

# 7 Enteral and Parenteral Nutrition in Critically Ill

**Abstract:** Metabolic response to critical illness is characterized by accelerated catabolism and it results in wasting and negative nitrogen balance. Nutritional support during catabolic phase will not only lead to positive nitrogen balance but also prevent weakness and, eventually, MODS and death. The preferred route of nutrient delivery is an oral route. However, critically ill patients are unable to eat because of endotracheal intubation and ventilator dependence. In others, oral feeding may be delayed because of impairment of chewing, anorexia, shock or depression. The two modalities available to provide nutrition in such cases are Enteral Nutrition (EN) and Parenteral Nutrition (PN). Enteral nutrition literally means providing food in the gastrointestinal tract. Enteral nutrition is widely used as it is more physiological, easier to administer, is associated with lower rates of infection and is cheaper. Depending on the site of feeding and functioning of gastrointestinal tract, various modifications of enteral formulation can be made. These changes ensure better patient outcome and lower rates of complications. When enteral nutrition fails to meet the nutritional requirements or when gastrointestinal feeding is contraindicated, parenteral nutrition support is initiated. Parenteral nutrition can be used to supply all the essential nutrients without using gastrointestinal tract. Parenteral nutrition can be provided through either a central or peripheral vein. Although an effective form of therapy, parenteral nutrition is expensive and cannot be continued for too long. It raises the cost of hospital stay.

Feeding is not considered medical therapy under ordinary circumstances. But when patients are critically ill and cannot eat themselves food takes the form of medical therapy.

The incidence of hospitalized malnutrition is well documented especially in critically ill patients. Despite advances in medicine, definitive indications for the use of nutritional support are unclear. Use of enteral and parenteral therapies is widespread for various reasons.

- a. Protein calorie malnutrition is common in a variety of hospitalized patients.
- b. Documented association is seen between malnutrition and increased morbidity and mortality.
- c. It seems intuitive that well nourished patients would respond more favorably to therapeutic interventions than malnourished patients.
- d. Nutritional support can be provided safely to wide variety of patients.
- e. Several randomized prospective clinical trials suggest that nutritional supports benefits patients.

Therefore, there is a clear cut evidence base for role of enteral and parenteral therapies in hospitalized as well as critically ill patients.

Nutrition support is delivery of formulated enteral or parenteral nutrients to appropriate patients for purpose of maintaining/restoring nutritional status.

Enteral nutrition refers to the provision of nutrients into the gastrointestinal tract through tube or catheter when oral intake is inadequate. Parenteral nutrition refers to provision of nutrients intravenously.

## Enteral Nutrition

By definition, enteral nutrition means 'within or by the way of GI tract'. In practice, enteral nutrition is generally considered tube feeding. The consensus of nutrition experts is that the gastrointestinal tract is more physiologically and metabolically effective than the intravenous route for nutrient utilization.<sup>1,2</sup>

Any disease process that adversely affects oral intake may ultimately lead to significant nutritional deprivation and depletion. Patients who cannot eat, will not eat, or should not eat, yet who have adequate function of the gastrointestinal tract, are candidates for enteral tube feeding.

Once the patient has been assessed and found to be a good candidate for enteral nutrition, the clinician selects the appropriate tube and route of access for tube placement. Enteral access selection depends on several factors: (1) anticipated length of time enteral feeding will be required, (2) degree of risk for aspiration or tube displacement, (3) presence or absence of normal digestion and absorption, (4) whether or not there is a planned surgical intervention, and (5) administration issues such as formula viscosity and volume.

