UNIT 4 MEDICAL NUTRITION THERAPY IN CRITICAL CARE

Structure

4.1 INTRODUCTION

The prevalence of malnutrition is a common problem in critically ill patients i.e. patients who have prolonged starvation for more than 2 weeks or intensive care unit (ICU) patients, or hospitalized patients with malnutrition. Malnutrition, we know, leads to poor outcomes and therefore should be avoided or treated promptly. In this context, nutritional support has become a routine part of the care of critically ill patients and it is now widely accepted for the treatment and prevention of malnutrition and other specific conditions of nutrient deficiencies. There is growing evidence that early and appropriate goal oriented nutritional support in the ill individual aids recovery. What is the nutritional support recommended for the critically ill patients? What is the principle and protocol for prescribing these nutritional supports? These are a few issues highlighted in this unit.

Objectives

After studying this unit you will be able to:

- describe the nutritional management of critically ill individuals,
- enumerate the special feeding methods for nutritional support to the critically ill individuals, and
- explain the principle and protocol for prescribing these nutritional support.

4.2 NUTRITIONAL MANAGEMENT OF THE CRITICALLY ILL

Evidence suggest that critically ill patients or hospitalized patients with malnutrition (macronutrient and/or micronutrient deficiency) suffer from increased infectious morbidity, prolonged hospital stays, and increased mortality. Moreover, even those hospitalized medical and surgical patients without antecedent malnutrition are typically subjected to stress, infection and impaired organ function, resulting in a hypercatabolic state. Often these patients are unable to meet their caloric needs, as they are either too sick or physically unable to ingest food. In fact, critically ill patients present with extreme degrees of metabolic disarrangement in protein and energy metabolism characterized by increased protein breakdown which is not entirely suppressed by protein or energy intake. In addition there are also extreme degrees of glucose and lipid intolerance. Thus providing adequate and optimal nutrition support to the critically ill under these conditions constitute a challenging endeavour. Nutritional support has

become a routine part of the care of critically ill patient and is now widely accepted for treatment and prevention of malnutrition and specific nutrient deficiencies. The main goal of nutrition support is to provide an optimum amount of nutritents and calories to prevent malnutrition from becoming the main cause for morbidity and mortality in the disease process. The other goals of nutrition support include:

- improve nutritional assessment indices,
- prevent single and multiple nutrient deficiencies,
- promote organ integrity and function,
- ameliorate clinical manifestations of the disease,
- favourably affect the disease process, and
- positively influence the patient outcome.

In fact, what proportion of the nutrients to be delivered to critically ill has been debated for years now. Interestingly, earlier concepts in critical care nutrition has undergone considerable changes in the past decade or so. For example, few years ago, 50-70 Kcal/kg per day was routinely being delivered during critical illness and currently, a pragmatic approach is to attempt administration of 25 *kilocalories* per *kilogram ideal body weight per day* for most patients. The total calorie daily requirement should be administered in a fluid volume consistent with the patient's needs (usually 1 ml/Kcal). Protein sources should comprise 15-20% of *the total daily calorie* requirement administered as protein or amino acid depending on the route of administration. The generally accepted amount of protein is between 1.2 and 1.5 g/kg per day, except in severe losses such as burns. 30-70%*of the total calories can* be given as *carbolzydrate.* This is usually given as glucose but fructose and sorbitol can also be used. Insulin may be required to maintain blood glucose concentration within normal limits, especially since insulin resistance is often seen as part of the response to stress. *15-30% of the total calories* can be given as *fat.* Critically ill patients often utilize fat better than carbohydrates as an energy source and although our normal diets contain around 30%fat, it is often advantageous to provide more than this to the patients in ICU (Intensive Care Unit) or in HDU (High Dependency Unit). at least 7% of total calories should be provided as Omega-6-polyunsaturated fatty acids (PUFA) and triglycerides to prevent essential fatty acid deficiency.

Regarding micronutrient requirements, approximately 1mmol/kg of both sodium and potassium are usually given but this figure will need to be altered when there are excessive losses, particularly common from excess sweating and gastrointestinal Iosses. An often forgotten electrolyte is phosphate and this is important since it is required for normal metabolic processes resulting in the formation of ATP. Other micronutrients, e.g. magnesium, iron, copper, zinc and selenium are also necessary, but in much smaller amounts. Fat soluble vitamins (vitamin A, carotene) and water-soluble vitamins are also important, but the precise requirement for specific vitamins remain unclear. Further, there is emerging data that increased antioxidant vitamins (vitamin A, E, C) may be beneficial in various high risk populations in ICU.

The *Harris-Beltedict* equation can be used to calculate resting energy expenditure (REE), for men and women, along with the usual multiplication factor to provide adequate calorie intake as given herewith:

***Calorie** requirements/day: 1.25 × REE* (for each 1°C above 37 add 10% extra allowance)

Women REE = 655 + (9.6 x weight in kg) + (1.85 × height in cm) − (4.7 x age in years)

***Men REE* = 66** + (13.7 x weight in kg) + (5.0 x height in cm) − (6.8 x age in years)

The significant reduction in calorie intake, as suggested above, has occurred for a number of reasons. One being the recent realization.that critically ill individuals during hypermetabolic stress are unable to utilize excess calories and that despite delivery of adequate nutrients, endogeneous glucose production is not reversed and in fact continues. Thus, the excess calorie delivery, in fact, has been shown to result in

numerous metabolic complications such as *hyperglycemia* (presence of high concentration of glucose in blood), *hyperinsulinemia* (excessive level of insulin in blood) and ***hepatic steatosis*** (accumulation of fat in the liver) as indicated in Figure 4.1. Severe hyperglycemia is associated with glycosurea (excess glucose in urine) and hyperosmolar dehydration leading to grave disturbances of fluid and electrolyte homeostasis in the critically ill. In addition hyperglycernia has also been shown to result in significant reduction in neutrophil cell function. Hyperinsulinemia, on the other hand, leads to increased sodium and water retention with resultant greatly increased ventilatory requirements due to impaired lung compliance as a result of increased lung and body water. Hyperinsulinemia also leads to inhibition of endogeneous lipolysis (hydrolysis of lipids) leading to greater carbohydrate utilization, increased carbon dioxide (CO_2) production and impairment of respiratory function leading to increased morbidity.

