Robert J. Tanenberg, MD, FACP
Professor of Medicine (Endocrinology) East Carolina University
Medical Director, Inpatient Diabetes Program, Vidant Med Ctr
600 Moye Blvd, Room 3E-129
Greenville, NC 27834
Phone: (252) 744-2567 Email: tanenbergr@ecu.edu

Use of a Computer-Guided Glucose Management System to Improve Glycemic Control
A 7-Year Retrospective Observational Study at a Tertiary Care Teaching Hospital

Robert J. Tanenberg, MD, FACP; Sandra Hardee, PharmD, CDE; Caitlin Rothermel, MPH; A.J. Drake III, MD

ABSTRACT

Blood glucose (BG) management using algorithmically based computerized systems can optimize the timing of BG checks and insulin dosing to improve patient outcomes. We evaluated the 7-year impact of the EndoTool® electronic Glycemic Management System (eGMS) in intensive and intermediate units at a single, 900-bed, tertiary care teaching hospital. Patients assigned to eGMS had an indication for IV insulin infusion, including uncontrolled diabetes, stress hyperglycemia, and/or postoperative BG levels >140 mg/dL. We measured time to achieve BG control, hypoglycemia incidence, and glucose variability. A total of 492,078 BG readings were obtained from 16,850 patients. The eGMS brought hyperglycemic patients' BG to ≤180 mg/dL within 1.5 to 2.3 hours. Minimal hypoglycemia was observed, with only 0.93% of values <70 mg/dL and 0.03% <40 mg/dL. Hypoglycemia showed year-on-year decreases, with a significant reduction in frequency, from 1.04% in 2009 to 0.46% in 2015 (*P*<0.0001). This study confirms that computerized IV insulin administration improves inpatient BG control while minimizing hypoglycemia.

METHODS

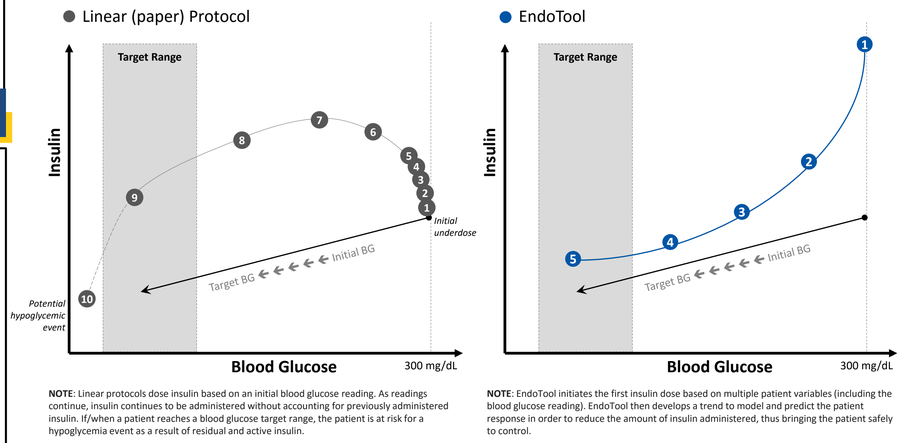
We collected retrospective data (1/2009-12/2015) on the impact of an eGMS in patients with an indication for IV insulin infusion (uncontrolled diabetes, stress hyperglycemia, and/or postoperative BG levels >140 mg/dL) from intensive and intermediate units at Vidant Medical Center (VMC), a 900-bed, tertiary care teaching hospital affiliated with East Carolina University. Patients included had: (a) ≥6 BG measurements; (b) a first BG measurement >70 mg/dL; and (c) a series of BG measurements with time gaps ≤4 hours. Hyperglycemia (≥180 mg/dL), hypoglycemia (<70 mg/dL), and time required to achieve glycemic control were evaluated.

