In Brief

Nutrition is one of the most complex aspects of glycemic control for hospitalized patients. Commonly cited recommendations encourage individualization of the nutrition care plan based on treatment goals and suggest that liberalization of the hospital diet improves nutritional intake. The addition of glycemic control targets complicates the nutrition care process further; indeed, providing appropriate nourishment and achieving glycemic control safely can sometimes seem impossible. But it can be done. This article focuses on some of the problems involved in trying to achieve these dual goals. It includes creative and practical solutions used by clinicians who have faced this challenge and suggests innovative changes that may be considered as part of hospital improvement initiatives to address glycemic control.

From Trays to Tube Feedings: Overcoming the Challenges of Hospital Nutrition and Glycemic Control

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The nutritional care of hospitalized patients attracts considerable attention among many disciplines. Providing adequate nutrition has clearly been shown to affect clinical outcomes.[1] Many patients eat poorly while in the hospital, and procedures, testing, surgery, and hospital routines so severely confound the processes required to adequately nourish hospitalized patients that malnutrition is a major concern. To compensate for these conditions, patients may be given extra foods and nutritionally dense supplements to boost their nutritional status. Patients who are preparing for or recovering from surgery or procedures may not be able to consume solid food and instead may receive intravenous (IV) dextrose, liquid diets, enteral feedings, or total parenteral nutrition (TPN).

More than 5 million patients are admitted to U.S. hospitals annually for a myriad of diagnoses.[2] Although it is not typically the primary reason for their admission, ~ 25% of these patients are known to have diabetes, and as many as one-third experience hyperglycemia while in the hospital.[3] These patients experience the same barriers to adequate nutrition as other patients, but their treatment is likely complicated by their glucose intolerance.

The most recent guidelines pertaining to hyperglycemia recommend that it should be treated regardless of whether the patient has a diabetes diagnosis.[4] In the ambulatory setting, one strategy for treating hyperglycemia is to modify food intake, focusing on reducing the consumption of the same types of high-carbohydrate foods that are used to boost energy intake among hospitalized patients. Recommendations to reconcile contradicting tactics for these two crucial concerns have been thoroughly described.[5] Specific recommendations include:

- The inclusion of a registered dietitian (RD) in an interdisciplinary team focused on glycemic control
- Implementation of less restrictive meal-planning systems
- Integration of blood glucose monitoring results with nutritional care
- Coordination of the timing of insulin administration, blood glucose monitoring, and meal service
- Ensuring adequate nutritional intake coupled with insulin therapy to reduce the risk of hyperglycemia

The evidence supporting these recommendations is strong, and many hospitals have worked diligently to implement each one. So why is it that, although all of these systems seem to be "go," barriers to optimal glycemia management and to complete and seamless implementation remain? What needs to be repaired so that hospitals can move forward with the process of excellent inpatient glycemia management while meeting patients' nutritional requirements?

Clinicians interviewed from hospitals who have implemented inpatient

programs were happy to share information about problems they perceive. Some may be recognized as issues that are much-discussed among inpatient clinicians. The following list, although not all-inclusive, represents common recurring issues.

- Inadequate nutritional intake in conjunction with glycemic control
- Implementing glycemic control processes with liberal meal-planning systems
- Difficulty coordinating timing of blood glucose testing, food delivery, and insulin injections
- Inadequately controlled blood glucose among patients receiving enteral feedings or TPN
- Inconsistencies and gaps in knowledge among health professionals

Inadequate Nutritional Intake in Conjunction With Glycemic Control

Hospitalized patients frequently consume less energy and protein than they need—a particularly challenging problem considering the increased needs seen with catabolic conditions. Some of the factors that contribute to the problem of inadequate intake are:

- Increased needs resulting from catabolic stress
- Altered appetite
- Nausea, vomiting, or other gastrointestinal complaints
- Timing of meals and snacks not consistent with patients' usual patterns
- Patients' food preferences or usual foods not offered
- Delayed or skipped meals because of scheduled procedures
- Patients' or their family members' lack of understanding of the nutrition plan
- Medical and hospital staffs' lack of knowledge about current trends in nutrition and meal-planning

Given the many challenges to adequate intake in hospitals, dietary restrictions for diabetes patients may actually contribute to poor nutritional intake.[6] Although dietary restrictions, such as potassium restriction for hyperkalemia or sodium and fluid restriction for dialysis patients, are sometimes a necessity, patients may find the foods available in the resulting meal plans to be unappetizing.