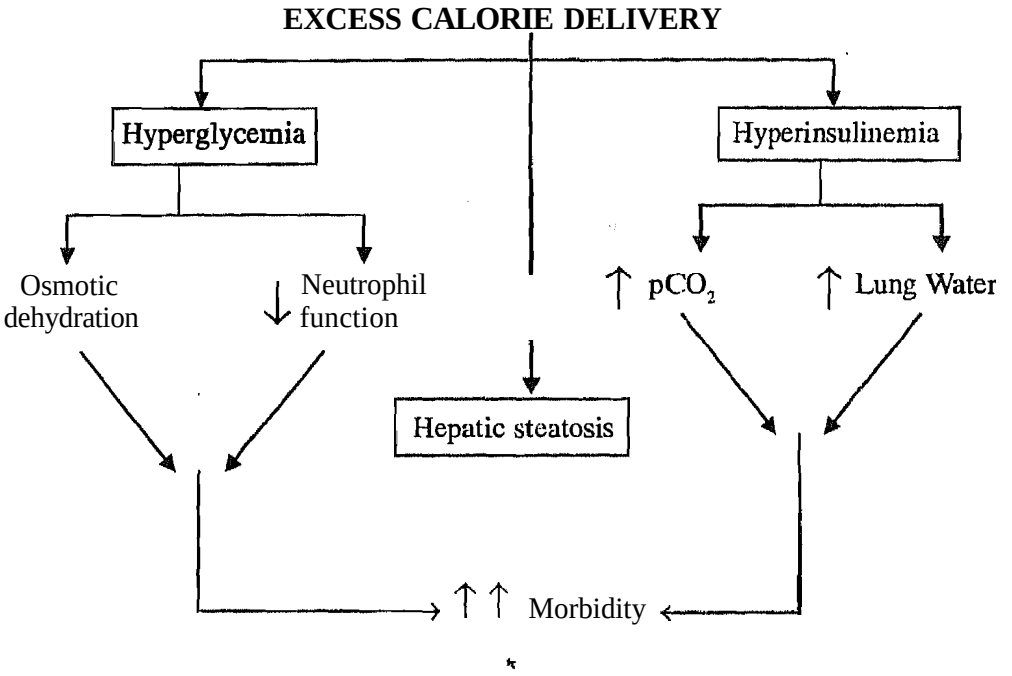

Figure 4.1: Effect of excess calorie delivery in the critically ill

The proportion of nutrients delivered to critically ill children has also undergone considerable change over the last decade or so. As a broad outline, calorie delivery amounts to 20-30 calories / kg / day during the unstable Ebb phase followed by 50-3.00 calories / kg / day during the recovery phase (depending on individual tolerance). What do we mean by the Ebb and the recovery phase? You will soon find out in the next unit. Protein intake of 1.5-3.0 g/kg per day depending on renal and hepatic functional status is optimal has been recommended that carbohydrate in the form of glucose should not exceed from 4-6 mg/kg/minute. Hyperglycemia is often encountered in the sick stressed infant and older child. Blood sugars therefore should be retained ideally below 200 mg/dL in the criticaly ill stressed children. Regarding, lipid delivery, it is being recognized that long chain fatty acids (LCT) are potentially immunosuppressive when either administered rapidly or in large quantities, hence increased utilization of alternate lipid sources is becoming popular. Lipid emulsions which include medium chain triglycerides (MCT) and ω-3-fatty acids are being increasingly used. The amount of lipid administered in the critically ill child has been reduced to 15-20% of total caloric intake,

Besides the nutrients discussed above, several other specific nutrients have been reported to improve some body functions or even outcomes of hospitalized patients. The nutrients and drugs that have been reported to have beneficial nutritional effects on specific body functions and/or clinical outcomes are listed in Table 4.1

Table 4.1: Nutrients and drugs that have been reported to have beneficial nutritional effects on specific body functions **and/or** clinical outcomes

Branched Chain Amino Acids	Alpha-ketogluterate
(isoleucine, leucine and valine)	Arginine
Medium chain triglycerides	Glutamine
Structured lipids	Nucleotides
o-3-fatty acids	Growth hormones

The question that we need to address next, is how to administer the nutritional support to the critically ill or in other words what should be the optimal route of nutritional delivery. The next section focuses on this aspect.

4.3 SPECIAL FEEDING METHODS IN NUTRITIONAL SUPPORT

From our discussion above, it is clear that an appropriate goal oriented nutritional support is of paramount importance in both decreasing morbidity, as well as, mortality in the hypermetabolic and stressed critically ill patient. Initial attempts to achieve nutritional goals in critically ill patients should be via oral route as highlighted in Figure 4.2. However, this may not be possible always. Sometimes a person cannot eat any or enough food because of an illness. The stomach or bowel may not be working quite right, or a person may have had surgery to remove part or all of these organs. Under those conditions, nutrition must be supplied in a different way. PEN is one such way. What does PEN stands for? PEN stands for *parentral* and *enteral* nutrition.

