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Medical Nutrition Therapy in Hospitalized Patients with Diabetes

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Abstract

Medical nutrition therapy (MNT) plays an important role in management of hyperglycemia in hospitalized patients with diabetes mellitus. The goals of inpatient MNT are to optimize glycemic control, to provide adequate calories to meet metabolic demands, and to create a discharge plan for follow-up care. All patients with and without diabetes should undergo nutrition assessment on admission with subsequent implementation of physiologically sound caloric support. The use of a consistent carbohydrate diabetes meal-planning system has been shown to be effective in facilitating glycemic control in hospitalized patients with diabetes. This system is based on the total amount of carbohydrate offered rather than on specific calorie content at each meal, which facilitates matching the prandial insulin dose to the amount of carbohydrate consumed. In this article, we discuss general guidelines for the implementation of appropriate MNT in hospitalized patients with diabetes.

Keywords

Nutrition support; Hyperglycemia; Diabetes mellitus; Parenteral nutrition; Hospital care; Enteral nutrition; Medical nutrition therapy

Introduction

Malnutrition among hospitalized patients is associated with depletion of body mass, poor wound healing, impaired immune function, impaired ventilatory drive, and weakened respiratory muscles, leading to longer hospital stay [1, 2•] and increased infectious morbidity and mortality [3, 4]. Malnutrition in critically ill patients is common with a prevalence of 40% in intensive care unit (ICU) [5]. Improving the nutritional state can restore immunologic competence and reduce the frequency and severity of infectious complications in hospitalized patients [6–9]. Inpatient medical nutrition therapy (MNT) aims to optimize glycemic control and to provide adequate calories to meet metabolic demands. Data from a large national database from over 1 million patients in the United States (surgical, medical, and trauma) indicated that specialized nutrition support is cost effective, and decreases infectious complications and length of hospital stay by 51% and by 9.7 days, respectively [8, 10, 11]. Current nutrition guidelines state that any patient unable to consume adequate nutrients orally (< 60% nutrition needs) for at least 5 days in the critically ill, or 7

to 14 days in the general population, should be a candidate for specialized nutrition support [12]. Expert opinion consensus suggests that all hospitalized patients should undergo nutrition assessment on admission with subsequent implementation of physiologically sound caloric support.

MNT is an essential component of inpatient glycemic management in patients with diabetes and hyperglycemia. Inpatient hyperglycemia in patients with and without diabetes is associated with an increased risk of adverse patient outcomes [13–17].

Lack of attention to MNT in the hospital contributes to unfavorable changes in blood glucose and in the coordination of appropriate insulin therapy [2•, 18••, 19]. Although there are no randomized controlled studies comparing different inpatient nutritional strategies, health care professionals should keep in mind that nutrition requirements often differ in the home versus the hospital setting. Nutritional management in the hospital is frequently complicated by hospital routines including abrupt discontinuation of meals in preparation for diagnostic studies or procedures, variability in appetite due to the underlying illness, limitations in food selections, and poor coordination between insulin administration and meal delivery that creates difficulties in predicting the efficacy of glycemic management strategies [18••].

General Approach to MNT

MNT is defined as a process of a nutritional assessment and individualized meal planning in consultation with a nutrition professional. The goals of inpatient MNT for patients with diabetes are to help optimize glycemic control, provide adequate calories to meet metabolic demands, address individuals needs based on personal food preferences, and provide a discharge plan for follow-up care [20–22]. Individuals with diabetes should receive MNT as needed to achieve treatment goals, preferably provided by a registered dietitian familiar with the components of diabetes MNT. Individualized MNT during hospitalization, along with intensive medical management, is generally required for patients with diabetes to achieve blood glucose targets [23]. MNT in the hospital can be challenging in the presence of acute medical illness, poor appetite, inability to eat, increased nutrient and calorie needs due to catabolic stress, and variation in diabetes medications. Key areas in implementing a successful MNT program in a hospital include establishing screening criteria for appropriate referral to a registered dietitian; identifying nutrition-related issues for patient clinical course and care plans; implementing and maintaining standardized diet orders such as consistent carbohydrate menus; integrating blood glucose monitoring results with nutrition care plans; using standing orders for diabetes education and diabetes MNT as appropriate; and standardizing discharge follow-up orders for MNT and diabetes education post-discharge when necessary [23].