Unless there is a crucial need for dietary restriction, most patients can safely "eat to appetite" and even be encouraged to increase their intake with the use of liberal diets, medical nutritional supplements, and snacks, along with the appropriate use of insulin to control blood glucose. Nutritional assessment and ongoing support by an RD knowledgeable in glycemic management is important to ensure safety and effectiveness.[5]

The trend of offering liberalized diets to hospitalized patients is not new. In 1997, hospitals were encouraged to dispense with unnecessarily restrictive diets, frequently designated as "the ADA [American Diabetes Association] diet," in favor of a variety of other approaches, including regular diets, individualized meal plans, carbohydrate counting, and consistent carbohydrate plans.[5] Yet, the change was not readily accepted, and 5 years later, Irl B. Hirsch, MD, lamented the overuse of restrictive diets in an editorial titled, "The Death of the "1800-Calorie ADA Diet."[7] Hirsch discussed his concerns about the inappropriate dietary restriction and subsequent underfeeding of one of his own hospitalized patients who was adept at managing his diabetes at home while being treated for cancer.

Glycemic Control and Liberal Meal-Planning

Many hospitals have now made progress in implementing more liberal approaches to meal-planning, including the use of consistent carbohydrate plans, regular diets with carbohydrate counting, and room service–style food delivery systems. These systems offer increased flexibility for patients and allow for more individualized, precise insulin therapy that provides tighter control. The nontraditional nature of these systems requires individual therapy, as opposed to the somewhat cookie-cutter approach to diabetes care that prevailed in hospitals for decades.

Everyone, including staff, patients, and family members, should be educated about the importance of sharing information about patients' food intake so that insulin doses can be calculated appropriately. This necessitates a supportive and accepting attitude about food. Hospital staff should convey to patients and families that it is acceptable to eat foods that are additional or instead of the hospital diet and should give them additional instructions about how and to whom to report the carbohydrate information of those foods so that insulin doses can be determined accurately.

Consistent carbohydrate diets

The consistent carbohydrate meal-planning system is the method most commonly recommended for hospitals.[5,8] This dietary approach provides consistency in the amount of carbohydrate served from day to day in meals and snacks (when snacks are a part of the plan). A wide variety of meals can fit into this system, increasing the variety of foods that can be sent to rooms on the patients' meal trays. Even foods once forbidden because of their sucrose content, such as cake, cookies, or ice cream, can be counted as allowed carbohydrate foods, provided there is attention to the portion size.

An important point to consider when establishing a consistent carbohydrate plan is that if it offers limited flexibility or restricts quantity, it may have the unintended consequence of limiting patients' intake. As it is commonly used, the diet bears a striking resemblance to the calorie-controlled diet formerly called an "ADA diet" (Table 1). The food choices are still proscribed by a specific pattern and limited by the total calorie level, confusing the two methods. Calories may be further restricted with the use of sugar-free or "diabetic" offerings, countering the goal of increasing intake in patients who are not eating well.

Appropriate diet ordering by physicians based on patients' actual nutritional needs is crucial for assuring that patients are offered the amount of food that is right for them.[4] One suggested nomenclature is " Regular Diet with Carbohydrate Counting." Computerized physician order entry systems can be used to guide physicians in writing appropriate diet orders.

Room service meal delivery systems

Room service–style hospital food service systems are becoming increasingly popular. In its purest form, hospital food service is provided 24 hours a day, 7 days a week, much like it is in a hotel.[9] Meals are served freshly prepared, attractively presented, and of hotel-grade quality. Many hospitals operate versions of this system that limit hours of operation, provide between-meal snack carts, limit