## Advantages of Enteral Feeding

1. Safer.
2. It is more physiologic.
3. Less expensive.
4. Fewer side effects as compared to parenteral nutrition.<sup>3</sup>
5. Maintains gastrointestinal immune barrier and, and avoids central catheter related complication.<sup>4</sup>

## Indications of Enteral Feeding

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Oral intake inadequate or contraindicated	Mechanical: stroke, central nervous system disorders, coma, oropharyngeal and esophageal disorders, partial or complete esophageal or gastric obstruction Poor appetite: chemotherapy, radiation therapy, drug effect, nausea Transitional feeding: advance from parenteral to oral intake Psychological: anorexia nervosa, depression, Alzheimer's disease
Increased nutritional requirements	Burns, trauma, sepsis, surgical or medical stress
Digestive and absorptive disorders	Inflammatory bowel disease, short bowel syndrome, pancreatitis, irradiated bowel, proximal and distal intestinal fistulae, immunocompromised syndromes
Metabolic and excretory disorders	Glycogen storage disease Hepatic encephalopathy Renal disease

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## Contraindications of Enteral Feeding

Enteral feeding is contraindicated in patients with peritonitis, distal intestinal obstruction, intractable vomiting or severe diarrhea.<sup>4</sup>

## **Nutritional Needs of a Patient**

Assessment of nutritional status of every patient is fundamental and includes four key components: nutritional history, anthropometric measurements, clinical examination and biochemical data. Assessment of these parameters will help to document presence of malnutrition and will help clinician to select best method for providing nutrients and allows objective monitoring of nutritional efforts. These assessments also are needed to estimate calorie, protein, micronutrient requirement and also help to select/make right kind of formula.<sup>4</sup>

## **Formula Composition**

### *Energy*

The patients caloric requirement will help to determine the quantity of formula needed. General purpose formula tolerated by patients provide 1 kcal/ml. Other formulations also provide 1.5-2 kcal/ml, which are used when it is necessary to restrict fluids of the patient with cardiopulmonary, renal and hepatic failure.

### *Proteins*

Proteins in the diet provide essential amino acids that body cannot make and provides nitrogen for the synthesis of nonessential amino acids. In body, proteins serves the following functions (a) organic catalyst, for the structural formation of cells, (b) act as antibodies, (c) control cell metabolism. Inadequate protein intake causes diminished protein content in the cells and organs and deterioration of the cells' capacity to perform their normal function. Insufficient protein intake can potentially affect all aspects of patient's care; for example; it can lead to muscle atrophy and can make it difficult to wean patient off ventilator.<sup>3</sup>

In addition to the importance of adequate amounts of protein is the quality of protein. For example, formulas for renal failure patients are designed with highest quantities of essential amino acids.

Protein is the most critical component of enteral formulations. Proteins can be modified in various ways in enteral formulation for example intact protein, hydrolyzed protein, amino acids. Intact proteins are whole proteins from food or proteins isolates are intact proteins that have been separated from their source, e.g. whey, lactalbumin. Intact protein and protein isolates require normal pancreatic enzymes to catabolize them into small polypeptides and free amino acids.<sup>3</sup>

Hydrolyzed protein is one which has been enzymatically hydrolyzed to smaller peptide fragments and free amino acids. Formulas containing di and tripeptides and crystalline amino acids are often referred to as elemental or predigested formulas. These formulas can be directly absorbed into the blood stream. These feeds can be administered when the feeds are administered via jejunum where only absorption of proteins take place.

## **Glutamine and Branched Chain Amino Acids**

Glutamine and Branched Chain Amino Acids are amino acids found in skeletal muscle. They have been identified as key amino acids in preserving nitrogen balance during stress and injury. Numerous studies have indicated that glutamine is necessary to maintain integrity of intestinal mucosa, immune function of lymphocytes to preserve muscle glutamine pool and to improve overall nitrogen balance. Glutamine is considered a essential amino acid in critically ill patients.<sup>3</sup>

The BCAA valine, leucine and isoleucine are EAA and therefore are contained in all enteral formulas. Standard enteral formula contain 20% of BCAA while enriched solutions have 45% BCAA.

## **Arginine and Nucleotides**

Arginine is a conditionally essential amino acid; that is, it can be conditionally essential after injury. Human and animal studies have shown that increased intake of arginine after trauma decreases nitrogen losses and accelerates wound healing.

Standard formulas contain arginine in the amount of 1-2 g/L, and enriched formulas contain 14-15 g/L.

## **Nucleotides**

The nucleotides are important intracellular molecules that participate in a wide variety of biochemical processes, the best known are DNA and RNA. Nucleotides are added to some formulas as immunity enhancers. In animals, dietary supplementation of nucleotides have shown to facilitate growth and maturation of developing gut.