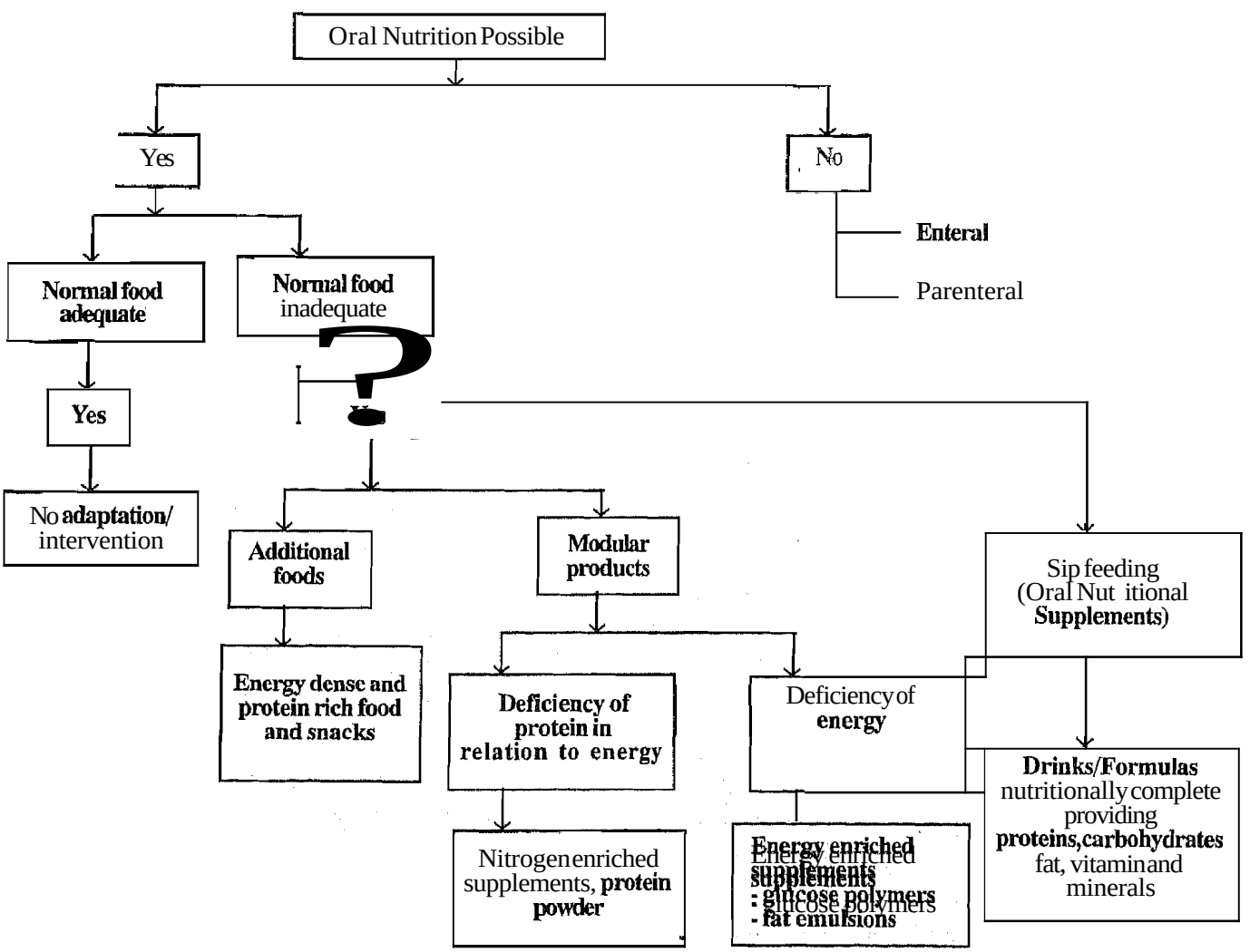

Figure 4.2: Oral feeding **option**

Both parenteral (pa-REN-te-rul) and enteral (EN-ta-rul) nutrition are in the form of a liquid. Enteral, is used when the gut is still partially working, but the patient cannot eat or absorb enough nutrients to stay healthy. Enteral is delivered directly into the stomach or intestine through a feeding tube. In *parenteral*, nutrients are delivered intravenously and the GI tract is bypassed entirely. Parenteral is given through a catheter, which carries the liquid directly into the bloodstream, where the body absorbs it. Figure 4.3 illustrates the two nutritional support methods.

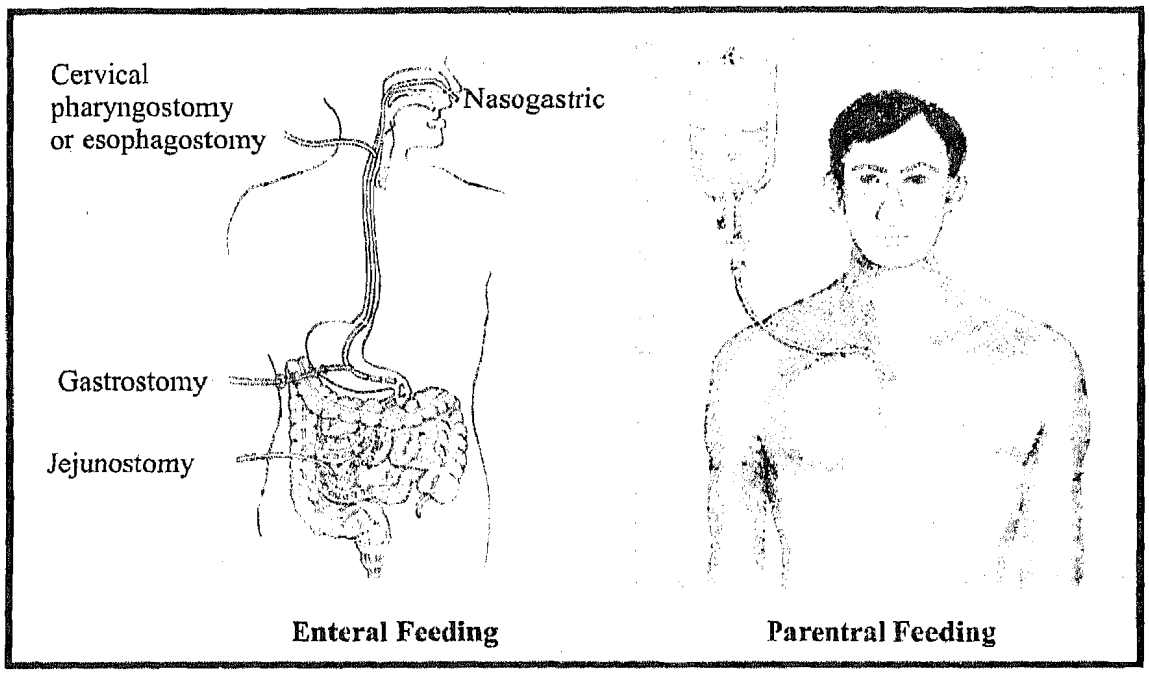

Figure 4.3: Enteral and parenteral nutrition support

The goal of nutrition intervention is to supply adequate nutrients to meet the patient's nutrient requirement by the most physiologic, safety and cost effective route. Let us get to know these two means of nutritional support better.

4.3.1 Enteral Nutrition (EN)

By definition, the term enteral means "within or by the way of the gastrointestinal (GI) tract." As described above, enteral is defined as provision of nutrition support through the gastro-intestinal (GI) tract or by accessing the gut. It also refers to feeding into the GI tract through a feeding tube. Enteral nutrition (EN) can be administered via transoral (oral ingestion of food), transnasal (administration of liquid feeds through feeding tube through the nose), or percutaneous transgastric routes (through stomach), or by a tube into the small intestine called a jejunostomy or percutaneous endoscopic jejunostomy (PEJ). Hence, *enteral nutrition* is *often* called tube *feeding.*

EN is a method of providing adequate nutrition that is expected to prevent, improve, or reverse malnutrition in patients who are not receiving adequate nutrition orally. Enteral, is used when the gut is still partially working, but the patient cannot eat or absorb enough nutrients to stay healthy.