Table 1. Sample Consistent Carbohydrate Meal Plan

		Low	Mild	Moderate	High
	Calories	1,400–1,600	1,800	2,000–2,400	2,500–3,000
Breakfast Servings	Meat	1	1	1	2
	Starch	1	2	3	4
	Milk	1 (skim)	1 (skim)	1 (2%)	1 (2%)
	Fruit	1	1	1	1
	Fat	1	2	2	3
	Carbohydrate Servings	**3**	**4**	**5**	**6**
Lunch Servings	Meat	3–4	3–4	3–4	6–8
	Starch	2	3	4	4
	Milk	0	0	0	0
	Vegetable	1	1	1	1
	Fruit	1	1	1	2
	Fat	2	2	2	3
	Carbohydrate Servings	**3**	**4**	**5**	**6**
Dinner Servings	Meat	3–4	3–4	3–4	6–8
	Starch	2	3	3	3
	Milk	0	0	1 (2%)	1 (2%)
	Vegetable	1	1	1	1
	Fruit	1	1	1	2
	Fat	2	2	2	3
	Carbohydrate Servings	**3**	**4**	**5**	**6**

Carbohydrate servings: starch, fruit, and milk

the patients to whom room service is offered, or limit the days of the week on which it is offered. Room service systems have become popular as patients have come to be viewed as customers, and this type of service may boost patient (customer) satisfaction.

"Room service is the wave of the future," said Sherry Jackson, RD, LD, an inpatient clinical dietitian and outpatient diabetes educator at Jane Phillips Medical Center in Bartlesville, Okla., one hospital making the transition from traditional food service to a room service system. Indeed, Rick Wade, a senior vice president of the American Hospital Association, estimated that 40% of the nearly 4,800 hospitals in the group had changed or planned to change exclusively to room service food programs within 5 years.[10]

One might expect this system to create additional challenges regarding the timing of blood glucose testing and the implementation of physiological (basal-bolus) insulin regimens. These challenges can be addressed by developing protocols for meal service delivery and implementing true nutritional insulin regimens as described elsewhere in this article. Hospitals that have already incorporated the concepts of carbohydrate counting and physiological insulin into their culture will be more prepared to effectively address the flexibility of room service timing and food selections.

Coordinating Blood Glucose Testing, Meals, and Insulin Administration

One of the most vexing and complex problems related to the delivery of nutrition while managing glycemia is the timing of glucose testing, tray delivery, and insulin administration.

Multiple much-referenced publications emphasize the importance of coordinating these functions, but few offer tangible guidance about how best to synchronize them. The addition of nutritional insulin to the diabetes care routine has added further confusion.

Perhaps some solutions can be revealed through examination of how these tasks are being accomplished now. For example, consider a morning diabetes routine as reported from New York Downstate Hospital in Brooklyn. This descriptive, nonexperimental study examined the duration of time between blood glucose monitoring and insulin administration, insulin administration and breakfast, and blood glucose monitoring and breakfast and the impact of these activities on pre-lunch blood glucose values. The results showed that insulin was given 93 ± 52.82 minutes after the patients' blood glucose was checked. After this span of time, the dose of insulin given may no longer be appropriate. In addition, breakfast time was 73 ± 37.06 minutes—almost 2 hours—after patients received insulin.[11]

This report noted that separate patient care teams were responsible for

each of these functions. The night staff checked patients' glucose levels close to the end of their shift at approximately 6:00 a.m. and then administered morning insulin. Breakfast usually arrived anywhere from 8:00 to 9:00 a.m., 2–3 hours later. When asked why the glucose monitoring and insulin administration did not occur closer to the delivery of breakfast, the nursing staff responded that mealtimes are too hectic, that they think insulin doses might be missed in the rush, and that they had always done it that way.

When process outcomes are not as desired, a change in process is indicated. The process outcome chosen was the pre-lunch blood glucose level, with a target of < 180 mg/dl. The target was achieved in 12 of the 27 patients studied. The study group was further divided into those who received their insulin > 45 minutes before breakfast and those who received their insulin < 45 minutes before breakfast. The > 45-minute group had a mean pre-lunch blood glucose level of 243 ± 90 mg/dl and the < 45-minute group had a mean blood glucose level of 172 ± 93 mg/dl. Clearly, there is room for improvement, and such data are helpful in demonstrating the need for change.

