive care units. I hope these recommendations would be used for better care throughout Sri Lanka.

I would like to use this opportunity to appreciate the Sri Lanka Medical Nutrition Association and college of anesthesiologists and intensivists for their untiring efforts in bringing these guidelines forward. The expertise in both organizations blends well in coming up with the evidence-based recommendations for improving the service in ICUs to an international levelled care. The application of the guideline would provide uniform patient care across the country with the optimal consumption of resources available.

As the Ministry of Health, we are looking forward to receiving continuous support from all parties involved in making this piece of work a successful reality. In conclusion, I express my gratitude to the pioneers from both critical care and clinical nutrition fields for the contribution they made all through this long journey in caring for critically ill patients.

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Director General of Health Service

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List of **Abbreviations**

- ASPEN - American Society for Parenteral and Enteral Nutrition
- ARDS - Acute Respiratory Distress Syndrome
- BIA- Body Impedance Analysis.
- BMI - Body Mass Index
- CRBSI Catheter Related Bloodstream Infections
- CT - Computerized Tomography
- DHA- Docosa Hexaenoic Acid
- ECMO - Extracorporeal Membrane Oxygenation
- EN - Enteral Nutrition
- EE- Energy Expenditure
- ESPEN - European Society for Clinical Nutrition and Metabolism
- ESPHGAN-European Society for Pediatric Gastroenterology Hepatology & Nutrition
- EPA- Eicosapentaenoic acid
- FODMAP- Fermented Oligosaccharides, Disaccharides, Monosaccharides And Polyols
- GLN- Glutamine
- IBW - Ideal Body Weight
- GRV- Gastric Residual Volume
- IJV- Internal Jugular Vein
- LFT- Liver Function Test
- MNT - Medical Nutrition Therapy
- MRI - Magnetic Resonance Imaging
- MUST - Malnutrition Universal Screening Tool
- NA-Not Available
- NG - Nasogastric
- NRS - Nutritional Risk Score
- PICC- Peripherally Inserted Central Catheter
- PNALD- Parenteral Nutrition Associated Liver Disease
- PN - Parenteral Nutrition
- REE- Resting Energy Expenditure
- RQ - Respiratory Quotient
- SGA - Subjective Global Assessment
- SIBO - Small Intestine Bacterial Overgrowth
- SPN - Supplemental Parenteral Nutrition
- SVC - Superior Vena Cava
- TPN - Total Parenteral Nutrition
- $PaCO_2$ - Partial pressure of Carbon Dioxide
- PaO_2 – Partial pressure of Oxygen

Introduction

The present guideline on "Nutritional management of adult critically ill patients" is an update and extension of the former local guideline on "Nutrition Support in ICU patients" which was published in 2014 and reviewed in 2016. This document is updated and amended based on current evidence and the latest guidelines implemented by European and American Societies of Parenteral and Enteral Nutrition (ESPEN and ASPEN) and European Society for Intensive Care Medicine (ESICM).

The ultimate goal is to integrate the best and most updated knowledge from the literature analyzed by the medical nutrition team and professionals from anesthesiology as well as by invited critical care professionals, to reach the best achievable recommendations. This review aims to address the best timing, route, dose, composition and complication management of medical nutrition therapy for critically ill patients. When adapted this guideline to the local setup, the recommendations were not the only excerpt from the international guidelines, but also consider on the judgment of the working group accounting the clinical relevance in a local setting.

The estimated prevalence of malnutrition among hospitalised patients in Sri Lanka ranges from 30% to 70%. Malnutrition in hospitalised patients is associated with many adverse outcomes including impaired immune system, prolonged ICU and hospital stay, increased recurrent hospitalisation, delayed recovery from disease, leading to increased morbidity and mortality. Therefore, evidence has shown hospital malnutrition ultimately impair the patient's quality of life and increased the health care cost.

When considering nutrition care in critically ill patients which coincide with several challenges. Usually, an acute illness associated with a "catabolic response" does not completely reverse even with nutritional support.

Many patients admitted to the Intensive Care Units (ICU) are malnourished on admission. Increased catabolism in critical illness further aggravates the risk of malnutrition. In complicated patients, malnutrition tends to recognized only in a late stage of treatment. Therefore, timely and tailored nutritional intervention is pivotal to prevent malnutrition of all patients in the ICU.

Following critically ill patients in ICUs are at higher risk of malnutrition:

- All patients staying in the ICU more than 48 hours
- Patients who need higher level of organ support in ICU
- Patients with sepsis
- Patients who are underfed >5 days
- Patients who presented with multiple chronic diseases.
- Patients more than 70 years of age

Metabolic stages *of* critical illness

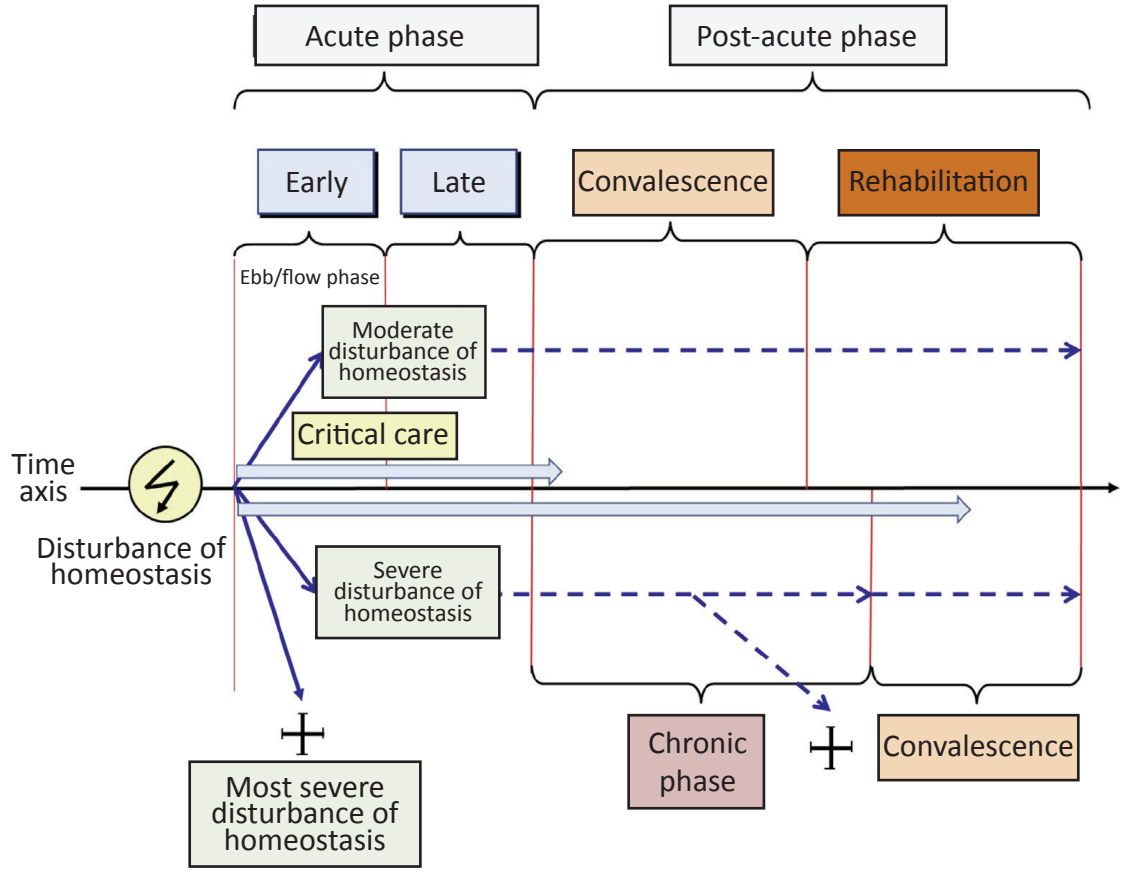
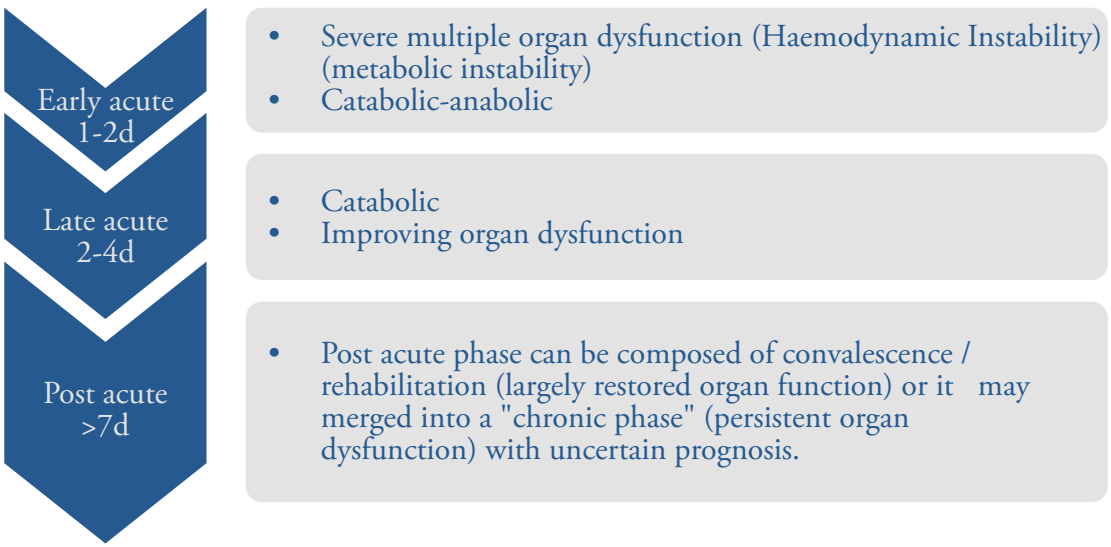


