CHAPTER II

REVIEW OF LITERATURES

Enteral nutrition, a delivery method of nutrients to the gastrointestinal (G.I) tract, is considered to be one of the optimal method of nutrition support for malnourished patients who have normal gastrointestinal function. When oral intake is unsatisfactory, maintenance of nutrition by tube feeding is an alternative.[5,7] This method of nutrition delivery systems should always be considered first as with appropriate education; it is simple, effective, economical, and safe for all patients either to nutritionally replete or to prevent malnutrition.[5,15,16] Enteral nutrition can be given by mouth, nasoenteric tube, or tube enterostomy.

The use of enteral nutrition has been dated back to Egyptian era many centuries before Christ. The earliest recorded evidence of enteral hyperalimentation was the use of rectal feedings.[17] In the post-World War II, tube feeding into the stomach or jejunum and peripheral infusions were considered preferable. Gastric tube for nutrition purpose was first employed by Capivacceous back to the sixteenth century. In 1910, Einhorn introduced the principle of feeding directly into the duodenum. Several studies reported during the 1930's and 1940's demonstrated the effectiveness of the jejunal tube feeding route. By the 1950's the benefits of enteral feeding were well recognized. The development of formulas had advanced to the degree where the roles of macronutrients and major micronutrients in the digestive and absorptive processes were being seriously addressed.[15,18]

Indications and Patient Selection [19]

The first steps in identifying patients in need of total or supplemental nutritional support are considerably from complete medical history, dietary review, and physical examination. Ideally, the oral route is preferred, but in most instances the patient is unable or unwilling to ingest adequate calories and protein. The enteral route has been chosen to be an alternative if the gastrointestinal tract is functioning.[5,15] There are four main categories of pateints who are candidates for enteral nutrition. These include[15]

(1) patients who cannot achieve their nutrition intake primarily because of decreased appetite. These patients have poor oral intake such as severe depression, anorexia nervosa, trauma etc.

(2) patients with mechanical problems that interfere with their ability to ingest nutrients. These patients usually have some oral problem that interferes with their ability to eat. The profile includes patients with facial and jaw injuries, chewing and swallowing problems.

(3) patients with metabolic gastrointestinal tract dysfunction which is the result of impaired digestion and absorption. Examples of patients in this category include radiation enteritis, pancreatitis etc.

(4) hypermetabolic patients who have an increase in energy and protein requirements secondary to severe stress and catabolism.

Factors that contraindicate use of the enteral therapy include severe gastrointestinal disturbances such as intractable vomiting, intestinal obstruction, and uppergastrointestinal bleeding.

Nutritional Requirements and Enteral Nutrition

Provision of adequate energy, nitrogen, specific vitamins, minerals, trace elements and fluid and electrolyte requirement is

fundamental to successful nutrition intervention.

1. Macronutrient requirements : protein and energy requirements

Individual requirements for dietary protein and energy are determined by the number of cells in the body and the rate of protein synthesis and degradation. For nutrition support, provision of adequate protein and energy is necessary in order to make nitrogen equilibrium.[20]

Protein requirements of adults vary with age and state of health. Factors in determining how protein requirements can be met are the quantity and quality of protein source. While the Recommended Dietary Allowances (RDA) suggest mean requirements for normals vary greatly among individual subjects. Low protein diets of high biological quality have proved to be efficacious in controlling uremia and maintaining nitrogen balance. Branched-chain amino acids have been shown to have a beneficial effect on anabolism after trauma and in septic states.[21]

Carbohydrates and fats are the best sources for energy requirement, because amino acids from proteins are needed for protein synthesis. Fats are concentrated energy sources which provide 9 Cal/g. It is currently believed that the percentage of fat in normal diet of Americans (40 to 45 percent) is too high, therefore, it would seem that the optimal carbohydrate to fat ratio is probable 3 to 1.

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2. Micronutrient requirements : vitamins and mineral requirements

The essentiality of vitamins and minerals to health has been known for centuries. Although vitamins and minerals constitute

only a small part of human tissue, they are essential in many vital processes. Vitamins are potent organic compounds mostly obtained from the diet, and their absence results in specific deficiency diseases. Minerals serve as major factors in regulation of acid-base and fluid-electrolyte balance in human organism. Minerals may be classified as macro- or micro-elements depending on the amount required in the diet. Vitamin and mineral requirements for patients receiving enteral feedings are not significantly different from regular oral administered.

