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SPECIAL FEATURE

Hyperglycemia Management in the Hospital: The Pharmacist's Role

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Abstract—Hyperglycemia is prevalent in the inpatient setting and is associated with increased morbidity and mortality in patients with diabetes and in those without diabetes. Too often hyperglycemia is underrecognized, underreported, and undermanaged. Insulin is the treatment of choice for most patients who have hyperglycemia and are hospitalized, and pharmacists are often responsible for ensuring its safe and effective use. Improving hyperglycemia management in patients who are hospitalized provides pharmacists with an opportunity to positively affect patient outcomes and health care costs. This article discusses the pharmacist's role in managing blood glucose levels; current recommendations for target blood glucose concentrations; the evolution of insulin treatment from sliding scale to algorithms/protocols to computer-guided decision-support systems; discharge planning; and patient education.

Key Words—clinical decision support, diabetes, hyperglycemia

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There is substantial evidence to show that the traditional method of prescribing and dispensing medication is no longer appropriate to ensure safety, effectiveness and adherence to drug therapy. While appropriate drug therapy is safer and more cost-effective than other treatment alternatives, ***there is no doubt that the personal and economic consequences of inappropriate drug therapy are enormous*** [emphasis added].

It is important for society to be assured that spending on pharmaceuticals represents good value for money. In view of their extensive academic background and their traditional role in preparing and providing medicines and informing patients about their use, pharmacists are well positioned to assume responsibility for the management of drug therapy.

World Health Organization, 2006[1]

Manifestations of Poor Glycemic Control

Hyperglycemia and hypoglycemia are extremely common laboratory findings in hospitalized patients and can be complicating features of underlying diseases and some therapies. However, we believe that extreme manifestations of poor glycemic control are reasonably preventable through the application of evidence-based guidelines and sound medical practice while in the hospital setting; specifically, we believe that they are preventable through the use of routine serum glucose measurement and control which are basic elements of good hospital care.

Centers for Medicare & Medicaid Services, 2009[2]

INTRODUCTION

According to a 2007 report by the Centers for Disease Control and Prevention, an estimated 23.6 million Americans (7.8% of the United States population) have diabetes; of those, 5.7 million cases are undiagnosed.[3] The report estimates that direct and indirect costs of diabetes amounted to $174 billion in the United States, of which $116 billion was for direct costs

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such as medications and hospitalizations.[3] It is 2 to 5 times more likely that patients with diabetes will be hospitalized than patients without diabetes, and many patients have undiagnosed diabetes before hospitalization occurs. These findings are, to some extent, the result of the continued expansion of the worldwide epidemic of type 2 diabetes. In the United States alone, there are approximately 1.6 million new cases of diabetes each year, and an additional 57 million American adults are at high risk for type 2 diabetes.[3] Several studies have shown that approximately one-third of patients admitted to hospitals with 1 or more plasma glucose levels higher than 200 mg/dL were newly diagnosed.[4,5]

It is widely accepted by medical practitioners that diabetes is a major independent risk factor for increased morbidity and mortality in patients who are hospitalized. However, less attention has been directed toward elevated blood glucose (BG) as a predictor of poor outcomes in such patients. This has happened despite the occurrence of hyperglycemia in a significant proportion of patients during their hospital stays, as well as considerable data supporting the use of intravenous (IV) insulin to achieve glycemic control. The recent consensus statement by the American Association of Clinical Endocrinologists (AACE) and the American Diabetes Association (ADA) states that hyperglycemia in patients who are hospitalized, irrespective of its cause, is unequivocally associated with adverse outcomes.[6] Hyperglycemia occurs in patients with known or undiagnosed diabetes, or it occurs during acute illness in those with previously normal glucose tolerance (termed *stress hyperglycemia*).

Although the costs of illness-related stress hyperglycemia are not known, it is likely that they are considerable in light of the poor prognosis of such patients.[6] This increased risk for morbidity and mortality associated with increased costs provides the hospital pharmacist a strong rationale for prioritizing the control of BG levels. Pharmacists must play an integral role in ensuring that glycemic control is a part of the therapeutic plan for patients who are hospitalized, regardless of whether a patient has a history of diabetes.

