Nutrition in Critically Ill Patients

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Introduction

- Nutritional Support has become a routine part of the care of critically ill patients
- Nutritional Support refers to enteral, parenteral provision of calories, proteins, electrolytes, vitamins, minerals, trace elements and fluids.
- These patients are hyper metabolic and have increased nutritional requirements.
- In critically ill patients malnutrition develop rapidly due to the presence of acute phase responses, which not only promote catabolism but also alter the response to nutritional support.
- Malnutrition once established exerts well-known deleterious effects by altering immunity, increasing susceptibility to nosocomial infections, decreasing wound healing and promoting organ failure.

A Practical Approach During Nutrition.

- When should nutrition supplementation be initiated .
- Which route should be used for the delivery of nutrient.
- What special precaution should be taken before initiating supplementation in the patients (Diabetic background, Cardiac Diseases, Chronic Renal Failure).
- Termination of Parenteral Nutrition

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Assessment of Nutritional Status

Nutritional Assessment in critically ill patient is very difficult. These are summarized as- A,B,C,D

- Anthropometric Measurements: It measures the current nutritional status

  Body Weight: 10% loss is considered **SIGNIFICANT**
  20% loss is considered **CRITICAL**
  30% loss is considered **LETHAL**

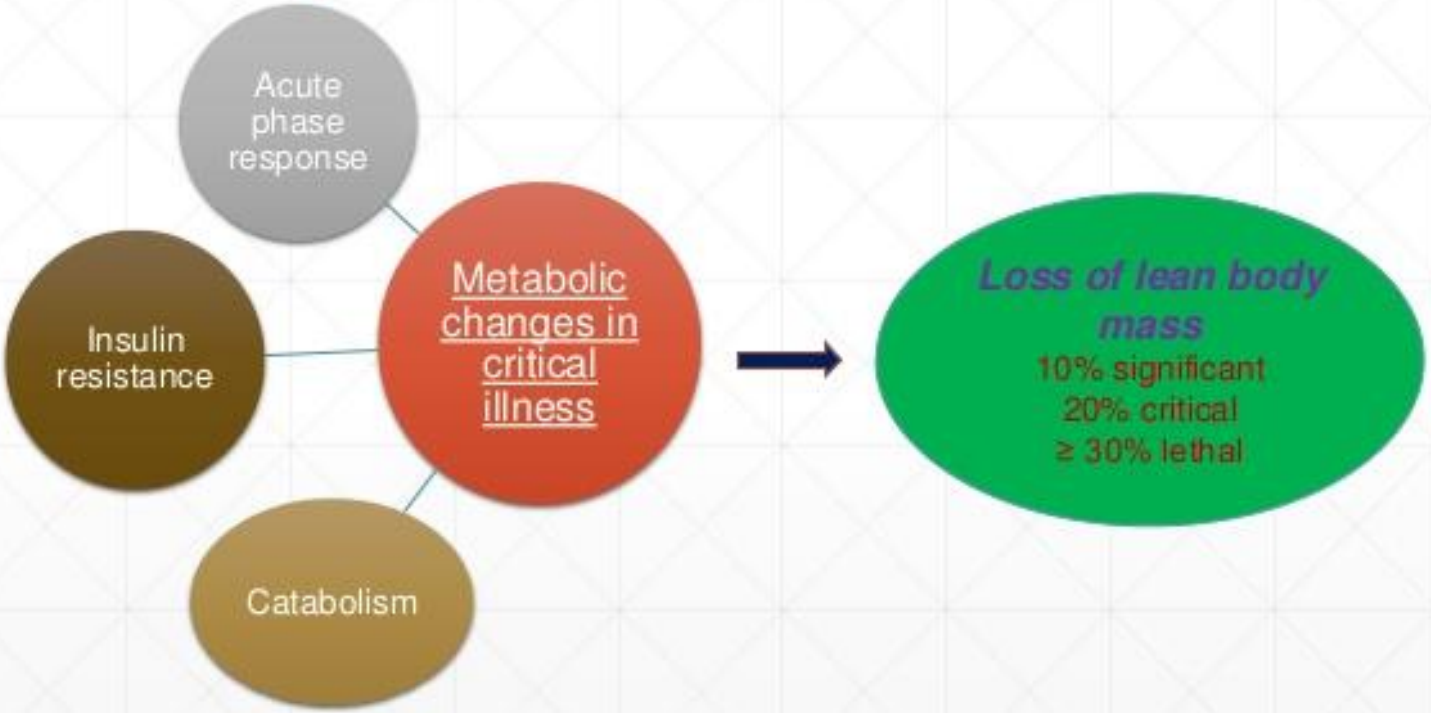
  Mid-Arm Circumference
  Skinfold thickness
  Head-Circumference
  Head Chest Ratio

