Rush University Guidelines and Protocols for the Management of Hyperglycemia in Hospitalized Patients

Elimination of the Sliding Scale and Improvement of Glycemic Control Throughout the Hospital

Abstract

The management of inpatient hyperglycemia has received much recent attention because of an expanding literature supporting the benefits of quality improvement and the creation of guidelines in this area. The authors began a process in 2002 to create modern protocols for glycemic control with intravenous insulin in their intensive care units and with subcutaneous basal-prandial insulin in all of their non-intensive care units. In this report, they describe both the process employed and the current protocols they are using. They also describe the process, perpetually ongoing, for educating nurses and residents in a large academic medical center. The annual cycle of senior residents passing on the regular insulin sliding scale to first-year interns and students can be broken. The hospital ward can be a valuable setting in which to teach basal/prandial insulin protocols, which will readily translate into the outpatient clinic. Where better to teach the importance and real-time usefulness of HbA1c than on the inpatient ward of a teaching hospital? Protocols to prevent and treat hypoglycemia can also be taught and widely accepted, hospital insulin formularies can be streamlined, and modern information technology can be used to track and improve multiple metrics of care for inpatients with hyperglycemia. The inpatient encounter with diabetic care can be a golden window of
opportunity for patient as well as physician and nurse education.

Traditionally, inpatient management of hyperglycemia has been a low priority, even though diabetes is the fourth most common comorbid condition in hospital discharges.\(^1\) Umpierrez et al reported a 26% prevalence of known diabetes in hospitalized patients, and an additional 12% of patients had unrecognized diabetes and hospital-related hyperglycemia.\(^2\) Hyperglycemia is associated with adverse outcomes and an increased risk of in-hospital mortality.\(^3,4\) After cardiac surgery, hyperglycemia has been linked to nosocomial infection, atrial fibrillation, and mortality.\(^5,6\) Uncontrolled inpatient hyperglycemia can lead to higher costs because of increased length of stay, complications, and readmissions.\(^7,8\) In 2001, Van den Berghe et al reported that maintaining blood glucose at 80 to 110 mg/dL (4.4-6.1 mmol/L) in a surgical intensive care unit (ICU) with an intravenous (IV) insulin infusion could significantly reduce the development of bacteremia by 46% and mortality by 52% in those patients who stayed in the ICU for longer than 5 days.\(^9,10\) Recently, Van den Berghe et al reported that a similar trial of IV insulin in a medical ICU reduced the need for mechanical ventilation, length of stay, and mortality by 19% in those patients who stayed in the ICU for longer than 5 days.\(^11\)

In 2002, Rush University Medical Center began implementing a standardized approach to achieve the goals outlined in the ADA/ACE position statement. This article describes current versions of the protocols that were developed in the efforts to modernize care for inpatient hyperglycemia and diabetes. Clearly, there are many different approaches that will be successful to achieve these goals. This is simply the approach that evolved at Rush University and is still a process in evolution.

Initially, attention was focused on maintaining normoglycemia after cardiac and transplant surgery in the surgical ICU with a continuous insulin infusion protocol (Table 1). This protocol was adopted from the Leuven protocol, setting a target blood glucose range of 80 to 120 mg/dL (4.4-6.6 mmol/L).\(^10\) The results using the protocol after cardiovascular surgery have been excellent, achieving a mean blood glucose level of 116 mg/dL (6.4 mmol/L), with only 0.1% of blood glucose readings <40 mg/dL (2.2 mmol/L).\(^14\) This protocol has been taught to the nursing staff of all medical and surgical ICUS in the institution and is now universally used. In addition, 2 specific protocols were written for the medical ICU: 1 for diabetic ketoacidosis and 1 for hyperglycemic hyperosmolar nonketotic syndrome (not shown).