RATIONALE FOR IMPROVED GLYCEMIC CONTROL IN THE HOSPITAL

Negative Impact of Hyperglycemia

The negative impact of hyperglycemia on patient outcomes has been documented in a variety of hospital settings and types of patients, including those who are critically ill, are under general medical-surgical care, have acute myocardial infarction, are undergoing cardiac surgery, and have suffered strokes.[7]

A retrospective review of the hospital records of 2,030 adults determined that 38% of the patients had hyperglycemia at the time of admission or during hospitalization.[5] Newly detected hyperglycemia was associated with a longer hospital length of stay (LOS), higher rate of intensive care unit (ICU) admission, lower likelihood of discharge to home, and greater need for transitional or nursing home care compared with patients with a history of diabetes or normoglycemia. Hyperglycemia was an independent marker of inpatient mortality in patients with newly detected hyperglycemia. The inpatient mortality rate was 16% in patients with newly detected hyperglycemia, 3% in patients with a history of diabetes, and 1.7% in patients with normoglycemia.

In another retrospective study of 826 patients who were critically ill and in an ICU, the hospital mortality rate escalated progressively with increases in the average BG concentration.[8] The average BG values were significantly higher among nonsurvivors than among survivors.

A systematic overview of 15 studies linking hyperglycemia and increased risk of death after myocardial infarction in patients with diabetes and in those without diabetes, revealed that hyperglycemia increased the risk of in-hospital mortality 3.9-fold in patients with diabetes and 1.7-fold in patients without diabetes.[9] Hyperglycemia also increased the risk of congestive heart failure and cardiogenic shock in patients without diabetes. An analysis of perioperative BG concentrations in 1,574 patients undergoing coronary artery bypass grafting revealed significant increases in postoperative hospital LOS (by 0.76 days), hospital charges (by $2,824), and hospital costs (by $1,769) with each 50 mg/dL increase in BG concentration.[10]

Benefits of Hyperglycemia Management

The etiology of adverse outcomes among patients with hyperglycemia is multifactorial, with a number of organ systems being impaired. Studies have found that most of these abnormalities are reversible when glucose levels are normalized.[11] The benefits of controlling hyperglycemia in patients who are hospitalized are well documented and recommended by numerous organizations, including AACE, ADA and the Institute for Healthcare Improvement.

In a 17-year, prospective, nonrandomized, interventional study of 4,864 patients with diabetes who underwent open-heart surgical procedures, cardiac-related mor-

Table 1. Inpatient Glycemic Targets as Recommended in National Guidelines

Clinical Setting	*American College of Endocrinology*[20]	*2008 American Diabetes Association Guidelines*[21]
Patients in the Intensive Care Unit	80 to 110 mg/dL	As close to 110 mg/dL as possible; generally less than 140 mg/dL
Medical-Surgical Floor		
Preprandial	80 to 110 mg/dL	Less than 126 mg/dL
Postprandial	Less than 180 mg/dL	Less than 180 to 200 mg/dL
Patients Who Are Pregnant		
Preprandial	Less than 100 mg/dL	
Postprandial	Less than 120 mg/dL	
Labor and Delivery	Less than 100 mg/dL	

tality was significantly higher for patients with postoperative BG concentrations greater than 175 mg/dL than for patients with concentrations less than 150 mg/dL.[12]

In the Diabetes Mellitus Insulin Glucose Infusion in Acute Myocardial Infarction (DIGAMI) study of 620 patients with diabetes and acute myocardial infarction, a significant reduction in mortality by 28% was observed after an average follow up of 3.4 years with intensive glycemic control using insulin-glucose infusion for at least 24 hours followed by subcutaneous insulin injections 4 times daily compared with standard treatment.[13] The reduction in mortality risk was even greater (51%) in a subset of 272 patients who were at low cardiovascular risk and who were not receiving insulin previously.

Although hyperglycemia is associated with adverse patient outcomes, intervention to normalize glycemia has yielded inconsistent results. Several recent trials enrolling patients who were critically ill have failed to show a significant improvement in mortality with intensive glycemic control or have shown increased mortality risk. More importantly, these recent randomized, controlled trials have highlighted the risk of severe hypoglycemia resulting from excessively strict glycemic control.[6,14-19] These outcomes have contributed to confusion regarding specific glycemic targets and the means for achieving them in patients who are critically ill, as well as in those who are not critically ill.

The Normoglycemia in Intensive Care Evaluation—Survival Using Glucose Algorithm Regulation (NICE-SUGAR) trial, which was designed to test the hypothesis that intensive glucose control reduces mortality at 90 days, concluded that a BG target of less than 180 mg/dL resulted in lower mortality than a target of 81 to 108 mg/dL.[16] The authors suggested that increased mortality with the low BG targets may have resulted from the reduced BG level, increased administration of insulin, occurrence of hypoglycemia, or methodologic factors specific to their trial.