Nutritional Indices:BMI Body Mass Index (BMI)

BMI= Weight in Kg/ Height in m^2

It is an independent predictor of mortality in seriously ill patients.

Importance of nutrition in critical care



- ***Biochemical tools***: Hemoglobin

  Albumin

  Transferrin

  Pre-albumin

  Lymphocyte Count

- *Clinical Assessment*: It is simplest and most practical method.

  Good nutritional History

  General physical examination

  Loss of subcutaneous fat(chest and triceps)

  Oedema

  Ascitis

- *Dietary Assessment*: It can be assessed by 24 hrs dietary recall

  Food frequencies

  Food daily Technique

  Observed food consumption

Nutritional Requirements:

To actually measure energy requirements we need sophisticated equipment.

Requirements are most often calculated using formulae.

One such formula is the Harris-Benedict Equation which estimates the basal energy expenditure (BEE) in Kcal/day

Harris Benedict equation (BEE)

For men: 66+(13.7xwt)+(5xht)-(6.7xAge)

For Women: 655+(9.6xwt)+(1.8xht)-(4.7xAge)

Resting energy expenditure (REE) in Kcal/24hr

REE=BEEX1.2→ [(3.9x$VO_{2)}$+(1.1xVCO_2)-61] X1440

Modifications in BEE

- **Fever→ BEEx1.1**
- **Mild Stress→ BEEX1.2**
- **Moderate Stress→ BEEX1.4**
- **Severe Stress→BEEX1.6**

Total Energy and fluid requirements:

- Energy requirements can be calculated in various ways but for all practical purposes- calorie intake is -

- 25Kcal/Kg/24 hr post elective Surgery
- 35Kcal/Kg/24 hr Polytrauma Sepsis and burns

- Additional 10% calories added for each 1°C rise in temperature

- Baseline water requirements for adults = 30-35 ml/kg/hr
- Addition must be made for fever (300-500ml/24 hr) for 1°C above normal and for other losses.

Calculation of daily requirement

- *Sample calculation for 60 kg, stable, euvolemic patient with good urine output and moderate stress*
- Fluid requirement: 35ml/kg = 2100 ml/day
- Calories: 25kcal/kg = 1500 kcal/day
- Proteins: 1g/kg = 60 g/day = 240 kcal/day (4kcal/g)
- Fats: 30% of total calories = 450 kcal/day = 50g fat(9kcal/g)
- Carbohydrates: 1500 – (240+450) = 810kcal = 202.5g of dextrose (4kcal/g)

Convert requirements into prescription

- Determine volume of lipid emulsion: 10% lipid emulsion

$$\text{Fluid volume reqd.} = \frac{\text{Amt. of substance(gm)} \times 100}{\text{Conc. Of substance(\%)}}$$

Volume of lipid emulsion = 50/10 x 100 = 500 ml

- Determine volume of amino acid infusion: 10 % solution

Volume of amino acids = 60/10 X 100 = 600 ml

- Selection of dextrose infusion: in remaining 1000 ml volume, 202.5g dextrose needs to be infused.

$$1000 = \frac{202.5}{\text{Conc. of subst.}} \times 100$$

- Concentration of substance = 202.5/1000 X 100 = 20.25%

  = 20% approx.

- *Prescription*: Pt. needs

  500ml of 10% lipid emulsion

  600ml of 10% amino acid and

  1000 ml of 20% dextrose

- A careful balance of macro-nutrients (protein, lipids and carbohydrates) provide the energy requirements whilst micronutrients (Vitamins and minerals) are required in very small amounts to maintain health .

- Proteins: Proteins provide 10-15% of total calories. Daily requirements of proteins-
- .8-1.2 g/kg→ Normal Metabolism
- 1.2-1.6gm/Kg-→ Hypercatabolism

- Nitrogen Balance:-2/3rd of nitrogen derived from protein is excreted in the urine.