Figure 1: [Source - G.Elke et al / clinicl nutrition ESPEN 33(2019)220-275]
[The 'ebb' phase comprises the hyper-acute early phase of hemodynamic instability which is a reason for ICU admission, while the 'flow' phase includes a subsequent period of metabolic instability and catabolism which can be more or less prolonged. The post-acute phase can be described as a "recovery" phase (duration >7 days), and which is followed by a "rehabilitation" phase (lasting several months). Alternatively, the "post-acute" phase may merge into a "chronic" phase (of uncertain duration) characterised by persistent organ dysfunction and an uncertain prognosis might be ended up by death as shown by below flow chart.



Goals of Medical Nutrition Therapy **(MNT)** in **Critically Ill Patients**

- Early identification and timely intervention to prevent and treat malnutrition
- To decrease the catabolic response to prevent oxidative cellular damage in preserving lean body mass.
- To prevent ICU acquired infections by providing positive immunologic modulation through intensive MNT
- To reduce ICU acquired myopathy and assist early weaning from organ supports
- To accelerate recovery from disease, shortened convalescence and shortened the length of ICU stay.

Steps of **MNT** in **Critically Ill Patients**

STEP 1: NUTRITIONAL SCREENING

STEP 2: NUTRITIONAL ASSESSMENT

STEP 3: CALCULATION OF MACRO AND MICRO-NUTRIENT REQUIREMENT

STEP 4: SELECTION OF ROUTE OF NUTRIENT ADMINISTRATION

STEP 5: DELIVERING OF TARGET NUTRIENTS

STEP 6: COMPLICATION MANAGEMENT

STEP 7: MONITORING, EVALUATION AND READJUSTMENT

Step 1 : Nutritional Screening

Screening of nutritional status is the first step in the MNT process. At risk for malnutrition should be considered in every critically ill patient staying for more than 48 h in the ICU.

Eligibility criteria

All ICU patients should be screened for malnutrition or potential risk of malnutrition.

Screening tools

To date, there is no any validated tool for critically ill patients to screen for malnutrition. While waiting for a validated screening tool, general clinical assessment should be performed to assess malnutrition. Validation of following screening tools in ICUs is still pending.

1. Nutritional Risk Screening 2002 (NRS 2002) (Annexure 1)
NRS includes a BMI 20.5 kg/m^2, weight loss >5% during the last 3 months, reduced dietary intake, and disease severity. NRS values >3 indicate at-risk patients, and values > 5 high-risk patients.

2. Subjective Global Assessment (SGA)
This screening tool incorporates weight loss, dietary intake, gastrointestinal symptoms, functional capacity, disease severity, physical signs of malnutrition etc. When weight loss percentage is available, this tool can be used.

3. Mid Upper Arm Circumference (MUAC)
Though it is not very accurate in critically ill when BMI and weight loss data are not available this tool can be used.

Step 2 : Nutritional Assessment

All at risk of malnutrition patients should undergo detailed nutrition assessment to arrive at a nutrition diagnosis.

Relevant parameters to assess:

1. History

- Weight loss & dietary history
- Disease severity & co-morbid conditions
- The function of the gastrointestinal tract

2. Nutrition focused physical examination

- General and system examination (Annexure 3)

3. Biochemical evaluation

- Full blood count, C- Reactive Protein (CRP), Blood sugar
- Renal and liver function tests
- Electrolytes (sodium, potassium, phosphate, calcium, magnesium)
- Iron studies when necessary
- Vitamin assays when necessary
- Other nutrition-related investigations when necessary Eg: fecal antitrypsin, fecal elastase, Hydrogen breath test, etc

4. Lean body mass (LBM) evaluation-

- LBM may be evaluated by ultrasound, computerized tomography (CT) scan or magnetic resonance imaging (MRI). An assessment of body composition in a critically ill patient by Bio-impedance Analysis (BIA) is often limited by the fluid compartment shifts therefore which may be checked indirectly using a phase angle.

- Muscle function may be assessed by a handgrip dynamometer being an especially good prognostic factor in conscious patients with Adult Respiratory Distress Syndrome (ARDS).

5. Global Leadership Initiative on Malnutrition Criteria (GLIM criteria)

GLIM criteria can be used to grade the severity of malnutrition. It need to be validated for different ethnic groups. (Annexure 2)

Step 3 : Calculation of Energy & Nutrient Requirement

Energy requirements

- Energy requirement of critically ill patients is not constant, attributed to fluctuations with the phase of the disease. Hence, the energy requirement should be determined by using indirect calorimetry (IC) which is the gold standard. However if a patient's oxygen concentration is less than 60%, indirect calorimetry may not yield reliable results.
- If IC is not available, the Reverse Fick method can be used. Here oxygen consumption (VO2) from pulmonary arterial catheter or carbon dioxide production (VCO2) derived from the ventilator can be used to calculate Resting Energy Expenditure (REE= VCO2 x 8.19). The Reverse Fick method has been demonstrated to be more accurate than weight based equations but less accurate than the IC.
- When IC is not feasible, VO2 or VCO2 measurements or simple weight-based equations (20-25kcal/kgBwt/d) can be used.
- The simple weight-based equations are more user friendly in practical settings. Non-dietary calories should be calculated into total calorie intake. (eg: use of propofol for sedation purposes, use of citrate anticoagulation for renal replacement therapy)
- Hypocaloric nutrition (HN) should be administered in the "early acute phase" (refer figure 1) of the acute illness. In HN which should not exceed 70% of total energy requirement (ie: less than 70% of IC value or 70% of Reverse Fick Method value or 20-25 kcal/kgBwt/d x 70%)
- In "late acute phase"(refer figure 1), if IC is used, isocaloric nutrition can be gradually implemented in critically ill patients.
- If IC is not available, HN (below 70% of estimated needs) may be continued over isocaloric nutrition in the "late acute phase" and throughout the first week of ICU stay in critically ill patients.
- In obese patients (BMI >30kg/m^2, when IC is not available, energy requirement can be calculated based on "adjusted body weight").

Disease phase	Organ dysfunction	Metabolic state	Approximate period	Energy target (with Indirect Calorimetry)	Energy target (without Indirect Calorimetry)
Acute phase					
Early acute phase (Ebb)	Severe multiple organ dysfunction (haemodynamic instability)	Catabolic	1-2d	Hypocaloric (<70% of goal)	20-25 kcal/kgBwt/d x70%
Late acute phase (Early flow)	Improving organ dysfunction (metabolic instability)	Catabolic - anabolic	2-4d	Gradually increase to isocaloric goal	20-25 kcal/kgBwt/d x70%
Post Acute phase					
Convalescence / rehabilitation (Late flow)	Largely restored organ function	Anabolic	>7d	IC value	>25Kcal/kgBwt/d (adjust accordingly)
Chronic phase	Persistent organ dysfunction	Catabolic	>7d	IC value	IC value

Carbohydrate requirements

- Minimum requirement - 2 g/kgBwt/day (100-150mg/day)
- Usual requirement - 3 – 4 g/kgBwt/day
- Maximum requirement - not exceeding 7 g/kgBwt/day

- The amount of carbohydrates in PN or EN should not exceed 5 mg/kgBwt/min to prevent "stress-induced hyperglycemia". Insulin protocols should be adopted accordingly.