Some of the benefits/advantages of EN include:

- it provides nutrition when oral intake is not possible or adequate,
- it is easier to administer, present fewer metabolic and infectious complications (as compared to parenteral route),
- the intake is easilylaccurately monitored,
- enteral access is easy, gut integrity and motility are preserved and the stress response is attenuated,

- it reduces the incidence of pathogen entry or bacterial translocation into the stomach cavity or circulation,
- it provides more complete nutrients, trace elements and short chain fatty acids, as well as, fibre.
- it provides atrophic effect on the gut by promoting pancreatic and biliary secretion, as well as, endocrine, pancrine and neural factors that help promote the physiological and immunologic integrity of the GI tract.
- the supplies are readily available, and
- it is cost effective as compared to parenteral nutrition.

In animal studies, EN has shown to promote gut motility, it reduces bacterial translocation, prevents mucosal atrophy and stimulates the secretion of IgA that helps to reduce infectious complications. There is also evidence that EN improves nutritional outcomes and results in greater wound healing.

Clinically, EN shouldnot be considered an 'all or none' therapy. For patients unable to take adequate nutrition by mouth despite an appropriate modified oral diet, EN can provide the remaining calories and proteins to meet estimated requirements. The indication for enteral feeding is therefore summarized in Figure 4.4

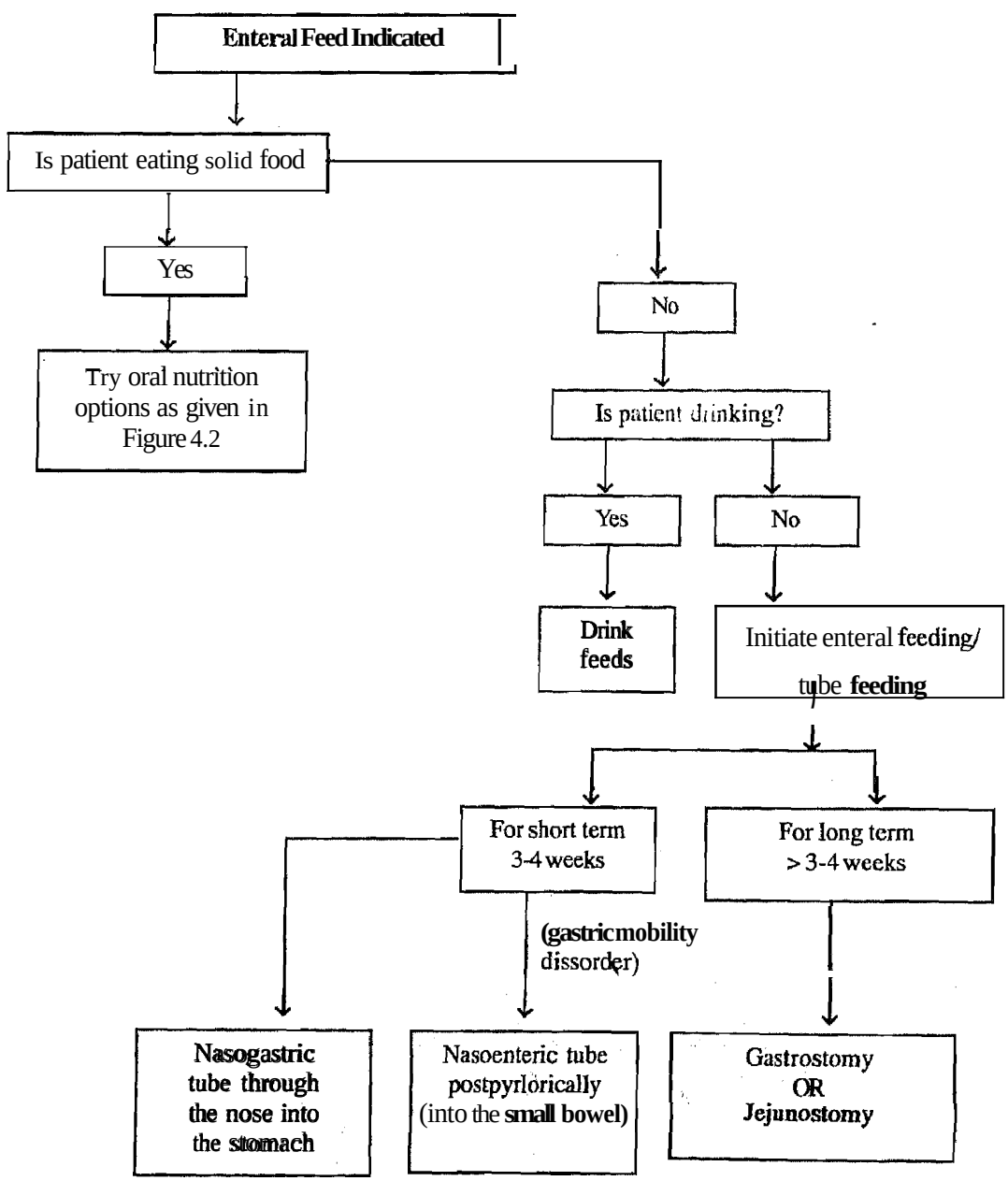

Figure 4.4: Indication for enteral feed

What are the conditions when enteral feeding is indicated? Table 4.2 summarizes some important conditions.