## **Taurine**

Taurine is conditionally essential nutrient since it can be synthesized by dietary cysteine or methionine.

## **High Nitrogen Products**

These have increased proportions of branched chain amino acids. These products are used for patients with catabolic stress. In one study, nitrogen retention appears to be better in patients with moderate to severe stress who were given products rich in branched chain amino acids.<sup>6</sup>

The amount of protein provided by formula depends on the amount of formula administered daily and concentration of protein in the formula. Most of formulas contain a nonprotein kcal: nitrogen ratio of 150:1 (with ranges between 100:1-200:1) which is thought to be optimal for patients. In patients who have sustained severe trauma, the requirement for protein synthesis are so great that lower ratio of calories to protein may be optimal. This ratio is expressed as non protein kcal to nitrogen. The conversion of nitrogen to protein and vice versa as follows: amount of  $N_2 = \text{Gm of protein}/6.25$ .

Most of the enteral formulations offer high nitrogen products. Patients who do not need high nitrogen formulas are likely to use amino acids for energy and increase urea production. As a result these formula should be given carefully to renal patients.

## **Carbohydrates**

Carbohydrates provide 30-90% of total calories of enteral formulas and in most of the formulas they are the principle source of energy. The main difference among the formulas are the form and composition of CHO. The CHO form ranges from starch to simple sugar and contributes to characteristic of sweeteners, osmolality, and digestibility. In general, the larger carbohydrate molecule have low osmolality, are less sweet and require longer time to digest than the shorter/smaller ones.<sup>3</sup>

Starches found in cereals, potatoes, legumes, and other vegetables are important sources of carbohydrates and are easily digested. As starches are insoluble in water, they are difficult to use in enteral formulations. Amylase rich flours made by sprouting and dry roasting cereals and pulses can be used for enteral feeding. Due to this kind of processing, starches become less viscous and are easy to feed through tubes. Oligosaccharides and polysaccharides are most abundantly used carbohydrates in enteral formulations. They require pancreatic enzymes and rarely cause intolerance. Disaccharides, e.g. sucrose and lactose, require disaccharide enzyme in the small bowel mucosa. Lactase deficiency is most prevalent disaccharide deficiency and hence most of the enteral formulas are lactose free.<sup>7,8</sup> Monosaccharides found in enteral formulas are

glucose and fructose. Due to their small molecule size, they make the formula hypertonic. Hydrolysis is not required for digestion, but tolerance may be limited by the absorptive capacity of the small bowel.<sup>7,9</sup>

### **Fiber**

Enteral formulas containing fiber may have potential clinical applications including ameliorating constipation and tube feeding-associated diarrhea, improving mucosal healing in inflammatory bowel disease, supporting gut barrier of critical patient and increasing intestinal adaptation in short bowel syndrome.<sup>10-15</sup> Predominant source of fiber in enteral formulas, is soya derived polysaccharides.

Fiber supplemented enteral formulas have been shown to improve bowel regularity in stable patients by increasing number of bowel movement per day.<sup>12</sup>

### **Lipids**

Fat is a dense source of energy and also serves as a vehicle for fat soluble vitamins and essential fatty acids. Most of the enteral formulas contain vegetable oil as primary source of fat. Vegetable oil is also a good source of essential fatty acid.

Fat does not contribute to osmolality of enteral formula. Common sources of fat in enteral formulations are soyabean oil, corn oil, medium chain triglyceride, lecithin, and milk fat. Other fat sources which have emerged as potentially important source of nutrients are immunoregulator like fish oils.

### **Long Chain Triglycerides**

Vegetable oils are predominant source of fat in enteral formulas. Long chain triglycerides are slowly cleared from blood stream and requires carnitine for its absorption. More information is needed to confirm their utility.

