

Managing Hyperglycemia in Hospitalized Patients

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Insulin infusion is used in the critical care setting for prevention of hyperglycemia and is administered most safely under a structured, dynamic, dose-defining algorithm. The ordering of basal-prandial-correction SC insulin therapy, appropriate for most hospitalized patients who are eating, is simplified and standardized to excellence by the development of institutional order sets or computerized order entry templates. Basal insulin therapy is prescribed as intermediate-acting insulin or long-acting insulin analogue. Prandial insulin therapy is delivered with meals to prevent excessive glycemic excursions from occurring after ingestion of meals and is prescribed as rapid-acting insulin analogue. Correction-dose insulin therapy is ordered as small doses of rapid-acting insulin analogue delivered to correct hyperglycemia and is prescribed with appropriate timing so as to avoid stacking with previously administered doses of rapid-acting insulin analogue. Patients knowledgeable in diabetes self-management will experience satisfaction under an institutional policy that allows self-management to continue under appropriate conditions during hospitalization. To craft appropriate institutional tools for patient care, the input and consensus of a multidisciplinary group of health care professionals, including primary care providers and hospitalists, as well as specialists in diabetes with backgrounds in endocrinology, nutrition and dietetics, nursing, pharmacy, laboratory sciences, and quality assurance, is required. (*Clinical Cornerstone*. 2007;8[2]:44–57) Copyright © 2007 Excerpta Medica, Inc.

Development of effective policies and protocols to address the problem of hyperglycemia in the hospitalized patient requires team effort. In order to craft appropriate institutional tools for patient care, the input and consensus of a multidisciplinary group of health care professionals, including primary care providers and hospitalists, as well as specialists in diabetes with backgrounds in endocrinology, nutrition and dietetics, nursing, pharmacy, laboratory sciences, and quality assurance, is required. From evidence-based guidelines, institutional pathways can be developed that will become familiar practice habits. Protocols and order sets provide structured templates, permitting individualization of care

while reducing the burden of writing orders in individual patient cases. Familiarization of professional staff with these pathways offers the possibility of standardization to excellence in the monitoring of glucose levels, use of IV insulin infusion and SC insulin therapy, educating patients and their families about the signs and symptoms of the patient's condition, and developing self-management programs that patients can follow at the hospital and on their return home.

For the primary care provider and diabetes specialist whose goal is to provide effective diabetes care and to promote hospital-wide improvements in the management of hyperglycemia, the first step is to participate in patient

management and to become thoroughly familiar with the institutional mechanisms for delivery of diabetes care. He or she should also volunteer to work with a committee or to chair a working group to bring about a change or improvement the institution has identified as a priority in the care of these patients. It is through the management of hospitalized patients with hyperglycemia and diabetes, a thorough knowledge of the institution's protocols, and the willingness to work toward improvements in those protocols that an individual health care provider may gain the greatest credibility as an agent of change.

This article will focus on the establishment of policies and protocols related to hyperglycemia in the hospitalized diabetes patient in 3 areas: a protocol for IV insulin infusion, order entry for SC insulin management, and facilitating self-management for the hospitalized diabetes patient.

PROTOCOLS FOR IV INSULIN INFUSION

Hospitals have an interest in developing protocols for IV insulin infusion that are safe and effective, deliver treatment over a full range of patient characteristics, and meet differing targets for glycemic control.¹⁻⁴ The use of IV insulin infusion has become a standard of care for patients in the surgical intensive care unit (ICU).^{1,2} Some institutions have introduced IV insulin infusion on intermediate or other wards^{5,6}; however, there exists some controversy over the level of glycemic control that might be required in other hospital settings. In addition, there may be settings in which SC insulin therapy would provide control comparable to IV insulin infusion.⁷

Generally, an IV insulin infusion protocol should be initiated by signature of the patient's provider, implemented by a nurse, and executed without the need for mathematical calculation or subjective judgment by the nursing staff. Nursing input at any given time includes knowledge of the patient's previous insulin infusion rate and the present blood glucose value. The nurse must also estimate the rate of blood glucose change under a method defined by the institution's protocol. Current methodology requires periodic determination by the nursing staff of point-of-care blood glucose values. Commercially marketed decision support systems for IV insulin infusion protocols are available, but no comprehensive comparative studies are available that show superiority of any specific product over competing systems. In the future,

the ideal decision support system will be fully computerized and will exhibit superiority over paper protocols such that reduction of both nursing effort and clinical error might be expected to justify cost. The ideal decision support system of the future will be linked to a glucose monitoring system and will not only calculate the insulin infusion rate but also regulate insulin delivery.⁸

Algorithm Design and the Discovery of Insulin Maintenance Requirement

The essential output of any dose-defining IV insulin infusion algorithm consists of the recommended insulin infusion rate and the next blood glucose test time. Older protocols assigned insulin infusion rates according to previous insulin infusion rates and current blood glucose values. More current protocols also incorporate patient insulin sensitivity. Insulin sensitivity is inferred by glycemic response at a given insulin infusion rate. According to their design, these protocols may use the glycemic response at a given infusion rate to require a new multiplier, to mandate column reassignment, or to govern selection or calculation of the next infusion rate.^{5,9-18} Treatment of hypoglycemia with concentrated dextrose is also driven by protocol. An important feature of any IV insulin infusion protocol is that it should define the insulin infusion rate unambiguously, without requiring mathematical calculations or subjective judgments by the nurse.