Table 4.2: Indications for enteric tube feeding for adults and children

Indications	Conditions
For Adults	
Neurological indications	Severe head injuries Cerebrovascular accidents Coma Neoplasms: advanced primary and secondary intracranial tumors Dysphagia associated with neurological disorders
Hypermetabolism	Postoperative major surgery Sepsis Trauma, bums, organ transplant, acquired immune deficiency syndrome
Surgical indications	Facial and jaw surgeries Head and neck surgeries Oropharyngeal surgeries Pharyngoesophageal surgeries Polytrauma associated with extensive abdominal surgeries Patients with bums for surgeries unable to take oral nutrition Surgery complicated with sepsis
Gastrointestinal (GI) disease	Short-bowel syndrome (if absorptive capacity of remaining bowel is sufficient e.g. approximately a minimum of 100 cm jejunal and 150 cm of ileal length of functioning small bowel with ileocecal value intact) Inflammatory bowel disease Minimal GI tract fistula output (less than 500 ml/d) Pancreatitis Oesophageal obstruction Malabsorption Fistulas
Cancer	Oral malignancies Oropharyngeal malignancies Nasopharyngeal malignancies Head and neck malignancies Oesophageal malignancies Gastric malignancies Chemotherapy Radiotherapy
Resistance to oral intake	Anorexia Dysphagia Severe depression
Malnutrition	Protein energy malnutrition with inadequate oral intake for at least 5 days Malnutrition preoperatively and postoperatively Malnutrition in cancer patients Malnutrition in patients with Acquired Immune Deficiency Syndrome (AIDS), who are unable to take oral nutrition Malnutrition in debilitated aged patients
Organ system failure	Respiratory failure Renal failure Cardiacfailure Central nervous system failure Hepatic failure Multiple organ system failure
For Children	Malnutrition, malabsorption, hypermetabolism, failure to thrive, prematurity , disorders of absorption, digestion, excretion, utilization, or storage of nutrients

Once the indication for enteral nutrition is established, the next issue that confronts us is what are the types of entcral feeds/formulas that are available and can be delivered? The Drug and Food Administration (FDA), USA recognizes *enteral formulas* as *a category of product independent from regular foods, dietary supplements or drugs*. Multitudes of enteral formulas are available for infusion. The formulas have been traditionally divided into *polymeric, oligomeric* and *modular*. However, there are feeds, which can be home made or prepared with natural food items, or feeds, which are based on polymeric enteric diets such as *disease specific feeds* or *opportunistic feeds*. These different types of enteral feeds with their salient features are reviewed in Table 4.3.

Table 4.3: Enteral feeds and their specific characteristics

Enteral Feeds/Formula	Specific Characteristics
Polymeric formulas (also called defined formula diets) This is the general purpose, most widely prescribed feed. It is the sole source of nutrition intake for critically ill individuals with or near normal GI function.	– Provide nitrogen as whole protein, oflen casein, egg white solids or soy protein. – Carbohydrate is provided as corn syrup, maltodextrins or glucose oligosaccharides, with sucrose added for sweetness in oral formulas. – Fat is usually provided as soy oil, although corn oil and safflower oil may be used. Medium-chain triglyccrides (MCT oil) are rarely used.
Oligomeric formulas (also called elemental or semi-elemental diets) Oligomeric diets are predigested and formulated to require minimal digestion by the gastrointestinal tract. In other words, these diets are "complete."	– Most of these formulas provide enough protein, calories, water; electrolytes, minerals, vitamins and trace elements in 2 L/day for most "nonstressed" patients – Provide nitrogen as oligopeptides from partially hydrolyzed whole protein or as crystalline amino acids. – Carbohydrate tends to be provided as glucose oligosaccharides or glucose. – Fat is usually present in small quantities, enough *to* meet the requirement for linoleic acid (an essential fatty acid), which is about 2-4% of total calories. MCT oil is added to some formulas. – Oligomeric diets have been commercially promoted as ideal for patients with decreased bile output (cholestasis), pancreatic insufficiency and short bowel.
*Modular **formulas/feeds*** (used *when* a particular component of the diet requires an increased intake or if a patient requires a special blend of diets) These modules are not required for the majority of patients, **and** are rarely used	– Modular formulas are those that contain or predominantly contain one kind of nutrient. – There are commercially available modules for protein, fat, carbohydrates, vitamins, electrolytes and trace elements. Examples of this might include burns or protein-losing enteropathy, if more protein is to be given; or liver disease, if less protein is to be given.
Blenderized feeds (For chronically ill patients with normal GI functions)	– Prepared by mixing the ingredients and delivered in an, easily digestible form. – Provide carbohydrates, proteins and fat in the amount as in the balanced diet. – For long-term nutritional management. – Natural food items are used to preparing the feed.
***Disease** specific feeds* (these are specially formulated polymeric enteral feeds)	– For renal patients – For liver disease patients (specialized amino acid solutions have been made for use in special circumstances. For example, liver disease, renal disease and "stress," such as trauma and sepsis. For liver disease, these solutions are composed mostly or exclusively of branched-chain amino acids, whereas for renal disease the solutions are predominantly essential amino acids,
Opportunistic** feeds* (with nutritional addition and substitution which are suggested ***to improve various aspects of organ function)	Addition and substitution include: – more middle chain triglycerides (MST) – increased level of n-3 fatty acids, carnitine, beta carotene, RNA, arginine, glutamine etc.
Drink feeds (*for* those *who* cannot eat solid foods but can ingest liquid diets)	Nutritionally complete enteral feeds based on polymeric enteral diets Palatable

Therefore, it is evident that various enteral formulas are available for infusion. So, which one to select? Well, the factors to consider when choosing an enteral formula include:

gastrointestinal function,

- the type of protein, fat, carbohydrate and fibre in the formula as related to the patients digestive and absorptive capacity,
- calorie and protein density of the formula (i.e. Kcal/ml, g protein/ml and Kcal: nitrogen ratio),
- sodium, potassium, magnesium and phosphorous content of the formula, especially for patients with cardiopulmonary, renal or hepatic failure, and
- viscosity of the formula related to tube size and method of feeding.

The nutrition composition of enteral forinulas given in Box 1.

Box 1 | **Enteral Formula Composition**

- Most of the formula provide 1.0-1.2 Kcal/ml. In high concentrations, they may provide 1.5-2.0 Kcal/ml.
- *Proteins* in enteral formulas provide 4% to 32% of total calories. Those formulas providing 18 to 32% of calories are considered high-protein solutions.
- ***Carbohydrates*** contribute 40% to 90% of total calories in enteral formulas. Carbohydrate sources used in formulas are pureed fruits and vegetables, corn syrup solids, corn and tapioca starch liydrolysates, maltodextrins, sucrose, fructose and glucose.
- Lipid provides 1.5% to 55% of the total calories of enteral formulas.
- ***Water*** recommended.
  - Healthy adult : 1 ml/Kcal or 35 ml/kg.
  - Healthy infant: 1.5 ml/Kcal or 150 ml/kg.
  - Elderly: consider 25 ml/kg with renal, liver, or cardiac failure; or consider 35 ml/kg if history of dehydration
  - Normal tube feeding: 1 Kcal/ml; 80% to 85% water

Some of the commercially available, ready to use enteral formulas/diets for paediatric patients are given in Table 4.4. This information, we hope will be of use, during your dietetic practice. So read this information carefully. Do add on to this list the other enteral feeds/formulas that you might come across during your study or practice.