### **Medium Chain Triglycerides (MCT)**

MCTs are 6-12 carbon long and are usually prepared from palm kernel or coconut oil. They offer many advantages over long chain triglycerides, as they are absorbed intact without appreciable pancreatic or biliary function and are subjected to more rapid clearance from blood stream.<sup>16</sup> They are transported to the liver principally via portal venous system where they cross mitochondrial membrane and can be oxidized independent of carnitine.<sup>17</sup> They should not be used in patients who are prone to high ketone levels as they produce ketones.<sup>18</sup>

### **Vitamins, Minerals and Trace Elements**

Enteral formulations must fulfil the RDA of vitamins and minerals. Supplemental vitamins and minerals may have to be administered when they are not in adequate dosages in the formula. The individual nutritional status should be monitored and amounts of vitamins and minerals should be adjusted accordingly. Known essential trace elements are present in most of the formula and necessary supplementations with additional trace elements is done only if deficiency is detected.

### **Water**

The daily water requirement for a healthy adult is 1 ml/kcal taken for approximately 30-32 ml/kg.<sup>19,20</sup> Fluid requirement of hospitalized patients varies and should be monitored and maintained. Water is given in addition to that provided by the formula as flushes at intervals

throughout the day. A minimum of 30 ml of water every 6 hours is recommended as a flush for tube patency alone.

## **Physical Characteristics of a Formula**

### **Osmolality**

Osmolality is a physical phenomenon of net permeability resulting in equilibrium across the cell membrane. It is a measure of concentration of free particles, molecule or ions in a given solution in water. These particles include electrolytes, minerals, carbohydrates, proteins or amino acids. It is measured by determining number of particles of solute present per unit weight of water and is expressed in milli osmoles per kg of water. All nutrients and dietary components except water contribute osmolality of the solution. Osmolality of enteral formulation is increased by nutrient hydrolysis. Therefore, formulas with hydrolyzed nutrient have higher osmolality. Lipids contribute minimally to osmolality with exception of MCTs, owing to their water solubility. Minerals and electrolytes contribute significantly.<sup>7,8,21</sup> It has been widely thought that isotonic formulas (osmolality ranging from 280-320 milli osmoles/kg) are tolerated better than hyper or hypotonic formulas.

### **Renal Solute Load**

Renal solute load refers to the constituents in the formula that must be excreted by the kidneys. Protein, sodium, potassium, and chloride are the major constituents of enteral formulas that contribute to the renal solute load. It is important, as there is obligatory water loss with each unit of solute. As a formula becomes more concentrated or the renal solute load increases, the patient requires more water.<sup>7</sup> Hydration status of enterally fed patients should be monitored daily, especially in pediatric and geriatric patients and those with excessive losses due to diarrhea, emesis, fistulas, or fever.

### **Nutritional Formulations**

A wide variety of commercially prepared formulas with variable sources and concentrations of protein, carbohydrate and fat are currently available.

### **Polymeric Formulas**

Polymeric formulas are composed of intact proteins, disaccharides and polysaccharides and variable amount of fat. The osmolality of polymeric formula is usually lower than that of elemental formulas. These formulas require a functioning gastrointestinal tract for digestion and absorption of nutrients. Polymeric formulas can be further subdivided into hypercaloric formulas, normocaloric formulas, etc.

### **Predigested Formulas**

Predigested formulas are composed of low molecular nutrients, have minimal residue and are thought to lead less stimulations of pancreatic and gastrointestinal secretion and are less allergic than other formulas.<sup>22</sup> These formulas have greater osmolalities than the polymeric formulas because of the small molecular weight of nutrients.

### **Modular Products**

Individual macronutrients modules such as glucose polymers, proteins, and lipids are available as additives to foods and enteral formulas to change overall fuel composition. Individually customized enteral formulas may also be formulated from modular products to yield

nutritionally complete formulas that meet patients need with fluid restriction, electrolyte imbalance, or specific nutrient requirements.

### **Disease Specific Formulas**

These products are designed for patients who have specific medical conditions that may require nutrient modification for example patients with hepatic encephalopathy require formulas high in branch chain amino acid and low in aromatic amino acid. There are specific formulas for hypermetabolic and stress patients, diabetic patients. Certain formulas contain arginine, ribonucleic acid and fish oils which can be used as immune enhancing formulas for cancer, post surgical, and burns patients.<sup>23</sup> Formulas are also available that are designed for specific conditions such as pulmonary disease or renal failure.