The metabolic needs of most hospitalized subjects can be supported by providing 25 to 35 calories/kg per day [24, 25], whereas some malnourished critically ill patients may require less caloric intake at 15 to 25 calories/kg per day [26]. This will translate into a diet on average containing 1800 to 2000 calories per day [21] or a diet containing approximately 200 g per day of carbohydrates divided between meals [25]. Care must be taken not to overfeed patients because this can exacerbate hyperglycemia. There is no single meal-planning system that is ideal for hospitalized patients. However, it is suggested that hospitals consider implementing a consistent carbohydrate diabetes meal-planning system [25]. This systems uses meal plans without a specific calorie level but with consistency in the carbohydrate content of meals. The carbohydrate components of breakfast, lunch, dinner, and snacks may vary, but the day-to-day carbohydrate content of specific meals and snacks is kept constant [21, 25]. It is recommended that the term “ADA diet” no longer be used,

since the American Diabetes Association (ADA) no longer endorses a single nutrition prescription or percentages of macronutrients [25].

Only a few prospective randomized controlled studies have compared the efficacy of different nutritional plans in reducing hyperglycemia or in improving clinical outcomes in hospitalized patients with diabetes. Several recent studies have reported on specific meal plans or formulations in improving glycemic control and in reducing glucose excursions in hospitalized subjects with diabetes. In one recent study conducted at a university-affiliated hospital, a standard consistent-carbohydrate meal plan was compared with a patient-controlled diabetes diet in regard to adherence to diet, glycemic control, and satisfaction [18••]. No differences in mean daily blood glucose concentration, frequency of severe hyperglycemia, or adherence to dietary regimen were observed between the two diet groups. In this study, both meal plans had advantages and disadvantages; although the standard meal plan group required less clinical resources and developed less hypoglycemic events, the patient-controlled diet reported more satisfaction with food selection.

Liquid Diets

Patients requiring clear or full liquid diets should receive approximately 200 g of carbohydrate per day in equally divided amounts at meal and snack times. Liquids should not be sugar free. Patients require carbohydrate and calories, and sugar-free liquids do not meet these nutritional needs. After surgery, food intake should be initiated as quickly as possible with progression from clear liquids to full liquids to solid foods as rapidly as tolerated [25, 27]. Research in the laboratory and clinical arenas has challenged the long-held belief that enteral nutrition (EN) should not be administered until bowel function has resumed, which is typically judged by a subjective bowel function assessment. However, increasing evidence indicates that early enteral feeding is safe and well tolerated, and results in reduction of wound morbidity and healing, fewer septic complications, diminished weight loss, and improved protein kinetics [27]. A “clear liquid diet” is the most frequently ordered postoperative meal regardless of early or delayed administration. Although generally well tolerated, this diet fails to provide adequate nutrients to the postsurgical patient. In contrast, advancement to a regular diet as the initial meal has been shown to be well tolerated and provides significantly more nutrients than a clear liquid diet [27].

Enteral Nutrition

Although the majority of non-critically ill hospitalized patients receive nutrition support as three discrete meals with or without scheduled snacks each day, some patients will require EN or parenteral nutrition (PN) support. Both EN and PN have been proven effective in preventing the effects of starvation and malnutrition in hospitalized patients; however, oral nutrition and EN are preferable to PN in clinical practice [12]. PN has been associated with gut mucosal atrophy, overfeeding, hyperglycemia, an increased risk of infectious complications, and increased mortality in critically ill patients [10, 28–31]. Advantages of enteral feeding over PN include lower costs, avoidance of central catheter-related complications, a more physiologic route, and a trophic effect on gastrointestinal cells [32].

Standard enteral formulas reflect the reference values for macro- and micronutrients for a healthy population and contain 1 to 2 cal/mL. Most standard formulas contain whole protein, lipid in the form of long-chain triglycerides, and carbohydrates. Standard diabetes-specific formulas provide low amounts of lipids (30% of total calories) combined with a high-carbohydrate (HCH) content (55% to 60% of total calories); however, newer diabetic formulas have replaced part of carbohydrates with monounsaturated fatty acids (up to 35% of total calories), 10 to 15 g/L of dietary fiber and up to 30% fructose [33, 34]. A number of outpatient and inpatient studies in subjects with type 2 diabetes have reported better

glycemic control (lower mean, fasting, and/or postprandial glucose levels), a trend toward decreased hemoglobin A_{1c} and lower insulin requirements with a low-carbohydrate high monounsaturated fatty acid (LCHM) formula compared with a standard HCH formula [35, 36]. In a meta-analysis of studies comparing newer enteral LCHM formulas with standard formulations, the postprandial rise in blood glucose was reduced by 18 to 29 mg/dL with the newer formulations [37]. Based on these results, it is generally accepted that newer LCHM diabetic enteral formulas are preferable to standard HCH formulas in hospitalized patients with diabetes [33, 37]. Composition of enteral formulas commonly used in the hospital is listed in Table 1.

