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Managing hyperglycemia and diabetes in patients receiving enteral feedings: A health system approach

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Abstract

Evidence of poor outcomes in hospitalized patients with hyperglycemia has led to new and revised guidelines for inpatient management of diabetes. As providers become more aware of the need for better blood glucose control, they are finding limited guidance in the management of patients receiving enteral nutrition. To address the lack of guidelines in this population, Duke University Health System has developed a consistent practice for managing such patients. Here, we present our practice strategies for insulin use in patients receiving enteral nutrition. Essential factors include assessing the patients' history of diabetes, hyperglycemia, or hypoglycemia and timing and type of feedings. Insulin practices are then designed to address these issues keeping in mind patient safety in the event of abrupt cessation of nutrition. The outcome of the process is a consistent and safe method for glucose control with enteral nutrition.

Keywords

Enteral nutrition; tube feeding; diabetes; hyperglycemia; inpatient; nocturnal nutrition

Introduction

Over the past two decades, the management of hyperglycemia and diabetes in the inpatient setting has been the focus of many studies and recommendations [1-10]. The extensive data from observational and randomized controlled trials (RCTs) indicating increased risk of complications and mortality, a longer hospital stay, a higher admission rate to the intensive care unit (ICU), and a higher need for transitional or nursing home care after hospital

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Declaration of interest

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discharge of patients admitted with hyperglycemia and diabetes has led to increased attention on blood glucose control in hospitalized patients [1,11-15]. As practitioners focus on improving inpatient glycemic management, they are often faced with numerous challenging patients, specifically those with renal or hepatic failure, on high dose glucocorticoids, immunosuppressants, or receiving parenteral or enteral nutrition. However, little has been written about the management of patients in these clinical scenarios. Here, we review the limited available literature and provide a detailed description of our current practice in managing patients receiving enteral nutrition.

Enteral nutrition and hyperglycemia

Enteral nutrition is the delivery of nutrition to the gastrointestinal tract distal to the oral cavity via either a temporary nasally or orally placed gastric or small bowel feeding tube or a more long-term percutaneously placed gastric or small bowel tube. Patients with an intact gut, yet an inability to consume sufficient oral nutrition, often require enteral nutrition, also known as “tube feeding”. The composition of enteral feeds varies based on the specific formula, but each consists of a combination of carbohydrates, proteins, and lipids to provide balanced nutrition tailored to each individual patient's nutrient requirements.

Numerous factors impact glucose control in the setting of enteral nutrition. Alteration in glucose absorption may occur in critically ill patients. Delayed gastric emptying may exist in patients with critical illness and those with long-standing or poorly controlled diabetes whether diagnosed with gastroparesis or not [16-18]. The effects of enteral nutrition, by way of continuous intestinal glucose exposure, on secretion and action of incretin hormones (gastric inhibitory polypeptide and glucagon-like peptide-1) are not entirely known and may contribute to hyperglycemia seen in patients with and without a history of diabetes [16,19,20].

Hyperglycemia has been reported in up to 30% of patients receiving enteral nutrition [21,22]. To date, there have been no RCTs conducted on acutely ill patients to assess glycemic control in patients treated with different enteral nutrition formulas. Most studies on enteral nutrition and glycemic control have been conducted in critically ill patients.

In 2009, Korytkowski et al. conducted the only RCT testing insulin therapy in patients on enteral nutrition [23]. In this study, patients were randomized to sliding-scale regular insulin (SSRI) alone or in combination with glargine. At the end of the trial, there was no difference in glycemic control between the groups. However, in the SSRI group almost half of the patients required the addition of NPH twice daily to improve glycemic control. Of note, 50% of the patients had no prior history of diabetes [23].

Several retrospective studies have demonstrated varying degrees of glucose control using basal insulin glargine once daily, NPH twice or every 6 hours, or biphasic insulin and SSRI with varying rates of hypoglycemia [24-26]. For example, in a study conducted by Fatati et al., the authors concluded that once-daily glargine insulin may be a good treatment option for patients on “artificial nutrition”, regardless of type of nutrition and history of diabetes [26]. Although this study suggests that glargine insulin may be safe and effective for use with enteral feedings, there are still concerns regarding the use of basal (long-acting) insulin

with enteral nutrition because of cessation or interruption of the feedings, which can cause profound hypoglycemia. Thus, in our institution, we often prefer the use of short-acting regular insulin or intermediate-acting insulin to cover enteral nutrition. Our regimen was developed after observing the risk of hypoglycemia in patients on enteral nutrition treated with solely long-acting insulin. For both basal and nutrition needs, practitioners should weigh the risks and benefits of insulin therapy with any patient in light of the possibility of insulin-induced hypoglycemia.