- Because protein is 16% Nitrogen, each gm of urinary nitrogen represents 6.25gm of degraded proteins.
- N Balance(g)=(Protein intake(g)/6.25)-(UUN+4)
- Positive Nitrogen Balance:Provide enough non-protein calories
- Negative Nitrogen Balance: insufficient intake of non-protein calories
- The goal of nitrogen balance is to maintain a positive balance of 4-6gms

- **Carbohydrate**: It Provides upto 50-60% of total calories or 70-90% of non-protein calories
- It provides 3.4 Kcal /g of glucose
- The total glucose load may be limited to 3.5-5gm/Kg/24hr depending upon severity of stress
- **Lipids**: Lipid emulsion provides 25-30% of total energy.

Maximum dose should be limited to 1gm/kg/24hr

It provides 9.3 Kcal/gm

Lipid Content

- Intralipid with PN is controversial because past studies have shown that long-chain fats can cause immune suppression. It can promote dysfunction of the reticuloendothelial system, enhance formation of prostanoids and leukotrienes, increase generation of ROS, and adversely affect the composition of cell membranes.
- Among trauma patients, the use of **PN without lipids versus with lipids** was associated with a **significant reduction in pneumonia** (48% versus 73%; *P*=0.05), **catheter-related sepsis** (19% versus 43%; *P*=0.04), **length of ICU stay** (18 versus 29 days; *P*=0.02), and **length of hospital stay** (27 versus 39 days; *P*=0.03).
- However, some fat—at least 5% of total calories—has to be provided as lipid emulsion to prevent essential fatty acid deficiency, although this issue is usually not important until after the first 10 days of hospitalization.

Hyperglycemia

- Hyperglycemia might be a key factor in the reduced efficacy and increased rate of complications associated with PN. Hyperglycemia impairs neutrophil chemotaxis and phagocytosis, leads to glycosylation of immunoglobulins, impairs wound healing, alters function of the complement cascade, and exacerbates inflammation.
- In an early meta-analysis, routes of feeding in trauma patients, mean blood glucose concentration was **greater than 200 mg/dL** in the PN group on postoperative days 7 to 9, whereas it was only **132 mg/dL** during the same period in patients receiving EN ($P<0.05$). Incidence of **infection was 44%** in the PN group and **17%** in the EN group ($P<0.05$).
- Therefore, one can infer that hyperglycemia (defined as a circulating glucose concentration > 200 mg/dL) is associated with poor outcome in different critically ill patient populations including trauma, strokes, and acute coronary syndromes. Using conventional glucose monitoring systems, **glucose levels below 180 mg/dL should be maintained** in critically ill patients.

Complications

Other Parenteral nutrition has the potential for severe complications.

- *Catheter-related sepsis and misdirected catheter.*
- *Electrolyte abnormalities* include hypophosphataemia, hypokalaemia and hypomagnesaemia, especially in the first 24–48 hours.
- *Hyperchloraemic metabolic acidosis* may result from amino acid solutions with a high chloride content. Replacing some chloride with acetate in the TPN solution will resolve this where necessary.
- *Rebound hypoglycaemia* may occur when TPN is discontinued suddenly. TPN should be weaned over a minimum of 12 hours. If it cannot be continued, an infusion of 10% dextrose should be started and blood sugars closely monitored.

- Oleic acid, is one of the lipids in TPN, is a standard method for producing the acute respiratory distress syndrome (ARDS), and this might explain why lipid infusions are associated with impaired oxygenation
- *Refeeding syndrome* may occur when normal intake is resumed after a period of starvation. It is associated with profound hypo-phosphataemia, and possibly hypokalaemia and hypomagnesaemia. With the restoration of glucose as a substrate, insulin levels rise and cause cellular uptake of these ions. Depletion of adenosine triphosphate (ATP) and 2,3-diphosphoglyceric acid (2,3-DPG) results in tissue hypoxia and failure of cellular energy metabolism. This may manifest as cardiac and respiratory failure, with paraesthesia and seizures also reported. Thiamine deficiency may also play a part.
- *Liver dysfunction* is common during TPN. Causes include hepatic steatosis, intrahepatic cholestasis and biliary sludging from gallbladder inactivity. The problems necessitating TPN in the first place may also cause liver dysfunction.
- *Deficiencies* of trace elements and vitamins (especially thiamine, folic acid and vitamin K) may occur.