Several studies in diabetic subjects have evaluated glycemic control among different EN formulas. Leon-Sanz et al. [36] studied blood glucose variations and lipid profiles in patients with diabetes hospitalized with neurologic disorders or cancer. Patients were randomized to receive LCHM formula (Glucerna; Abbott Laboratories, Abbott Park, IL) or standard HCH formula (Precitene Diabet; Laboratorios Novartis). Glucerna was slightly better tolerated with a threefold less incidence of diarrhea, but was associated with more nausea. There were no significant differences in glycemic control or lipids between LCHM and HCH. Both groups had average daily blood glucose levels of 220 mg/dL during hospitalization. In another nonrandomized study, 22 subjects with type 2 diabetes who had permanently placed percutaneous endoscopic gastrostomy feeding tubes received LCHM formula (Glucerna) (carbohydrates 25%, fiber 17 g/L, monounsaturated fatty acids 27.7%) or standard diabetic formula (carbohydrates 54%, fiber 18 g/L, monounsaturated fatty acids 10.4%) for 5 days [38•]. Compared with use of standard diabetic formula, the administration of LCHM reduced postprandial glycemic excursion, glycemic variability, and insulin requirements [36]. A different study in ambulatory patients with diabetes reported that diabetic formulas given as boluses every 3 h results in lower postprandial peaks of blood glucose compared with administration of standard isocaloric formula [39•]. In long-term care facilities, the use of diabetic-specific enteral formulas has been associated with improved metabolic control compared with regular enteral formulas [35, 40].

Use of EN support can be associated with adverse effects or risks including bacterial colonization of the stomach, high gastric residual volumes, and risk of aspiration pneumonia [41, 42]. In patients with diabetes, EN may aggravate hyperglycemia and worsening metabolic control. Unanticipated dislodgement of feeding tubes, and temporary discontinuation of nutrition due to nausea or for diagnostic testing may result in increased risk of hypoglycemic events in patients treated with insulin or with oral antidiabetic agents [43•, 44].

Parenteral Nutrition

The beneficial effect of PN in improving the nutritional status of critically ill patients is well established [10]. A number of clinical trials have suggested that the administration of PN in severely malnourished patients lowers the rate of postoperative infections and hospital complications [45, 46]. However, recent randomized trials and meta-analyses have suggested that PN may be associated with increased risk of infectious complications and mortality in critically ill patients [6, 10, 47–49]. In addition, the use of PN has been linked to aggravation of hyperglycemia independent of a prior history of diabetes [2•, 46]. Hyperglycemia in such patients is associated with higher risk of cardiac complications, infections, sepsis, acute renal failure, and death [50–52]. In one study, a strong correlation was reported between PN-induced hyperglycemia and poor clinical outcomes. Blood glucose measures above 150 mg/dL prior to and within 24 h of initiation of PN were predictors of both increased inpatient complications and hospital mortality [53]. This data also indicated the need for careful selection of patients, appropriate nutrient composition,

and appropriate correction and management of hyperglycemia as important considerations with inpatient use of PN.

The increased risk of complications and mortality observed with PN therapy may be related to the development of hyperglycemia [50, 53, 54]. Recommended macronutrient composition of PN is at least 2 g/kg per day of glucose (the only carbohydrate in PN formulations), 0.7 to 1.5 g/kg per day of lipid emulsions, and 1.3 to 1.5 g/kg per day of amino acids calculated per ideal body weight [26, 55]. One method of reducing PN-induced hyperglycemia is to reduce the amount of infused dextrose to 100 to 150 mg/day to meet metabolic demands of brain and basic cellular functions [26]. Insulin can be also added to the PN mixture but to date there are no randomized controlled studies that guide effective and safe administration of insulin in this group of patients. The timing of PN initiation in the ICU has been long debated, partly due to lack of randomized trials [56]. A recent large multicenter European study [57••] compared early initiation of nutrition support with intravenous dextrose (20% solution) on ICU day 1 and EN plus PN on day 2 with late initiation of nutrition support using intravenous dextrose (5% solution) on day 1, EN on day 2, and PN after day 7. Those in the early nutrition group experienced significantly longer length of ICU stay, higher rates of infectious complications, and higher indices of organ dysfunction. A mean reduction in total health care cost of €110 (about \$1600 per patient) was calculated with use of late initiation of nutrition support. It is noteworthy that blood glucose levels were the same in both groups averaging 102 to 107 mg/dL, but the amount of insulin infused used was significantly lower with late initiation of PN support.