Because the evidence does not allow for confident recommendations to create an overall guideline, hospital pharmacists should collaborate with other disciplines to determine specific glycemic goals within their institutions. A multidisciplinary team should consider the level of evidence of the individual studies, particularly the following factors: whether the hypothesized benefit was realistic, whether power was sufficient for detecting this effect, whether the tools for measuring and controlling BG were adequate, whether the targets were reached, and whether the comparator level of glycemic control was relevant.[20] If these criteria are satisfied, the team should then assess how comparable the patients in these studies are to their own patients.

INPATIENT GLYCEMIC TARGETS

The goal of hyperglycemia management in the hospital is to normalize glucose levels while avoiding hypoglycemia. The American College of Endocrinology[21] and ADA[22] have identified targets of glycemic control based on the findings of randomized clinical trials and observational studies (see Table 1).

Pharmacists must recognize that some barriers to widespread adoption of glucose control exist. These include the increased risk of severe hypoglycemia, concerns about the external validity of some studies, difficulty achieving normoglycemia in patients who are critically ill, and requirements for greater resources.[7] Working with a multidisciplinary team will aid

PHYSIOLOGIC FACTORS
Previously undiagnosed diabetes
Preexisting glucose intolerance
Stress- or illness-related hyperglycemia after acute illness
Trauma
HOSPITALIZATION-RELATED FACTORS
Total parenteral nutrition
Glucocorticoid therapy
Enteral feeding formulas
Predisposition of patients who experience hyperglycemia during hospitalization and develop diabetes

Figure 1. Factors causing hyperglycemia in patients who have diabetes and are hospitalized.[6]

pharmacy efforts in developing best practices for management of hyperglycemia within hospitals.

GLUCOSE MANAGEMENT

Patients exhibiting hyperglycemia are typically admitted for diagnoses other than uncontrolled hyperglycemia. For this reason, glycemic management is usually not the primary treatment end point. The stress of the underlying illness may cause or worsen insulin resistance.

Patients who are hospitalized often have irregular and unpredictable eating patterns because of anorexia, nausea, or fasting for diagnostic tests or procedures. Therapeutic medications including glucocorticoids frequently exacerbate underlying hyperglycemia or lead to development of new hyperglycemia. These concerns may be the cause of clinicians resorting to sliding-scale insulin (SSI) therapy. This practice continues despite evidence that the sliding scale is ineffective and potentially dangerous.[11]

A practice pattern that deserves particular attention from hospital pharmacists is the persistent overuse of SSI for management of hyperglycemia. Prolonged therapy with SSI as the sole regimen is ineffective for most patients (and potentially dangerous for those with type 1 diabetes).[6] Sliding scales replace insulin in a nonphysiologic manner, do not take into account individual differences in insulin requirements, and focus attention on isolated reactions to hyperglycemia rather than maintenance of normoglycemia. Also, SSI orders written at admission often are not adjusted during the entire hospital stay[23,24] and may be associated with an increased LOS.[23,25] The use of SSI places patients with type 1 diabetes at high risk for ketoacidosis if a basal insulin is not added. For these reasons, it is prudent for hospital pharmacists to discourage the use of SSI alone.

Oral Hypoglycemic Therapy

Often patients who are admitted to the hospital for a diagnosis other than hyperglycemia will continue taking their currently prescribed medications, which may include oral hypoglycemic agents. Pharmacists should assess patients for glucose levels, anticipated LOS, and other factors that may contribute to hyperglycemia (see Figure 1). Depending on this assessment, oral hypoglycemic agents may be contraindicated during a patient's hospital stay.[26] For example, sulfonylureas increase the risk of hypoglycemia because of their long duration of action in a patient population with inconsistent meal intake and timing. Caution must be exercised with the use of metformin because of the potential development of a contraindication (such as renal insufficiency, unstable hemodynamic status, or need for imaging studies with radiocontrast dye) during hospitalization.[6] Thiazolidinediones may cause salt and water retention and, thus, should be withheld in patients experiencing edema or in those with advanced or uncompensated heart failure.[11]

Basal-Bolus Insulin Therapy

Scheduled subcutaneous administration of insulin may be a beneficial method for achieving and maintaining glucose control in patients with diabetes or stress hyperglycemia who are not in the ICU.[5] The recommended components of inpatient subcutaneous insulin regimens are a basal, a nutritional, and a supplemental (correction) element. Subcutaneous insulin should be continued in all patients with type 1 diabetes and in most patients with type 2 diabetes who are taking insulin as outpatients.[11] For patients with type 2 diabetes, insulin requirements often decrease when a patient is not eating and the insulin dose should be decreased as necessary.