In the hospital, when ICU patients who were treated with an IV insulin infusion were transferred to a general medical or surgical unit, the IV insulin needed to be transitioned to a subcutaneous insulin regimen. This proved difficult in the inpatient culture, in which sliding-scale regular insulin was routinely employed for patients with poor glycemic control. Therefore, a comprehensive new set of guidelines was needed that would transition patients from an IV insulin infusion to a modern basal/prandial subcutaneous insulin regimen (Table 2).

The first step was to write subcutaneous insulin protocols for hyperglycemic patients on the general medical-surgical floors. The Section of Endocrinology developed these in collaboration with the Department of Medicine Error Reduction Committee, Department of Nursing, the pharmacy, and Information Services (IS). The guidelines call for basal insulin to be ordered for all patients who require subcutaneous insulin therapy. The sole use of a regular insulin sliding scale is no longer allowed for any patient. When patients tolerate an oral diet, prandial insulin is also ordered. In addition, all patients may receive a correctional insulin supplement if hyperglycemia persists while basal and prandial insulin components are being adjusted. As a patient’s insulin requirements change, it is straightforward to revise the correction doses as needed.

Working with IS, order sets were created in the computerized physician order entry system for basal, prandial, and correction dose insulin. The correction dose insulin is in a simple format and is easily available to the nurse at the bedside. To avoid any errors that might arise from hand copying correction dose orders, IS designed a solution...
whereby a duplicate sheet of these orders is printed and placed in the bedside chart where blood glucose results and insulin orders are documented. Thus, the nurse can manage unexpectedly high blood glucose levels based on these prewritten orders. This eliminates multiple calls to the residents, saves nursing time, and facilitates the timely treatment of an elevated blood glucose level. Unlike a sliding scale of the prior era, the correction dose scales may not stand alone but rather may only support orders for daily basal and prandial insulin.

### Table 1
Rush University Continuous Intravenous Regular Insulin Infusion Protocol

<table>
<thead>
<tr>
<th>Initial titration phase</th>
<th>Maintenance phase (begin once glucose is less than 120)</th>
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</thead>
<tbody>
<tr>
<td>Initial glucose 120-220</td>
<td>Stop regular insulin drip and give 1 amp D50% and resume insulin at 50% of the previous rate when glucose &gt;120</td>
</tr>
<tr>
<td>Initial glucose more than 220</td>
<td>Begin with 2 U/h (no bolus)</td>
</tr>
<tr>
<td>Subsequent glucose more than 140</td>
<td>Increase by 2 U/h</td>
</tr>
<tr>
<td>Subsequent glucose 120-140</td>
<td>Increase by 1 U/h</td>
</tr>
<tr>
<td>Glucose less than 60</td>
<td>Decrease by 25%/h</td>
</tr>
<tr>
<td>Glucose 60-80</td>
<td>Maintain or change by 10%/h ↓ or ↑</td>
</tr>
<tr>
<td>Glucose 80-120</td>
<td>Increase by 25%/h</td>
</tr>
<tr>
<td>Glucose 120-160</td>
<td>Increase by 50%/h</td>
</tr>
<tr>
<td>Glucose more than 160</td>
<td></td>
</tr>
</tbody>
</table>

Insulin infusion rates will be titrated to maintain glucose levels between 80-120 mg/dL (4.4-6.6 mmol/L).

Physicians must include an order in physician order entry starting the protocol.

Access central line if possible. Please remember regular insulin drip should not hang alone; piggyback it into any compatible intravenous (IV) fluid running at least 20-40 mL/h.

Glucose checks are every 1 h until stable.

Glucose checks can be every 2 h once the infusion rate is stable for 3 h.

Once the infusion rate is stable for 6 h, the glucose checks may be every 3 h as long as there is no change in caloric intake or overall condition.

When patient is ready to transfer to subcutaneous (SQ) insulin, contact the primary service to order the first dose of SQ insulin.

If there was no prior history of diabetes and the drip rate is less than 1 U/h, then SQ insulin is not needed.

One of 2 formulas is used to transition to the first dose of SQ insulin.

