Taking Control of Hyperglycemia to Improve Patient Care:

How one hospital resolved a low benchmark indicator and became a "best practice" site through the use of EndoTool® glycemic control software.

Sondra Boecker, RN, CDE
Wilson Memorial Hospital
Sidney, Ohio

Sondra Boecker, RN, CDE, has a background in nursing that started 40 years ago. She has been a certified diabetes educator (CDE) since 1990 and has developed several patient education programs at Wilson Memorial Hospital where she has worked since 1986. Since graduating from nursing school, Sondra has cultivated a passion for diabetes education.

Linda Barhorst, BSN, CDE,
Coordinator of Diabetes Wellness Center
Wilson Memorial Hospital
Sidney, Ohio

Linda Barhorst, BSN, CDE, has been providing diabetes education to patients since 1998. Her nursing career began in 1978 and has held various positions at Wilson Memorial Hospital. Since 1998, Linda has served as Coordinator of the Diabetes Wellness Center at Wilson Memorial Hospital.

JS, a 53-year-old diabetic male, was scheduled for foot surgery. When the patient was admitted to a hospital, his blood glucose levels were between 400 and 500 mg/dL. Because of decreased healing ability and increased risk of infection associated with high blood glucose levels, the surgery was cancelled. The surgeon released the patient from this hospital and informed the patient's endocrinologist that the much-needed surgery could not be performed until better control of his diabetes was achieved. The endocrinologist asked the surgeon to reschedule the surgery, but this time at Wilson Memorial Hospital, where the patient's hyperglycemia could be managed by utilizing the EndoTool Glucose Management System, a computer-driven software program which assists the clinician in adjusting the patient's insulin dose. JS was admitted to Wilson and started on intravenous insulin and EndoTool. His blood glucose level decreased from 399 mg/dL to 140 mg/dL within 5 hours. The patient successfully underwent surgery and remained on EndoTool for an additional 24 hours with his blood glucose levels within the desired range. No hypoglycemia occurred.

As 29-year-old RR approached the date of her baby's birth, she became increasingly concerned about her diabetes. Her daily insulin requirements had reached 200 units and involved a complicated routine of several different insulins injected at multiple times throughout the day. One week before the baby's due date, RR's membranes ruptured and at 6:30 a.m. she was admitted to the hospital. At 8:23 a.m., her blood glucose level was 173 mg/dL and her physician started her on continuous intravenous insulin. At 9:34 a.m., her blood glucose had substantially decreased to 124 mg/dL and by 10:30 a.m., it had reached the target level of 105 mg/dL. RR's blood glucose remained stable throughout her labor. At 6:40 p.m., because her labor failed to progress, RR underwent an emergency C-section and delivered a healthy baby girl. RR remained on EndoTool until 9 a.m. the next day with stable blood glucose levels. There were no complications for mother and daughter and both were discharged home on the third post-op day.

Introduction and Background

Hyperglycemia on admission or anytime during a patient hospital stay is common and is associated with poor clinical outcomes and mortality in patients with and without a history of diabetes. One study shows that inpatients with newly diagnosed hyperglycemia had a significantly higher mortality rate and a lower functional outcome than patients with a known history of diabetes or normoglycemia.[1] Trauma patients and patients with medium, high, worsening and highly variable hyperglycemia were found to have significantly increased ILOS (ICU length of stay), HLOS (hospital length of stay), ventilator days, infection rate and mortality compared to patients with controlled glucose levels ($p < 0.01$).[2]

These are just a few of the studies that describe the importance of achieving and maintaining good blood glucose control. Controlling the blood glucose levels has been shown to decrease morbidity and mortality in the critically ill[3] and is now recommended by numerous organizations, including the American Diabetes Association[4] (ADA) and the Institute for Healthcare Improvement.[5] These studies have used protocols requiring intensive monitoring of glucose levels (i.e., initially every 30 to 60 minutes until blood glucose (BG) stabilizes and then every 4 hours) and numerous intravenous insulin infusion dose calculations and adjustments.[5] Although tighter glycemic control is becoming the standard of care, it may be associated with hypoglycemia and increased workloads and stress on those managing the blood glucose.[6,7]