The strategy of any protocol for IV insulin infusion is to discover the maintenance requirement for insulin under ambient conditions of illness, carbohydrate exposure, and concomitant therapies. With this knowledge, appropriate corrective adjustments of the insulin infusion rate may be assigned during an upward or downward trend of blood glucose values. Whereas the true maintenance requirement can be best defined during euglycemic intervals of stability, the maintenance rate can be estimated prior to attainment of euglycemia by observing the glycemic response to insulin infusion.

The Role of the Multidisciplinary Team in Developing and Adopting an IV Insulin Infusion Protocol

An example of the development of an insulin protocol gives historical insight into the role of the multidisciplinary team in the institutional development and adoption of such protocols. At Luther Midelfort Mayo Health

KEY POINT

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System in Eau Claire, Wisconsin, the specific algorithmic content of the Markovitz protocol for correction of hyperglycemia was initiated at the request of the cardiac surgery team and created first from an equation designed by an endocrinologist.¹³ The endocrinologist selected specific parameters and column maintenance rates and put the equations of the algorithm into discontinuous tabular form together with column change rules. The rules for use of the table were tested and judged to be implementable through the cooperation of a working group that included members from the departments of cardiovascular surgery, endocrinology, nursing, pathology, and quality resources. The protocol was initially used in the ICU and then approved for use in selected cases outside the ICU.

At the University of North Carolina (UNC),¹⁴ the Clinical Management Committee charged one of its endocrinologists with the task of developing the tabular protocol for institutional use and appointed a multidisciplinary committee to oversee the development of a locally implementable version of the protocol. The result was a protocol used in the cardiothoracic ICU (shown in Appendix 2 of reference 14), having a tighter glycemic target range than the earlier version from Wisconsin.¹⁴ The trauma service at UNC determined that an even tighter protocol was needed for patients in the surgical ICU and requested that the endocrinologist develop a protocol revision. The next revision, which again was implemented after multidisciplinary input, came to be used for the majority of trauma, burn, and general surgical ICU patients who required IV insulin infusion.¹⁹ The most recent version of the paper tabular protocol restricts the column maintenance rate to 6 possible values (1, 2, 3, 4, 6, or 8 units/hr).¹⁹ The paper protocol fixes, in advance, certain protocol parameters that actually should differ between patients and patient populations. Therefore, limitations of the paper protocol are recognized.²⁰

As a further extension of previous work, an electronic protocol now is under development at UNC that will use 2 design principles from the earlier tabular paper protocols: (1) a linear rule relating insulin infusion rate to blood glucose value for hyperglycemia, and (2) an exponential rule for euglycemia. Both rules use the column maintenance rate of the paper protocol as a parameter for the calculation of insulin infusion rate. The electronic protocol will add a third rule: calculation of the maintenance rate.²¹ Oscillations in maintenance rates are less frequent and of lesser magnitude than oscillations in insulin infusion rates. It is hoped that by targeting the maintenance rate rather than the infusion rate for reiterative correction, stabilization of the patient will be achieved.

ORDER ENTRY FOR SUBCUTANEOUS INSULIN MANAGEMENT

There exist a number of prescribing patterns appropriate for the use of SC insulin under differing patient conditions. Whereas an IV insulin infusion can be ordered with a single signature, the completion of orders for SC insulin requires a more complex decision pathway for the prescriber; therefore, a comprehensive order template for SC insulin must also be more complex.

Basal-Prandial-Correction Therapy for Patients Who Are Eating

For hospitalized hyperglycemic patients who are eating, an accepted strategy for the maintenance of glycemic control is SC basal-prandial-correction therapy.^{22,23} Basal-prandial-correction therapy, preferred for patients with type 1 diabetes who are not using insulin pump therapy, is also an outpatient management strategy for selected patients with type 2 diabetes.^{24–28} In the hospital setting, the use of oral antidiabetic agents is generally discontinued. Unless oral intake of food is curtailed during the hospital stay, $\geq 50\%$ of the total daily dose of insulin should be prescribed as a rapid-acting prandial insulin analogue given with meals to prevent excessive glycemic excursions from occurring after ingestion of meals. The remainder of the daily insulin dose should be prescribed as a long-acting basal insulin analogue given once or twice daily. Correction-dose therapy is ordered as small doses of rapid-acting insulin analogue delivered to correct hyperglycemia and is prescribed with appropriate timing so as to avoid stacking with previously administered doses of rapid-acting insulin analogue. The addi-

tion of rapid-acting correction-dose insulin to a structured anticipatory plan of scheduled insulin is to be differentiated from sliding scale insulin (SSI) used as monotherapy. Because of its lack of efficacy and medical risk, eliminating SSI monotherapy for patients with diabetes should be a high priority.^{29–34}