It is recommended that bedside fingerstick glucose measurements be obtained before each meal and at bedtime for patients who are eating and every 6 hours for patients who are fasting or receiving continuous enteral or parenteral nutritional support. A 3:00 AM fingerstick glucose measurement is recommended for patients in whom the basal insulin dose is increased so

that any nocturnal hypoglycemia can be identified. For patients with type 2 diabetes, a premeal, rapid-acting insulin should be added before meals if there is excessive daytime hyperglycemia with a basal insulin alone. The selection of initial basal and prandial insulin doses should factor in the severity and type of medical illnesses, diabetes classification, and weight (as a measure of insulin resistance).[11]

The term *correction insulin* refers to the use of additional short- or rapid-acting insulin in conjunction with scheduled insulin doses to treat BG levels above desired targets. These correctional insulin orders differ from SSI because they are not used to replace basal/prandial regimens and are preferred.[6]

As inpatient insulin orders become more complex, the potential for medication errors increases. Intensive insulin therapy requires both ongoing staff education and precise written orders. Preprinted order sets prompting consideration of basal, bolus, or correctional insulin by physicians have been published by a number of centers.[11] Order sets generally include low-, medium-, and high-dose correctional insulin options. Studies suggest that standardized order forms may significantly reduce medication errors and lead to careful consideration of insulin choices by clinicians.

Intravenous Insulin

Because of the extremely short half-life of circulating insulin, IV delivery allows rapid dosing adjustments to address alterations in the status of patients and, thus, is recommended in a variety of acute clinical settings to achieve rapid glycemic control. Such conditions include hyperglycemic emergencies such as diabetic ketoacidosis (DKA) and hyperglycemic hyperosmolar syndrome, myocardial infarction, stroke, patients with type 1 diabetes undergoing surgery, prolonged fasting in patients who are insulin deficient, labor and delivery, and marked hyperglycemia accompanying glucocorticoid therapy.[11] Intravenous insulin therapy is ideally administered by means of validated written or computerized protocols that allow for predefined adjustments in the insulin infusion rate based on glycemic fluctuations and insulin dose.[6] In many hospitals multidisciplinary teams including pharmacists have developed protocols with target BG ranges. These paper protocols are effective but may be fairly complex and associated with higher rates of hypoglycemia.[27]

Computer-Guided Decision-Support Systems for Intravenous Insulin

In patients for whom continuous IV insulin therapy is appropriate, optimal treatment should include frequent and automatic adjustments of dosage. These dosage adjustments should be based on frequently taken BG measurements. A computer system that only requires a current BG reading for data analysis and provides patient-specific IV insulin recommendations can facilitate delivery of such therapy. The appropriate insulin infusion rate for an individual is calculated by the computer software based on the previous 4 BG readings observed and the rate of change of BG concentrations, and these calculations are repeated frequently (every 1 to 4 hours) to provide individualized, continuous, variable-rate IV insulin therapy. Using mathematical modeling, trends of glucose readings are analyzed to formulate a patient-specific, physiologic, insulin-dosing curve. Adjustments are automatically made in the dosing curve to minimize and help prevent episodes of hypoglycemia and hyperglycemia. This is easily accomplished by the caregiver entering the patient's current BG reading into the software, which then calculates the individual patient's insulin dose and indicates when the next reading should be taken.

Such systems hold promise for reducing the risk of insulin infusion rate calculation errors, which are a major safety concern, in efforts to provide continuous variable-rate IV insulin therapy, standardize insulin therapy,[23] reduce the work and stress associated with managing good glycemic control, and decrease the incidence of hypoglycemia.[26]

PATIENT CASE

In 2005 Wilson Memorial Hospital, a 71-bed, full-service community hospital in western Ohio, updated their preprinted SSI order to a preprinted order form with 4 algorithms for BG control. Changing from one algorithm to another required that nurses obtain a physician order, which was time consuming. In addition, physicians were not satisfied with the paper-driven algorithms because these algorithms were not sophisticated enough for meeting the glycemic treatment goals of all patients. Both nursing and medical staff believed that the algorithms were not effective because they were too labor intensive.