EndoTool is a computer-guided glucose management software system specifically designed to customize the insulin dosing to the individual patient, even those with frequently changing requirements. 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 simply by the caregiver entering the patient's current blood glucose value. EndoTool has been shown to subjectively reduce the work and stress associated with managing tight glycemic control (TGC), as well as decrease the incidence of hypoglycemia.[8]

Reasons for Implementation of EndoTool

In 2005, Wilson Memorial Hospital, a 71-bed, full service community hospital in western Ohio, changed its preprinted sliding insulin scale order to a preprinted order form with four algorithms for blood glucose control. In order to change from one algorithm to another, the nurse needed to obtain a physician order, which was time-consuming. In addition, physicians were not satisfied with the paper-driven algorithms as they were not sophisticated enough to meet the glycemic treatment goals for all patients. Both nursing and medical staff believed the algorithms were too labor-intensive to be effective.

In 2007, RALS (Remote Automated Laboratory System), a glycemic benchmarking service, reported Wilson Memorial's mean blood glucose to be 183.9 mg/dL (ICU and medical surgical units mean BGs were 184.1 mg/dL and 183.8 mg/dL, respectively). This placed Wilson Memorial in the lowest quartile of effective glycemic control for all benchmarked hospitals across the nation (top quartile is defined as superior). The staff at Wilson Memorial was disturbed that these high glucose levels included not only diabetic patients but other in-house patients as well, with the possible effect of prolonging hospitalizations. Based on 1) concern that inpatient glycemic control was suboptimal, 2) difficulty using the paper algorithms and 3) lack of consistency in diabetes care and management, possible solutions were sought.

"As a diabetes educator, I was concerned about the inpatient hyperglycemia I sometimes saw in the patients I was called to educate in the hospital. Some of these patients were difficult to control or were not able to be controlled on the insulin/sliding scale method we were using. I also facilitate two support groups in which I heard frustration from patients who felt their blood sugars were not controlled as well as they could do themselves while they were in the hospital. This was especially true of the insulin pump group."

— S. Boecker, RN

"As the point-of-care coordinator, I review Accu-Chek™ results and noticed patients with elevated (200-400 mg/dL) glucose results which stayed that way for days, with no apparent improvement, sometimes even after four or five days! This was a bad situation for the patient and the hospital."

— D. White, MT

Multidisciplinary Committee Formed

Wilson Memorial Hospital already had a functioning multidisciplinary Diabetes Advisory Committee. Members of this committee attended a seminar regarding the need for optimizing inpatient hyperglycemia management and new tools to help accomplish treatment goals. An Inpatient Blood Glucose Committee was formed to search for a solution. This committee consisted of medical, nursing and hospital administrators, nurses on the floor and critical care units, diabetic educators, lab personnel, pharmacists, physicians and information technology personnel. They reviewed alternative paper algorithms as well as three different computer monitoring glucose systems. After multiple demonstrations from each system, it was decided to use Hospira's EndoTool® Glucose Management System. The committee also determined to make EndoTool available for use throughout the hospital, as opposed to limiting its use to the Med Surg and ICU units.

Defining the Optimal Target for Blood Glucose Levels

The Inpatient Blood Glucose Committee considered the published literature and ongoing trials regarding TGC and intensive insulin therapy (IIT).[2,3] They decided to utilize the blood glucose target levels as suggested by the 2008 ADA guidelines.[4]

ADA Standards of Medical Care in Diabetes—2008 for Patients in Hospitals[4]

- Critically ill patients: blood glucose levels should be kept as close to 110 mg/dL as possible and generally <140 mg/dL. These patients require an intravenous insulin protocol that has demonstrated efficacy and safety in achieving the desired glucose range without increasing risk for severe hypoglycemia.
- Non–critically ill patients: Fasting glucose <126 mg/dL and all random glucoses <180–200 mg/dL, these goals are reasonable if they can be safely achieved. Insulin is the preferred drug to treat hyperglycemia in most cases.