### **Formula Selections**

Selection of appropriate formulas is based on patient's medical and nutritional status, digestive and absorptive capabilities which indicate whether predigested or polymeric formulas can be used.

The suitability of a feeding formula for a patient should be evaluated on the basis of the following characteristics:

1. Functional status of patient's GI tract.
2. Physical characteristic of formula such as osmolality, fiber content, caloric density and viscosity.
3. Macronutrient ratio.
4. Digestion and absorption capacity.
5. Specific metabolic needs.
6. Contribution of the feeding to fluid and electrolyte needs or restriction.
7. Cost effectiveness.<sup>5</sup>

### **Administration of Tube Feeding**

Proper administration of enteral formulas ensures safe delivery of desired nutrients, enhanced patient tolerance and optimal nutrition support. There are various methods of feeding patients. Choice of technique depends upon gastrointestinal function, feeding site, and ultimately patient response.

#### *Bolus Feeding*

Bolus feeding is rapid administration of large volumes of formula over a short period of time usually by syringe. This form of feeding is least cumbersome, but is associated with increased possibility of aspiration, regurgitation and gastrointestinal side effects. A rate of 30 ml/min or a volume of 500-750 ml/feed appears to mark physical tolerance limit.<sup>24</sup>

#### *Continuous Feeding*

*Continuous infusion is controlled:* Delivery of prescribed volume of formula at constant rate over a continuous period of time, using infusion pumps or gravity assisted sets. This method is considered advantageous since gastric cooling is minimized and few gastrointestinal tract side effects are experienced.<sup>25</sup> Continuous infusion into jejunum is more analogous to normal gastric emptying.

#### *Intermediate Infusions*

In intermediate feeding, total quantity of formula needed for 24 hrs is divided into equal portions and required fractions are administered in 3-6 feeding. Each feeding is administered over 30-90 minutes period.

### **Technique of Feeding**

1. Selection of appropriate formulas
2. Elevate the head of the patient's bed to at least 30 degree to horizontal levels before feeding begins.
3. Aspirate through nasogastric or gastrostomy tube before initiating feeding to determine whether retained gastric secretions are present.
4. Begin feeding schedule of 100-150 ml of isotonic or slightly hypertonic formulas every 4 hours.
5. Increase formula amount by 50 ml every 1 or 2 feeding upto 450 ml/4 hours.
6. Flush the tube at least with 30 ml of water after feeding and every 4 hours to maintain patency.

### **Complications of Enteral Feeding**

1. Mechanical complications associated with tube type and its position: nasal catheter dislocation/obstruction, reflux of gastric contents leading to aspiration pneumonia, tube leakage.
2. Gastrointestinal complications: delayed gastric emptying, constipation, nausea, vomiting, cramping, abdominal pain, malabsorption and diarrhea.

### **Parenteral Nutrition**

Parenteral nutrition is a form of intravenous therapy that provides opportunity to replenish or maintain nutritional status.<sup>26</sup> Parenteral nutritional was originally developed to nourish those whose gastrointestinal tract was not capable of digesting and absorbing nutrients. The ultimate indication for parenteral nutrition continues to be nonfunctioning tract and documented inability to tolerate enteral feeding. In addition, patients should be at nutritional risk.

Central parenteral nutrition is delivery of nutrients through the large diameter vein usually subclavian or superior vena cava. Peripheral parenteral nutrition is usually delivered through small veins usually in fore arm. Central parenteral nutrition is indicated when volume and concentration of solution preclude peripheral administration and when anticipated duration of therapy is greater than 7 days to 2 weeks and when substantial depletion of body fat and protein has occurred. Peripheral parenteral nutrition is preferred when solution concentration is less than 1000 mOsm/l, and duration of therapy is less than 10 days.