In 2007 Remote Automated Laboratory System (RAL), a glycemic benchmarking service, reported Wilson Memorial Hospital's mean BG reading as 183.9 mg/dL (mean BG readings for the ICU and medical-surgical units were 184.1 mg/dL and 183.8 mg/dL, respectively). This placed Wilson Memorial Hospital in the lowest quartile of effective glycemic con-

- **Determine all *Accu-Chek* readings within the previous 24-hour period that are greater than 180 mg/dL. Input values and corresponding times taken by patient into spreadsheet.**
- **List initial diabetes mellitus regimen and the date and time of any changes in the spreadsheet.**
- **Document any recommendations made by the pharmacy in the spreadsheet.**
- **Review the chart, looking for the following:**
  1. **Blood sugar readings greater than 180 mg/dL**
  2. **Diabetic medications patient was taking initially (Were these medications appropriate?)**
  3. **Other medications (eg, steroids)**
  4. **Trends**
     - **Is the patient's blood sugar elevated only at certain times of day (morning, after meals, or bedtime), or is it constantly elevated?**
     - **Is there potential for the dawn phenomenon or the Somogyi effect?**
- **Document time when *EndoTool* was started and stopped and all subsequent *Accu-Chek* readings. Is the post-*EndoTool* regimen effective?**
- **Determine if the patient can be transitioned from intravenous insulin to subcutaneous insulin?**
- **Patient demographics: Do patients live alone? Will they be able to give themselves injections properly? Do they have insurance? If they cannot afford insulin, lancets, test strips, and so on, will they be compliant? If they were taking an oral regimen at admission, were they compliant with that regimen?**

Pharmacists' recommendations to physicians

- **Patient is a candidate for *EndoTool*.**
- **Patient's regimen should be converted from intravenous to subcutaneous insulin.**

Figure 2. Pharmacist's daily functions when managing hyperglycemia using a computer decision-support system for intravenous insulin.

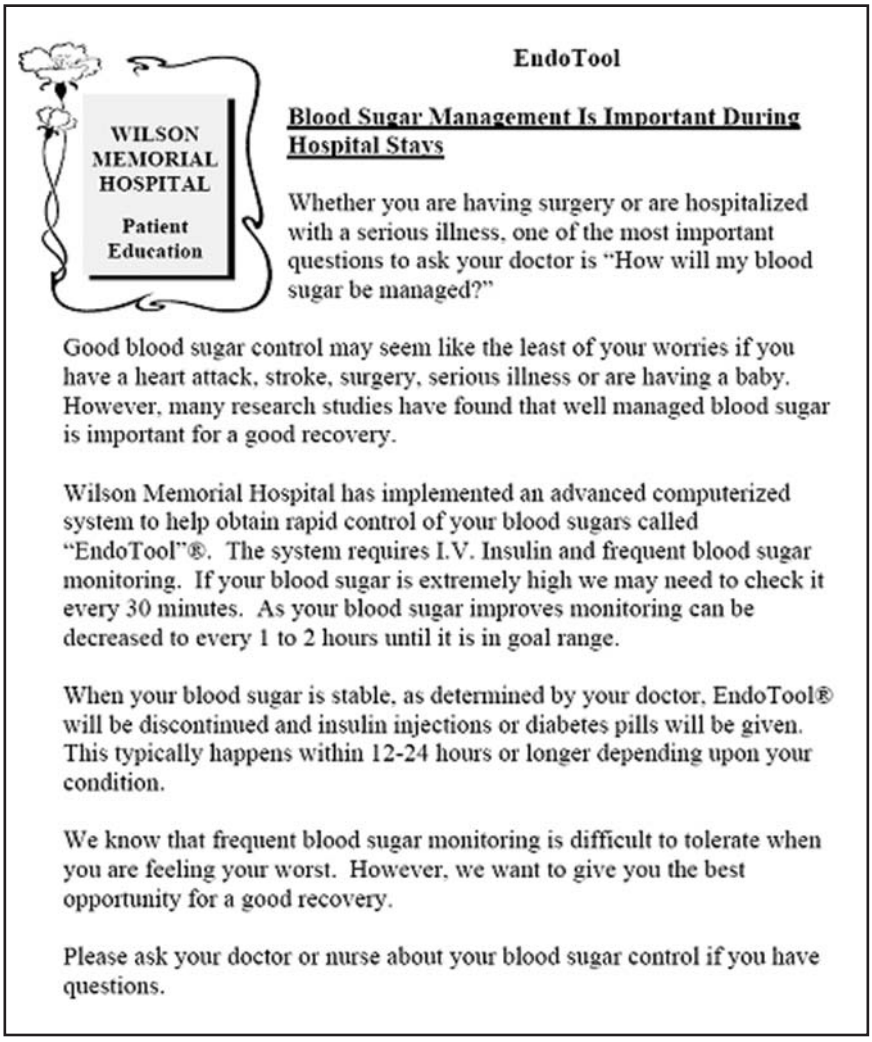
trol for all benchmarked hospitals across the nation (top quartile is defined as superior).