The increased rate of PN-associated complications may also be related to the administration of lipid emulsions with high content of linoleic acid and ω -6 polyunsaturated fatty acids (PUFA) [58–61]. The only US Food and Drug Administration approved lipid formulation for PN use is soybean oil–based lipid emulsions. Experimental reports have indicated that lipid emulsions based on soybean oil and rich on ω -6 PUFA promote generation of arachidonic acid–derived eicosanoids; this exaggerates inflammatory response during stress and trauma [62], immunosuppression and impaired neutrophil and macrophage function [58], and impaired endothelial function [9, 63]. Soybean-based lipid emulsions inhibit lymphocytes, macrophages, and neutrophil function as well as impair reticuloendothelial function and reduce plasma lipid clearance [9, 61, 64–66]. We and others recently reported that a 48-hour infusion of a commercial soybean oil lipid emulsion commonly used in PN (Intralipid®; Fresenius Kabi, Homburg, Germany) results in blood pressure elevation, endothelial dysfunction, and abnormal autonomic nervous system activity in ambulatory obese subjects [9, 63, 67, 68].

Concern regarding potential complications associated with the use of high ω -6 PUFA formulations has led to the development of alternative lipid emulsions for PN. Lipid emulsions with lower linoleic acid content by partly replacing soybean oil with olive oil (ClinOleic®; Baxter, Chicago) have improved the safety of PN [66, 69]. Several in vitro, animal, and human studies have shown that the impairment of immune function, oxidative stress, glucose metabolism, endothelial function, and inflammation that occurs with soybean oil–based emulsions is avoided with olive oil lipid emulsions [58, 63, 66]. We recently reported the results of a prospective, randomized, controlled, crossover study comparing the vascular, metabolic, immune, and inflammatory effects of 24-hour infusion of PN containing soybean oil–based (Intralipid®), olive oil–based lipid emulsion (ClinOleic®), lipid-free PN, and normal saline in healthy subjects [60]. We found that soybean oil–PN increased systolic blood pressure compared with olive oil, and reduced brachial artery flow-mediated dilatation from baseline (–23% at 4 h and –25% at 24 h, both $P<0.01$). In contrast, olive oil–PN did not change blood pressure or endothelial function [60]. These findings suggest that use of olive oil–based PN may have beneficial cardiovascular effects

independent of carbohydrate metabolism. Randomized controlled trials with relevant clinical outcome measures are needed to determine potential clinical benefit with olive oil–based versus soybean-based lipid emulsions in hospitalized patients.

Conclusions

MNT is an essential component of inpatient glycemic management in patients with diabetes and hyperglycemia and contributes to an anabolic environment in patients with an acute illness requiring hospitalization. Lack of attention to MNT in the hospital contributes to unfavorable changes in blood glucose and inappropriate use of insulin therapy [2•, 18••, 19]. No randomized controlled studies have compared different nutritional strategies in the hospital, but the use of consistent carbohydrate diabetes meal-planning system has been shown effective in facilitating glycemic control in the hospital setting [18••, 21]. This system is based on the total amount of carbohydrate offered rather than on specific calorie content at each meal. An advantage to the use of consistent carbohydrate meal plans is that they facilitate matching the prandial insulin dose to the amount of carbohydrate consumed [21]. In surgical patients or in those patients requiring clear or full liquid diets, delivery of approximately 200 g of carbohydrate per day in equally divided amounts at meal and snack times is recommended. Use of clear liquids containing sugar is recommended. After surgery, food intake should be initiated as quickly as possible and as tolerated with progression from clear liquids to full liquids to solid foods [25, 27]. A “clear liquid diet” is the most frequently ordered as the first postoperative meal. Although generally well tolerated, liquid diets fail to provide adequate nutrients to the postsurgical patient. After surgery, food intake should be initiated as quickly as possible, and progression from clear liquid to full liquid to solid foods should be completed as rapidly as tolerated [21]. Table 2 provides a summary of a nutrition approach to the hospitalized patient with diabetes.