Adjunctive nutrition

Certain substances have been used as adjuncts to feeding solutions, in attempts to modulate the metabolic and immune responses to critical illness.

- Glutamine
- Arginine
- Selenium
- Antioxidants Vitamins

Glutamine

- The amino acid, **Glutamine**, plays a central role in nitrogen transport within the body. It is used as a fuel by rapidly dividing cells, particularly lymphocytes and gut epithelial cells and is also a substrate for synthesis of the important endogenous antioxidant, glutathione.
- Although l-glutamine is not an essential amino acid under normal conditions, plasma l-glutamine concentration decreases during critical illness, and low circulating levels of l-glutamine have been associated with immune dysfunction and increased mortality. Thus, glutamine may be regarded as a "conditionally essential" amino acid.
- glutamine supplementation is associated with a significant reduction in mortality, reduction in infectious complications and no overall effect on length of stay.
- Therefore, glutamine has been recommended as a daily nutritional supplement in ICU patients (0.2– 0.4 g/kg/day).

ARGININE AND IMMUNONUTRITION

- In the absence of illness, l-arginine supplementation fails to demonstrate any significant effects on immune function. Upon immune activation, l-arginine transport is significantly increased in both myeloid and lymphoid cells.
- Guidelines for arginine supplementation can be summarized as follows:

1. Higher than normal arginine supplementation is necessary. Normal is 3 to 5 g/d.
2. Combination of arginine, omega-3 fatty acids, and nucleotides have been extensively tested and proven to provide a clear clinical benefit. Arginine alone should not be used.
3. Patients undergoing major elective surgery benefit from the use of immuno-nutrition formulas containing arginine. The risk of infections is reduced approximately 40%. This has been endorsed as a grade A recommendation by all major nutrition societies and the Society of Critical Care Medicine (SCCM).
4. Ideally it should be started preoperatively as an oral dietary supplement and continued in the postoperative period as early as possible. In general, these diets should be started 5 days prior to surgery and continued 5 to 10 days postoperatively.
5. A clear benefit of l-arginine-containing immuno-nutrition has not been observed in medical patients, particularly those with sepsis.

SELENIUM

- Selenium is necessary in the regulation of glutathione peroxidase, the major scavenging system for oxygen free radicals. Low plasma selenium levels are common in ICU patients, and a number of small studies have shown potential benefits, but these could not be reproduced in two recent larger trials.

ANTIOXIDANT VITAMINS

- In critical illness, oxidative stress arises as the result of an imbalance between protective antioxidant mechanisms and generation of ROS.
- This imbalance may be due to excess generation of ROS, low antioxidant capacity, or both. Plasma and intracellular concentrations of the various antioxidants are abnormally low in subpopulations of critically ill patients.
- Thus for critically ill patients, selenium supplementation in combination with other antioxidants (vitamin E or alpha tocopherol, vitamin C, *N*-acetylcysteine, zinc) may be beneficial.

Which Nutrient for which population!!!

	Elective Surgery	Critically Ill				
		General	Septic	Trauma	Burns	Acute Lung Injury
Arginine	Benefit	**No benefit**	Harm(?)	**(Possible benefit)**	**No benefit**	**No benefit**
Glutamine	**Possible Benefit**	PN Beneficial (Recommend)	…	EN Possibly Beneficial: **Consider**	EN Possibly Beneficial: **Consider**	…
Omega 3 FFA	…	…	…	…	…	**Recommend**
Anti-oxidants	…	**Consider**	…	…	…	…

Canadian Clinical Practice Guidelines JPEN 2003;27:355

Daily requirements for electrolytes

NUTRIENT	Enteral route	Parenteral Route
Sodium	500mg (22mEq/Kg)	1-2mEq/Kg
Potassium	2g (51mEq/Kg)	1-2mEq/Kg
Chloride	750 mg(21mEq/Kg)	As needed to maintain acid-base bal.
Calcium	1200mg (30mEq/Kg)	5-7.5mEq/Kg
Magnesium	420mg(17mEq/Kg)	4-10mEq/Kg
Phosphorus	700mg(23Meq/Kg)	20-40mEq/Kg