Table 4.4 : Enteral nutrition commercial formulas for paediatric use

Product	Company	Calories/100 g
NOURISH	Claris	518
SIMYL MCT	FDC	460
PEDIA SURE (powder, reconstitute with water, ideal for both oral and tube feeding)	Abbott	496
PROSOYAL	FDC	506
IMPACT (IB)	Novartis	484
NOVASURE	Novartis	400

RESOURCE JUNIOR (contain lactose, fibre and gluten free)	Novartis	200 (per sachet of 42 g)
LACTODEX (complete low lactose, low fat nutrition during diarrhoea)	Raptakos	55 (each 100 ml of reconstitution)
LACTODEX-LBW(feeding of preterm/ LBW infants until sufficient mother's milk is available)	Raptakos	80.3 (each 100 ml of reconstitution)
MILK CARE LBW (life saving formula for premature/LBW infants)	Dalmia	501
ZEROLAC (for lactose intolerance, acute chronic diarrhoea)	Raptakos	64 (each 100 ml of reconstitution)
ENERGEX (lactose intolerance to cow's milk)	Indon	506
TROPHOX (protein supplement)	Rapatakos	

Source: Nutrition in Diseases Management. Update Series 1: Pediatric and Enteral Nutrition in the Indian Context. Centre for Research on Nutrition Support System.

Besides the formulas listed above few enteral formulas for older children (over 4 years of age) are also included in Table d5.

Table 4.5: Enteral formulas for children over 4 years of age

Complete Balanced Nutrition Formula	Balanced Formula with Additives	Semi-elemental, Partially Hydrolyzed	Disease Specific
PEDIASURE (Powder) FRESUBIN-liquid:lactose, cholestrol and gluten free NUTREN 1.0-powder RESOURCE - powder: lactose free HORLICKS PLUS: Powder	Fresubin Isofibre Nutren fibre	PERATIVE-partially hydrolyzed protein SURVIMED OPD - oligopeptide PEPTAMEN - exceptional peptide formula	DIABETIC Glucerna Fresubin Diabetic Resource Diabetic Nutrocal DM HEPATIC Fresubin Hepa Resource Hepa RENAL *Nephro* - post dialysis, 475 Kcal, can be given orally *Suplena*- pre dialysis. 475 Kcal, can be given orally *Nutrenal CRF* - pre dialysis, 518 Kcal, can be given orally *Nutrenal* TM - post dialysis, 518 Kcal, can be given orally

Source: Nutrition in Diseases Management. Update Series 1: Pediatric and Enteral Nutrition in the Indian Context. Centre for Research on Nutrition Support System.

In the formulas listed above, you would have noticed the calorie content given for each formula. How is the energy and protein content of the formula determined? The formula used includes:

- Kcal/ml x ml given = Kcal
- % protein x Kcal = Kcal as protein
- Kcal as protein x 1 g/4 Kcal = g protein

Let us try to understand this equation with the help of an example.

Example: Patient drinks 100 ml of a 18.2% protein product that has 1 Kcal/ml. Therefore the calorie, protein content would be:

- 1 Kcal/ml x 100 ml = 100 Kcal
- 0.182 % protein x 100 Kcal = 18.2 Kcal
- 18.2 Kcal × 1g protein/4 Kcal = 4.55 g protein

The common methods of administering the enteral formulas include:

- Continuous method = slow rate of 50 to 150 ml/hr for 12 to 24 hours,
- Intermittent method = 250 to 400 ml of feeding given in 5 to 8 feedings per 24 hours, and
- Bolus method = may give 300 to 400 ml several times a day.

With a detail review of the nutrient composition and method of administering the enteral formulas, we shall end our study on enteral nutrition by reviewing the disadvantages and complications, if any linked with enteral feeding.

Disadvantages and Complications of Enteral Feeding

There are a few common complications linked with the use of enteral feeding. These complications include:

- Access problems (tube obstruction)
- Administration problems (aspiration, tube migration)
- Gastrointestinal complications (diarrhoea)
- Metabolic complications (overhydration)

Besides the complications mentioned above, use of cnteral feeding is associated with increased risk of bacterial contamination especially in case of home made blendcrized formula. Further, they may be labour intensive and may require site care and monitoring. They are 'less palatable' and do cost more than oral diets.

Next, let us get to know about the parenteral nutrition. Before we begin our study, however let us review what we have learnt so far by answering the check your progress exercise 1 given next.

Check Your Progress Exercise 1

1. Enumerate the nutrient requirements of the critically ill adult.

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2. What are the types of nutrition support we can provide to a critically ill individual? Elaborate.

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3. When is enteral nutrition indicated? List atleast disease conditions.

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4. List the different types of enteral formulas/feeds which can be made available for the critically ill patient.

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Now that we are clear on enteral nutrition let us get to know about parenteral nutrition.

4.3.2 Parenteral Nutrition

Enteral nutrition, we learnt, above means within or by the way of gastrointestinal tract. Parenteral nutrition, on the other hand, refers to nutrients delivered to the patient in a manner other than through the gastrointestinal (GI) tract – usually delivered intravenously (bypassing the digestive tract) as you may have noticed in Figure 4.3. Parenteral nutrition is one of the ways people receive food when they cannot eat and there is a dysfunctioning of the digestive tract. It is a special liquid food mixture administered into the blood through a vein. The mixture contains all the protein, sugars, fat, vitamins, minerals, and other nutrients needed. It is sometimes called "total parenteral nutrition," "TPN," or "hyperalimentation." Parenteral nutrition, in fact, can be of two types - total parenteral nutrition (TPN) and partial parenteral nutrition (PPN). TPN supplies all of the patient's daily nutritional requirements. Partial parenteral nutrition, on the other hand, supplies only part of the patient's daily nutritional requirements, supplementing oral intake. Many hospitalized patients receive dextrose or amino acid solutions by this method as part of their routine care.