- Excessive glucose-based energy provision is associated with hyperglycemia, enhanced CO2 production, enhanced lipogenesis, increased insulin requirements compared to lipid added energy provision.

Protein requirements

- Marked proteolysis and muscle loss is coincide with critical illness and which is associated with ICU acquired weakness. Therefore, evidence has suggested to increase protein intake along with appropriate physical activity in critically ill patients.
- Generally 1.3 g/kgBwt/day is recommended in critically ill patients. The utilization of protein depends on an adequate energy intake, and usually 1g of protein often needs 30-40kcal energy.
- In obese patients (BMI >30kg/m^2) protein intake should be calculated according to adjusted body weight.
- Protein intake should begin with 75% of the protein target and should be increased subsequently to 100% of the target by the end of the acute phase.

Specific amino acids requirements – Glutamine (GLN) - It is an immune-modulating amino acid that acts as the main fuel for enterocytes. It has specific clinical indications as mentioned below. Under physiological conditions, sufficient GLN levels are maintained by both endogenous synthesis (skeletal muscle and liver) and daily dietary intake. (80g of mixed protein diet contains approximately 10g GLN).

However, all critically ill patients are not GLN depleted. It is recommended to provide additional enteral GLN for critically ill burn and trauma patients as follows.

Special situation	Additional enteral doses of GLN
Burn > 20% body surface area	0.3-0.5 g/kgBwt/day for 10-15 days as soon as enteral nutrition is commenced
Trauma	0.2-0.3 g/kgBwt/day for the first 5 days with enteral nutrition
Trauma with complicated wound healing	0.2-0.3 g/kgBwt/day administered for 10 to 15 days

Lipids requirements

- 30 – 35% of total calories should be from lipids. For intravenous lipids, the recommendation is 1 g/kg Bwt/d with a tolerance of up to 1.5 g/kgBwt/day. Parenteral lipid infusion should be delivered at least over 12 hours/day.
- Intake of non-dietary calories (eg: propofol) should be calculated to total energy intake. Propofol solution contains 1.1 kcal/mL and provides a significant hidden calorie load.
- When patients receiving lipid emulsion, 0.1-0.2g/kgBwt/day of essential fatty acids are recommended (Eicosapentanoic acid/EPA and Docosahexanoic acid/DHA).

Micronutrient (trace elements and vitamins) and anti-oxidants requirements (see- Annexure 6)

- Providing micronutrients in chronic and acute deficiency is an integral part of nutritional support. Usually PN solutions do not contain adequate micronutrients for stability reasons. There are no available studies regarding PN with or without micronutrients. Nonetheless, evidence shows persistently low Zn levels as an important biomarker in sepsis. Therefore, separate micronutrient prescriptions are recommended in critically ill patients.

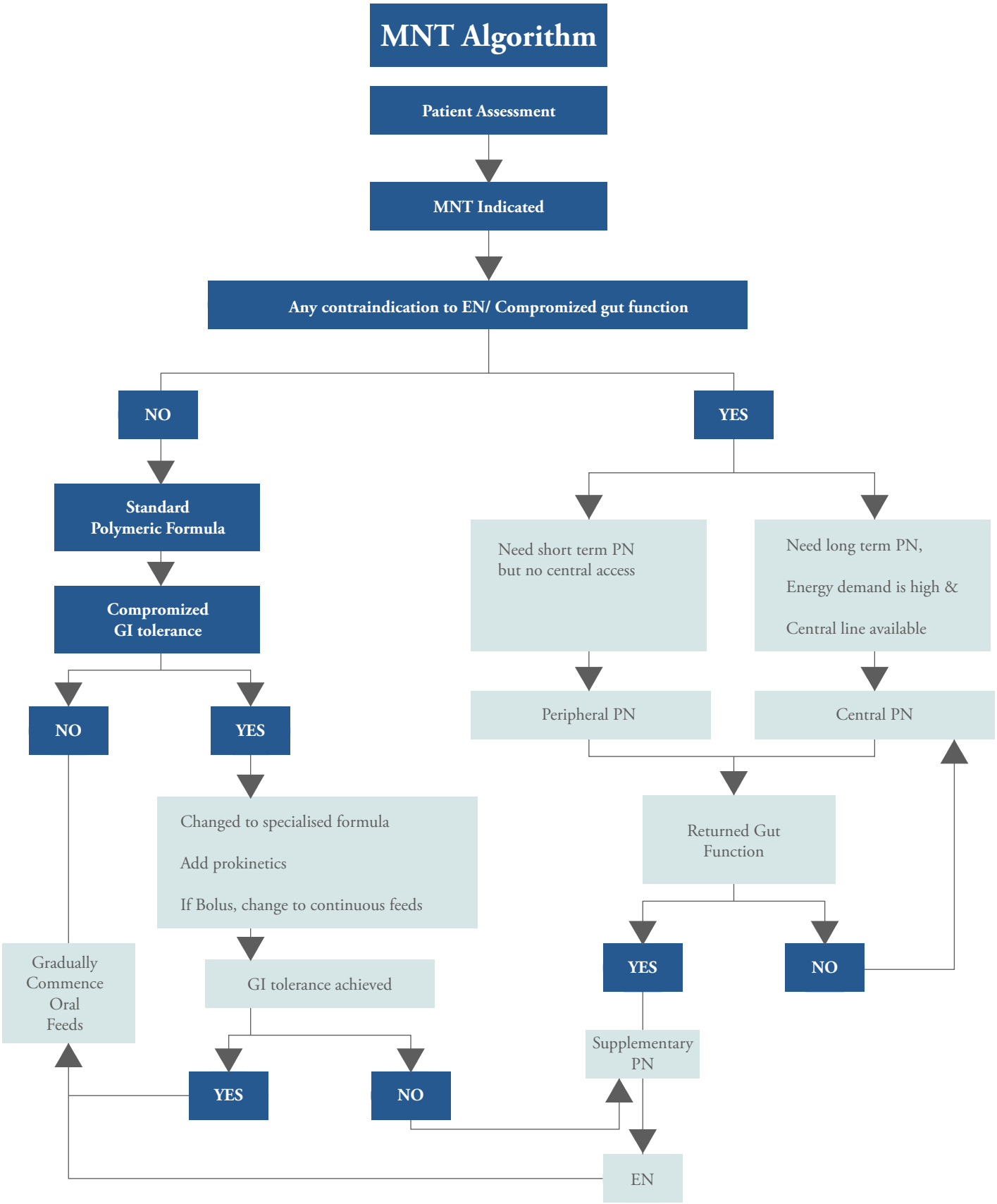
- Continuous renal replacement which tends to cause acute micronutrient deficiencies and particularly of severe copper deficiency needs appropriate micronutrient correction.

- Lack of evidence related to micronutrient replacement during PN has created the uncertainity of the correct timing of its initiation. Micronutrients (i.e. trace elements and vitamins) can be provided daily with PN particularly, vitamin C, E, zinc, copper and selenium.

- Antioxidants as high dose monotherapy should not be administered without proven deficiency.

- If plasma 25-hydroxy-cholecalciferol< 12.5 ng/ml (<50 nmol/l), enternal or intramuscular vitamin D3(300,000 IU) as a single dose within a week after hospitalisation.

Step 4 : Decision on the route of Nutrient Administration



Enteral nutrition (EN)

- If there is no contraindication, feeding should be started within 24 – 48 hours of ICU admission. Patients who are capable to eat, oral diet is preferred over EN or PN in intensive care units.
- If oral intake is not feasible, early EN (within 48 hours) should be commenced rather than delaying EN.
- When initiating EN, standard polymeric formula is recommended in ICU settings. Standard polymeric formulas are isotonic or near isotonic, so will be well tolerated.
- Literature do not support routine recommendation of any specialty formula such as disease specific(diabetes), organ specific (pulmonary, renal, hepatic), semi-elemental, elemental, or immune modulating formulas in critically ill patients.
- EN should be withheld in patients with unstable hemodynamics (mean arterial blood pressure <50 mm Hg). If patients are being initiated inotropes (eg, norepinephrine, epinephrine, dopamine) or escalating doses are required, EN should be withheld until achieve the hemodynamic stability. Can start EN, while patient is on stable, low dose of inotropes under close supervision to detect possible early signs of gut ischemia.