RESULTS

Data were available for 100% of treated patients. Over 7 years, 492,078 BG readings were obtained from 16,850 patients. Between 2009 and 2015, eGMS brought hyperglycemic patients to glucose levels ≤180 mg/dL within 1.5 to 2.3 hours. After achieving glucose control, excursions (>180 mg/dL) occurred in only 4% of patients, at an average duration of 1.91 hours. Patients in cardiovascular surgery units required ~4.5 to 4.8 hours to achieve a BG target of 140 mg/dL; ~98% of patients achieved this target. Most cardiovascular ICU and IU patients reached a BG target of 120 mg/dL (88.7% and 93.7%, respectively), while about half of patients with a lower BG target (90 mg/dL) achieved this level. Patients experienced minimal hypoglycemia, with 0.93% of BG values <70 mg/dL and 0.03% <40 mg/dL. ANOVA analysis of the percentage of glucose values <70 mg/dL from 2009 to 2015 showed a statistically significant reduction in hypoglycemia frequency from 1.04% in 2009 to 0.46% in 2015 (*P*<0.0001).

Comparison of Linear (Paper) Protocol and eGMS Nonlinear Physiologic Dosing on Insulin Administration and Blood Glucose Control

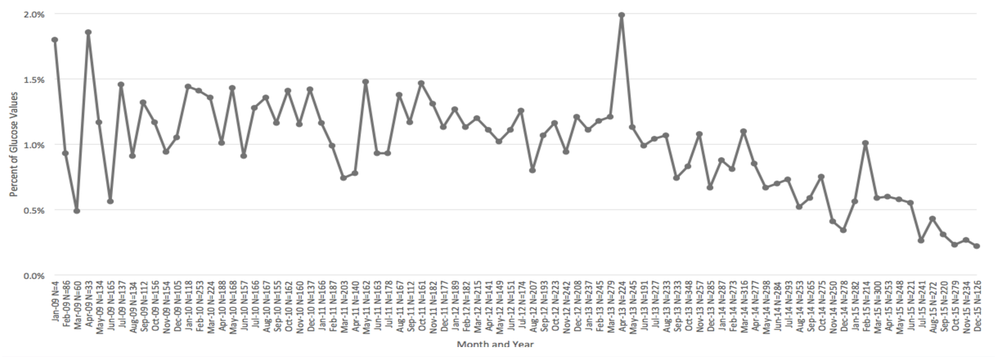
Figure 1 (Impact of EndoTool's Non-linear Dosing)



NOTE: Linear protocols dose insulin based on an initial blood glucose reading. As readings continue, insulin continues to be administered without accounting for previously administered insulin. If/when a patient reaches a blood glucose target range, the patient is at risk for a hypoglycemia event as a result of residual and active insulin.

NOTE: EndoTool initiates the first insulin dose based on multiple patient variables (including the blood glucose reading). EndoTool then develops a trend to model and predict the patient response in order to reduce the amount of insulin administered, thus bringing the patient safely to control.

Percentage of VMC Patient Glucose Values <70 mg/dL with eGMS: 2009 to 2015



DISCUSSION

Hyper-/hypoglycemia in hospital settings independently predict morbidity and mortality. Protocol-driven insulin administration improves BG outcomes, and algorithmically based computerized systems can optimize the timing of BG checks and insulin dosing. This eGMS integrated with hospital information systems to manage IV insulin delivery by developing patient-specific physiologic insulin dosing curves based on individual characteristics.

Use of this system in ICUs and IUs by VMC resulted in a marked improvement in quality of care. Notable results included low, cumulative hypoglycemia rates and a significant reduction in year-upon-year hypoglycemia incidence, even as patient volume more than doubled. Patients also experienced relatively rapid time to BG control ≤180 mg/dL, with low rates of glucose excursions. Postsurgical cardiovascular patients, who had more stringent BG targets, were able to achieve higher BG values still within the target range; thus, eGMS was effective at achieving and maintaining cardiovascular patients at the higher end of the 90 to 140 mg/dL target range. This study was a retrospective, single-center analysis; ideally, future studies will evaluate patient outcomes both prior to and following eGMS implementation.

CONCLUSIONS

The use of computer-based systems to manage glucose levels in hospitalized patients with diabetes improves glycemic control. Use of the EndoTool eGMS resulted in significant improvements in overall glucose control, assessed as hyperglycemia, hypoglycemia, and glucose variability. It is likely that other facilities could achieve similar improvements in glycemic control and patient outcomes using this system.