When is the use of parenteral nutrition indicated? Parenteral nutrition support is indicated in the presence of compromised nutritional status when adequate nutrients (protein and calories) cannot be provided by oral or enteral route or when oral or enteral feeding is insufficient (as in burns or polytrauma), undesireable (as in the case of fistulas), ineffective (short bowel syndrome, severe malabsorption) or impossible (intestinal obstruction or pseudo obstruction). In other words, parenteral nutrition is generally used when the enteral route is either inaccessible or its use is contraindicated. It is also used as a supplement to enteral feeding if adequate nutrition is not possible via the enteral route alone. This type of nutrition is used in the most critical patients, which may have one or more of the following symptoms:

- Intestinal obstruction or ileus,
- Inadequate digestive or absorptive capacity,
- Uncontrollable vomiting (this is particularly life threatening to a diabetic patient),
- Inability to tolerate food for any reason (e.g. head trauma, burns to mouth/face/ oesophagus),
- High risk of aspiration because patient is unconscious or has a neurologic problem, and
- Need for complete GI tract rest due to digestive disease, healing time needed for GI tract lesions or surgical repairs, acute pancreatitis or hepatitis.

In infants and children parenteral nutrition is indicated during intestinal failure (short gut, protacted diarrhoea, post-operative abdominal or cardio-thoracic surgery, radiation etc.), organ failure (acute renal or liver failure), and hyper-catabolism (as in extensive burns, severe trauma etc.).

The advantages of using parenteral nutrition is that it:

- provides nutrients when less than 2 to 3 feet of small intestine remains, when surgical procedures are carried out and
- allows nutrition support when GI intolerance prevents oral or enteral support

Parenteral support is generally given for a short period (two weeks or so), at which point the patient has hopefully begun to recover from the symptoins that caused the need for this type of support in the first place. PN may include a combination of sugar and carbohydrates (for energy), proteins (for muscle strength), lipids (fat), vitamins, electrolytes, and trace elements. Electrolytes include sodium, potassium, chloride, phosphate, calcium, and magnesium. Trace elements include zinc, copper, manganese, and chromium. Vitamins include, vitamins - A, C, D, E, K, B_1 (thiamine), B_2 (riboflavin), niacin, pantothenic acid, B, (pyridoxine), B_{12}, biotin, choline (cofactor for enzymatic reactions), and folic acid.

Let us take a closer look at the nutrient composition of parenteral nutrition.

Carbohydrates are principally provided through glucose and dextrose. Parenteral nutrition is initiated with a glucose infusion at a dosage of 5 mg/kg/minute and increased in daily increments to a maximum of 25 gm/kg/day.

Protein requirements can be met by providing the appropriate amounts of amino acids. The range in adults is from 0.5 to 3.5 g/kg/day. Protein requirement of 1.2 to 1.5 g protein/kg ideal body weight (IBW) is recommended in case of mild or moderate stress and 2.5 g protein/kg IBW in case of burns or severe trauma as you would read later in Unit 5. Proteins are generally provided as crystalline amio-acid solution in standard 500 ml bottles. The solutions vary in amino-acid concentration (3, 3.5, 5, 7, 8.5, 10% solutions) and composition. They can be selected based on underlying disease condition.

Lipids in parenteral nutrition are used as a source of essential fatty acids and encrgy. Fat emulsion solutions are available as 10% (1.1 Kcal/ml) or 20% (2 Kcal/ml) preparations, and are derived from soybean, safflower, or cotton-seed oil, with the fat mainly present as triglyccride. The ultimate total daily dose of parenteral lipid emulsion should not exceed 4 g/kg. 500 ml of 10% lipids given once or twice a week is enough to prevent the deficiency of esscntial fatty acids.

The *fluids* should be customized and prepared on a daily basis as per requirement and tolerance. 30 to 50 ml per kg is the fluid recommendation. The calculated quantities of aminoacids, glucose and electrolytes are mixed in a bottle to which calcium gluconate, phosphates, multivitamin and heparin is added. The nutrient mixing should be carried out under aseptic conditions.

An example of the daily intravenous requirements, particularly for infants and children, for few nutrients is given in Table 4.6.

Table 4.6: Daily intravenous nutritional requirements in infants and children

Body weight	Kcal/ kg	Fluid (ml/kg)	Carbohy-drate (g/kg)	Protein (g/kg)	Fat (g/kg)	Sodium (mmol/kg)	Potassium (mmol/kg)
< 10 kg	100	100-120	14	2.5	3	3	2.5
10 - 30 kg	75-100	60 - 90	7.5	2.0	2	3	2.5
> 30 kg	45 -75	40 - 90	5	1.5	2	3	2.5

Some of the parenteral products available in Indian market are highlighted in Table 4.7.

Table 4.7: PN products available in Indian market

Product	Strength	Volume (ml)	Protein Content (g)
A. Amino Acid Infusions			
1. Standard infusions			
Aminosteril KE	5%	500 ml	25
Aminosteril PAD"		250 ml	12.5
		100 ml	5
Celemin	10%	500 ml	50
Aminosyn			
Aminoplasmal		250 ml	25
Aminodrip		200 ml	20
		100 ml	10
2. Infusions for specialized situations			
– Branched Chain Amino Acids (BCAA) Enriched (42%)	8%	500 ml	40
– (Used in Hepatic Patients)- Aminosteril Hepa	5%	500 ml	25
– Rich Arginine (Used in Renal Patients) Aminosteril		500 ml	

*Aminsteril PAD (100 ml are specifically designed for Pediatric use.

B. Lipid Infusions

There is no MCT containing PN preparation available in India which is exclusively for pediatric use (100 ml).

Product	Strength (%)	Volume (ml)	Energy Content (Kcal)
MCT/LCT Solution-	10%	500 ml	450 cal
Lipofundin	20%	250 ml	450 cal
LCT Solution only	20%	500 ml	900 cal
Lipofundin	20%	100 ml	180 cal
Celepid	20%	500 ml	900 cal
	20%	250 ml	450 cal
	10%	500 ml	450 cal
Lipolipid	10%	500 ml	450 cal
	10%	100 ml	90 cal
	20%	500 ml	900 cal
	20%	250 ml	450 cal
Intrallpid	10%	500 ml	450 cal
	10%	100 ml	90 cal

C. Dextrose

Strength	Volume
5%	500 ml
10%	500 ml
20%	500 ml
25%	As Ampules
50%	500 ml Ampule and 100 ml bottle

*Aminsteril PAD (100 ml are specifically designed for Pediatric use.

Source: Nutrition in Diseases Management. Update Series 1: Pediatric and Enternal Nutrition in the Indian Context. Centre for Research on Nutrition Support System.