Daily requirements for trace elements

	Enteral route	Parenteral Route
Chromium	30mcg	10-15mcg
Copper	0.9mg	0.3-0.5mg
Fluoride	4 mg	Not well defined
Iodine	150mcg	Not well defined
Iron	18mg	Not well defined
Manganese	2.3mg	60-100mcg
Molybdenum	45mcg	Not well defined
Selenium	55mcg	20-60mcg
Zinc	11mg	0.5-5mg

Daily Requirement of Vitamins

Water Soluble Vitamins	Enteral route	Parenteral
Thiamine B_1	1.2mg	3.0mg
Riboflavin B_2	1.3mg	3-6mg
Pantothenic acid	5mg	15mg
Niacin	16mg	40mg
Pyridoxine B_6	1.7mg	4mg
Biotin B_7	30mcg	60mcg
Folic Acid B_{10}	400mcg	400mcg
Cyanocobalamine B_{12}	2.4mcg	5mcg
Ascorbic acid C	90mg	100mg
Fat Soluble Vitamin		
Retinoic Acid A	900mcg	1000mcg
Ergocalciferol D	15mcg	5mcg
Alpha-tocopherol E	15mg	10mg
Phytomenadione K	120mcg	1mg/24hr

TIME TO START NUTRITION

- The timing of initiating nutritional support is a complex issue involving various factors which includes –
- -Preillness nutritional status
- -Type severity and stage of critical illness and organ failure
- -Route of feeding and use of special diets.

In general

- Early Feeding –Beginning of nutrition within 24-48 hrs after an acute onset.
- Conventional Feeding:Initiating nutrition within 3-10 days.
- Late Feeding: Refers to the nutrition after the 10 days.

Early Enteral Nutrition:

- **Indication:** Severe trauma (abdominal, major burns)
- ARDS(acute respiratory distress syndrome)
- Major abdominal Cancer surgery
- Acute Malnutrition

- **Contra-indication:** Loss of Bowel anatomical integrity
- Severe Splanchnic Ischemia
- Shock
- Generalised Peritonitis

- Early pareneteral nutrition has no place in the ICU in patients without pre-existing malnutrition.

Route of Nutrition

- Nutritional Support can be given through one of the three routes-

- Oral
- Enteral
- Parenteral

- **Oral:** If the patient can eat then they should be encouraged to do so. It is important to know that patient receiving adequate nutrition or not.

Enteral:

Indication: when oral intake has been inadequate for 1-3 days. Patients who are at risk of bacterial translocation across the bowel (Burn Victims).

Contraindications:

- Circulatory Shock
- Intestinal Ischemia
- Complete mechanical bowel obstruction or Ileus .
- Severe Diarhhoea
- Pancreatitis.

Methods of enteral feeding

- **Nasogastric Tube** : most common method
- **Naso-duodenostomy tube**
- **Naso-jejunal tube**
- **Percutaneous feeding gastrostomy**
- **Jejunostomy tube.**

Modes of administration :

- **Bolus Feeding** :

administration of 200-400ml of feed over 20-30 minutes several times a day.

- **Intermittent feeding-**

Administartion of 200-400 ml of feed over 30-60 minutes several times a day.

- **Continuous Feeding:**

Feed given at continuous rate over 16-24 hrs per day.It is preferred for small-intestine feeding.

Feeding Formulas for enteral Feeding

- There are many commercially prepared feeds available:
- **Polymeric Preparation**: These contain intact proteins, fat and carbohydrate which requires digestion prior to absorption, in addition to electrolytes, trace elements, vitamins and fibers. These feed tend to be lactose free as lactose intolerance is common in unwell patients.

- **Elemental Preparation:** These preparations contain the macronutrients in absorbable form (i.e. proteins as peptides or amino acids, lipids as medium chain triglycerides and carbohydrates as mono- and disaccharides.

Disease specific formulae:

- These are usually polymeric and feed designed for :

- **Liver diseases**: Low sodium and altered amino-acids contents
  (to reduce encephalopathy)

- **Renal Disease:** Low phosphate and Potassium 2kcal/ml
  (to reduce fluid intake)

- **Respiratory Disease:** High fat Content reduce CO_2 production

SPECIFIC ADDITIVES:

- **Glutamine:** Principal food for bowel mucosa. Essential for hypermetabolic, stressed patients.