### **Indications<sup>27</sup>**

The basic indications for use of parenteral nutrition is the requirement for nutrition when the gastrointestinal tract is either not working, not available, or not appropriate. Parenteral nutrition may be useful for (but is not limited to) the following situations:

1. Non functioning gut e.g. paralytic ileus
2. Malnourished patients in whom the use of intestine is not anticipated for >7 days after major abdominal surgery
3. Patients with specific conditions severely affecting gastrointestinal tract (such as severe mucositis following systemic chemotherapy, upper gastrointestinal strictures or fistulae, severe acute pancreatitis where jejunal feeding is contraindicated).



4. In those patients with major resections of the small intestine (short bowel syndrome) before compensatory adaptation occurs.
5. Patients in the Intensive Care Unit (ICU) with systemic inflammatory response syndrome (SIRS) or multiple organ dysfunction syndrome (MODS).

The duration of parenteral nutrition in most of the described category depends upon the return of normal gut function. Provision of parenteral nutrition for < 7 days is usually not clinically indicated as the risk outweighs the benefit, but is accepted that sometime this will occur as a consequence of early identification and intervention in 'at-risk' patients. All patients referred for parenteral nutrition should have also been referred to the ward dietitian for a full nutritional assessment.

Long-term parenteral nutrition may be required in a small number of patients for various reasons:

1. Extreme short bowel syndrome of any etiology.
2. Other causes of prolonged intestinal failure (atresia, radiation enteritis, some inflammatory or motility disorders).

### **Proteins/Amino Acids<sup>28</sup>**

The primary function of protein in parenteral nutrition is to maintain nitrogen balance, thus preventing skeletal muscle from being degraded from gluconeogenesis. Protein requirement can be very high during intensely catabolic state. A positive nitrogen balance may not be feasible during the first few days of the catabolic stress. A positive caloric balance is necessary to establish a positive nitrogen balance. For delivered amino acids to be incorporated into new protein rather than catabolize, the ratio of nonprotein calories to gram of nitrogen should approach 150:1. This ratio is based on the fact that 10-15% or more of required calories during catabolism are derived from protein breakdown. The protein requirements of patients on parenteral nutrition may be difficult to calculate because of non measurable protein loss from wounds or draining body fluid and because of increase need resulting from inflammation, immobilization and other conditions.<sup>27</sup>

Commercial amino acids are available. Dilute solutions are most often used for peripheral administration. Amino acid profiles of parenteral solutions are based on FAO-WHO recommendations for optimal proportion of essential amino acid. Supplemental arginine and histidine are included as they are essential during stress.<sup>28</sup>

### **Carbohydrates<sup>28</sup>**

Primary function of parenteral carbohydrate is to serve as energy source. Optimum carbohydrate is an amount adequate to spare protein without exacerbating hyperglycemia. Commercial carbohydrates consist of D-glucose, dextrose monohydrate in sterile water.

### **Fat<sup>28</sup>**

Parenteral lipids provide as a source of essential fatty acids and calories. They can be substituted for dextrose calories for patients with glucose intolerance or used as concentrated caloric source for patients who require volume restriction.<sup>28</sup> Fats have lower respiratory quotient than carbohydrates, which is a rationale for use of lipids to provide large proportions of nonprotein calories in patients with respiratory failure.<sup>27</sup> Because fat emulsions are isotonic, they can be administered through peripheral vein. Alternatively they may be directly added to parenteral nutritional solution.<sup>28</sup>

### **Electrolytes**

Electrolytes requirement for patient receiving total parenteral nutrition may vary depending on body weight, presence of malnutrition or catabolism, the degree of electrolyte depletion, change in organ function, ongoing electrolyte losses and disease process. Guidelines for electrolyte management of patients receiving parenteral nutrition should be used in conjunction with clinical judgment.

### **Vitamins**

Vitamin requirements during parenteral nutrition therapy are uncertain because they are not based on balanced studies. Recommendations for parenteral nutrition therapy have been made by American Medical Association, Nutrition Advisory Group.<sup>27</sup> Patients with multiple vitamin deficiency or with markedly increased requirement may be given multiple doses as indicated by clinical status.<sup>4</sup>

### **Water**

Water requirements vary depending on the capacity of patient to excrete an osmotic load. Usually requirements are 30 ml/kg in normal adult or approximately 1 ml/kcal delivered. An additional 360 ml/d is recommended for each centigrade of temperature elevation. Also 300-400 ml of water/day may be necessary for new intracellular fluid if anabolism is being induced.