Patients who are to have nothing by mouth (NPO) or have minimal oral intake (most postoperative patients and others) should receive insulin glargine dosed at 20 times the last stable IV insulin rate.

Patients who are receiving high-dose steroids (transplant, neurosurgery) as well as most patients who are eating a solid diet or are receiving tube feeds should receive NPH dosed at 8 times the last stable IV insulin rate and insulin aspart dosed at 4 times the last stable IV insulin rate.

The regular insulin drip may not be discontinued until 2 to 3 h after the SQ insulin glargine or 1 h after SQ NPH/aspart is given.

Please document the SQ insulin on the diabetic record.
To reduce the chance of insulin-related errors and to create a more standardized hospital-wide approach to insulin therapy, the inpatient insulin formulary was streamlined to regular insulin for IV infusions only, NPH or glargine insulin for basal choices, and aspart insulin as the only choice for both prandial and correction dosing. The pharmacy, the Quality Improvement Department, and the Quality Assurance Committee of the medical staff supported this effort. Hypoglycemia was frequently noted to occur in diabetic patients receiving enteral tube-feeding nutrition and long-acting insulin. Tube feeds are often interrupted with resulting hypoglycemia. A hospital-wide protocol was created for the prevention of these episodes of hypoglycemia and for a uniform treatment of all episodes of hypoglycemia (Table 3). The blood glucose threshold of less than 70 mg/dL (3.9 mmol/L) was chosen following the recommendations of the 2005 ADA Working Group on Hypoglycemia.15 The hypoglycemia...
The protocol is easy for the residents to order for every insulin-treated patient and gives nurses throughout the hospital an order set to use in the case of these emergencies, thus saving precious time wasted with multiple pages and calls.

HbA1c testing has emerged as a valuable tool for the management of inpatient hyperglycemia. An elevated HbA1c in a diabetic inpatient indicates that the preadmission diabetic management plan requires revision prior to discharge. An elevated HbA1c in an inpatient without a prior history of diabetes identifies the need to initiate diabetes education, outpatient follow-up, and often diabetic therapy. Thus, as recommended by the 2006 ADA Standards of Medical Care, HbA1c determinations are performed on all inpatients with hyperglycemia unless recent results are available.

Multiple educational in-services were done on all units and shifts by an endocrinologist and by the inpatient diabetes nurse clinical specialist to familiarize the physicians, nurses, and pharmacy staff with the new protocols. The diabetes specialized nutritionist developed a standard diet meeting the goals defined by the ADA for initial diabetic inpatient orders, which later could be adjusted by the unit dietitian based on individual patient assessment and needs. Established goals of medical nutrition therapy for hospitalized patients with diabetes were followed to provide adequate calories for illness and recovery and to maintain optimal control of blood glucose. Additional goals included addressing individual needs based on personal and cultural food preferences and providing a plan for continuing self-management. Initially, all adult patients with a history of diabetes are started on an 1800-calorie consistent carbohydrate, low-cholesterol, low-fat diet, providing 50% of calories from carbohydrates. Carbohydrate content is distributed evenly between 3 meals and an evening snack. All patients are screened for nutrition status, and patients found to have nutritional risks are referred to a registered dietitian for further assessment. During the nutrition assessment and evaluation process, the registered dietitian provides nutrition counseling as needed. If further education is needed, patients are referred for outpatient medical nutrition therapy or diabetes self-management education.