- **Dietary Fiberss:** Fragmented fibers.- Cellulose, pectin, gums
  Non-Fragmented fibers- Lignin
- Fibers have several action that can reduce the tendency for diarrhea.

- **Branched chain amino-aids:**Leucine, Isoleucine and valine for trauma and hepatic encephalopathy patients.

- **Carnitine:** Necessary for transport of fatty acids into mitochondria for fatty acid oxidation. Carnitine deficiency occurs in cardiomyopathy, skeletal muscle myopathy and hypoglycemia.

How to give enteral nutrition?

- Confirm tube position: Clinically and radiographically if possible.
- Secure the tube well.
- Sit patient up- At least 30° to minimize the risk of reflux and aspiration of gastric contents
- Aspirate regularly (e.g. 4 hourly) to ensure that gastric residual volume is less than 200ml.
- Avoid bolus feeding: Large volume of feed in stomach will increase the risk of aspiration of gastric content
- Use-Pro-kinetics : If patient not tolerated enteral feed then prokinetics given : Metoclopramide 10mg iv tds

Complications of Enteral Feeding:

- Occlusion of the feeding tube
- Reflux of the gastric contents into the airway
- Diarrhoea
- Bloating and abdominal discomfort.

Parenteral Nutrition:

- The only absolute indication of parenteral nutrition is gasto-intestinal failure.

- Parenteral Nutrition can be given as separate components but is more commonly given as a sterile emulsion of water, protein, lipids, carbohydrates, electrolytes, vitamins and trace elements.

- **Route of Infusion:**

- **peripheral**
- **central**

Peripheral Parenteral Nutrition PPN:

- The maximum osmolarity that can be tolerated by peripheral vein is 900 mosm/L.

- The concentration of various solutions that can be given safely via peripheral veins are –

  Glucose-5-10%

  Amino-acids- 2-4%

  Lipids-10-20% as both concentration are iso-osmolar.

- PPN is unsuitable for patients –

  Poor peripheral venous access

  High energy and nitrogen requirements

  High Fluid requirements

  Requiring nutrition for longer time.

Central Parenteral Nutrition: CPN

- IV catheter should be inserted under all aseptic conditions
- It should be used only for purpose of parenteral nutrition.
- Confirm the position of catheter by X-ray Chest .

INTRAVENOUS NUTRIENT SOLUTIONS:

- **Carbohydrates:**These are provided by dextrose solutions. These are available as 5%,10%,20%,50%,70%
- **Proteins:** These are given as amino acid solution . They Contain 50% essential and semi-essential amino acid
- **Lipids:** Intravenous Lipid Emulsions consists of submicron droplets of cholesterol and phospholipids surrounding a core of Long Chain Triglycerides. It is available in 10% and 20% Strength.
- It provides a source of essential fatty acids –linolenic acid (w-3 fatty acid) and linoleic(w-6 fatty acid)
- **Electrolytes and micronutrients** As given in Table.

TERMINATION OF PARENTERAL NUTRITION

- Goal: to restart oral/ enteral feeding as soon as gastro-intestinal function improves.
- Gradual transition from PN to oral/ enteral nutrition
- Reduce infusion rate upto 50% for 1-2hrs before stopping
- When 60% of total energy and protein requirements are taken orally/ enterally. PN may be stopped.

COMPLICATION OF TPN:

- **Catheter related:** Pneumothorax, Hemothorax, Chylothorax, Air embolism, Cardiac Tamponade, Catheter sepsis.

- **Metabolic:**Azotemia, Hepatic Dysfunction, Cholestasis, Hyperglycemia/ Hypoglycemia, excessive CO_2 production, metabolic acidosis/alkalosis, electrolyte imbalances.

- **Refeeding Syndrome**

- **Overfeeding**

MONITORING OF PATIENTS:

- Vital Signs: Temperature, blood pressure, pulse, respiratory rate
- Fluid balance- Weight , edema, input-output.
- Delivery equipment: Nutrient Composition, tubing, pumps, catheter, dressing
- On first day measure blood sugar every 6hrs for 24hrs
- During first week measure serum electrolytes, blood urea, sugar and serum triglycerides daily.
- Unstable patients may require blood sugar and serum electrolytes measurements twice daily.
- Serum Calcium, AST, bilirubin, alkaline phosphate, phosphorus magnesium and blood counts at least twice a week.
- Prothrombin time and albumin once a week
- Once the desired infusion rate of TPN has been achieved and blood chemistry is Normal monitoring may be reduced to once a week.