Implementation of EndoTool:

Training

A housewide education was needed for the nursing staff and the physicians. Physicians and consultants from the EndoTool vendor team presented information about the positive effects of achieving effective glycemic control to the entire medical staff. Upon buy-in from the medical staff, the nursing and pharmacy departments were in-serviced. Prior to implementing EndoTool, the EndoTool clinical specialist reviewed current practices of glucose control at Wilson Memorial Hospital. The Pharmacy department changed the base solutions of most antibiotics to normal saline from dextrose. Preprinted order sets were developed for ease of use and placed on the hospital intranet. Order sets were built into the pharmacy information system to ensure consistency when entering IV admixtures in the medication administration records.

"Hospira coordinated with the Education Department to hold three days of training for the entire nursing staff. The EndoTool software system went 'live' on the second day of training. The Hospira team was present for first start-ups and provided valuable materials (PowerPoint and pamphlets) for ongoing education."

— L. Barhorst, RN

"Hospira's EndoTool training team was absolutely awesome! Extremely knowledgeable."

— J. Steinke, RN

Clinical Impact: Coming Out on Top

The EndoTool system went "live" in April, 2008 with the pharmacy department charged with identifying appropriate patients to place on EndoTool. Specifically, patients' charts were reviewed if their blood glucose level was >180 mg/dL on a medical floor, >140 mg/dL on a surgical floor or in critical care and >100 mg/dL for obstetrics. Initially there was some resistance from physicians until they felt they could "trust the software". However, when the medical and nursing staffs saw how easy EndoTool was to use, and how effective it was in controlling blood glucose, doubt turned to confidence and then to optimism.

During the first month, the EndoTool software was used on 25 patients. Results that compare BG readings in patients who were managed with a previous paper algorithm to patients managed with EndoTool are presented in Table 1. Aside from an increase in BG readings within the target range with EndoTool, a decrease in patients experiencing hypoglycemia occurred, as evidenced by an 80% decrease in BG readings under <70 mg/dL.

Table 1: Blood Glucose levels with and without EndoTool

Category	Blood Glucose mg/dL	Paper Algorithm	With EndoTool®	Change
Hypoglycemia	<70	4%	0.8%	80% Decrease
	>70-<150	48%	63%	30% Increase
	>70-<200	53%	84%	60% Increase
Extreme Hyperglycemia	>200	26%	12%	54% Decrease

Other important clinical endpoints include:

- The 3rd quarter report from RAL's Glycemic Benchmarking program has shown remarkable improvement. (Table 2)

Table 2	Before EndoTool	After EndoTool
Housewide	183.9 mg/dL	162.2 mg/dL
ICU	184.1 mg/dL	147.1 mg/dL
Medical Surgical Floor	183.8 mg/dL	165.4 mg/dL

- The average time to achieve two consecutive BG readings under 150 mg/dL is 4.8 hours throughout the hospital using EndoTool.
- Physicians and nurses note that transitioning to subcutaneous insulin is much easier when the patient has been managed with EndoTool.

Not only did these results spell success to the staff and patients at Wilson Memorial Hospital, they were recently named a top performer by the RAL's benchmarking program!

EndoTool Use in Diabetic Ketoacidosis (DKA)

ML, a 27-year-old female, was admitted to the hospital with diabetic ketoacidosis (DKA) and a blood glucose level of 566 mg/dL. She was treated with intravenous insulin per the standardized paper protocol. She was released after 48 hours; however, her blood glucose levels were never less than 172 mg/dL. She was readmitted 20 days later at 7 p.m. with a blood glucose level of 1001 mg/dL and rediagnosed with DKA. She was treated again with intravenous insulin, but this time she was placed on EndoTool. By 4 a.m., ML's blood glucose level was reported as 133 mg/dL. EndoTool was discontinued the next day at 8 in the morning. ML was converted to subcutaneous insulin and EndoTool calculated a correction scale for BS > 119 mg/dL. She was then discharged that evening.