Formulas

Enteral formulas for hospitalized patients have proceed from the home-blenderized whole food diets, highly refined, "predigested" nutrients in combination or in isolated form. Blenderized food formula has certain advantages over commercial formulas that carbohydrate, protein, fat, and fluid may be specially formulated, eventhough there is less flexibility with its vitamin, mineral and electrolyte content. In addition, blenderized food may be less costly than commercial formulas. However, there are many problems associated with its preparation and administration. Prepared food often yields a heterogenous viscous solution and has bacterial growth while commercial formula provides a sterile, homogeneous solution. In recent years, many commercial formulas have been developed in liquid and powder forms. All the enteral formulas differ in content of residue of lactose, source of amino acid, carbohydrate, fat, other nutrients, osmolality, taste, and expense. Selection of a suitable enteral solution for each case requires an understanding of these factors.[19]

Commercial formulas may be classified into two types.

1. Defined formulas. These formulas claim to be complete in all essential nutrients.[7,23] The nutrient composition in the formula varies widely. There are two types of defined formula.

1.1 Elemental formulas.[3,19] These solution are low in residue and are composed of a predigested and easily absorbed protein. Amino acids and hydrolyzed proteins are solely protein source in these formulas. Carbohydrate sources are monosaccharides and oligosaccharides which require little amylase activity. However, these formulas are low in essential fatty acids. All essential minerals and vitamins are included in the elemental formulas. These formulas are indicated in patients with malassimilation.

Elemental solutions have several disadventages. Most are unpalatable. Elemental diets are also hyperosmolar and thus cause an osmotic diarrhea if infused too rapidly.

1.2 Polymeric formulas. The osmolarity of polymeric solutions is lower than that of elemental solutions.[19] It is because polymeric solution are composed of high molecular weight protein, carbohydrate, and fat. Most products are based on milk protein so lactose content is a major problem in lactose intolerance. Protein isolates are substituted for some lactose free formulas.[5,7,16] Fat contributes a greater percentage of the total calories than in elemental diets, and this tends to improve palatability. The preparations are complete with respect to vitamins and minerals. Most polymeric mixtures can be tolerated for weeks or months. These solutions are less expensive than the elemental preparations and are usually isoosmolar. The main disadvantage of polymeric preparations is the restricted nutrient composition.[16]

2. Modular feedings. They are specialized enteral solutions used in specific disease states. Protein, carbohydrate, fat, vitamin, and mineral supplements are combined and prepared in varying proportions tailored to each patients.

Characteristics of the Enteral Formulas

1. The formulas must be complete in essential nutrients. Protein, carbohydrate, fat, vitamin, and mineral content can meet the requirement of the body.[5,7] Commercial formulas that are restricted in lactose content may be claimed as ideal formulas.[5,7,16]

2. Carbohydrate, protein, and fat provide the energy source ranging from 45 to 55 percent, 15 to 20 percent and 30 to 35 percent, respectively, in standard formulas.[15]

3. Non-protein calories to nitrogen ratio must be 150 Cal per 1 g nitrogen.[24]

4. Most of formulas provide average 1 Cal/ml but in high caloric density formulas can provide up to 2 Cal/ml. These formulas are useful when water and sodium intake must be limited.[24]

5. The osmolality of the formula has a direct effect on gastrointestinal side effects. The osmolality of serum is approximately 300 mOsm/kg of water, and enteral solutions range from 300-800 mOsm/kg of water. Hyperosmolar solutions can cause diarrhea, vomiting, cramps, and nausea.[19]

6. Enteral formula must not have bacterial contamination. Aseptic technique is required for good manufacturing practice.[15]

Nutritional Composition of the Enteral Formula

1. Protein[15,23]

The protein content is the most critical component of enteral formulas, as amino acids are required for the maintenance of body cell mass and is necessary for virtually all major bodily functions. All commercially available enteral formulations contain high-quality protein.[25] Sources of amino acids include:[3,19]

(1) intact protein in the form of pureed meat, eggs, or milk

(2) protein isolated from casein, soybean, or egg white

(3) hydrolyzed protein

(4) crystalline amino acids

The molecular form in which nitrogen is supplied in the enteral formula has considered bearing on solution osmolality and rate of nitrogen absorption. The large molecular weight proteins as well as hydrolyzed protein require further digestion, breaking them down to the most absorbable units. The advantage is the tonicity characteristicof the solutions is lower than crystalline amino acid solutions.