The primary benefit of basal-prandial-correction therapy for hospitalized patients who are eating is that prandial insulin analogue therapy can be interrupted when meals are missed without compromising basal insulin analogue therapy (**Figure 1**). The most common mistake among providers who are newly converted to the use of scheduled insulin is to add basal insulin to sliding scale orders without providing for scheduled prandial coverage, resulting in postprandial hyperglycemia and daily elevation of blood glucose levels. A common scenario leading to hypoglycemia is the use of basal insulin in increasing doses to compensate for progressive daily prandial glucose elevations. If meal omission should occur on a subsequent day, there is then the risk for hypoglycemia (**Figure 2**).²⁷

For patients inexperienced in self-management and hospital staff unfamiliar with advanced carbohydrate monitoring, a meal plan with a consistent carbohydrate count should be ordered.³⁵ **Table I** provides an example of orders that might be appropriate for a patient admitted to the hospital with osteomyelitis of the lower extremity preparing for surgery and having uncontrolled type 2 diabetes.

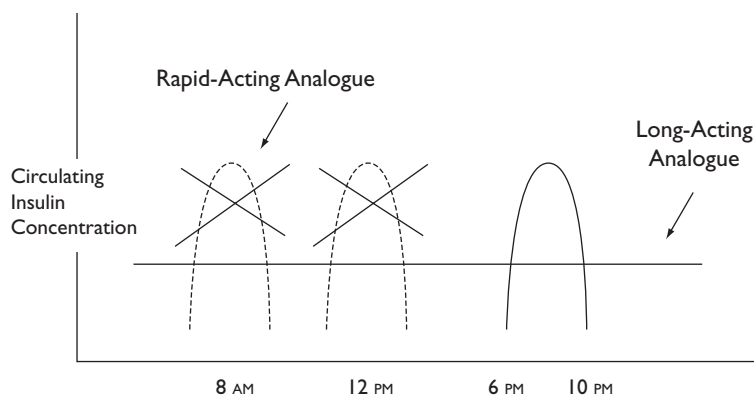


Figure 1. For procedures or for brief noneating (NPO) status, orders provide for holding the prandial insulin dose but maintaining some part of the basal insulin dose. Basal insulin is given as a long-acting insulin analogue (glargine or detemir) once or twice a day. Prandial insulin is given as rapid-acting insulin analogue with meals. Instructions for prandial insulin should state “Hold if NPO” and should define a threshold below which the prandial dose is to be reduced or withheld. Instructions for basal insulin should state “Do not withhold” for patients with type 1 diabetes. For patients with type 2 diabetes, instructions regarding the desired reductions in basal insulin in case of NPO status should be specified if any reduction is intended.

KEY POINT

For hospitalized patients who are eating, an accepted strategy for the maintenance of glycemic control is SC basal-prandial-correction therapy. For these patients, prandial insulin analogue therapy can be interrupted when meals are missed without compromising basal insulin analogue therapy.

Prescribing Insulin for Patients Who Are Not Eating Discrete Meals

For patients assigned to basal-prandial-correction therapy whose diet/nutrition status is changed to *nothing by mouth* (NPO), there should be instructions on the order entry indicating whether or not to withhold each component of insulin therapy. For patients with type 1 diabetes, *do not withhold* comments entered on the order sheet in conjunction with *basal insulin* generally are appropriate, as requirements for basal insulin tend not to change during NPO status for these patients if the dose was initially established correctly.³⁶

Generally, the greatest barrier to creating a hypoglycemia prevention protocol is the lack of comprehen-