CONCLUSION:

- Malnutrition is associated with a poor outcome in critical illness.
- Enteral Nutrition is mainstay of nutritional support and should be started early in all patients in whome it is safe to do so.
- Parenteral nutrition has definite role but only in selected patients.
- In all patients receiving nutritional support it is vital to achieve glucose control with insulin therapy and important not to overfeed.

ESPEN guideline on clinical nutrition in the intensive care unit

Summary of statements: Intensive Care

Subject	Recommendations	Grade	Number
Indications			
	Patients should be fed because starvation or underfeeding in ICU patients is associated with increased	C	1.1
morbidity and mortality			
	All patients who are not expected to be on normal nutrition within 3 days should receive PN within 24 to 48 h if EN is contraindicated or if they cannot tolerate EN.	C	1.2
Requirements			
	ICU patients receiving PN should receive a complete formulation to cover their needs fully.	C	1.3
	During acute illness, the aim should be to provide energy as close as possible to the measured energy expenditure in order to decrease negative energy balance.	B	2.1
	In the absence of indirect calorimetry, ICU patients should receive 25 kcal/kg/day increasing to target over the next 2–3 days.	C	2.1
Supplementary PN with EN			
	All patients receiving less than their targeted enteral feeding after 2 days should be considered for supplementary PN.	C	3
Carbohydrates			
	The minimal amount of carbohydrate required is about 2 g/kg of glucose per day.	B	4
	Hyperglycemia (glucose >10 mmol/L) contributes to death in the critically ill patient and should also be avoided to prevent infectious complications.	B	5
	Reductions and increases in mortality rates have been reported in ICU patients when blood glucose is maintained between 4.5 and 6.1 mmol/L. No unequivocal recommendation on this is therefore possible at present.	C	5
	There is a higher incidence of severe hypoglycemia in patients treated to the tighter limits.	A	5

Summary of statements: Intensive Care

Subject	Recommendations	Grade	Number

Lipids

Lipids should be an integral part of PN for energy and to ensure essential fatty acid provision in long-term ICU patients. B 6.1

Intravenous lipid emulsions (LCT, MCT or mixed emulsions) can be administered safely at a rate of 0.7 g/kg up to 1.5 g/kg over 12 to 24 h B 6.8

The tolerance of mixed LCT/MCT lipid emulsions in standard use is sufficiently documented. Several studies have shown specific clinical advantages over soybean LCT alone but require confirmation by prospective controlled studies. C 6.4

Olive oil-based parenteral nutrition is well tolerated in critically ill patients. B 6.5

Addition of EPA and DHA to lipid emulsions has demonstrable effects on cell membranes and inflammatory processes. Fish oil-enriched lipid emulsions probably decrease length of stay in critically ill patients. B 6.6

Amino Acids

When PN is indicated, a balanced amino acid mixture should be infused at approximately 1.3–1.5 g/kg ideal body weight/day in conjunction with an adequate energy supply. B 7

When PN is indicated in ICU patients the amino acid solution should contain 0.2–0.4 g/kg/day of L-glutamine (e.g. 0.3–0.6 g/kg/day alanyl-glutamine dipeptide). A 8

Micronutrients

All PN prescriptions should include a daily dose of multivitamins and of trace elements. C 9

Route

A central venous access device is often required to administer the high osmolarity PN mixture designed to cover the nutritional needs fully. C 1.3

Peripheral venous access devices may be considered for low osmolarity (<850 mOsmol/L) mixtures designed to cover a proportion of the nutritional needs and to mitigate negative energy balance. C 1.3

If peripherally administered PN does not allow full provision of the patient's needs then PN should be centrally administered C 1.3

Mode

PN admixtures should be administered as a complete all-in-one bag B 1.4

1. Should we use parenteral nutrition (PN)? When should we start PN?
   Recommendation: Patients should be fed because starvation or underfeeding in ICU patients is associated with increased morbidity and mortality. Grade C