The study examined practices at only one hospital, but we suspect that these results might be replicated in many hospitals across the country. Hospitalization provides the perfect opportunity to educate patients lacking in knowledge or requiring adjustments in their self-care routines about tactics for their own self-management. Yet, the example set for patients within the hospitals, as described above, is quite different from the advice diabetes educators and physicians give patients about their self-care at home.

What hospital system changes might result in improved coordination of meals, blood glucose testing, and insulin administration and allow us to reliably achieve blood glucose targets? Blood glucose testing, meal delivery, and insulin administration are interwoven elements of care that affect outcomes. As hospitals reengineer their mealtime processes to allow for coordination of these three care elements, they must consider the complexity of unit activity and strive to simplify it or adapt their processes to it.

In Great Britain, efforts to establish "protected mealtimes" discourage unit activities unrelated to mealtimes to allow the nursing staff and patients to focus solely on mealtime activities.[12] One British study found that activities such as physician visits, testing and therapy on and off the unit, and visits to the bedside commode occurred during meals, diluting patient and staff focus at mealtime.[13]

An Australian study examined the activities of nurses during mealtime in an acute care hospital and revealed a disconnect between the role of the nutritional services staff delivering trays and the nursing staff expected to assist patients once the meals were set before them.[14] In this report, a nurse was quoted as saying that it is difficult to assist patients during meals because they occur during the noon medication rounds. Although not reflected in the study discussion, the findings appear to suggest that patients suffered nutritionally because every activity occurring around mealtime was viewed as unrelated to the meal, and mealtimes were seen as interfering in some way with nurses' ability to perform their assigned tasks.

These findings apply in many U.S. hospitals, as well. In this era of shorter lengths of stay and flow initiatives aimed at increasing hospital efficiency, it is probably not realistic to consider implementing protected mealtimes. However, the studies provide evidence supporting the need for a change in how hospital staff view mealtimes, what resources are allocated to the essential activities related to mealtime, and the coordination among the staff members preparing and delivering meals, testing blood glucose, and administering insulin.

For improving the coordination of these three crucial activities, we suggest the following steps:

- Devise a team approach to meeting patients' needs at mealtime
- Base nutritional insulin doses on food actually consumed
- Involve patients and their families in their care

Team approach to mealtime

Given that potentially one-third or more of all patients on a unit require mealtime diabetes care activities,[3] a process incorporating a team approach should be devised to meet these needs. This process may require individuals from different departments to assume responsibilities and work schedules that cross traditional boundaries.

For example, a nurse and an assistant from nutritional services may work in tandem to deliver meals to patients with diabetes. The nurse role would include checking blood glucose before the food is brought into the patient room and then administering mealtime medications, including insulin, to these patients. The assistant would deliver the food, help the patients with tray placement, open packages, fetch missing or replacement items, and finally assess meal intake using mealtime percentages or a carbohydrate counting method selected by the facility before removing the tray from the room. This same assistant might help patients make selections for subsequent meals.

By working in tandem and simplifying the process, such a team could minimize errors in timing and communication. Staff assigned to such teams could receive training that would confer a high expertise level for that focus. This ideal scenario requires a change in the traditional ways in which unit work is done and the breaking of conventional departmental roles and boundaries that have been in place for decades. With such a large percentage of patients whose outcomes can be significantly improved by achieving recommended blood glucose levels, increased focus on the mealtime activities that affect glycemic control is prudent. Increased patient satisfaction may be an additional resultant benefit.

Calculating nutritional insulin doses based on carbohydrate intake

Several excellent resources are available to assist clinicians with detailed information about determining appropriate insulin doses for hospitalized patients. Many hospital protocols include the use of nutritional insulin but may use imprecise or undefined processes to ensure accuracy. To attain good glycemic control, mealtime insulin doses must match patients' carbohydrate intake. Systems must be in place to allow carbohydrate to be either estimated or counted to accurately calculate nutritional insulin doses.

Standards must dictate the allowed time interval between rapid-acting insulin administration and meal consumption, and formal processes must be in place to ensure that the standards are met. Achieving the manufacturer's recommended inter-

val will likely require reengineering of current processes that are barriers to optimal timing, requiring the use of systematic process improvement methodology. Staff education should include the concept that when patients are taking nutrition by mouth, rapid-acting insulin can be given just after the meal, based on the carbohydrate the patient has actually consumed. Correction doses should still be given if indicated.