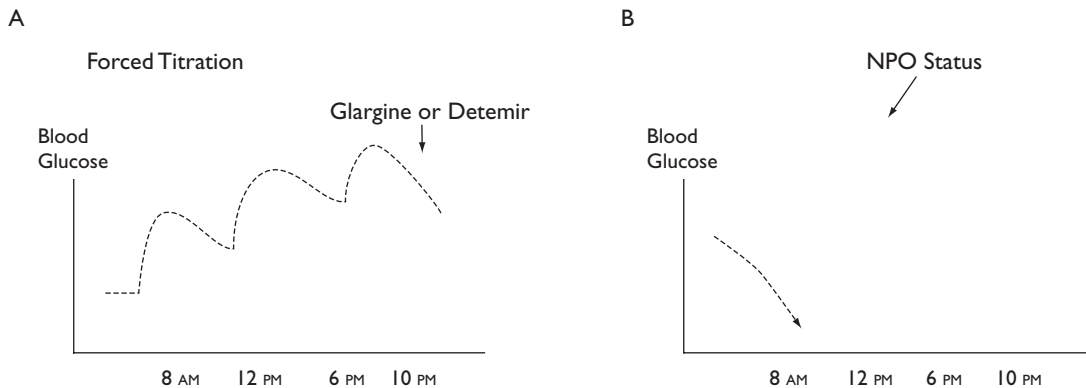


Figure 2. For patients receiving insufficient prandial coverage, high doses of long-acting basal insulin analogue (glargine or detemir) may contribute to or result in hypoglycemia in the hospitalized patient. (A) Long-acting insulin analogue is sometimes misused through forced titration to a high daily dose in order to catch up overnight for insufficient prandial coverage. Sliding scale insulin given at bedtime may exacerbate the risk for hypoglycemia. (B) If a patient receives an excessively high daily dose of long-acting basal insulin and hospital routine interrupts the usual daytime meal plan, the long-acting basal insulin delivered in the evening may result in delayed hypoglycemia. NPO = nothing by mouth. Adapted with permission.²⁷

TABLE I. ORDERS FOR A HYPERGLYCEMIC PATIENT* WITH OSTEOMYELITIS PREPARING FOR SURGERY.

- Point-of-care monitoring of blood glucose before meals, at bedtime, and at 3:00 AM
- Glargine: 36 units at bedtime
 - Cut 50% if NPO
- Aspart: 12 units with meals
 - Withhold if NPO
 - Cut 50% if blood glucose <90 mg/dL
- Aspart +2 units with meals, at bedtime, and at 3:00 AM, as needed (prn) for blood glucose 150–199 mg/dL
- Aspart +4 units with meals, at bedtime, and 3:00 AM, as needed (prn) for blood glucose \geq 200 mg/dL
- Consistent carbohydrate meal plan

NPO = nothing by mouth.

*Hypothetical patient with uncontrolled type 2 diabetes who needs ~72 units of insulin daily while eating and whose need for immediate control of hyperglycemia is thought to outweigh the risk for nocturnal hypoglycemia during hospitalization.

sive guidance on what to do in the case of NPO status. However, if a provider is required to attach advance instructions to each insulin order, describing whether to administer the insulin dose or to modify it if carbohydrate exposure is interrupted, the protocol for hypoglycemia prevention becomes straightforward and easily implemented.³⁷ But a provider must also have a strategy in place for hyperglycemic patients during longer-term intervals of altered carbohydrate exposure, such as during enteral tube feedings.³⁸ The use of standardized order sheets, both for patients who are eating and for those who

are not, makes treatment requirements for these patients readily available and easy to implement.³⁹

Standardized Order Sets

Prescribing instructions are made familiar to physician and nursing staff and are facilitated by use of standardized order sets that guide and teach.^{40,41} Orders for SC insulin must be matched to pharmacy, nursing, dietary, and laboratory orders. To prevent omissions, there is need for a menu of choices that will serve as a reminder to prescribers. The menu of a glycemic man-

agement order set should allow for selection from several standardized patterns of blood glucose monitoring and should provide active pharmacy orders for use of 50% dextrose in water and/or glucagon, as needed, for the treatment of hypoglycemia. The menu should present several patterns for scheduled basal and nutritional insulin such that the desired types of insulin and the pattern of insulin timing can be selected according to carbohydrate exposure; the orders can then be completed simply by entering the required insulin doses. The menu must address several issues, including nutritional status or requirements, glycosylated hemoglobin (A1C) measurement, diabetes-related consultations, and call parameters (ie, high and low blood glucose alert parameters) that advise the prescriber when a revision to scheduled insulin therapy may be needed. The menu must also address patient education.

Because nocturnal or postprandial insulin dosing may be inappropriate for some patients, the orders for blood glucose monitoring should be clearly differentiated from the orders for correction doses of insulin. If correction doses are to be given, the specific times at which these doses should be administered, as well as the blood glucose value for which the dose is applied, must be clearly indicated.

Computerized Order Entry Simplifies Daily Dose Revision

Paper order sets are used by many institutions to present a menu as described above. A computerized order entry includes the same information. With a computerized order entry system, however, additional directions, such as “do not withhold” or “withhold if NPO,” can be created as part of a drop-down menu of additional comments that can be entered with each insulin order. Once all of the details of each component of a patient’s daily insulin treatment regimen are entered, including medication name or type, dose, frequency, route of administration, and additional comments, it is a simple matter to adjust the patient’s insulin doses without having to reenter all of this detailed information. A particularly helpful element of some electronic order entry systems is the ability to assign a drug to a premedication status rather than a routine (ie, scheduled or programmed) or as needed status. At our institution, premixed 70/30 neutral protamine Hagedorn (NPH)/regular insulin is sometimes ordered as premedication for overnight tube feedings.