- Always use EN rather than PN if possible due to its beneficial effects such as,
  - Reduce gut atrophy, preserving intestinal epithelium and tight junctions.
  - Improve gut motility and gut immunity
  - Preserving secretion of brush border enzymes.
  - Avoid translocation of organisms
  - Cost-effective

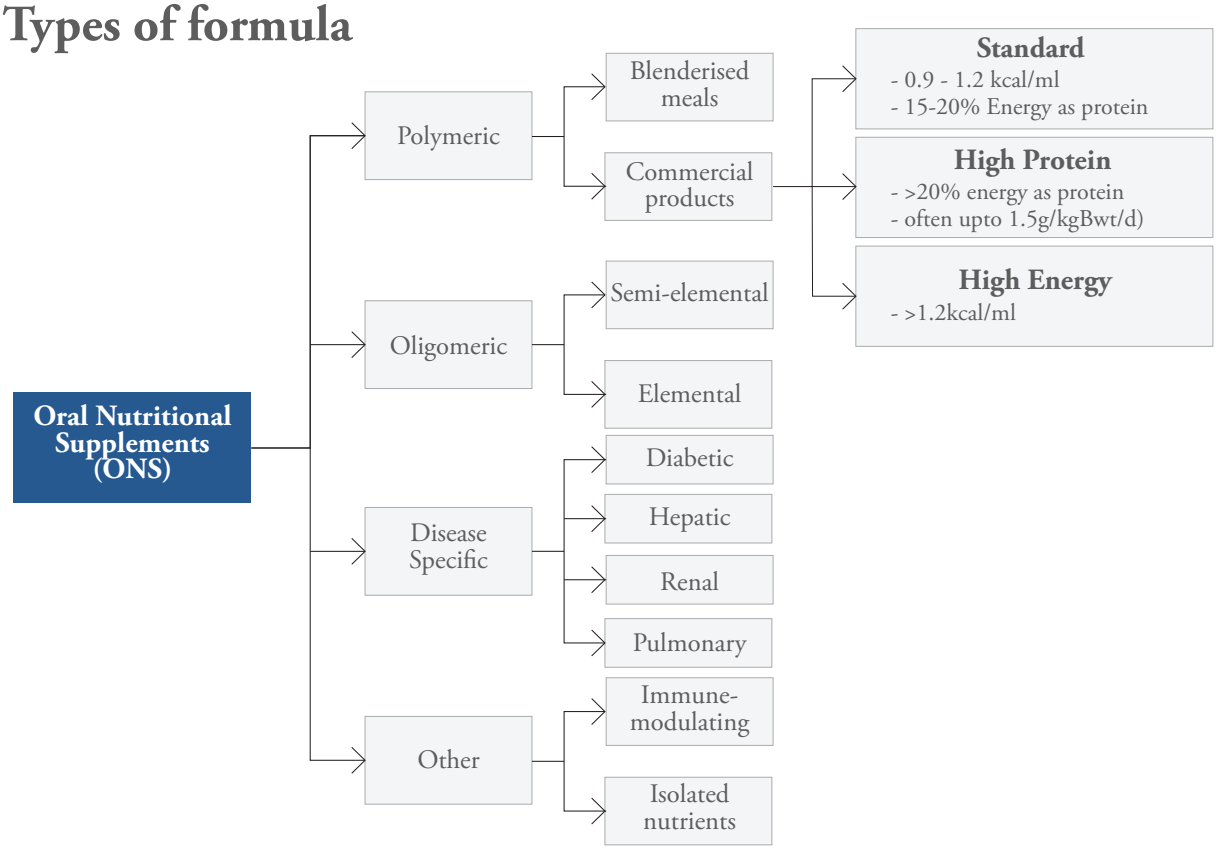
- If EN does not tolerate, at least trophic feeding (10–20 mL/h or 10–20 kcal/h up to a maximum of 500 kcal/day) should be encouraged which is athe minimal administration of nutrients having beneficial effects on EN.
- Full EN and PN within 48 hours shall not be provided in critically ill patients' perspective of preventing metabolic derangement. (see STEP 4 – calculation of energy requirement)
- In the early phase of critical illness, hyperalimentation should be avoided by any route as early full feeding adds to the endogenous energy production which amounts to 500 to 1400 kcal/day.
- Early full feeding also increases the risk of refeeding complications.
- Monitoring of established EN with continued measurements of GRV does not require and that EN should be delayed when GRV is >500 mL/6 h. In this situation, the application of prokinetics should be considered. (see- EN related complication management - page 19)
- If GRV not improved with prokinetic agents, post-pyloric feeding should be used.
- The routine use of the post- pyloric route is currently not justified, considering the post pyloric tube placement requires expertise, and the time delay in initiation of EN.

Methods of delivering EN

Modes of administration could be either one of the following. Even though bolus feeding is much physiological, continuous feeding is preferred to bolus feeds in critically ill patients. However, heterogeneity of the studies regarding bolus and continuous feeding have decreased the strength of this recommendation.

Type of EN feeding	Method	Indications and advantages
1. Bolus	• 200-400ml of feeds down a feeding tube over 10-15 min at least every 3 hours during daytime. Use a syringe or gravity drip via a feeding container	• More physiological • Friendly with ambulation • May improve the quality of life (support patient`s autonomy)
2. Intermittent	• Feed over 20-60 min at least every 3 hours during daytime • Used infusion pump or gravity-drip.	• Transmission from continuous to bolus feeding • When bolus feeding is poorly tolerated
3. Continuous	• 24 hours at a steady rate (mL/h) • Volume infused vary from < 50 mL/h to > 150 mL/h, depend on patient's requirements and tolerance • Used infusion pump or gravity-drip method	• Post pyloric feeding or small bowel feeding • Improve feeding tolerance
4. Cyclic	• Similar to continuous feeding but run less than 24 h per day at a higher rate (mL/h) • Used infusion pump or gravity-drip.	• Friendly with ambulation and improved quality of life • Option for nocturnal feeding