The new guidelines have been well received by the medical and surgical house staff and especially by nursing. Early on in the process, it was clear that the unit nurses were very interested in improving diabetes management, and they continue to be an integral part of making the protocols work. In 2003, the standardized approach described above was initiated on the 4 medical

<table>
<thead>
<tr>
<th>Rush Adult Hypoglycemia Prevention and Treatment Protocol</th>
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<tbody>
<tr>
<td>1. If the patient is alert and eating and blood glucose 50-69 mg/dL (2.8-3.8 mmol/L), give 15 g of carbohydrate (CHO; 4 oz of juice).</td>
</tr>
<tr>
<td>2. If the patient is alert and eating and blood glucose is less than 50 mg/dL (2.8 mmol/L), give 30 g of CHO (8 oz of juice).</td>
</tr>
<tr>
<td>3. If the patient is to take nothing by mouth (NPO) or not alert and blood glucose is less than 70 mg/dL (3.9 mmol/L), give 25 g (1 amp) of 50% dextrose intravenously (IV) and notify physician.</td>
</tr>
<tr>
<td>4. Recheck blood glucose every 20 min and retreat hypoglycemia as above until blood glucose is greater than 70 mg/dL (3.9 mmol/L).</td>
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<tr>
<td>5. Provide a snack/meal within 1 h after correction of hypoglycemia if not NPO.</td>
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<tr>
<td>6. NPO patients may require additional intervention (ie, 5% dextrose IV fluids).</td>
</tr>
<tr>
<td>7. For patients on continuous enteral tube feeds and insulin:</td>
</tr>
<tr>
<td>a. Short interruptions (1-2 h): call physician for 10% dextrose IV fluids at the same rate as the previous tube feeds or give 2 h of feeding as a bolus prior to interrupting the feeding.</td>
</tr>
<tr>
<td>b. For longer interruptions (greater than 2 h), call physician for 10% dextrose IV fluids at the same rate as the previous tube feeds.</td>
</tr>
<tr>
<td>c. Continue 10% dextrose until the feedings are resumed or until the dose of insulin has worn off (12 h for NPH and 24 h for glargine).</td>
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</table>
Management of Hyperglycemia in Hospitalized Patients

Initial approach to inpatient hyperglycemia

Check HbA1c and begin 4 times a day (QID) glucose measurements by finger stick.

Patients who were treated with oral antidiabetic agents prior to admission should be placed on basal insulin if they are to take nothing by mouth (NPO; eg, postop) or if glucose is >140 mg/dL (7.7 mmol/L). It is best to avoid sulfonylureas in NPO patients, metformin in severely ill patients or patients with serum creatinine >1.5, and glitazones in patients with heart failure. In general, most inpatients with type 2 diabetes should be started on insulin therapy and have oral agents discontinued while they are hospitalized.

The hypoglycemia protocol must be ordered on all patients.

HbA1c >6.5% represents suboptimal diabetic control, and diabetic prescription should be improved prior to discharge.

Each oral diabetic agent can only lower HbA1c by 1% to 2%.

Inpatient blood glucose targets:

- Intensive care unit (ICU): 80-120 mg/dL (4.4-6.6 mmol/L)
- Non-ICU AM (fasting): 80-120 mg/dL (4.4-6.6 mmol/L)
- Non-ICU after meals: no more than 140-180 mg/dL (7.7-9.9 mmol/L)

There are potentially 3 types of subcutaneous (SQ) insulin that will need to be ordered: basal, prandial, and correction.

Basal insulin guidelines

First, select a basal insulin. The 2 choices are once-daily glargine insulin or twice-daily NPH insulin.

If a patient is new to insulin and NPO, start with glargine insulin 0.2-0.4 U/kg SQ every 24 h. Glargine (Lantus) may be given daily at 8 AM or 6 PM. This is recommended for all postop patients, except ICU patients who are treated with an intravenous (IV) insulin infusion.

If a patient is new to insulin and eating, start with NPH 0.2 U/kg every 8 AM and 0.1 U/kg every 6 PM, or glargine as above.

If a patient is admitted and already taking glargine insulin, initially continue the same daily dose at either 8 AM or 6 PM whether NPO or eating.

If a patient is admitted already taking NPH insulin, initially continue the same doses if eating. If NPO, reduce the AM dose by 50% and continue the same PM dose.

If a patient is currently treated with 70/30 or 75/25 insulin, continue 70% of these total doses as NPH insulin.