An Inpatient Blood Glucose Committee was formed to search for a solution for the hospital. This committee consisted of pharmacy staff, physicians, nursing and hospital administrators, nurses on the floor and critical care units, diabetic educators, laboratory personnel, physicians, and information technology staff. The committee reviewed alternative paper algorithms, as well as 3 computer-guided glucose systems. After multiple demonstrations from each system, it was decided that Hospira's *EndoTool Glucose Management System* should be used. The committee also determined that this glucose management system should be made available for use throughout the hospital, as opposed to limiting its use to the medical-surgical and ICU units. The published literature and ongoing trials regarding tight glucose control and intensive insulin therapy were considered by the Inpatient Blood Glucose Committee,[16,28,29] and it was decided that the BG target levels as suggested by the 2008 ADA guidelines should be used[22] (see Table 1).

Before implementing the computer decision-support systems for IV insulin, the pharmacy department changed the base solutions of most antibiotics to normal saline from dextrose. Preprinted order sets were developed and placed on the hospital's Intranet for ease of use. Order sets were built into the pharmacy information system to ensure consistency when entering IV admixtures into medication administration records.

The *EndoTool* system went live in April 2008, and the pharmacy department was initially charged with identifying patients whose conditions were appropriate for use of this system (see Figure 2). Specifically, charts were reviewed if a patient's BG level was greater than 180 mg/dL on a medical floor, greater than 140 mg/dL on a surgical floor or in critical care, and greater than 100 mg/dL in obstetrics. Patient education was conducted by nursing, diabetic educators, and/or pharmacists (see Figure 3).

During the first month, IV insulin computer decision-support was used for 25 patients. Results that compare BG levels in patients whose care was managed with a paper algorithm with patients whose care was managed with the software system are presented in Table 2. Aside from an increase in BG readings within the target range with IV insulin computer decision support, a decrease in patients experiencing hypoglycemia occurred, as evidenced by an 80% decrease in BG readings less than 70 mg/dL. The average time to achieve 2 consecutive BG readings less than 150 mg/dL was 4.8 hours throughout the hospital using IV insulin computer decision support. Subjectively, pharmacists, physicians, and nurses noted that transitioning to subcutaneous insulin was much easier when the patient had been managed with the IV insulin computer decision-support tool. Also, Wilson Memorial Hospital was recently named a top performer by the RAL's benchmarking program.



WILSON MEMORIAL HOSPITAL
Patient Education

EndoTool

Blood Sugar Management Is Important During Hospital Stays

Whether you are having surgery or are hospitalized with a serious illness, one of the most important questions to ask your doctor is "How will my blood sugar be managed?"

Good blood sugar control may seem like the least of your worries if you have a heart attack, stroke, surgery, serious illness or are having a baby. However, many research studies have found that well managed blood sugar is important for a good recovery.

Wilson Memorial Hospital has implemented an advanced computerized system to help obtain rapid control of your blood sugars called "EndoTool"®. The system requires I.V. Insulin and frequent blood sugar monitoring. If your blood sugar is extremely high we may need to check it every 30 minutes. As your blood sugar improves monitoring can be decreased to every 1 to 2 hours until it is in goal range.

When your blood sugar is stable, as determined by your doctor, EndoTool® will be discontinued and insulin injections or diabetes pills will be given. This typically happens within 12-24 hours or longer depending upon your condition.

We know that frequent blood sugar monitoring is difficult to tolerate when you are feeling your worst. However, we want to give you the best opportunity for a good recovery.

Please ask your doctor or nurse about your blood sugar control if you have questions.

Figure 3. Patient education for an intravenous insulin computer decision-support system. IV = intravenous.