Duke Health System approach for managing hyperglycemia with enteral nutrition

Our clinical practice areas are focused on adult patients in an academic medical center (Duke University Hospital) and a community teaching hospital (Duke Regional Hospital).

The majority of our patients on enteral nutrition is outside of the critical care area and requires new starts of subcutaneous insulin with enteral nutrition. Across these clinical areas, we have developed a consistent practice for the management of patients on enteral feedings via consensus of experts. We developed our tube feeding practices over the past 8–10 years based on experience without having written protocols or having Institutional Review Board approval, but rather having generally agreed upon norms of practice. Over this time period we have used three different point of care blood glucose meters in the inpatient setting and four different electronic medical records. Over the past 2 years, Nova Hospital Glucose Monitoring System's Stat Strip has been our glucose testing device and Epic has been our electronic medical record.

Our goal for blood glucose control in patients on continuous enteral nutrition is 140–180 mg/dl (7.8–10 mmol/l), which meets the recommendations by the American Diabetes Association and American Association of Clinical Endocrinologists. Below we provide our approach to treating these patients.

Key considerations in beginning therapy to achieve blood glucose control include:

- Prior history of diabetes, hyperglycemia, or hypoglycemia
- Timing of feedings: continuous, bolus, or nocturnal
- Consumption of oral nutrition in addition to tube feeding.

Continuous enteral nutrition

Intravenous (IV) insulin is the method of choice for blood glucose control in the ICU [7,10]. In the case where a critically ill patient becomes a candidate for enteral nutrition and is on IV insulin, we maintain the insulin infusion until the goal rate of tube feeding is reached and the patient is on a steady rate of IV insulin. This steady rate of IV insulin is then multiplied by 20 (a quick method of determining ~80% of the total daily dose [TDD] of insulin). If the patient has a history of diabetes, we consider giving 30%–40% of the TDD as basal insulin and the remainder is divided into four shots of scheduled regular insulin. If the patient does not have diabetes, then the TDD is divided into four shots of scheduled regular insulin given every 6 hours.

Our preference with hyperglycemia outside of the critical care area is to test capillary blood glucose using point of care testing every 6 hours and providing regular insulin with scheduled doses (plus correction scale in select patients) every 6 hours. By using short-acting regular insulin, we can provide 24-hour coverage but have the ability to adjust doses or completely stop therapy when necessary: such as in declining renal function, or more importantly discontinuation or interruption of tube feedings (NPO for procedures, high residuals, clogged, or dislodged tube).

In patients with underlying diabetes and known basal insulin needs, we carefully consider adding basal insulin, weighing the risk of hypoglycemia with the benefits of not missing basal requirements, particularly in patients with type 1 diabetes mellitus. The basal insulin provides for true basal needs with nursing instructions written to hold all regular insulin (which is covering only nutrition) if the tube feedings are held. Initiation of insulin is based on weight (Figure 1). For patients receiving continuous nutrition, the TDD is divided into four and initially distributed equally among the doses of regular insulin every 6 hours.

Bolus enteral nutrition

Blood glucose control in patients receiving bolus tube feedings can be achieved by two methods. One is using short-acting scheduled regular insulin every 6 hours with tube feedings timed every 3 hours and the other is using rapid-acting insulin (lispro, aspart, glulisine) with every 3- to 4-hour tube feeding. The advantage of using rapid-acting insulin with each feed is that it can be given immediately after the feeding assuring a match of nutrition and insulin.

Case

Ted is a 92 kg, 61-year-old male with a history of poorly controlled type 2 diabetes on oral agents as an outpatient who is admitted with a cerebral vascular event resulting in dysphagia. Initially he is on continuous tube feedings. A starting regimen of insulin while on continuous enteral nutrition would be: $96 \text{ kg} \times 0.5 \text{ units} = 48 \text{ units}/4 = 12 \text{ units}$ of subcutaneous regular insulin every 6 hours.