2. Should we wait for recovery and the ability of the patient to take normal nutrition or should we start PN in patients who have not resumed normal intake within 10 days?
Recommendation: All patients who are not expected to be on normal nutrition within 3 days should receive PN within 24–48 h if EN is contraindicated or if they cannot tolerate EN. (Grade C)

3. Should we use central venous assess for PN administration?

Statement: A central venous access device is often required to administer the high osmolarity PN mixture designed to cover the nutritional needs fully (Grade C). Peripheral venous access devices may be considered for low osmolarity (<850 mOsmol/L) mixtures designed to cover a proportion of the nutritional needs and to mitigate negative energy balance (Grade C). If peripherally administered PN does not allow full provision of the patient's needs then PN should be centrally administered (Grade C)

4. Should we use all-in-one bags for PN administration?

Recommendation: PN admixtures should be administered as a complete all-in-one bag (Grade B)

5. How much parenteral nutrition should critically ill patients receive?

Recommendation:

During acute illness, the aim should be to provide energy as close as possible to the measured energy expenditure in order to decrease negative energy balance. (GradeB). In the absence of indirect calorimetry, ICU patients should receive 25 kcal/kg/day increasing to target over the next 2–3 days (Grade C)

6. Is there an indication for parenteral nutrition supplementary to enteral nutrition?
Recommendation: All patients receiving less than their targeted enteral feeding after 2 days should be considered for supplementary parenteral nutrition (Grade C).

7. Carbohydrates: what are the requirements?
Recommendation: The minimal amount of carbohydrate required is about 2 g/kg of glucose per day (Grade B)

8. Carbohydrates: which level of glycemia should we aim to reach?
Recommendation: Hyperglycemia (glucose >10 mmol/L) contributes to death in the critically ill pt and should also be avoided to prevent infectious complications (Grade B). Reductions and increases in mortality rates have been reported in ICU patients when blood glucose is maintained between 4.5 and 6.1 mmol/L. No unequivocal recommendation on this is therefore possible at present. There is a higher incidence of severe hypoglycemia in patients treated to the tighter limits (Grade A)

9. Should we use lipid emulsions in the parenteral nutrition of critically ill patients?
Statement. Lipid emulsions should be an integral part of PN for energy and to ensure essential fatty acid provision in long-term ICU patients. (Grade B).

10. Do LCT/MCT lipid emulsions offer clinical advantage over LCT alone?
Recommendation: The tolerance of mixed LCT/MCT lipid emulsions in standard use is sufficiently documented. Several studies have shown specific clinical advantages over soybean LCTalone but require confirmation by prospective controlled studies (Grade C)

MCT: medium chain triglycerides
LCT: long chain triglycerides

11. Is there evidence that olive oil-based parenteral nutrition is well tolerated in critically ill patients?
Recommendation: Olive oil-based parenteral nutrition is well tolerated in critically ill patients. (Grade B)

12. Does the addition of EPA and DHA to lipid emulsions have an effect on inflammatory processes, morbidity or mortality?

Recommendation: Addition of EPA and DHA to lipid emulsions has demonstrable effects on cell membranes and inflammatory processes (Grade B). Fish oil-enriched lipid emulsions probably decrease length of stay in critically ill patients. (Grade B)

13. Mixed lipid emulsions and concentration issues

14. Is it safe to administer lipid emulsions (LCT without or with MCT, or mixed emulsions) and at which rate?

Recommendation: intravenous lipid emulsions (LCT, MCT or mixed emulsions) can be administered safely at a rate of 0.7 g/kg up to 1.5 g/kg over 12–24 h (Grade B)

15. How much should be administered to meet protein requirements?

Recommendation: When PN is indicated, a balanced amino acid mixture should be infused at approximately 1.3–1.5 g/kg ideal body weight per day in conjunction with an adequate energy supply (Grade B)

16. Is there an indication for specific amino acids?

Recommendation: When PN is indicated in ICU patients the amino acid solution should contain 0.2–0.4 g/kg/day of Lglutamine (e.g. 0.3–0.6 g/kg/day alanyl-glutamine dipeptide) (Grade A)

17. Are micronutrients required in ICU patients?

Recommendations: All PN prescriptions should include a daily dose of multivitamins and of trace elements. (Grade C)