Types of formula



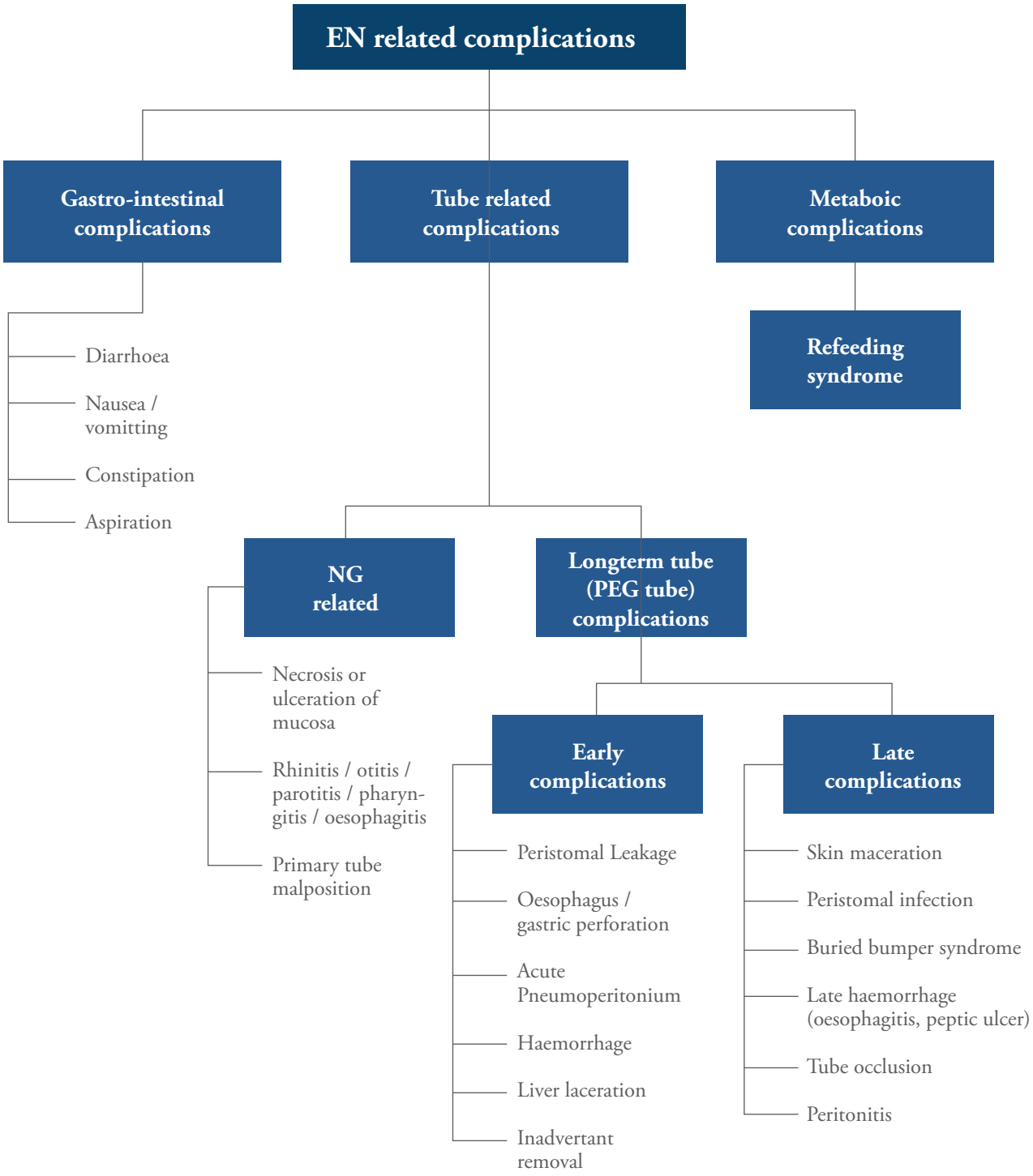
Special situations in EN

Early EN should be administered (adapted by ESPEN 2019)
1. Patients after some upper GI surgery, abdominal aortic surgery
2. Patients with traumatic brain injury, stroke (ischemic or hemorrhagic)
3. Patients with spinal cord injury
4. Patients with severe acute pancreatitis
5. Patients with abdominal trauma when the continuity of the GI tract is confirmed/restored
6. Patients receiving neuromuscular blocking agents
7. Patients managed in a prone position
8. Patients with open abdomen
9. Patients receiving Extracorporeal membrane oxygenation (ECMO)

Delayed EN should be administered (adapted by ESPEN 2019)
1. If hemodynamically unstable whereas low dose EN can be started as soon as the shock is controlled with fluids and vasopressors/inotropes while remaining vigilant for signs of bowel ischemia
2. Severe hypoxemia (PaO_2<50) - Till patient has stable hypoxemia
3. Hypercapnia ($PaCO_2$ >80)- Till compensated or permissive hypercapnia (PaO_2-70 -75 enteral nutrition can be resumed)
4. Acidosis (Serum lactate >3-4 mmol/l, pH <7.2)
5. Active upper GI bleeding - Whereas EN can be started when the bleeding has stopped and no signs of re-bleeding are observed
6. Overt bowel ischemia
7. High-output intestinal fistula if reliable feeding access distal to the fistula is not achievable
8. Abdominal compartment syndrome (Intra-abdominal pressure >20 mmHg)
9. Gastric aspirate volume if above 500 ml/6 h

Low dose EN should be administered (adapted by ESPEN 2019)
1. In patients receiving therapeutic hypothermia and increasing the dose after rewarming
2. Intra-abdominal hypertension without abdominal compartment syndrome. Whereas temporary reduction or discontinuation of EN should be considered when intra-abdominal pressure values further increase under EN (>20mmHg)
3. Acute liver failure. When acute and immediately life-threatening metabolic derangements are controlled with or without liver support strategies, independent of the grade of encephalopathy.

This diagram shows the EN related complications



Management of EN related complication

Look for the possible complications provided below and adopt the preventive and management regimes.

Gastric feeding intolerance (High gastric residual volume - GRV)

- High GRV can be neglected up to 500 ml.
- Try to decrease opiates and noradrenaline use, optimize glycemic control
- Correct electrolytes imbalances and prevent fluid overload.
- IV erythromycin (100 - 250 mg tds) or IV erythromycin (3-7 mg/kgBwt/day) for 2 – 4 days should be used as first-line prokinetic therapy.
- Alternatively, IV metoclopramide (10mg tds) for 2-4days.
- The effectiveness of prokinetics is decreased to one third after 72 h & if GRV persists > 500ml, the post-pyloric feeding should be considered.

Diarrhoea

- Continue the feeds while evaluating etiology.
- If bolus intolerance- change to the infusion
- If high delivery rate - Reduce the feeds by half (120ml/hour is equivalent to the physiologic flux into the duodenum from the stomach)
- If high osmolality – Use an isotonic solution
- If polymeric feed not tolerates, consider low molecular formula (special feeding formulas containing amino acids or small peptides may be helpful)
- Maintain an ideal temperature of feed (avoid cold feeds)
- Exclude antibiotic-associated diarrhoea (Clostridium difficile)
- Take universal precautions to prevent infections
- Consider Low FODMAP diet / lactose free/ gluten-free
- Review drug list to detect any diarrhoea causing preparations (antibiotics, magnesium antacids, sorbitol, etc)
- If on fiber-free formula, change to fiber included formula and vice versa. But, avoid soluble or insoluble formulas in patients with high risk of gut ischemia or severe dysmotility.
- No clinical evidence with probiotics. Therefore, routinely not indicated

Pulmonary Aspiration

- Elevate head end of bed 30 - 45, the semi-recumbent position is preferred.
- Consider prokinetics
- Start continuous feed using an enteral infusion pump
- Look for endo-trachial cuff pressure
- Do not give bolus feeding while in prone ventilation.

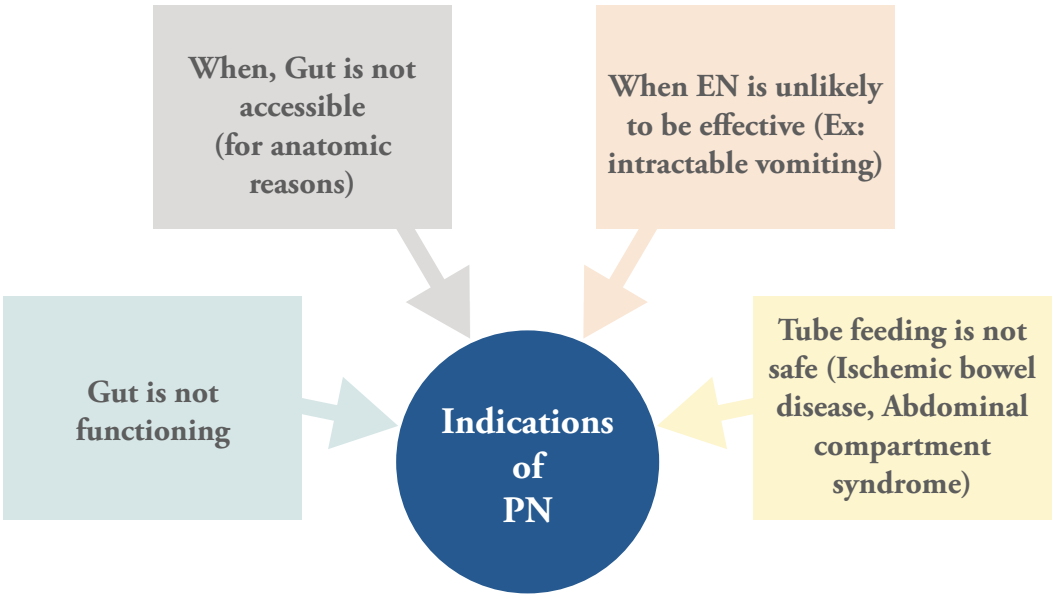
Tube migration & displacement

- NG tube has to be inserted preferably by a skilled person
- Take Chest X-Ray to confirm the placement.
- Properly tape the tube without pressure and tension
- Check the tube position before each feed
- Use tubes that fit the stoma site, prevent leakage at stoma site
- Routinely inspect & cleanse ostomy site

Tube Occlusion

- Flush feeding tube with water before & after medications and before and after each feed
- Avoid giving medications and feeds together
- Give each drug separately (minimize drug interactions)

Parenteral Nutrition (PN)