Restriction of water is necessary during volume overload and presence of hyponatremia. Patients who become hyperosmotic may need additional free water on daily basis.<sup>29</sup>

### **Trace Elements**

Trace elements are those nutrients that makeup less than 4 gm or 0.01% of total body content. Trace elements are commercially available as combination products or single entity injections. Individual trace elements may be supplemented in appropriate doses as specific patients deficiency dictates.

### **Osmolality and Osmolarity**

Osmolality refers to number of water attracting particles per weight in kilograms. Osmolarity refers to number of milli osmoles in a liquid or solid in a liter of solution. While osmolality is most often used in reference to enteral feeding, osmolarity is preferred term for parenteral solutions. Body maintains serum osmolality between 280-300 mOsm/kg. While TPN administration might potentially change serum osmolality, the large volume of blood, rapid blood flow, and renal regulatory mechanism mediate this process. To avoid the irritation to veins, solutions with osmolarity greater than 900 mOsm/l are not usually administered peripherally.

### **Initiation of Parenteral Nutrition**

Prior to initiation of parenteral nutrition, a baseline biochemistry should be checked and fluid and electrolyte abnormalities should be corrected.<sup>27</sup>

### **Monitoring**

During first week of parenteral nutrition (and subsequently if patient is unstable with respect to fluid and electrolyte or metabolic issues) the patient should be monitored intensively.<sup>27</sup>

### **Reintroduction of Diet**

Diet should be reintroduced in a graded fashion.

## Complications

The complications of parenteral therapy can be divided into three categories: technical – Pneumothorax, malposition, subclavian artery puncture, air embolism etc; septic – catheter related sepsis, septic thrombosis; and metabolic – hyperglycemia, hypoglycemia, hyperkalemia, hypophosphatemia, etc. With proper patient monitoring, most of these complications can be minimized.<sup>4</sup>

## Home Total Parenteral Nutrition (Home TPN)

Patients can be discharged to their home on TPN.<sup>30-32</sup> Most of the patients requiring these therapy either have malignancies or intestinal complications related to therapy for malignancies (resection or radiation), inflammatory bowel disease or one of variety of intestinal disorders including severe gastrointestinal motility disturbance or short bowel syndrome following trauma, or ischemia insult. The major determinant of outcome of home TPN is patients underlying disease. In case of home TPN, comprehensive training of the patient and his family is necessary before discharge.

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## Multiple Choice Questions

1. **In jejunostomy feeds \_\_\_\_\_ formulas should be used:**
  - A. Modular
  - B. Polymeric
  - C. Elemental
  - D. All of them
2. **The non-protein kilocalories : nitrogen ratio of \_\_\_\_\_ is thought to be optimal for patients:**
  - A. 100:1
  - B. 200:1
  - C. 150:1
  - D. 50:1
3. **\_\_\_\_\_ do not contribute to osmolality of enteral feeds:**
  - A. Minerals
  - B. Carbohydrates
  - C. Proteins
  - D. Fats
4. **\_\_\_\_\_ are the kind of fats that are absorbed intact without appreciable pancreatic or biliary function and they can cross mitochondrial membrane and oxidize independent of carnitine:**
  - A. MUFA
  - B. MCT
  - C. PUFA
  - D. Saturated fat
5. **\_\_\_\_\_ formulas provide individual nutrients like glucose polymers, protein, and lipids as additive to enteral formulas to change fuel composition of the feeds:**
  - A. Polymeric
  - B. Elemental
  - C. Modular
  - D. Kitchen formulas
6. **\_\_\_\_\_ has lowest respiratory quotient among all the macronutrients:**
  - A. Carbohydrate
  - B. Proteins
  - C. Fats
7. **\_\_\_\_\_ solutions are isotonic and hence they can be administered through peripheral vein in case of parenteral nutrition:**
  - A. Carbohydrates
  - B. Fats
  - C. Proteins