DIABETES SELF-MANAGEMENT FOR THE HOSPITALIZED PATIENT

Diabetes patients are often frustrated to lose autonomy with respect to self-management during a hospital stay. Through advanced knowledge of carbohydrate counting, the skill of assigning prandial doses is useful for both type 1 and type 2 diabetes, such that patients who are able to eat in the hospital and who already have this skill may experience the greatest satisfaction with care if they are allowed to continue to exercise self-management.^{27,28,42–44} In addition, several studies have shown that use of continuous SC insulin infusion can provide improvement over injection-based therapy for some patients and that insulin pump therapy is effective not only in patients with type 1 diabetes but also in those with type 2 diabetes and in older adults.^{45–56} For patients who are able to self-manage their disease, therefore, specific decisions may be best left to them. Certainly, health care providers can offer these patients tips on their care as a result of a new medical circumstance; for example, after renal transplant, a patient using an insulin pump might be advised of the probable need to increase the amount of basal and bolus insulin therapy they may need. Yet despite the knowledge of the health care provider and diabetes specialist about the spectrum of possible outcomes in response to a given intervention, it is likely that a patient who is proficient in diabetes self-management knows more about his or her individual likelihood of experiencing a specific consequence than does the specialist.

KEY POINT

Patients who understand the concept of carbohydrate counting and who already are knowledgeable in self-management may experience the greatest satisfaction with care if they are allowed to continue to exercise self-management in the hospital.

Development of a Hospital Patient Diabetes Self-Management Program

At our institution, the need was recognized for a policy that would allow patients with experience in the manage-

ment of their diabetes to continue to self-manage while being hospitalized. There has been precedent elsewhere for such treatment and a call for careful program development⁵⁷⁻⁵⁹; however, to ensure regulatory compliance and patient safety, a local program had to be developed. A multidisciplinary team, including specialists in nursing, pharmacy, diet/nutrition, the point-of-care laboratory, legal and medical issues, as well as house officers, worked on the development of this program under the leadership of the quality improvement department (**Table II**). Under the program, a patient is not required to sign a consent form.

Guidelines were established with respect to patient eligibility, change of cannula insertion site, call parameters, order entry of insulin dosing instructions, and recording of actual insulin delivery, all of which serve to guard patient safety and to meet pharmacy regulatory requirements. In addition, a copy of the patient log, showing blood glucose self-monitoring results, insulin doses taken, and carbohydrates ingested, is required to be retained as part of the patient's permanent medical record. No specific schedule for point-of-care blood glucose monitoring is required of nursing staff, except at the judgment of the patient's physician.

The program was presented to focus groups through the leadership of the continuous quality improvement department. It was also presented to the following committees before adoption as hospital policy: the medication safety committee, the forms committee (medical information management), the computerized order entry steering committee, the nursing standards committee, the pharmacy and therapeutics committee, and the medical executive committee. The program has 5 associated docu-

ments: an order entry form (**Appendix 1**), the patient log (**Appendix 2**), the nursing policy, the hospital policy, and a patient information sheet. The Hospital Patient Diabetes Self-Management Program is now widely used in the hospital on adult services, after adoption as hospital policy in the summer of 2005. Work on the program had commenced in the autumn of 2002.

CONCLUSIONS

The evolution of IV insulin protocols, the development of standardized order sets and computerized order entry templates for SC insulin management, and the implementation of a diabetes hospital patient self-management program require interdisciplinary effort. With input from diabetes specialists and primary care providers, multidisciplinary teams, through the development of institutional policies and protocols, can standardize to excellence the management of hyperglycemia in the hospital environment.

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TABLE II. UNIVERSITY OF NORTH CAROLINA HOSPITALS DIABETES SELF-MANAGEMENT PROGRAM FOR THE HOSPITALIZED PATIENT.

- The patient must be willing and must be judged competent by physician and nursing staff to participate in the self-management program.
- The program is available for SC insulin injection therapy and continuous SC insulin infusion.
- Although removal of an insulin pump during anesthesia is not obligatory when the cannula insertion site is not in the operative field, removal of the old cannula and insertion of a new cannula and infusion set by the patient is required on awakening, before resumption of bolus therapy.
- Participation of the patient in the program does not relieve the physician of the duty to monitor and treat the patient.
- The decision that self-management is appropriate can be revised during the course of the hospital stay.
- The patient who does not know how to conduct self-management is not a candidate for participation in the program.
- The patient who does not carry the necessary supplies into the hospital is not a candidate for participation in the program.
- An endocrine consultation is required.
- Nursing education and patient information on the program are offered.