One successful process involves the use of carbohydrate servings and portions of meals eaten to estimate carbohydrate intake.[15] In this method, consistent carbohydrate meal-planning is used to ensure that consistent servings of carbohydrate foods are served to patients. A carbohydrate serving is best described as a serving of food, usually starch, fruit, or milk, which provides ~ 15 g of carbohydrate. When nutritional insulin is required, a fixed dose of insulin is prescribed to cover the amount of carbohydrate served in a single meal, but the dose can be adjusted if a patient does not eat the entire meal. The adjustment is based on the percentage of the meal eaten. For example, if the patient eats half of the food served, the dose is reduced by half. This system is often selected for its simplicity in implementing by the nursing staff. Nurses are already trained in accurate estimation of the percentage of the total meal eaten, so this system takes advantage of an existing skill.

Alternatively, some hospitals base nutritional insulin doses on insulin-to-carbohydrate ratios ordered by physicians or delineated on standardized order sets. These ratios are similar to those typically used for tight glycemic control in the home setting, either with multiple daily injections or with insulin pump therapy. Using this method, the number of carbohydrate grams a patient eats is calculated immediately after each meal, and the nutritional insulin dose is based on that calculation. This system is most effective when used in conjunction with meal-planning systems in which the exact carbohydrate content of foods served is counted in grams rather than servings. Although precise, this system requires detailed attention to the food intake of patients, competence in carbohydrate counting, and math calculations or reference tables to determine appropriate nutritional insulin doses.

At Integris Baptist Medical Center (IBMC) in Oklahoma City, Okla., inpatient nurse clinicians April Merrill, MS, APRN-BC, and Risé Kester, APRN, MS, CNS, along with a supportive interdisciplinary committee, have implemented hyperglycemia protocols hospital-wide and eliminated the use of sliding-scale insulin regimens. This hospital offers diabetes and hyperglycemia patients "regular" diets without restrictions on food selections or amounts. Meal trays designated as "Regular Diets with Carbohydrate Counting" are delivered with printed information on the tray detailing the carbohydrate content of each item in grams. Carbohydrate information can also be obtained from special lists made available from the dietary department and the Nutrition Facts labels on nutritional supplements and other foods. Nurses, nurse aides, patients, and family members are engaged in the process of noting the carbohydrate content of each meal or snack eaten and communicating the information to the nurse administering nutritional insulin. An insulin-to-carbohydrate ratio for rapid-acting insulin is applied to all nutritional intake from food and beverages, allowing for precise doses of insulin to be delivered to patients.

Involving patients and their families in their care

Involving patients and their families can aid in improving the timing of meal service, blood glucose testing, and insulin administration.[16] Patients or their family members who have effectively managed their diabetes at home typically experience a shift in diabetes care responsibilities to staff during a hospital stay. At a minimum, empower them to remind patient care staff to check blood glucose and give insulin at the correct times, assist with carbohydrate counting of foods eaten, or report amounts of foods eaten.

Systems can be developed to communicate this expectation and promote a partnering culture. Desert Springs Hospital in Las Vegas, Nev., has developed in-room signs reminding patients to call the nurse to check blood glucose and give insulin before they begin to eat.

When feasible, take empowerment a step further and allow patients or their family members to manage blood glucose as they would at home, including performing blood glucose testing and insulin administration.[4] This can be safely done when patients are cognitively stable, physically able to successfully administer the insulin, comfortable performing self-monitoring of blood glucose, and have adequate oral intake. Patients most suitable are those who are experienced in using insulin at home, competent in carbohydrate counting, accustomed to multiple daily injections or insulin pump therapy, and comfortable with sick-day management.

Inadequate Glycemic Control in Patients Receiving Tube Feeding or TPN

The success of nutrition support depends on appropriate delivery of the right combination of nutrients to patients; patients requiring nutrition support are at very high risk for hyperglycemia.[17] This is of special concern for patients without a diabetes diagnosis who receive enteral nutrition or TPN and experience unexpected hyperglycemia for the first time during hospitalization. Patients without a previous diagnosis of diabetes who experience hyperglycemia in the hospital have a dramatically increased risk for mortality compared with that of previously diagnosed patients.[3]

However, despite the wealth of available information about this issue and the widespread implementation of insulin protocols, clinicians interviewed agreed that there are still many episodes of hyperglycemia during nutrition support. These are sometimes induced by measures to prevent hypoglycemia, a barrier to good management that is described frequently in the inpatient management literature.