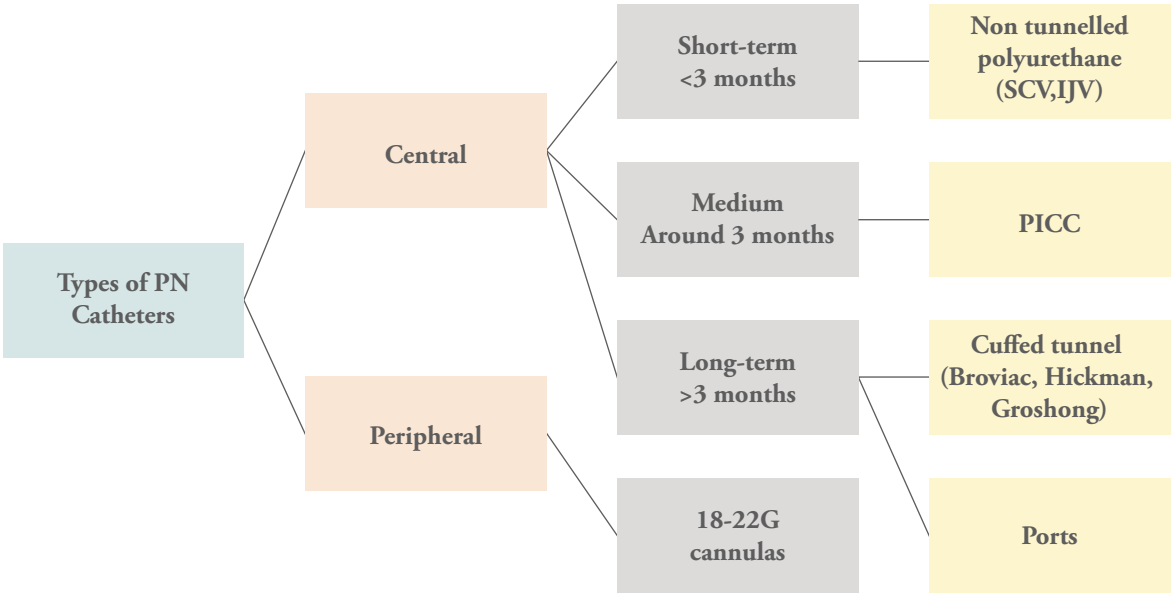


- PN should not be started until all strategies to maximize EN tolerance have been attempted.
- Just in case, if EN cannot be provided, PN can be commenced instead of no nutrition in severely malnourished critically ill patients.
- All patients receiving less than 60% of their targeted EN after two days, can be considered for supplementary PN (SPN). However, according to latest evidence, the best timing to prescribe supplemental PN remains debated. Therefore, the benefits of initiating SPN should be assessed on an individual basis.
- The optimal time point for SPN aiming to achieve full caloric needs is suggested to be between 4 to 7 days

Methods of delivering PN

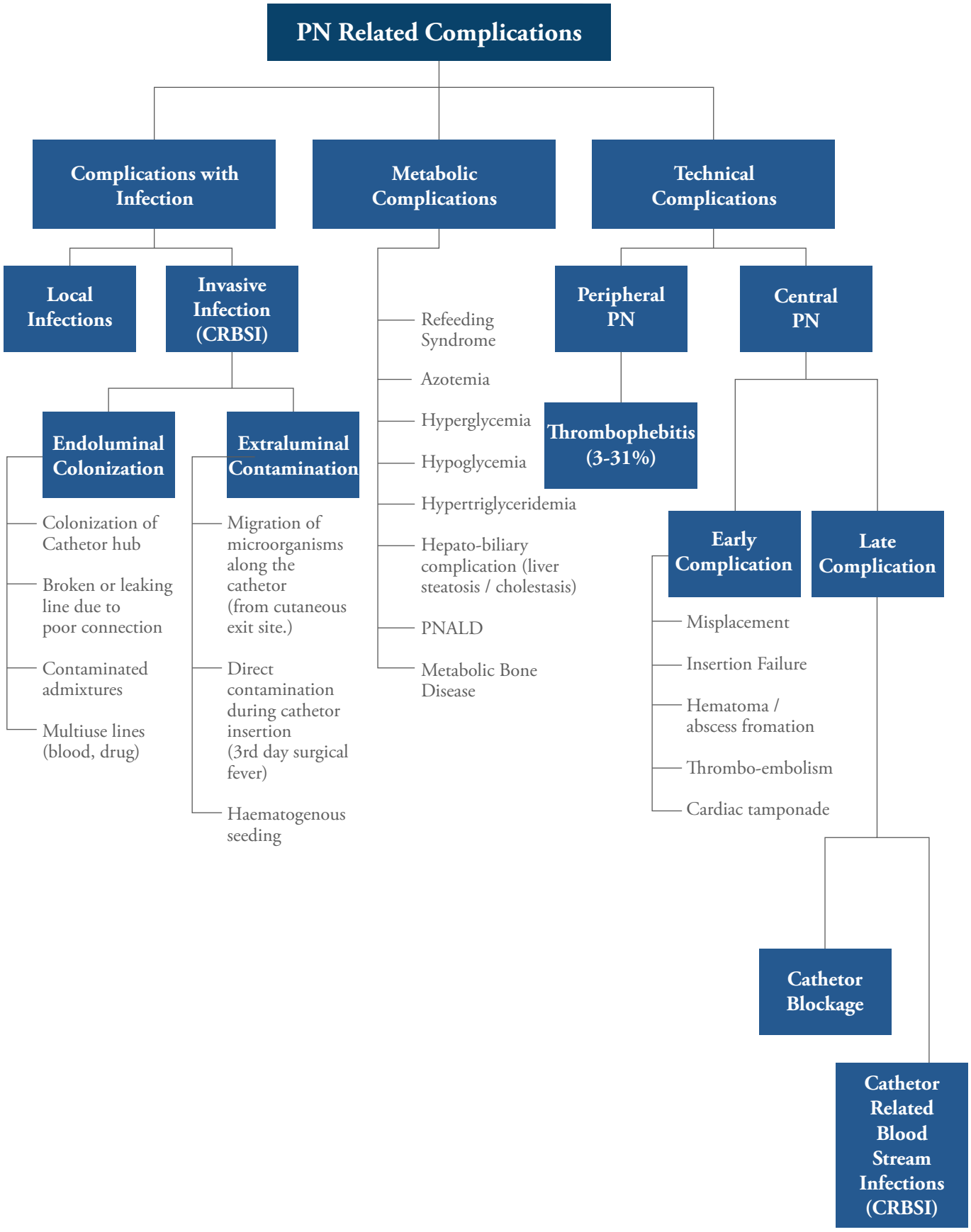
When choosing the appropriate route of access (central venous or peripheral venous catheter), the following criteria should be taken into consideration.

- Condition of the patient (type of illness, the current state of health etc.)
- Accessibility of the venous system
- Composition of the infused solution and amount of energy to be administered
- The osmolality of PN products
- The planned duration of PN (short-term or long-term)



Types of PN catheters	
Central venous catheter	Peripheral venous catheter
• Need PN support more than 7 to 10 days • Patients with difficult peripheral venous access • Can use for hyperosmolar solutions (osmolarity> 850 mosmol/l) • Need glucose concentration > 125 g/l • Need high nutrient requirement • Need a strict fluid restriction • Need administration of solution with pH < 5 or pH > 9 • Need for multiple lumen intravenous treatment	• Need PN for a short duration (7 – 10d) • Severely and moderately malnourished patients with lack of central venous access • Can use osmolarity up to 850 mosmol/l • When a central venous PN is not justified due to catheter sepsis or bacteremia

Types of PN formula	
Multi bottle system	Combined systems
1. Dextrose solutions • Concentration available from 5% up to 70% • 12.5% is safe for peripheral administration. **2. Amino acids solutions** • Standard amino acids (5 or 10%) • Organ-specific amino acids (hepatic or renal insufficiency) • Special amino acid additive (glutamine) **3. Lipid emulsions** • Intralipid or Lipofundin 10%, 20% • Lipid with Fish oil • As SMOF (Soya bean oil, Medium -chain triglycerides, olive oil and Fish oil) fatty acid mixtures. Multi bottle system, as high risk of microbial contamination due to line manipulations which need 3 pumps. But the cost is low and can prepare a tailored plan	• Compounding system "All in One" hospital mixtures (not available in Sri Lanka) Amino acids, glucose and lipids are combined in a single infusate, along with electrolytes, vitamins and trace elements as required. • Designed for immediate intravenous administration, with no mixing or admixing required before administration. • Fewer line manipulations, reduced cost (only capital investment for laminar flow cabins) • Need 1 infusion • Can store in fridge ~ 5-7d (shelf life)
2. Water and fat-soluble vitamins • 9 essential water-soluble vitamins (B complex and vitamin C) • 4 essential fat-soluble vitamins (Vitamin A, D, E, K)	"Ready to Use" Commercial preparations 1. **Two-chamber bags-** (glucose and amino acids) 2. **Three chamber bags-** (lipid, amino acids and glucose) • Separate chambers - Shelf life ~ 12 months in room temperature • Not a tailor-made, Costly
3. Trace elements • 8 essential trace elements and fluoride (Chromium, manganese, iron, copper, zinc, molybdenum, selenium, iodine)	