2. Fat [15,19,23]

Fat, which provides concentrated energy, exists in two main forms as long-chain triglycerides (LCT) and medium-chain triglycerides (MCT) in enteral formulas. Other advantages of fat are a carrier for fat-soluble vitamins, a source of essential fatty acid, and making formula palatable.

Major sources of fat in formulas are butterfat from milk, corn oil, safflower oil, soybean oil, lecithin, mono- , diglycerides and MCT oil.

Vegetable oils in formulas provide long-chain triglycerides which are a rich source of essential fatty acids. The estimated requirement for essential fatty acids, especially linoleic acid, is approximately 3 to 4 percent of the total energy. Therefore deficiency is unlikely to occur in most patients receiving enteral formulas. Medium-chain triglyceride, made up of fatty acids that vary from 6-12 carbons in length, is an alternative to long-chain triglyceride in formulas.

Medium-chain triglycerides[19,26] do not depend on the action of pancreatic lipase and bile acid solubilization for absorption. Instead, they diffuse across the intestinal mucosa and go directly

into the portal circulation (Figure 1). In the endoplasmic reticulum of hepatocyte, medium-chain fatty acids cross the double mitochondrial membrane very rapidly and do not require the presence of carnitine, unlike the long-chain fatty acids, then undergo beta-oxidation (Figure 2).

The use of MCT oil is specifically indicate in fat maldigestion and absorption problems. An important limitation of MCT oil is the lack of the essential fatty acid linoleic acid. The metabolic side effect observed with the use of MCT oil are related to its extensive oxidation within the liver, which may induce ketogenesis. In cirrhotic patients may lead to increased mental impairment because liver capacity to oxidize fatty acids from MCT has been deminished.

3. Carbohydrate [15,19,23]

Carbohydrates provide the energy source in enteral formulas, ranging from 40 to 90 percent of total calories. With the exception of lactose, carbohydrate is the most easily digested and absorped component in formula. The source of carbohydrate, ranging from starch to simple glucose, contributes the characteristic of osmolality,sweetness and digestibility. There are four main types of carbohydratesource including :

(1) Starch (polysaccharides). In commercial formulas, starch is supplied from cereal solid and food starch. Starch is hydrolyzed by the pancreatic enzyme alpha-amylase to dextrin, maltose, and isomaltose. Starch intolerance is rare. Because of its high molecular weight, starch lowers osmolality and decrease sweetness of the formula.

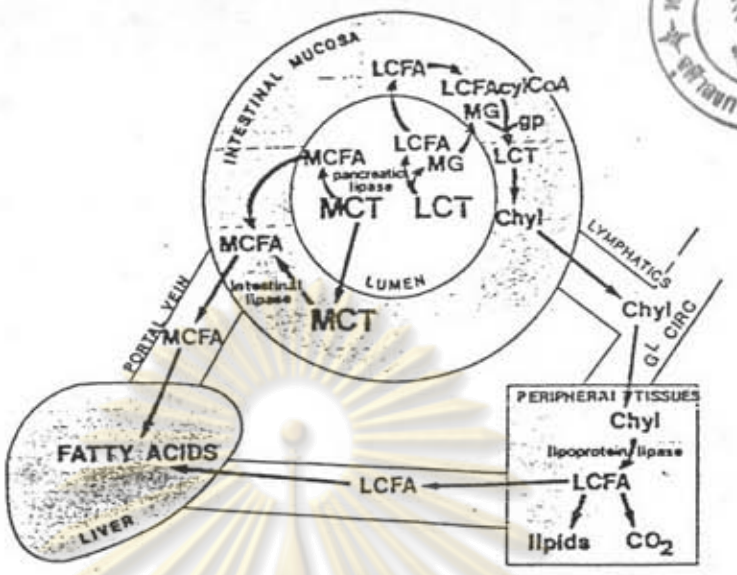

Figure 1 Digestion, absorption and tranport of fats [26]
MG, monoacylglycerol; Chyl, chylomicrons;
gp, ∝-glycerophosphate; GL CIRC, general circulation