Following are some tips for managing nutrition support safely, gleaned from practicing inpatient clinicians.

Enteral feedings

Enteral formulas should be chosen based on their ability to provide the most appropriate mix of nutrients for individual patients. Choose the appropriate formulas to meet patients' needs, and manage blood glucose with the appropriate use of insulin. There is controversy surrounding the question of the need for specialized formulas for hyperglycemic patients; more research is needed on this topic.

Basal insulin doses should be just enough to maintain normal blood glucose levels during times when patients are not receiving any nutrition. Basal

Table 2. Calculation of Nutritional Insulin Dose for Enteral Feeding

Physician order for the patient:
- House enteral formula: 100 ml/hour, regular insulin every 4 hours
- Insulin-to-carbohydrate ratio: 1 unit of regular insulin:10 g of carbohydrate
- Correction factor: 1 unit of regular insulin to lower blood glucose by 30 mg/dl
- Target blood glucose: 110 mg/dl

The house formula provides 154.7 g carbohydrate per 1,000 ml.

Nutritional insulin dose calculation:
Based on the physician order, the patient is expected to receive 400 ml of formula over the next 4 hours.
400 ml ÷ 1,000 ml × 154.7 g = 61.88 g carbohydrate/4 hours
The insulin-to-carbohydrate ratio is 1 unit of regular insulin:10 g of carbohydrate
61.88 g ÷ 10 g = 6.188 units of regular insulin, rounded to 6 units

Correction insulin dose calculation:
The patient's blood glucose is 130 mg/dl. The patient's target glucose is 100 mg/dl.
The correction factor is 1 unit of regular insulin to lower blood glucose by 30 mg/dl.

$$\text{Formula: } \frac{\text{Current Blood Glucose} - \text{Target Blood Glucose}}{\text{Amount 1 Unit of Insulin Will Lower Blood Glucose}} = \text{Units of Insulin to Reach Goal}$$

$$\text{Calculation: } \frac{130-100}{30} = 1 \text{ unit of regular insulin to correct blood glucose to goal of 100 mg/dl}$$

The total bolus dose is
6 units for nutritional insulin
+ 1 unit for correction dose
= 7 units to be administered

needs are usually met with either glargine or detemir, although NPH insulin can be used as basal insulin in some instances.

For continuous tube feedings, nutritional and correction insulin can be given as a bolus dose every 4–6 hours, matching the anticipated carbohydrate intake with the expected action and duration of the insulin used. To calculate the nutritional insulin for continuous tube feedings, determine the amount of carbohydrate to be given during the period of time between doses. Then apply a formula using the prescribed insulin-to-carbohydrate ratio to determine a dose that will prevent hyperglycemia from the carbohydrate content in the formula being given. Sample calculations are shown in Table 2. Although still widely practiced, allowing 6 hours between doses of regular insulin may result in inadequate duration of insulin coverage, because insulin action may diminish before the next dose, resulting in hyperglycemia.

For bolus and intermittent tube feedings, nutritional and correction doses of regular or rapid-acting insulin can be given immediately after the feeding, just as is done with discrete solid meals.

Correction doses of insulin are used only when blood glucose is higher than target, to return it to acceptable levels. Unlike sliding-scale insulin used as a primary means of controlling blood glucose, correction insulin is used to treat hyperglycemia that occurs despite basal and nutritional insulin administration. To calculate a correction dose, find the difference between the current blood glucose level and the target. Apply the prescribed correction factor formula to calculate the amount of insulin needed to treat the hyperglycemia. An example is included in Table 2.

The same type of insulin is used for nutritional and correction doses, so they can be given together. Unlike the dosing for patients receiving food by mouth, these doses should be administered for patients receiving enteral feedings or TPN in advance of the feeding.