PN Related Complications
Complications with Infection
Metabolic Complications
Technical Complications
Local Infections
Invasive Infection (CRBSI)
Refeeding Syndrome
Azotemia
Hyperglycemia
Hypoglycemia
Hypertriglyceridemia
Hepato-biliary complication (liver steatosis / cholestasis)
PNALD
Metabolic Bone Disease
Peripheral PN
Central PN
Thrombophebitis (3-31%)
Endoluminal Colonization
Extraluminal Contamination
Colonization of Cathetor hub
Broken or leaking line due to poor connection
Contaminated admixtures
Multiuse lines (blood, drug)
Migration of microorganisms along the cathetor (from cutaneous exit site.)
Direct contamination during cathetor insertion (3rd day surgical fever)
Haematogenous seeding
Early Complication
Late Complication
Misplacement
Insertion Failure
Hematoma / abscess fromation
Thrombo-embolism
Cardiac tamponade
Cathetor Blockage
Cathetor Related Blood Stream Infections (CRBSI)

Management of PN related complications

Peripheral vein thrombophlebitis
• Aseptic techniques during catheter placement and care • Choice of the smallest gauge possible • Use of polyurethane and silicone catheters • Use of lipid-based solutions, The appropriate osmolarity & PH (5 and 9) • Adequate fixation (transparent adhesive membranes or sutureless fixation devices)
Catheter-related infections
• Use of single-lumen catheters • Appropriate insertion site, Adhere to central venous catheter care bundle • Disinfection of hubs, stopcocks, and needle-free connectors • Regular change of administration sets
Nausea and vomiting due to too fast infusion
• The maximum infusion rate of amino acids up to 0.1 g/kgBwt/h • Infusion time of amino acids at least 7 hours (500 ml of a 10% amino acid solution) depending on body weight; infusion over 24 hours is recommended. • The maximum infusion rate of lipids up to 0.15 g/kgBwt/h • The recommended flow rate of All-in-One 3 ml/kgBwt/h
Hyper-/hypoglycemia
• Continued/cyclic TPN with tapering, Blood glucose monitoring, at least 4 hourly. • Maintain blood glucose levels between 140-180mg/dl • Adopt insulin infusion.
Hypertriglyceridemia
• Change in a lipid formulation • Monitor triglycerides weekly & adjust lipid dose (Target is to keep level <250mg/dl)
Fluid and electrolyte disturbances
• Daily weight, electrolytes monitoring • Check ABG appropriately
PN associated liver disease (PNALD) /cholestasis
• Enteral stimulation- (start small dose EN or trophic feeding) • Encourage cyclical PN • Avoid over feeding (glucose <7mg/kgBwt/min, ideally 4-5mg/kgBwt/min; fat <1g/kgBwt/d) • Replace with SMOF • Precautions to prevent infections [(Catheter-related bloodstream infections (CRBSI), Small bowel bacterial overgrowth (SIBO)] • Treat for SIBO (Rifaximin 550mg bd, metronidazole prophylaxis) • Consider use of ursodeoxycholic acid (20-30mg/kgBwt/d) • Treat for short bowel syndrome – consider intestinal lengthening
Bone disease
• Adequate supplementation of Calcium, vitamin D and mobilisation • Prevent aluminum, cadmium, strontium toxicity • Use bisphosphonates if necessary, Monitor bone density

Step 5 : Monitoring of Nutrition Support

Nutritional monitoring

- Total amount of nutrients provided
- Reaching nutritional goals
- Bodyweight or MUAC
- Any signs of malnutrition

Clinical and metabolic monitoring

Parameter	Daily	Thrice a Week	Weekly	PRN
Weight	Initially		✓	
Mid Upper Arm Circumference(MUAC)			✓	
Glucose	Initially	✓		
Electrolytes	Initially	✓		
PO4--/Mg++/Ca++/BUN/Cr		Initially	✓	✓
Triglycerides			✓	✓
Total Bilirubin/ LFT		Initially	✓	✓
Albumin				✓
FBC	✓			

In ICU, laboratory parameters are important to prevent or detect severe complications such as refeeding syndrome or liver dysfunction related to nutrition, as well as to assist in the achievement of normoglycemia and normal electrolyte values.

Energy adjustment should be done according to the clinical situation.

Step 6 : Complication Management

Refeeding Syndrome (ESPEN blue book)

Refeeding syndrome is the most common complication and defined as a range of metabolic and electrolyte alterations occurring as a result of the reintroduction and/or increased provision of calories after a period of decreased or absent caloric intake.

1-3 Days	4-6 Days	7-10 Days
• Start at 10 kcal/kgBwt/d, slowly increase to 15 kcal/kg/d (50-60% carbohydrate, 30-40% fat and 15-20% protein) • 100% RDA of minerals & trace elements (except iron) – Annexure 6 • 200% RDA of vitamins • IV Thiamine 200-300mg daily • Fluid only to achieve zero balance (20-30 ml/kgBwt/d) • Restrict sodium to < 1 mmol/kgBwt/d	• Energy:10-20kcal/kgBwt/d Electrolytes - Aims to restore normal levels as above; • If Phosphate <0.6mmol/l- Give IV phosphate 30-50mmol over 12hrs • If Mg <0.5mmol/l – give IV MgSO4 24mmol over 12 hrs • If K+ <3.5mmol – give IV KCl > 20-40mmol over 4-8 hrs • Continue vitamins and minerals (except iron) • Fluid to 25-30 ml/kgBwt/d	• Energy: 20-30 kcal/kgBwt/d • Electrolytes, vitamins & minerals as above (If needed can commence iron D7 onwards) • Fluid to 30 ml/kg/d
• Comprehensive clinical assessment • Electrolytes daily • Other lab parameters • If severe do ECG • Bwt daily (if possible)	• Electrolytes & Bwt every 3rd day	• Biochemistry & Bwt weekly

Electrolyte management		
Hypokalemia	• Potassium up to 0.5 mmol/kgBwt/hour; in renal patients maximum 0.25 mmol/kgBwt/hour	Daily
Hyperkalemia	• Dextrose/insulin infusion • Correction of acidosis	Daily
Hypomagnesaemia	• Maintenance requirement 0.2 mmol/kgBwt/d intravenously (or 0.4 mmol/kgBwt/d orally) • Mild to moderate hypomagnesaemia (0.5-0.7 mmol/l) - Initially 0.5 mmol/kgBwt/d over 24 hours intravenously, then 0.25 mmol/kgBwt/d for 5 days intravenously • Severe hypomagnesaemia (<0.5 mmol/l) - 24 mmol over 6 hours intravenously, then as for mild to moderate hypomagnesaemia	Daily
Hypermagnesemia	• Decrease Mg intake	Daily
Hypocalcemia	• IV Calcium gluconate	Daily
Hypercalcemia	• Isotonic saline • Inorganic phosphate	Daily
Hyponatremia	• Find the cause • Fluid restriction or diuretics • Increase sodium in feed	Daily
Hypernatremia	• Increasing fluid intake, alter Na rich drug preparations, feeds, etc.	Daily
Hypophosphatemia	• Maintenance requirement 0.3-0.6 mmol/kgBwt/d orally • Mild hypophosphatemia (0.6-0.85 mmol/l) 0.3-0.6 mmol/kgBwt/d orally • Moderate hypophosphatemia (0.3-0.6 mmol/l) 9 mmol infused into a peripheral vein over 12 hours • Severe hypophosphatemia (<0.3 mmol/l) 18 mmol infused in to peripheral vein over 12 hours	Daily

Annexure 1 : Nutrition Risk Score (NRS) - 2002

	Initial screening I	Yes	No
1	Is BMI < 20.5?		
2	Has the patient lost weight within the last 3 months?		
3	Has the patient had a reduced dietary intake in the last week?		
4	Is the patient severely ill? (e.g. in intensive therapy)		

Yes: If the answer is 'Yes' to any question, the final screening is performed.
No: If the answer is 'No' to all questions, the patient is re-screened at weekly intervals.
If the patient e.g. is scheduled for a major operation, a preventive nutritional care plan is considered to avoid the associated risk status.