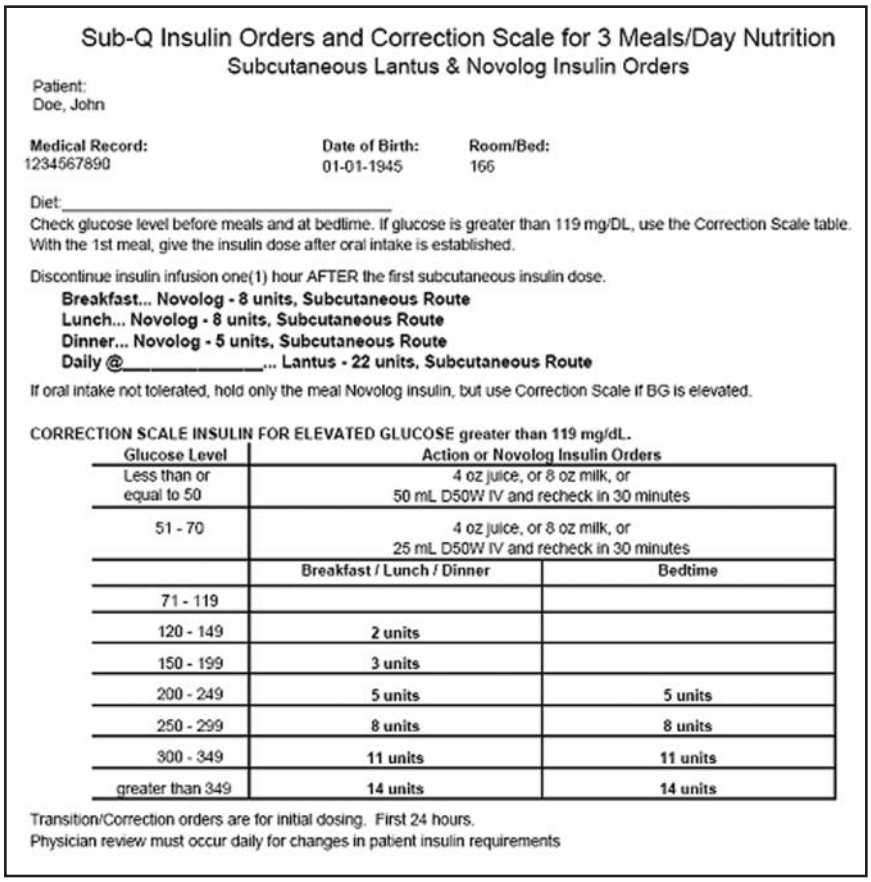
Intravenous Insulin Computer-Guided Decision Support Use: Case Series

BH, a 27-year-old woman, was admitted to the hospital with DKA and a BG level of 566 mg/dL. She received IV insulin per the standardized paper protocol. She was released after 48 hours; however, her BG levels were never less than 172 mg/dL. She was readmitted 20 days later at 7 PM with a BG level of 1,001 mg/dL, and DKA was rediagnosed. BH again received IV insulin, but this time her treatment was administered using *EndoTool*. By 4:00 AM her BG level was reported as 133 mg/dL. Intravenous insulin was discontinued at 8 AM the following day. BH's treatment was converted to subcutaneous insulin, and the computer decision-support system calculated a correction scale for BH of greater than 119 mg/dL. She was discharged that evening.

KS, a 28-year-old man in whom diabetes had not been previously diagnosed, came to the Wilson Memorial Hospital emergency department with classic symptoms of polyuria, polydipsia, and dehydration. His BG level was 444 mg/dL at 11:00 PM. New-onset diabetes was diagnosed; KS was admitted

Table 2. Blood Glucose Levels With and Without Intravenous Insulin Computer Decision Support During First Month of Implementation

Glycemic Status	*Blood Glucose (mg/dL)*	*Paper Algorithm (n = 84)*	*With Intravenous Insulin Computer-Guided Decision Support (n = 25)*	*% Change Between Paper and Computer-Guided Support*
Hypoglycemia	Less than 70	4%	0.8%	80% decrease
	Greater than 70 and less than 150	48%	63%	30% increase
	Greater than 70 and less than 200	53%	84%	60% increase
Extreme hyperglycemia	Greater than 200	26%	12%	54% decrease



Sub-Q Insulin Orders and Correction Scale for 3 Meals/Day Nutrition
Subcutaneous Lantus & Novolog Insulin Orders

Patient:
Doe, John

Medical Record: 1234567890 Date of Birth: 01-01-1945 Room/Bed: 166

Diet:_____
Check glucose level before meals and at bedtime. If glucose is greater than 119 mg/DL, use the Correction Scale table.
With the 1st meal, give the insulin dose after oral intake is established.