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Appendix I.

Insulin Pump Basal Rates and Boluses by Continuous Subcutaneous Infusion of Insulin

Basal Rates Using Rapid-Acting Insulin Analogue

- Below, select 00:00 or 12 AM (midnight), and beneath this selection indicate the programmed 00:00 or 12 AM basal infusion rate of rapid-acting insulin analogue.
- At each time when the basal rate changes, select a box from the upper row, enter the time of the programmed change of basal rate, and in the box beneath, enter the basal rate in units of rapid-acting insulin analogue per hour that commences at the selected time.

Time	<input type="checkbox"/> 00:00 or 12 AM	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Units/ hour											

Entries above are in units of insulin per hour. Each rate is continued until the time of day when a new rate starts.

Boluses of Rapid-Acting Insulin Analogue

Instructions for completion are to the left of each section below.

Select mealtimes:	<input type="checkbox"/> Breakfast	<input type="checkbox"/> Lunch	<input type="checkbox"/> Supper	<input type="checkbox"/> Snacks
Prandial doses of rapid-acting insulin analogue: Below each selected mealtime, complete one rule.	_____ units/meal or units/serving* or 1 unit/ _____ g [†]	_____ units/meal or units/serving* or 1 unit/ _____ g [†]	_____ units/meal or units/serving* or 1 unit/ _____ g [†]	_____ units/meal or units/serving* or 1 unit/ _____ g [†]
Correction doses of rapid-acting insulin analogue: Complete one rule.	<input type="checkbox"/> _____ unit(s) for every _____ mg/dL blood glucose elevation above _____ (target blood glucose) or <input type="checkbox"/> units = [actual blood glucose – (_____ , target blood glucose)] ÷ (_____ , insulin sensitivity factor [‡]) or <input type="checkbox"/> other rule: _____			
Select one timing plan for correction doses.	<input type="checkbox"/> before meals <input type="checkbox"/> before and between meals with frequency not to exceed q 2 hour			

*Serving = one 15-g serving of carbohydrate.

[†]g = grams of carbohydrate.

[‡]Insulin sensitivity factor = expected drop of blood glucose in mg/dL after administration of 1 unit of rapid-acting insulin analogue.

Hold parameters and comments: _____

Example of an order entry form for insulin pump basal rates and boluses by continuous subcutaneous infusion of insulin. This is an editorial modification of the form used as part of the University of North Carolina Hospital Patient Diabetes Self-Management Program.

Appendix 2.

<p>Diabetes Self-Management Program: Patient Log Instructions to patient:</p> <ul style="list-style-type: none"> • Complete this form every day that you participate in the Diabetes Self-Management Program. • Keep your entries to the form current throughout the day. • Show a completed form (midnight to midnight of the previous day) to your nurse every morning at 8:00 AM and at discharge, before separating copies. • Keep your copy, and allow your nurse to collect the chart copy. • If you need insulin, syringes, alcohol swabs, or lancets, notify your nurse. • If you feel you are losing your capability to self-manage, notify your nurse. <p>Thank you for helping us comply with quality improvement measures and regulatory requirements.</p>	<p>RN to record daily: Brand name of patient glucose meter _____</p> <p>Lot # of strips _____</p> <p>Expiration date of strips _____</p> <p>Code # of strips/meter _____</p> <div style="border: 1px solid black; padding: 5px; margin-top: 5px;"> <p>Call the nurse if your blood glucose is less than: _____ or greater than: _____ mg/dL</p> <p>Date: _____</p> <p>Nurse Signature: _____</p> </div>																																								
<p>Basal rate by pump:</p> <ul style="list-style-type: none"> • Enter times when basal rate changes (upper row) starting at midnight (00:00 or 12 AM). • Enter basal rate in units of rapid-acting insulin analogue/hour (lower row). <table border="1" style="width: 100%; border-collapse: collapse; margin-top: 5px;"> <tr> <td style="width: 10%;">Time</td> <td style="width: 10%;">00:00 or 12 AM</td> <td style="width: 10%;"></td> <td style="width: 10%;"></td> <td style="width: 10%;"></td> <td style="width: 10%;"></td> <td style="width: 10%;"></td> <td style="width: 10%;"></td> <td style="width: 10%;"></td> <td style="width: 10%;"></td> <td style="width: 10%;"></td> <td style="width: 10%;"></td> </tr> <tr> <td>Units/hour</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> </table>		Time	00:00 or 12 AM											Units/hour																											
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<p>Intermediate-acting, long-acting, peakless, or premixed insulin by subcutaneous injection: [Examples: NPH; glargine; detemir; 70/30; 75/25; 50/50]</p> <table border="1" style="width: 100%; border-collapse: collapse; margin-top: 5px;"> <tr> <td style="width: 33%;">Time:</td> <td style="width: 33%;">Time:</td> <td style="width: 33%;">Time:</td> </tr> <tr> <td>Type of insulin:</td> <td>Type of insulin:</td> <td>Type of insulin:</td> </tr> <tr> <td>Dose (units):</td> <td>Dose (units):</td> <td>Dose (units):</td> </tr> </table>		Time:	Time:	Time:	Type of insulin:	Type of insulin:	Type of insulin:	Dose (units):	Dose (units):	Dose (units):																															
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Dose (units):	Dose (units):	Dose (units):																																							
<p>Mealtime and correction-dose insulin:</p> <ul style="list-style-type: none"> • Complete left-hand column by checking off method of carbohydrate counting and insulin type. • Use blank columns to enter time, blood glucose results, carbohydrates counted as grams or servings, and insulin dose in units. <table border="1" style="width: 100%; border-collapse: collapse; margin-top: 5px;"> <tr> <td style="width: 20%;">Time</td> <td style="width: 10%;"></td> <td style="width: 10%;"></td> <td style="width: 10%;"></td> <td style="width: 10%;"></td> <td style="width: 10%;"></td> <td style="width: 10%;"></td> <td style="width: 10%;"></td> <td style="width: 10%;"></td> <td style="width: 10%;"></td> </tr> <tr> <td>Blood glucose</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>Carbohydrates counted by <input type="checkbox"/> grams <input type="checkbox"/> servings</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td><input type="checkbox"/> Rapid-acting insulin analogue <input type="checkbox"/> Regular insulin</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> </table>		Time										Blood glucose										Carbohydrates counted by <input type="checkbox"/> grams <input type="checkbox"/> servings										<input type="checkbox"/> Rapid-acting insulin analogue <input type="checkbox"/> Regular insulin									
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<p>Daily Total Insulin Dose by Pump (complete section to the right before turning in the Patient Log at 8:00 AM): Enter 24-hour daily total insulin dose shown on the pump screen from 12 AM (00:00 or midnight) to 12 AM (midnight) for date above (yesterday):</p> <div style="text-align: right; margin-top: 10px;"> _____ units </div>																																									