In the 11 months prior to the implementation of EndoTool, Wilson Memorial Hospital treated 19 patients for DKA. The average LOS was 3.3 days and the average cost was $9,743.28 per DKA patient. After EndoTool was started, the average LOS was 2.66 days and the average cost was $6,128.12 per DKA patient, resulting in a decrease LOS of 0.6 days and a decreased cost of $3,615.16 per patient. Extrapolation of this data would indicate a potential annual savings of $74,932.41. Also, because DKA patients such as ML may achieve better hyperglycemic control during their hospitalization when utilizing EndoTool, decreased number of admissions or longer intervals between admissions may be realized, which would further decrease costs and increase savings.

"EndoTool has been effective in patients admitted for hyperglycemia. We have been able to keep the length-of-stay in some patients to less than 24 hours. This is very important to us and our community, as our patients are not always insured (self pay)."

— L. Barhorst, RN

"As Director of Pharmacy, utilizing EndoTool is very exciting! We have the opportunity to improve patient care and save money at the same time."

— M. Eppley, PharmD

"Overall, implementing EndoTool has been a positive development instilling a rising level of confidence and increased comfort level amongst nurses and physicians in administering tight glycemic control. Patients have improved blood sugar control. Treating significant insulin-resistance due to infection has been easier. No significant hypoglycemia reported."

— P. Kumar, MD

Conclusion

The importance of good glycemic control in hospitalized patients has been well documented in the literature. Some studies have shown a decrease in morbidity and mortality when glucose is effectively controlled during a patient's hospitalization. Wilson Memorial Hospital switched from using paper correction protocols to Hospira's EndoTool glucose management system to achieve optimal glycemic control in its patients with high blood glucose levels while minimizing hypoglycemia. Even though the benefits of good glycemic control are well known among healthcare professionals, implementing such a strategy took careful planning and devotion from the multidisciplinary team. Overall, EndoTool allowed rapid and better glucose control, usually achieving target levels within five hours. When administering intravenous insulin, it is typical to fear hypoglycemia; however, Wilson Memorial Hospital witnessed an 80% decrease in hypoglycemia with the use of EndoTool.

References:

1. Umpierrez GE, Isaacs SD, Bazargan N, You X, Thaler LM, Kitabchi AE. Hyperglycemia: an independent marker of in-hospital mortality in patients with undiagnosed diabetes. *J Clin Endocrinol Metab.* 2002;87:978–982.
2. Bochicchio GV, Sung J, Joshi M, Bochicchio K, Johnson SB, et al. Persistent hyperglycemia is predictive of outcome in critically ill trauma patients. *J Trauma.* 2005;58:921–924.
3. Kosiborod M, Inzucchi S, Krumholz H, et al. Glucometrics in patients hospitalized with acute myocardial infarction: Defining the optimal outcomes-based measure of risk. *Circulation.* 2008;117:1018-1027.
4. American Diabetes Association. Standards of medical care in diabetes–2008. *Diabetes Care.* 2008;31(suppl 1):S12-S54.
5. Institute for Healthcare Improvement. Implement effective glucose control: establish a glycemic control policy in your ICU. http://www.ihi.org/IHI/Topics/CriticalCare/IntensiveCare/Changes/ImplementEffectiveGlucoseControl.htm. Accessed January 30, 2009.
6. Arabi YM, Dabbagh OC, Tamim HM, et al. Intensive versus conventional insulin therapy: A randomized controlled trial in medical and surgical critically ill patients. *Crit Care Med.* 2008;36:3190–3197.
7. Geller HS, Burgess WP, Coyle JP. Computer Generated Glucose Management In The Operating Room. Presented at Society of Cardiovascular Anesthesiologists 28th Annual Meeting. April 29-May 3, 2006.
8. Saager L, Collins GL, Burnside B, Tymkew H, Zhang L, et al. A randomized study in diabetic patients undergoing cardiac surgery—comparing computer-guided glucose management with a standard sliding scale protocol. *J Cardiothoracic Vasc Anesth.* 2008;22:377-382.

For more information on Advancing Wellness™, contact your Hospira representative at **1-877-946-7747** or visit **www.hospira.com**

Advancing Wellness™

Hospira, Inc., 275 North Field Drive, Lake Forest, IL 60045 P09-2047-Apr., 09