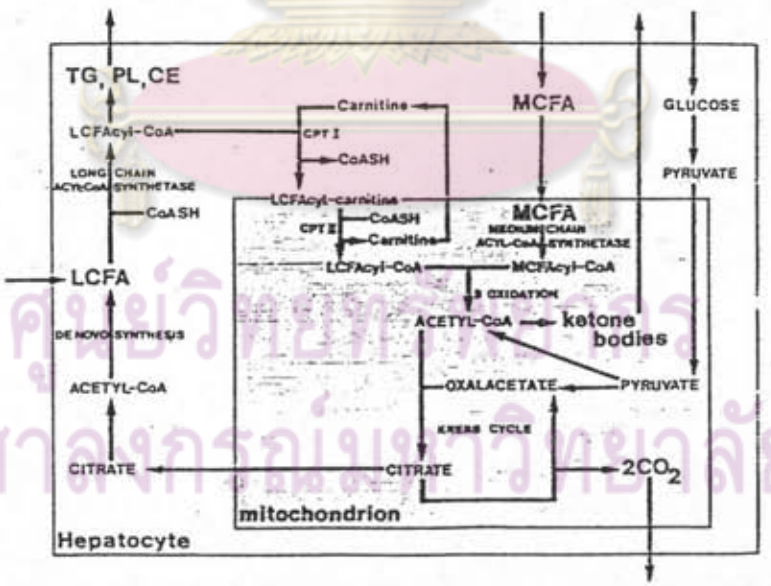

Figure 2 Hepatic metabolism of fatty acids [26] TG, triacylglycerols;
PL, phospholipids; CE, esterified cholesterol;
CPT, carnitine palmityl tranferase

(2) Glucose polymers. They are carbohydrates that result from the hydrolysis of starch. These shortered polymeric chains enhance the solubility of the solution. Because of their reduced molecular weight, they increase osmolality and sweetness. Glucose polymers are rapidly hydrolyzed in the intestine by the same pancreatic enzymes that hydrolyze starch molecules. Like starch, intolerance to glucose polymers is rare.

(3) Disaccharides. The disaccharides found in normal diets and enteral formulas are sucrose, lactose and maltose. These disaccharides require the action of specific disaccharidases for hydrolysis to their monosaccharides :glucose, galactose and fructose. Digestion of maltose and sucrose occur rapidly in the small intestine while lactose is hydrolyzed slowly. The presence of disaccharides in formula will increase the osmotic concentration, as they are smaller molecules than the glucose polymers.

Lactose is a disaccharide found primarily in milk and milk products. It is accomplished by the action of the enzyme lactase, properly named beta-D-galactosidase.[9] The deficiency in lactase allows free lactose to remain unabsorbed, and the latter, and in turn, exerts a direct osmotic effect on the small bowel and colon. Fermentation of lactose by intestinal bacteria gives rise to organic acids that may induce nausea, vomiting, flatulence, and diarrhea.

Lactose Intolerance [9,27]

In most mammals, including the majority of humans, intestinal lactase levels are at their highest immediately after birth, then decreasing with weaning until very low levels of lactase are present in adult. However, a minority of human groups maintains comparatively high levels of lactase and capable to digest and absorb lactose throughout adult life.

Whether due to the normal post-weaning decrease or any injury to the intestinal mucosa, low lactase levels are responsible for limited hydrolysis of lactose. Lactase deficiency can be primary or secondary. In primary deficiencies there is an enzyme or carrier defect, for examples, include lactase deficiency found in many adults and lactase or sucrase-isomaltase deficiency present at birth. Secondary deficiencies may arise due to a disease or disorder of the intestinal tract, and these defects would have been disappear when the disease is resolved. Such diseases could include protein deficiency, celiac disease,and intestinal infection.

Adult lactase deficiency is the most common of all enzyme deficiencies, with well over half of the world adults being lactose intolerance. Small quantities of lactose can be tolerated, however, and most individuals can tolerate up to 100 ml of milk (5 g lactose) without symptoms. Congenital lactase deficiency has been reported, but is rare. Lactose intolerance is treated by removing lactose from the diet, using lactose-reduced milk products, or consuming products that promote in vivo hydrolysis of lactose.