Example of a patient log, which the patient is expected to complete every day. This is an editorial modification of the form used as part of the University of North Carolina Hospital Patient Diabetes Self-Management Program.

Dialogue Box

EDITORIAL BOARD

What do you consider the most salient components of the University of North Carolina inpatient diabetic treatment program?

BRAITHWAITE

In my opinion, there were 3 pivotal developments in this program. The first was the development of an IV insulin protocol for appropriate hospital units. The second was the development of a standardized method of entering orders for SC insulin. The third was the development of the self-management program for hospitalized patients with diabetes.

EDITORIAL BOARD

Does the standardized method of entering orders for SC insulin rely on standardized meals?

BRAITHWAITE

Not always. For people who don't yet know how to perform advanced carbohydrate counting, which would be the majority of hospitalized patients with hyperglycemia, we can order a consistent carbohydrate diet for them. However, for people capable of self-management, we allow them to select from the general menu. For people on tube feeding, the composition is determined by their nutritional needs.

EDITORIAL BOARD

What is the glucose threshold above which tightening glycemic control has been found to reduce hospital morbidity?

BRAITHWAITE

That number has yet to be precisely determined. A target glucose range of 80 to 110 mg/dL was used by Van den Berghe in her trial, which demonstrated a reduction in hospital mortality and morbidities in patients in the surgical intensive care unit (ICU). It should be noted, however, that those glucose values were determined on a whole blood gas analyzer. Since glucose values in the United States are plasma-correlated, the equivalent num-

bers here would be 10% or 15% higher, ie, an upper level of 120 mg/dL would be comparable to Van den Berghe's 110 mg/dL. It should also be recognized that it was only in a retrospective analysis of the data that Van den Berghe demonstrated a difference between an upper threshold of 110 mg/dL versus 150 mg/dL with regard to reducing mortality in the surgical ICU. In addition, the patients were not really randomized to that middle group—randomization was to a range of 80 to 110 mg/dL or to a higher range. For the group randomized to the higher range, insulin infusion was initiated at 215 mg/dL, and the target was 180 to 200 mg/dL. Furthermore, recent European studies have failed to show any advantage to targeting upper glucose values as low as 110 mg/dL, and, in fact, have found an increased risk of hypoglycemia when striving for a value that low. The bottom line is that nobody would have a problem with 110 mg/dL as a target if we knew that we could get patients there safely. Realistically, most decent protocols can easily keep most patients under 120 to 140 mg/dL. Suffice it to say that it is generally agreed that a value <140 mg/dL most of the time with most ICU patients would be a safely achievable goal.

EDITORIAL BOARD

In which hospitalized patients does tight glycemic control provide a reasonable risk/reward ratio?