If a patient is currently treated with detemir insulin, substitute unit per unit with glargine.

Revise glargine insulin dose daily if 6 AM blood glucose level is out of the target range (80-120 mg/dL [7.7-9.9 mmol/L]).

Revise AM NPH insulin dose if 6 PM glucose is out of the target range (110-160 mg/dL [6.1-8.8 mmol/L]).

Revise PM NPH dose if 6 AM glucose is out of the target range (80-120 mg/dL [4.4-6.6 mmol/L]).

To change twice-daily (BID) NPH to once-daily glargine give 80% of the total daily dose of NPH as glargine at 8 AM.

Glargine and detemir may not be mixed with other insulins; all other insulins are mixable.

Hyperalimentation

Hyperglycemic patients who are placed on continuous tube feeds should receive equal doses of NPH at 8 AM and 8 PM. Insulin doses should be revised daily based on QID blood glucose levels. Remember to begin 10% dextrose (D10W) IV fluid immediately if tube feeds are ever interrupted in patients receiving insulin. Use the same rate as the tube feeds.

(continued)
units. The details of the initial approach that was used for the reeducation of the medical house staff and its results have been previously described.17 A pocket-sized inpatient diabetes management guidelines card was issued to all residents in 2003 and 2004. Beginning each July, new residents receive ward-based tutorials for inpatient diabetes.

Hyperglycemic patients on total parenteral nutrition (TPN) should have regular insulin added to the TPN bag each day as well as receiving NPH insulin SQ every 12 h until the TPN has enough insulin.

High-dose glucocorticoids
Steroid therapy may create new hyperglycemia and will worsen preexisting hyperglycemia. Oral agents are ineffective and NPH ± aspart insulin is usually required BID, often at high doses. Unlike methylprednisolone and dexamethasone, prednisone given each AM lasts only ∼20 h and PM dosing of NPH requires reduction or elimination to avoid AM hypoglycemia.

Prandial insulin guidelines
Prandial insulin is rapid-acting insulin that specifically accompanies meals when patients are eating.
Aspart insulin (Novolog) is always preferred to regular insulin because of aspart’s more rapid onset (15 min), peak (60 min), and shorter duration (3 h).
Aspart insulin is given 0-20 min after each meal at 8 AM and 6 PM to patients on NPH basal insulin. Thus, the registered nurse can assess the quantity of the meal consumed before giving the corresponding dose of prandial aspart.
Aspart insulin is given 0-20 min after each meal at 8 AM, 1 PM, and 6 PM to patients on glargine basal.
If a patient is admitted already taking lispro, glulisine, or regular insulin, substitute unit per unit with aspart.
If a patient is admitted already taking prandial insulin and is eating, initially continue the same doses.
If a patient is admitted already taking 70/30 or 75/25 insulin, convert each total dose to 70% NPH and 30% aspart. Give the 30% aspart doses at 8 AM and 6 PM.
If a patient is new to insulin and eating, start with 0.1 U/kg aspart insulin after meals at 8 AM, 1 PM, and 6 PM if receiving glargine basal or at 8 AM and 6 PM if receiving NPH basal insulin.
Revise prandial insulin doses daily if prelunch, predinner, or bedtime blood glucose levels are out of the target range of 110-160 mg/dL (6.1-8.8 mmol/L).