(4) Monosaccharides. Formulas that contain pure glucose as their sole source of carbohydrate will be very sweet and hypertonic.

4. Vitamins and Minerals [15]

Most nutritional formulas are designed to be nutritional complete, vitamins and minerals are added in order to provide completely essential nutrients. Vitamins and minerals in the formula provide to meet the Recommended Dietary Allowance (RDA,1980).

5. Fiber

Formulas prepared from blenderized natural foods are a rich source of fiber. But in the new ready-to-use formulas, extracts of food sources, residue or fiber content is minimized. Residue content is an important consideration when treating patients with fistulae or chronic intestinal disease

Selection of a Defined Formula. [28]

One logical approach to dietary management is to alter the digestive potential of the bowel by the use of formula. When lactase is severely depressed and glucoamylase activity is only moderately depressed, the obvious carbohydrate source is glucose polymers or dextrins. Similarly, with deficient proteolytic activity, protein in the formula should be partially hydrolyzed, and with a change in absorptive surface area and reduced bile salts in the duodenum, a portion of the long chain triglycerides should be substituted with medium-chain triglycerides.

Before using a formula, one must decide the severity of bowel dysfunction. Table 1 lists formula categories for the various diseases entities.

Complications During Enteral Nutrition Support. [5,29]

The complications associated with enteral feeding fall into three categories, namely,mechanical, gastrointestinal and metabolic.

Mechanical problems associated with the tube itself vary in according to tube and positions. Samples of this sort of complication are nasopharyngeal discomfort from prolonged intubation, laminal obstruction, etc.

Table 1 Formula Categories for the Various Disease Entities

Disease category	Formula type
Decrease dietary intake	Nutritionally complete
Without malabsorption	Lactose-containing
Lactose intolerant	Lactose free
	Diet supplements
Decrease absorptive capacity	Fat-containing
Deficient bile or lipase	MCT
Deficient proteases,bile, epithelial damage	Hydrolyzed protein
	Low-fat
	Protein hydrolysate
	Amino acid
Inborn errors	
Galactose-free	Lactose free
Fructose-free	Sucrose, fructose free
Amino acidopathy	Modulation of specific amino acid
Lipid and bile acid abnormalities	MCT-containing formula

Gastrointestinal side effects, including distention, cramping, vomiting and diarrhea, are the most frequently found complications of tube feeding. These symptoms can also be associated with antibiotics and other medications such as quinidine. However, the most commonly diet-related cause of these symptoms are unrecognized lactose intolerance or rapid infusion of a hyperosmolar formula. A dietary history will determine the lactose intolerance, and the formula must be adjusted appropriately.

Metabolic complication is the result of metabolic and fluid-electrolyte imbalance. When hyperosmolar nutrients are administered, hypertonic dehydration will occur because of fluid imbalance. Glucose intolerance can occur with diets that use carbohydrate as the primary caloric source. Patients with systemic diseases, such as cardiac failure, will require appropriate medifications of the tube feeding regimen to avoid fluid overload. Complications of enteral nutrition support are summerized in Table 2.

Table 2 Complication of Enteral Nutrition Support

Complication	Therapy
Mechanical	
Nasopharyngeal irritation	Ice chips, topical anesthetics, decongestants
Luminal obstruction	Flush, replace tube
Mucosal erosions	Reposition tube, ice water lavage, remove tube
Tube displacement	Replace tube
Aspiration	Discontinue tube feeding
Gastrointestinal	
Cramping/distention	Change formula if patient is lactose intolerant; reduce infusion rate
Vomiting/diarrhea	Reduce infusion rate, dilute formula, add antidiarrheal agents
Metabolic	
Hypertonic dehydration	Increase free water
Glucose intolerance	Give insulin, reduce infusion rate
Hyperosmolar nonketotic coma	Discontinue tube feeding
Hepatic encephalopathy	Decrease amount of protein
Renal failure	Decrease phosphate, magnesium, potassium; protein restriction; essential amino acid solution
Cardiac failure	Reduce sodium content, fluid restriction