Discontinue insulin infusion one(1) hour AFTER the first subcutaneous insulin dose.
Breakfast... Novolog - 8 units, Subcutaneous Route
Lunch... Novolog - 8 units, Subcutaneous Route
Dinner... Novolog - 5 units, Subcutaneous Route
Daily @_____... Lantus - 22 units, Subcutaneous Route

If oral intake not tolerated, hold only the meal Novolog insulin, but use Correction Scale if BG is elevated.

CORRECTION SCALE INSULIN FOR ELEVATED GLUCOSE greater than 119 mg/dL.

Glucose Level	Action or Novolog Insulin Orders	
Less than or equal to 50	4 oz juice, or 8 oz milk, or 50 mL D50W IV and recheck in 30 minutes	
51 - 70	4 oz juice, or 8 oz milk, or 25 mL D50W IV and recheck in 30 minutes	
	Breakfast / Lunch / Dinner	Bedtime
71 - 119		
120 - 149	2 units	
150 - 199	3 units	
200 - 249	5 units	5 units
250 - 299	8 units	8 units
300 - 349	11 units	11 units
greater than 349	14 units	14 units

Transition/Correction orders are for initial dosing. First 24 hours.
Physician review must occur daily for changes in patient insulin requirements

Figure 4. Subcutaneous insulin transition orders. BG = blood glucose; D50W = dextrose 50% in water; IV = intravenous; Sub-Q = subcutaneous.

to the hospital, and treatment was started using *EndoTool*. By 8:00 AM the following morning, his BG level was 131 mg/dL. KS received diabetes education and was discharged early the next day without further complications.

NK, a 53-year-old man with a history of bilateral diabetic foot ulcers and methicillin-resistant *Staphylococcus aureus,* was admitted to the hospital for surgical debridement of foot ulcers. On admission his BG level was 409 mg/dL, and treatment was administered with *EndoTool.* Within 6 hours, his BG level lowered to 142 mg/dL, at which time it was determined that NK could be taken to surgery. NK's condition improved, and 3 days later, he was prescribed antibiotics and discharged to his home.

Transitioning From Intravenous Insulin Infusion to Subcutaneous

Patients receiving IV insulin infusion must be transitioned to a subcutaneous insulin therapy regimen when appropriate, and this transition must occur at some point during the hospital stay. The infusion should not be discontinued until subcutaneous insulin has been initiated to prevent recurrent hyperglycemia. Notably, a minimum of 12 hours using *EndoTool* is necessary before conversion to subcutaneous dosing. *EndoTool* calculates the patient-specific subcutaneous dose required for the individual patient when transitioning from IV insulin based on the hospital's preferred short- and long-acting subcutaneous insulin (see Figure 4).

PATIENT EDUCATION

Preparation for transition to the outpatient setting should be an important goal of inpatient diabetes management. This requires a shift from hospital personnel providing diabetes care to the patient being responsible for self-management. Successful coordination of this transition requires a team approach that may involve physicians, nurses, pharmacists, and dieticians. Hospitals with certified diabetes educators benefit from their expertise during the discharge process.

Because the mean hospital LOS in the United States is usually less than 5 days and the capacity for learning new material may be limited during acute illness, diabetes-related education is frequently restricted to an inventory of basic "survival skills." AACE and ADA recommend that the following areas be reviewed and addressed before a patient is discharged from the hospital[6]:

- Level of understanding related to the diagnosis of diabetes
- Self-monitoring of BG levels and explanation of home BG goals
- Definition, recognition, treatment, and prevention of hyperglycemia and hypoglycemia
- Identification of a health care provider who will be responsible for diabetes care after discharge
- Information regarding consistent eating patterns
- When and how BG-lowering medications should be taken, including administration of insulin (if the patient is receiving insulin for ongoing management at home)
- Management of sick days
- Proper use and disposal of needles and syringes

SUMMARY

Recognizing the importance of inpatient glycemic control is vital

for the hospital pharmacist. Pharmacists should be an integral part of a multidisciplinary team that identifies reasonable, achievable, and safe glycemic targets. This team also should implement protocols, procedures, and system improvements that are necessary tools to achieving glycemic targets for patients while also preventing hypoglycemia. Improving hyperglycemia management in patients who are hospitalized and participating in patient education provides pharmacists with an opportunity to positively affect patient outcomes and health care costs.

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