Now that we have a basic understanding about parenteral nutrition, it is also important for us to realize that there are certain precautions and complications linked with the use of parenteral nutrition. These are enumerated herewith:

- Blood parameters needs daily check.
- This type of nutritional support requires administration within the hospital due to the need to use sterile technique in handling the catheter and solution.
- Also patient's requiring this support are generally very critical and need the supervision of 24 hour intensive care support, and
- The risk of infection is the greatest worry with this type of nutrition requiring catheter. Aseptic (sterile) technique must be used at all times. Sepsis is the most frequent serious complication during PN, resulting in increased morbidity (due to technical and metabolic complications), mortality and healthcare costs. Common sources of infection include Staphylococcus *aureus*, Staphylococcus *epidermidis*, Candida species, Pseudomonas species, and *Escherichia coli.*

  Sudden termination of TPN can cause hypoglycemia, particularly in malnourished patients. In patients on cyclic PN, the rate should be halved for 1 hour prior to discontinuing it (Refer to Box 2 which presents advice on how to transition from PN to enteral to oral feeding).

Box 2	**Transitioning** to Oral Feeding

To ensure that the patients nutrient needs are met, TPN infusion should continue while oral feedings are initiated. At times the digestive tract atrophies if not used for more than two weeks; in such situations the food may not be tolerated well at first. TPN should be continued until nutrient needs are met with food. To enhance tolerance the following tips may be of use:

- If the patient is consuming an enteral formula, serve it diluted.
- Encouraging the patient to sip small volumes frequently at first.
- Gradually increase volumes and time between feedings.
- If the patient is to be weaned lor food, use transitional diets starting with clear liquids.

'Having gone through the discussion above, we hope your understanding about the parenteral nutrition would be somewhat clear. To help you recapitulate what you have learnt so far we have included some questions in check your progress exercise 2. Answer these questions and check your understanding on the topic.

Check Your'Progress Exercise 2

1. What is parenteral nutrition? How does it differ from enteral nutrition?

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2. What are the indications for providing parenteral support to patients?

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3. Why does the use of parenteral nutrition require great precaution?

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4.4 LET US SUM UP

In this unit, the focus was on the nutrient requirements of tlie critically ill individuals and on the types of nutrition support to be provided to such individuals.

We studied that the earlier concepts in critical care nutrition have undergone considerable changes in the past decade or so. Currently, a pragmatic approach is to provide 25 kilocalories per kilogram ideal body weight per day for most patients, The total caloric daily requirement should be administered in a fluid volume consistent with the patient's needs (usually 1ml/Kcal). Protein sources should comprise 15-20% of the total daily calorie requirement. The generally accepted amount of protein is between 1.2 and 1.5 g/kg per day, except in severe losses such as burns. Glucose should comprise 30-70% of the total calories and fats 15-30%.

Both parenteral and enteral nutrition are the types of nutrition support administered to the critically ill patients. Both are in the form of a liquid. Enteral is delivered directly into the stomach or intestine through a feeding tube. In *parenteral*, nutrients are delivered intravenously and the GI tract is bypassed entirely. The indication for administration of these feeds varies and different types of products are available in the market. Some of the enteral feeds can be homemade as well. Nutritional support, therefore, does influence the outcome of critically ill patients and evidence suggests that the consistent achievement of nutritional goals is important and this should be feasible through the enteral or parenteral route.

4.5 GLOSSARY

Catheter : a flexible tube used to deliver fluids into or withdraw fluids from the body.

Hepatic steatosis : refers to simple fatty liver, i.e. the accumulation of fat in the liver cells with no inflammation or scarring.

Hyperglycemia : a condition characterized by the presence of an abnormally high concentration of glucose in the blood.

Hyperinsulinemia : a condition, present in people with Diabetes Mellitus (type 2) or insulin resistance where excess levels of circulating insulin is present in blood.

Jejunostomy : a way to provide food through a tube placed into the small intestine

4.6 ANSWER TO CHECK YOUR PROGRESS EXERCISES

Check Your Progress Exercise 1

1. The patient should be provided ≈ 25 Kcal/kg ideal body weight per day. The total energy to be provided by Various macro-nutrients should be in the following proportions: Carbohydrates : 30-70% of total calories, proteins: 15-20% of tlie total calories (or 1.2-1.5 g/ kg IBW/ day) and fat: 15-30% of the total calories.

2. Nutrition support is generally provided to the patient when he/she cannot consume food orally or has impaired capacity to digest/ absorb. Two major forms of nutrition support are:

   - Enteral nutrition which is provided when the gastrointestinal tract is working partially/completely. It can be provided through nasogastric/naso-jejunal route or by conducting gastrostomies.

   - Parenteral Nutrition is given through the large central vein or peripheral veins when the gastrointestinal tract is not functioning.

3. Enteral nutrition can be given both as a substitute or as a supplement to oral intake. It is indicated during hypermetabolic states such as cancer, malnutrition, fever; impaired/altered functioning of brain, kidneys, liver etc.; resistance to oral feeding such as GERD, severe vomiting etc.; and in diseases of the gastrointestinal tract such as pancreatitis, cholelithiasis, fistulas, obstructions/ fistulas.

4. Depending upon the underlying disease condition, duration of illness and the current status of G.I tract any of the following enteral feed formulas may be used alone or in conjunction with each other. The major types of enteral formulas are polymeric, oligomeric, modular formulas, blenderised, disease specific, opportunistic and drink feeds.

Check Your Progress **Exercise 2**

1. Parenteral nutrition refers to administration of nutrition outside the digestive tract i.e. intravenously. It is a method of delivering nutrients with the help of a catheter directly into the blood stream. Whereas, enteral nutrition is delivered directly into the stomach or intestine through a feeding tube.

2. Parenteral nutrition is generally supplied when no part of the gastro-intestinal tract (particularly small intestine) can be successfully utilized to facilitate digestion and/ or absorption of food/ nutrients. It is usually given in critically ill patients who are suffering from burns of the gastro-intestinal tract, carcinomas of the gut, atrophy of the small intestine, blockage of the rectum/ colon, surgery of the small/large intestine or other organs associated with digesting of food and patients suffering from multiple complications such as diabetes with autonomic neuropathy and chronic renal failure.

3. Parenteral nutrition require great precaution because:

   i) infection can occur at the catheter insertion site and therefore dressings must be changed daily.

   ii) Technical complications such as pneyumothorax and haemothorax can occur.

   iii) Metabolic complication can occur.