Because the interruption of tube feedings is a frequent occurrence in hospitals and insulin is dosed 4–6 hours before the end of each feeding period, staff must be prepared to prevent hypoglycemia. Protocols can be developed to include giving patients IV dextrose to make up for missed carbohydrate when feedings are interrupted. John Muchmore, MD, PhD, an endocrinologist at IBMC, recommends using the dextrose concentration that can be safely infused while providing the needed carbohydrate.

For example, at 7:00 a.m., a patient receives a nutritional dose of 6 units of regular insulin in anticipation of 400 ml of the house enteral formula, which contains ~ 62 g carbohydrate. The formula is to be given during the next 4 hours. But because of a schedule change for a procedure, the tube feeding is stopped after only a few minutes into the 4-hour period that was covered in advance by the insulin dose given. Because insulin has already been given, the missed grams of carbohydrate should be given as IV dextrose gradually over the next 4 hours. This "correction carbohydrate" of 62 g could be delivered effectively with either 1,240 ml of D5, 620 ml of D10, or 310 ml of D20. Fluid status may be a factor in deciding which concentration to use, and the choice of D20 will require access to a central line, but each of the above choices will deliver the 62 g dextrose needed to prevent hypoglycemia.

When the gut is used for feedings, incretin hormones, which play a role in glucose homeostasis, are stimulated. These hormones suppress the action of glucagon, decreasing gluconeogenesis. The enteral feedings protocol at IBMC allows for fine-tuning of their process by adding one more step to the supplemental dextrose administration described above. The protocol reduces the amount of IV dextrose to be given by 20% to adjust for the absence of the incretin effect of the gut. In the scenario of the held enteral feedings, reducing the dextrose delivery by 20% anticipates additional glucose from gluconeogenesis, reducing the

Table 3. Carbohydrate Content of Dextrose Concentrations

1,000 ml of D5	= 50 g of carbohydrate
1,000 ml of D10	= 100 g of carbohydrate
1,000 ml of D20	= 200 g of carbohydrate

probability of hyperglycemia and the need for correction insulin later. This step would not be applied to patients with impaired gluconeogenesis, such as those with end-stage liver disease.

TPN considerations

Patients on TPN who require basal insulin should receive it independently of nutritional or correction doses. If basal insulin is given subcutaneously, it should be just enough long-acting insulin to maintain glucose goals should the TPN be interrupted or held. Nutritional doses of regular insulin can be given every 4 hours along with correction doses as described above.

For patients in the intensive care units or the medical units of some hospitals, continuous IV infusions of regular insulin provide basal insulin coverage. In this situation, correction and nutritional doses can also be delivered as IV boluses of regular insulin every 4 hours or rapid-acting insulin can be given subcutaneously.

Patients receiving TPN will also experience the absent incretin benefit described above because of the bypassing of the gut, with subsequent unsuppressed glucagon. For that reason, insulin needs are often higher on TPN than one would expect for the same patient receiving nutrition by mouth or enteral nutrition.

Some hospitals choose to add regular insulin to TPN bags. When this approach is used, the insulin added should be considered nutritional insulin, covering the dextrose only.

For example, 10 units of regular insulin added to a bag of 20% dextrose solution of TPN would be the equivalent of 1 unit of regular insulin for 20 g of carbohydrate. Table 3 lists the carbohydrate/dextrose content of the various concentrations of dextrose solutions.

Because levels of insulin resistance can change during hospitalization, large amounts of insulin should not be used for coverage of basal and nutritional needs. There is a risk of hypoglycemia when patients become less insulin resistant, as one would expect with tapered glucocorticoids, infections that resolve, and other situations. This would also necessitate a reformulated TPN with less insulin—a preventable and expensive step considering the high cost of TPN formulas.