Nocturnal enteral nutrition

Continuous and bolus tube feeding regimens certainly provide a challenge for the provider in achieving blood glucose control, but an often greater challenge lies in treating patients with nocturnal tube feedings. We find that nocturnal tube feedings are used most often in patients requiring longer duration of enteral nutrition while rehabilitating from extended acute illness or recovering from recent surgery. In order to fully participate in acute rehabilitation, these patients need to be free of feeding pumps during the day, yet still require full nutrition support while they are awaiting further surgery or healing. If the patient has been on continuous tube feedings and this is being changed to the same carbohydrate and caloric content in a more condensed time frame, the 24 continuous feeding TDD of insulin can be used to determine a starting insulin schedule for overnight.

To cover a nocturnal feeding schedule, we prefer to use a combination of regular and intermediate-acting NPH insulin in an effort to minimize sleep interruptions. We do not use

oral antidiabetic medications in patients receiving enteral nutrition either in the hospital or recommend them upon discharge.

We have developed a formula for a standard 14-hour nocturnal feeding schedule (Figure 2). This can be used to provide starting doses of insulin that can be adjusted according to the blood glucose response. As is the case with all patients on insulin, the provider must reassess blood glucose control and adjust insulin doses on a daily basis until the glycemic goal is achieved. When beginning this regimen, we recommend assessing blood glucose values a minimum of six times in the first 24 hours: at the start of tube feedings, 4 hours later, 2 hours later, 3–4 hours later, at the end of tube feedings and mid-day. Each glucose value provides specific data on the accuracy of prior doses of insulin. Once blood glucoses are in target, overnight monitoring can be decreased to allow for uninterrupted sleep.

Case

John is a 56-year-old male with esophageal cancer status post esophagogastrectomy. He has a history of pre-diabetes and hyperglycemia with acute illness. He has developed an anastomotic leak post-operatively and therefore is now strictly NPO. He has been on goal rate of continuous feedings of Nutren® 2.0 formula via a percutaneous jejunostomy tube and receiving regular insulin 16 units at 06:00, 16 units at 12:00, 12 units at 18:00, and 12 units at 24:00 with blood glucoses ranging from 130 mg/dl to 170 mg/dl (7.2 to 9.4 mmol/l). However, his feeding schedule is changing to nocturnal tube feedings tonight from 18:00 to 08:00 with a more concentrated formula but with the same total carbohydrates. Using the aforementioned formula and a TDD of 56 units of regular insulin, we recommend that on the first day he should receive 14 units of regular insulin at 18:00, 28 units of NPH plus 7 units of regular insulin at 22:00, and 14 units of NPH at 08:00. In our experience we have found that patients usually need more insulin overnight with the more concentrated carbohydrates.

D10 protocol for interrupted enteral nutrition

In the event enteral nutrition is stopped, patients who have received subcutaneous insulin need dextrose supplementation to prevent hypoglycemia. Our protocol provides for IV 10% dextrose solution (D10) at 50 ml/hour if enteral nutrition is held (Figure 3). Glucose monitoring is changed to every 3 hours and the patient remains on D10 until their tube feedings are restarted or their glucose is > 180, at which point the D10 would be discontinued. Additionally, subsequent insulin doses are decreased to one-fourth dose until enteral feedings are resumed.

Conclusion

Patients receiving enteral nutrition frequently require insulin to prevent hyperglycemia. In our experience, insulin requirements for patients with preexisting diabetes are higher when on tube feedings than when consuming an oral diet. While not all hospitals have these exact kinds of complex patients, the processes can be adapted for different populations. We have presented our approach, which evolved over time, with patients who challenged us to improve their glucose control.

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Select best profile:

- Very lean, very sensitive to insulin, new hyperglycemia, elderly – **0.3 units/kg/day**
- Normal body habitus and history of diabetes – **0.4 units/kg/day**
- Overweight and history of diabetes – **0.5 units/kg/day**
- Obese, on corticosteroids, or known to be insulin-resistant – **0.6–0.8 units/kg/day**

Significant renal impairment ($\text{CrCl} < 45 \text{ mL/min}$) – decrease TDD by 50%

Figure 1.

Determining TDD of insulin.

Abbreviations: CrCl = Creatinine clearance; TDD = Total daily dose.

Where $X = \frac{1}{4}$ total daily dose (TDD) on continuous tube feedings.

X units of Regular insulin at the start of tube feedings

$\frac{1}{2}$ X units of Regular insulin + 2X units of NPH 4 hours later

X units of NPH at the end of tube feeding in patient with a history of diabetes or on

low dose of prednisone in the am

Figure 2.

Formula for transitioning patients from continuous to cyclic or nocturnal enteral nutrition.

Abbreviation: TDD = Total daily dose.

Figure 3.
D10 algorithm for interrupted tube feedings for adults.