Correction dose guidelines
Further downward adjustment of elevated blood glucose is achieved through the use of correction doses of aspart insulin, which may be given QID as needed. These function as a third layer of insulin supplementing the basal and prandial insulin doses.
Correction doses are recommended for all blood glucoses greater than 140 mg/dL (7.7 mmol/L).
Begin the correction scales with an aspart dose equal to 10% of the initial total daily insulin dose and increase by 5% to 10% more for each 40 mg/dL (2.2 mmol/L) increase in glucose level.
If a patient is NPO, the scales for each of the 4 times per day can be the same. Otherwise, the scale for bedtime should be half as much insulin as a mealtime scale.
Patients should not receive a correction scale unless they are first receiving daily basal insulin.
Correction doses are not to be used as stand-alone sliding scales, nor may they be used as a substitute for prandial insulin.
management. An endocrinologist teaches 2 to 4 first-year residents for 30 to 60 minutes each day until each resident has had 6 to 8 hours of this activity and feels comfortable to effectively use the inpatient protocols. In July 2005, all subcutaneous insulins except NPH, glargine, and aspart were eliminated. With wide institutional support, the newest version of the inpatient diabetes guidelines is mandatory for all patients and services throughout the hospital. An endocrinology-pediatrics committee wrote a set of pediatric-specific modifications to the adult protocols.

To make the new guidelines easily accessible to all house staff, attending staff, nursing staff, and pharmacy staff, the protocols are disseminated in 4 different ways. A 6-panel pocket card with the latest version of the guidelines is distributed to all first-year residents on all services, all third-year medical students, all nursing units, and as many other individuals and departments who request a copy (Table 4). Second, a copy of the diabetes management card is posted on the hospital internal Web site, available on every computer terminal in the medical center. Also available online are other diabetes management guidelines that are not on the pocket card because of space constraints such as details for transitioning patients from IV to subcutaneous insulin and the hypoglycemia prevention and treatment protocol. Third, computerized physician order entry pages for ordering insulin have a direct link to the internal Web site pages containing all of the guidelines. A specific set of pages in the physician order entry system was created for all orders related to blood glucose control. Clustered in this area are orders for the diabetic diet, point-of-care blood glucose testing, hypoglycemia prevention and treatment, HbA1c testing, basal insulin, prandial insulin, and correction dose insulin. This has clearly facilitated the process of order entry for the physicians and has improved the ease and quality of communication with the nursing staff. Last, a permanent copy of the current IV insulin protocol was placed at the bedside of every intensive care patient, and a copy of the hypoglycemia prevention and treatment protocol was placed at the bedside of every patient in the hospital.

The full support of nursing leadership has been ever present throughout the process, and this clearly is a requirement for success. In 2004, an inpatient diabetes nurse clinician/educator was recruited to coordinate the overall effort on all medical units. The inpatient educator provides timely education for patients, is the resource for nurses, and gives clinical direction to the medical house staff as needed. IS created a daily report of all patients in the hospital who have orders for point-of-care blood glucose testing and/or insulin therapy. Thus, the population of inpatients with diabetes and/or hyperglycemia can be readily identified and tracked, and those patients and house staff with educational needs are targeted on a daily basis. The inpatient educator has been well received by both the nursing and the resident/attending medical staff. Institutional support is being generated for a second inpatient diabetes nurse clinician to focus on all of the surgical units. Other centers have described similar success with collaborative inpatient teams of endocrinologists and diabetes nurse educators. Trends in blood glucose control on each hospital unit are now closely monitored via monthly reports from the database into which all of the inpatient point-of-care blood glucose data are downloaded. These reports are available from most inpatient blood glucose monitoring systems and thus should be easily used by most hospitals to track similar quality improvement efforts. An example of a recent blood glucose report from a general medical unit, a general surgical unit, the surgical ICU, and the medical ICU is shown in Figure 1.

In summary, academic medical centers have an obligation to set the highest standards for patient care and to ensure that all resident physicians graduate fully trained in these standards. Significant improvements in the training of residents in the standards of inpatient diabetic care are now required. The perpetuation of inpatient hyperglycemia with sliding scale insulin is no longer acceptable. Since the basic principles for inpatient diabetes care are now closely aligned with those for outpatient diabetes care, hospital-based resident teaching programs in modern diabetic management are an excellent opportunity for meeting the obligation to train physicians who will be prepared for the impending epidemic of diabetes. This article describes the process and the tools that were required to accomplish this goal at Rush
University Medical Center. It is anticipated that these tools can be adapted for use in other academic medical centers.

References