Inconsistencies and Gaps in Staff and Physician Knowledge

Inadequate knowledge of diabetes, hyperglycemia, and appropriate management of blood glucose levels represents a barrier to improved management of hyperglycemia in the hospital.[18] To assist patients in achieving treatment goals, all team members, including physicians, must communicate and support the same messages.[4]

A recent study sought to uncover some of the attitudes about hospital hyperglycemia and barriers to care by surveying midlevel practitioners in a 200-bed tertiary care teaching hospital. The survey revealed that most midlevel practitioners responding felt only somewhat comfortable managing hyperglycemia and hypoglycemia and using subcutaneous insulin. Most respondents reported feeling not at all comfortable with the use of IV insulin and insulin pumps. Other barriers to good glucose control included fear of hypoglycemia and lack of familiarity with hospital policies and procedures related to glucose management. The authors concluded that, although practitioners surveyed recognized good glucose control as important, there is a need for continued reinforcement. Educational efforts should focus on therapeutic strategies that are effective in the hospital and ensure that practitioners are familiar with hospital policies and procedures.[19]

Implementation of an inpatient program requires ongoing education for all hospital staff. There must be a commitment by hospital administration to the education of all involved in patient care, including nurses and ancillary staff.[20] The education should improve overall understanding of diabetes, hyperglycemia, hypoglycemia, and the appropriate management of these conditions. Nursing personnel should develop a thorough understanding of the types of insulin used in the hospital and their action profiles so that they can assess patients' needs appropriately.

Education can come in many forms—workshops, computer-based programs, in-service training sessions, or other hospital-specific methods. Diabetes and hyperglycemia education must be comprehensive enough to allow health professionals within the institution to "sing from the same page." Education of staff will help change the culture of diabetes and hyperglycemia management by replacing outdated notions with current knowledge and standards of care that allow for changes in practice.

IBMC has supported comprehensive staff education since 1997 with a 7-hour workshop provided by an outside consulting company. There, the increased focus on the problem of diabetes and hyperglycemia has created a culture that accepts as normal aggressive management, including subcutaneous insulin and IV insulin infusion protocols. In addition to facilitating excellent diabetes and hyperglycemia care, IBMC was able to demonstrate financial benefits associated with improving diabetes awareness and management.[21] Two inpatient diabetes/hyperglycemia clinicians, with the backing of an interdisciplinary team, help staff nurses become proficient at initiating and managing insulin protocols and providing survival-skills education to their patients. Staff receives education on the basics of nutrition, as well as the basics of carbohydrate counting and physiological insulin regimens, and they learn the "nutrition red flags" that warrant seeking a nutrition consultation.

JPMC has carried education a step further by providing a 3-hour course focusing on diabetes and hyperglycemia specifically designed for nurse aides. The goal of this program is to increase the involvement of nurse aides in helping solve some of the difficult challenges, especially the problem of timing between blood glucose monitoring, insulin injections, and food tray delivery. Shannon Bailey, MS, RD/LD, CDE, the inpatient clinician at JPMC, notes that since initiating the education program 2 years ago, nurse aides have stepped up their efforts to perform blood glucose tests in a timely manner, report food intake more accurately, and inform her about patients with diabetes and hyperglycemia issues. "They come up to me now in the halls and ask me to check on

patients they have concerns about. It's made a big difference," she said.

Because of the ever-changing knowledge and technology regarding diabetes and hyperglycemia, the need for staff education is continuous. Updates, in-services, newsletters, skills fairs, and computer-based or other types of self-directed programs can facilitate the ongoing education process.

Conclusion

Hospitals operate with numerous complex and fragmented systems. System processes produce the desired result within individual units and departments, but often do not serve the needs of the entire organization. Today's complex, fragmented hospital systems put great pressure on providers and center care on the needs of the system itself, not the needs of patients. Every hospital and every unit has unique characteristics and resources, so solutions must come from within.

Although there are no studies to compare the superiority of one hospital's system over another, experience from the outpatient setting implies that an intentional plan for matching insulin with carbohydrate intake will contribute to improvement in blood glucose in the hospital. Studies of different meal delivery systems, their impact on hospital glycemia, patient nutritional status, and detailed information about the steps taken to achieve good results are needed to bring clarity to this question. Until then, it is prudent to use process improvement methodology that has been adopted by the facility.

Solutions must overcome the divisions that are common between hospital departments and can impede true system development. They must also be evidence-based and patient-and family-focused. Successful solutions are likely to require shifts in traditional roles and time-honored ways of operating. This is especially true when making glycemic management process changes. The results—improved outcomes and increased patient satisfaction—are worth the effort.

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