In critically ill patients, who are in a catabolic state, EN and PN can prevent and correct the effects of starvation and malnutrition. Solid evidence indicates that EN is preferable to PN because of the higher risk of infectious and noninfectious complications with PN therapy [24, 32]. Specialized diabetic enteral formulas appear to reduce postprandial hyperglycemia, as well as glycemic variability and insulin requirements compared with the use of standard formula in patients with type 2 diabetes. Recent randomized trials and meta-analyses have reported that PN may result in increased risk for infectious complications and mortality in critically ill patients [6, 10, 47–49]. The increased risk of complications and mortality during PN therapy may be related to the development of hyperglycemia [50, 53, 54] or to the administration of soybean-based lipid emulsions with high content of linoleic acid and ω -6 PUFA [58, 59, 61, 70]. Avoidance or correction of hyperglycemia with intensified insulin treatment or the use of new lipid emulsions with low concentration of saturated fatty acids may improve clinical outcome in critically ill patients treated with PN [62, 69].

Future studies are needed to determine the safety and beneficial effects of specialized diabetic versus standard enteral formulas in improving glycemic control in the hospital and long-term care facilities. In addition, randomized controlled trials are needed to determine the safety and efficacy in clinical outcome between intensive versus less intensive insulin therapy and between new versus traditional-based lipid emulsions in critically ill patients.

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Table 1

Composition of standard and diabetes-specific enteral formulas commonly used in hospitalized patients

	Calories (kcal/mL)	Carbohydrate (g/L)	Fat (g/L)	Protein (g/L)	Manufacturer
Standard formula					
Jevity® 1.0 Cal	1.0	155	35	44	Abbott Nutrition ^a
Nutren® 1.0	1.0	127	38	40	Nestle Nutrition ^b
Osmolite® 1.2 Cal	1.2	158	39	55	Abbott Nutrition
Jevity® 1.2	1.2	169	39	56	Nestle Nutrition
Fibersource® HN	1.2	160	39	53	Nestle Nutrition
Isosource® 1.5 Cal	1.5	170	65	68	Nestle Nutrition
Jevity® 1.5	1.5	216	50	64	Nestle Nutrition
Diabetes-specific formula					
Glucerna® 1.0 Cal	1.0	96	54	42	Abbott Nutrition
Nutren® Glytrol®	1.0	100	48	45	Nestle Nutrition
Glucerna® 1.2 Cal	1.2	115	60	60	Abbott Nutrition
Diabetisource® AC	1.2	100	59	60	Nestle Nutrition
Glucerna® 1.5 Cal	1.5	133	75	82	Abbott Nutrition

^aAbbott Park, IL^bGlendale, CA

Table 2**General approach to nutrition in hospitalized patients with diabetes**

1	Medical nutrition therapy should be included as a component of the glycemic management program for all hospitalized patients with diabetes and hyperglycemia
2	<p>Medical nutrition assessment:</p> <ul style="list-style-type: none"> • Recognize accompanying comorbid conditions • Determine caloric and macronutrient intake requirements • ~25 kcal/kg/day^a • ~200 g/day of carbohydrates^a • ~0.8–1.0 g/day of protein^a • Determine route of nutrition administration and nutritional formulas • Oral nutrition: <ul style="list-style-type: none"> – Recommend meal plans with consistent carbohydrates to improve the coordination of insulin doses to carbohydrate ingestion – Provide three separate meals, no snacks • Enteral nutrition: <ul style="list-style-type: none"> – Standard formula 1.0 cal/mL (eg, Jevity^b, Nutren 1.0^b) or – Diabetes-specific formulas 1.0 cal/mL (eg, Glucerna^c, Nutren Glytrol^b) or – Low-carbohydrate formulas 1.2–1.5 cal/mL (eg, Peptamen AF^b, Oxepa^c) • Parenteral nutrition: <ul style="list-style-type: none"> – Avoid overnutrition – Dextrose content at least 2 g/kg/day – Lipid content 0.7–1.5 g/kg/day – Amino acid content 1.3–1.5 g/kg/day • Select glycemic target goals for patients with diabetes and hyperglycemia • Order bedside capillary point-of-care testing as the preferred method for guiding ongoing glycemic management during nutrition support • Recommend the following schedules for point-of-care testing before meals and at bedtime in patients who are eating, or every 4 to 6 h in patients who are NPO or who are receiving continuous enteral feeding • Provide diabetes and nutrition education before discharge

^aMay vary depending on degree of illness and baseline nutritional status

^bNestle Nutrition, Glendale, CA

^cAbbott Nutrition, Abbott Park, IL

NPO—nothing by mouth