Final screening II

Impaired nutritional status		The severity of disease (≈ increase in requirements)	
Absent Score 0	Normal nutritional status	Absent Score 0	Normal nutritional requirements Hip fracture
Mild Score 1	Wt loss >5% in 3 months or Food intake below 50-75% of normal requirement in the preceding week	Mild Score 1	Chronic patients, in particular with acute complications: cirrhosis, COPD Chronic hemodialysis, diabetes, oncology
Moderate Score 2	Wt loss >5% in 2 months or BMI 18.5 - 20.5 + impaired general condition or Food intake 25-50% of normal requirement in the preceding week	Moderate Score 2	Major abdominal surgery Stroke Severe pneumonia, hematologic malignancy
Severe Score 3	Wt loss >5% in 1 months (>15% in 3 months) or BMI <18.5 + impaired general condition or Food intake 0-25% of normal requirements in the preceding week	Severe Score 3	Head injury Bone marrow transplantation Intensive care patients (APACHE>10)

Total score = score nutritional status + score (disease severity)

Adjustment for age: if ≥ 70 years: add 1 to total score above

Age adjusted total score =

Score 0: No risk

Weekly re-screening of the patient, if the patient is scheduled for major surgery, consider a preventive nutritional care plan

Score 1-2: Enhanced risk

Weekly re-screening of the patient, if the patient is scheduled for major surgery, consider a preventive nutritional care plan

Score ≥3: High risk

A nutritional care plan is initiated

Annexure 2 : GLIM Criteria

	PHENOTYPE CRITERIA			ETIOLOGY CRITERIA	
	Weight loss (%)	Body mass index (kg/m^2)	Muscle mass[a]	Food intake, malabsorption or GI symptoms	Disease burden/ inflammation
STAGE 1/ MODERATE MALNUTRITION (REQUIRES 1 PHENOTYPIC AND 1 ETIOLOGIC CRITERION)	5 - 10% within the past 6 mo, or 10-20% beyond 6 mo	<20 if <70 yr, <22 if ≥70 yr Asia:<18.5 if <70 yr, <20 if ≥70 yr	Mild to moderate deficit (per validated assessment methods - see below)	Any reduction of intake below ER for >2 weeks, or moderate malabsorption symptoms[b]	Acute disease/injury[d], or chronic disease related[e]
STAGE 2/ SEVERE MALNUTRITION (REQUIRES 1 PHENOTYPIC AND 1 ETIOLOGIC CRITERION)	>10% within the past 6 mo, or >20% beyond 6 mo	<18.5 if <70 yr, <20 if ≥70 yr Asia: TBD	Severe deficit (per validated assessment methods - see below)	50% intake of ER for >1 week, or severe malabsorption/GI symptoms[c]	Acute disease/injury, or chronic disease related[e]

GI = gastro-intestinal, ER = energy requirements, yr = year, mo = month.

[a] For example fat-free mass index (FFMI, kg/m^2) by dual-energy absorptiometry or corresponding standards using other body composition methods like bioelectrical impedance analysis (BIA), CT or MRI. When not available or by regional preference, physical exam or standard anthropometric measures like mid-arm muscle or calf circumferences may be used. Thresholds for reduced muscle mass need to be adapted to race(Asia). Functional assessments like hand-grip strength may be used as a supportive measure.

gastrointestinal symptoms of moderate degree - dysphagia, nausea, vomiting, diarrhoea, constipation or abdominal pain.

[c] Gastrointestinal symptoms of severe degree - dysphagia, nausea, vomiting, diarrhoea, constipation or abdominal pain.

[d] Acute disease/injury-related with severe inflammation. For example, major infection, burns, trauma or closed head injury.

[e] Chronic disease-related with chronic or recurrent mild to moderate inflammation. For example, malignant disease, chronic obstructive pulmonary disease, congestive heart failure, chronic renal disease or any disease with chronic or recurrent Inflammation. CRP may be used as a supportive laboratory measure.

Annexure 3 : Nutrition focused physical examination

1. General appearance • Comfortable • In pain, Ill looking • Dyspnoeic • Emaciated	8. Neck • Goitre • Lymphadenopathy
2. Hair • Colour • Thin, Sparse • Pluckability	9. Muscle • Clavicle • Shoulder • Triceps/ Biceps muscle and fat
3. Face • Febrile • Temporalis muscle wasting • Buccal – Check against resistance • Seborrhoeic dermatitis	10. Upper arms • Check for Phrynoderma • Mid Upper Arm Circumference
4. Eyes • Pallor • Icterus • Bitot spots • Nystagmus • Peri orbital fat pad	11. Hand • Small muscle wasting • OK signHandgrip strength • Nails (Koilonychia, White nails, Clubbing) • If a patient with liver disease, Palmar erythema, Flapping tremor
5. Mouth • Angular stomatitis • Cheilosis • Open the mouth Check for dentition • Fluorosis • Dental caries • Gum hypertrophy/Bleeding • Oral Hygiene • Mucositis and fungal infections (Candidiasis)	12. Leg • Dry/scaly • Scratch marks • Ulcers • Eczema • Sole ulcers • Loss of skin appendages (hair and nails) • Amputations • Oedema • Expose Quadriceps (Media side wasting) • Patella prominence • calf muscles • Hip flection • Knee extension
6. Tongue • Glossitis • Coated tongue	13. Back • Kypho- scoliosis • Muscle wasting • Pressure ulcers • Sacral edema
7. Throat • Tonsils • Inflamed • Uvula movement	

Annexure 4 : Calculations of Parenteral Nutrition

1) Energy Requirement

20-25 kcal/kgBwt/d

Eg: 70 x 25 = 1750 kcal/d

2) Protein Requirement

1.2–1.5g protein per kg per day; 1.2x70=84g

10% aminoplasmin contain 100g of protein per 1000ml; 1ml=0.1g

Daily 10% aminoplasmin requirement= (1.2x70)÷0.1 = 840 ml

3) Carbohydrate Requirement

CARBOHYDRATE = 50 - 55% (minimum of 2g/kgBwt/day) 1750x 50% = 875 kcal

Carbohydrate 1g produces 4 kcal

50% dextrose contains 500g in 1000ml; ie 1ml = 0.5g

Daily 50% dextrose requirement = (875÷ 4) ÷ 0.5 = 437.5ml

4) Fat Requirement

About 30% of calories to be supplied by fat
Eg: 1750 x 30% = 525 kcal

1g of fat produces 9 kcal

10% Lipofundin contains 100g of lipids in 1000ml; 1ml = 0.1g

Daily 10% Lipofundin requirement = (525 ÷ 9) ÷ 0.1 =583 ml

Consider Energy provided by Propofol; 10% Propofol provides 1.1kcal/ml as fat

5) Fluid Requirement

30-35ml/kgBwt/day

= 35 x 70 = 2450 ml/day

Consider the volume of fluid given as infusions

Minerals Daily Requirement

	Daily requirement/kg	For a 70kg adult
K+	1-2 mmol	140 mmol
Mg++	0.2 mmol	14 mmol
Phosphates	0.3-0.6 mmol	21 mmol

Should be guided by the monitoring serum level

Final Prescription For 24 Hours

- 10% Lipofundin - 583 ml
- 50% Dextrose ~ 440ml
- 10% Aminoplasmin - 840ml
- KCl - 140 mmol
- MgSO4 - 14 mmol
- IV phosphate 21 mmol
- Parenteral vitamin mix
- the balance fluid requirement to be prescribed as an appropriate intravenous fluid

Annexure 5 : Micronutrient & Mineral Recommendation

Trace element	Enteral	Parenteral
Zn	8-11mg/d	2.5-5mg/d
Cu	0.9mg/d	0.3-0.5mg/d
Cr	20-30 µg/d	10-15 µg/d
Mn	60-100 µg /d	0.6-1mg/d
Se	55 µg /d	20-60 µg /d
Iodine	150 µg /d	Not routinely added
Iron	12-15mg/d	Not routinely added
Fluoride	3-4mg	Not routinely added

Electrolytes	Enteral	Parenteral
Na	2-4 mmol/kg/d	1-2 mmol/kg/d
K	2-4 mmol/kg/d	1-2 mmol/kg/d
Mg	0.15-0.25 mmol/kg/d	0.1mmol/kg/d
Ca	0.25-0.4 mmol/kg/d	0.25-0.4mmol/kg/d
Phosphate	1-2 mmol/kg/d	0.3-0.5mmol/kg/d
Chloride	2-3 mmol/kg/d	2-3 mmol/kg/d

Vitamin	Enteral	Parenteral
Vitamin A	2300-3000 IU	3000IU
Vitamin D	600-800IU	2000IU
Vitamin E	10 IU	10 IU
Vitamin K	90-120mg	150 µg
Vitamin C	50-100 mg	50-100 mg
B1	1.2-1.4mg	6mg
B2	1.1-1.3mg	3.6mg
B3	14-16mg	40mg
B12	2.4 µg	5 µg

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