BRAITHWAITE

Although benefit was shown by Van den Berghe in keeping the target glucose <110 mg/dL in surgical ICU patients, a subsequent study by her in medical ICU patients failed to show the same survival advantage. It appeared that the longer-stay surgical patients, whom you cannot predict in advance, were the ones who experienced an advantage. Thus, in patients other than those in the surgical ICU, the evidence is less persuasive or controversial that glucose levels <110 mg/dL need to be targeted. For these patients, some people believe that a reasonable threshold would be 145 mg/dL, a level supported by a retrospective study by Finney.

Dialogue Box

EDITORIAL BOARD

Would you recommend that patients who have undergone an uncomplicated coronary artery bypass graft stay a few extra days in the ICU just to facilitate tight glucose control using an insulin drip?

BRAITHWAITE

No. In such patients, I believe that using a basal-prandial-correction protocol designed to keep the glucose level between 90 and 130 mg/dL would be fine once they become stable enough to go to the floor.

EDITORIAL BOARD

In determining the total daily insulin requirement for hospitalized patients with type 1 diabetes, do you use the same daily dose they were using before being admitted?

BRAITHWAITE

Most patients with type 1 diabetes are pretty close to their true insulin need. If there is any doubt about it, though, a reasonable starting place is 0.5 unit/kg body weight, divided roughly equally between the basal and prandial insulins, or perhaps slightly heavier on the prandial side than the basal side.

EDITORIAL BOARD

How do you calculate the dose in a patient with type 2 diabetes who has never been on insulin?

BRAITHWAITE

If the patient is truly at ideal body weight, it would be the same recommendation as for the patient with type 1 diabetes—0.5 unit/kg body weight. In practice, however, I usually use the low-end dose published in outpatient studies—0.3 unit/kg body weight, divided equally between the basal and prandial insulins. Although I know others who use higher doses, I am not comfortable going much higher than this when initiating insulin for patients who are naive to insulin.

EDITORIAL BOARD

For that calculation, ie, 0.3 unit/kg body weight, do

you use their actual body weight or their ideal body weight?

BRAITHWAITE

Their actual body weight. But I would bet that for most heavysset patients, the dose calculated at 0.3 unit/kg would probably be fairly close to the 0.5 unit/kg dose if you were to use their lean body weight.

EDITORIAL BOARD

What is meant by *stacking*?

BRAITHWAITE

The mainstays of basal-prandial-correction therapy are the *basal insulin* and the premeal *prandial insulin*. Correction-dose therapy is ordered as small doses of rapid-acting insulin analogue, usually delivered along with the prandial insulin, to correct premeal hyperglycemia. Correction-dose therapy is prescribed with appropriate timing so as to avoid “stacking” with previously administered doses of rapid-acting insulin analogue. In the hospital setting, *stacking* refers to the risk of “the left hand not knowing what the right hand is doing.” It usually arises when someone orders sliding-scale insulin every 4 or 6 hours without taking into account that the patient might also be receiving correction dose and prandial insulin with meals. The sliding scale is “out of synchrony” with the prandial insulin. If someone orders a postprandial glucose test and then uses that opportunity to prescribe another dose of rapid-acting analogue on a sliding scale, the dose of rapid-acting analogue (which can linger for 4 to 5 hours) given before an earlier meal may still be in the patient’s system. Another problem is that the target blood glucose during the postprandial time frame differs from the premeal target. The full effect of the premeal dose of insulin will not yet have been seen, so that when a correction dose of insulin ordered from the sliding scale is given at a postprandial time, there may be stacking, or overlap of effect, with the premeal dose. This obviously can precipitate an episode of hypoglycemia, which is why using the time between meals for correction is

Dialogue Box

problematic. You really should hold off until at least 4 or 5 hours *after* the most recent rapid-acting analogue dose before you administer another correction dose.

EDITORIAL BOARD

For patients on basal-prandial-correction therapy, you stated that basal insulin should be continued for those with type 1 diabetes if they were not eating (NPO status). What about in patients with type 2 diabetes?

BRAITHWAITE

In patients with type 2 diabetes, it's a bit more complicated. I'd look at their total daily dose of insulin and, if their basal insulin constituted more than half, I'd reduce

the basal insulin to one half the total daily dose and then reduce it 50% more, if they were NPO. For example, if the patient is taking 60 units of glargine and 12 units of aspart daily, the total daily dose would be 72 units. Based on the basal-to-prandial insulin ratio, I would suspect that the patient is likely "playing catch-up" every night with glargine because of the inadequacy of the prandial coverage. In other words, if we were to monitor their glucose values throughout the day, very likely the highest ones would be toward the end of the day, with a drop occurring during the night. I would then figure that the true (and optimal) basal requirement was really 36 units, assuming they were not also being managed with oral agents. If the true basal requirement was 36 units, I would then reduce that dose by 50%, to 18 units.