CLINICAL RESEARCH STUDY

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Computerized Insulin Order Sets and Glycemic Control in Hospitalized Patients

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ABSTRACT

BACKGROUND: The purpose of this study was to evaluate the impact of computerized provider order entry subcutaneous insulin order sets on inpatient glycemic control and ordering behavior.

METHODS: This was an interrupted time series study of non-intensive care patients at an urban teaching hospital. The primary outcome was proportion of capillary blood glucose in optimal range (4.0-10.0 mmol/L [72-180 mg/dL]) during the 6 months before and after a change to a computerized provider order entry-integrated insulin order set. Secondary outcomes included other measures of glycemia (hyperglycemia [>13.9mmol/L (250 mg/dL)], hypoglycemia [<4.0 mmol/L (72 mg/dL)], severe hypoglycemia [<2.2 mmol/L (40 mg/dL)]) and ordering behavior (use of basal-bolus-correctional insulin regimens). Comparisons of sensitivity-based versus generic correctional scale were also conducted.

RESULTS: A total of 63,393 measurements were obtained from June 2011 to June 2012. Order set usage was limited (51.5%). The weekly proportion of capillary blood glucose within the optimal range was not significantly different after the switch to computerized provider order entry order sets (pre-period: 64.9% vs post-period: 65.3%, $P = .996$). There were no differences in the proportions of moderate or severe hyperglycemia (pre-period: 10.9% vs post-period: 12.0%, $P = .061$) and hypoglycemia (pre-period: 1.9% vs post-period: 1.6%, $P = .144$). However, an increased proportion within the optimal range was seen in those with an order set featuring a sensitivity-based correctional scale versus orders without (65.3% vs 55.0%, $P < .001$). Increased basal-bolus-correctional ordering was observed after protocol implementation (20.3% vs 23.6%, $P < .0001$).

CONCLUSIONS: With low institutional uptake, computerized insulin order sets did not improve inpatient glycemic control.

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KEYWORDS: Computerized provider order entry; Diabetes; Glucometrics; Inpatient glucose control; Insulin; Order sets

Glycemic control in hospitalized patients has been increasingly recognized as a clinical challenge. Poor glycemic control is associated with adverse outcomes, including nosocomial infections, increased costs of care, increased length of stay, and increased mortality.[1-6] Although prespecified glucose targets are advocated in national clinical practice guidelines, often the day-to-day glucose measurements of hospitalized patients do not meet such clinical benchmarks. Furthermore, there is wide variability to the insulin regimens prescribed in-hospital. Despite supporting evidence[7,8] and expert recommendations supporting the more physiologic basal-bolus-correctional insulin regimen in hospitalized patients,[9,10] the use of sliding-scale insulin as a monotherapy remains pervasive and deeply ingrained in clinical practice.[11,12]

To improve evidence-based practice and workflow, provider-directed point-of-care clinical decision support tools such as standardized order sets have been developed. A prior study at our institution[13] demonstrated the efficacy of a

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paper-based standardized correctional insulin order set intervention in not only reducing hyperglycemia by 39%, but also improving processes of care. However, it remains unknown whether the benefits of these paper-based order sets will be translated in an analogous fashion to electronic-based interventions as more hospitals, including our institution, switch to computerized provider order entry systems. Although computerized provider order entry is often implemented with the goal of improving workflow and medication safety, several studies suggest that poorly designed computerized provider order entry systems may impede performance and also generate new unintended errors unique to computerized systems.[14-16]

Our objective was to evaluate the impact of computerized provider order entry with integrated insulin order sets on clinical outcomes and processes of care in an urban teaching hospital setting, utilizing an interrupted time series design. We hypothesize that these outcomes would improve in the post-implementation phase.

CLINICAL SIGNIFICANCE

- Overall glycemic outcomes were not improved after real-world computerized physician order entry-integrated insulin order set implementation.
- Effectiveness was likely impacted by poor order set uptake and speaks to a strong need for careful order set implementation.
- Computerized provider order entry-integrated insulin order sets may improve ordering practices consistent with guideline-based care.

METHODS

Study Design

An interrupted time series design was used to examine the influence of a hospital-wide implementation of computerized provider order entry-integrated insulin order set. We used the STROBE checklist adapted to interrupted time series studies[17] to report our findings.

Setting and Data Sources

This study was conducted at St. Michael's Hospital (Toronto, Ontario, Canada), a large tertiary and quaternary care urban academic center with over 550 inpatient beds. Connectivity-based point-of-care capillary blood glucose testing was initiated in all its non-intensive care units from July through October 2009. Siemens Soarian Clinicals with computerized provider order entry system was subsequently implemented across all inpatient and outpatient units from March 2010 through June 2011. In addition to order entry capabilities, this interface allows clinicians access to patient demographic information, medications, laboratory and radiographic results, ambulatory medical records, operative notes, and discharge summaries.

Intervention

In an effort to reduce in-hospital hyperglycemia, a paper-based insulin order set was first developed and implemented successfully by a team of expert clinicians, as described previously.[13] It promoted the use of basal-bolus-correctional insulin and adjusted the recommended correctional scale according to insulin sensitivity. This insulin clinical decision support systems order set was adapted in conjunction with information technologists to create a set of evidence-based insulin orders in the computerized provider order entry system. It was pretested through an iterative process, and after approval the set was made available to hospital clinicians. However, a pre-existing order set that featured generic insulin correctional scale (not tailored to insulin sensitivity) was also available hospital-wide. The integration of insulin clinical decision support systems orders into computerized provider order entry occurred simultaneously across all inpatient wards in December 2011.

Data Collection

Retrospective data collection took place among 12 adult medical and surgical wards hospital-wide during the 6-month pre-implementation period (during which computerized provider order entry with only paper-based insulin order sets was available on the cardiovascular surgery ward) and the 6-month post-implementation period separated by a 4-week washout period. Percentage of uptake for various correctional insulin order sets by different clinical units was also recorded. Additional data collected included patient demographics, type of anti-hyperglycemic agents, and use of insulin.

Study Sample

We included all consecutive patients over the age of 18 years admitted to a non−intensive medical/surgical care unit who had a known diagnosis of diabetes (either type 1 or type 2), were prescribed antidiabetic agents or subcutaneous insulin during hospital stay, or had evidence of in-hospital hyperglycemia in the study period (defined as random capillary blood glucose >11.0 mmol/L [198 mg/dL]; and/or fasting capillary blood glucose >7.0 mmol/L [126 mg/dL]). The latter was added to include individuals with otherwise undiagnosed diabetes and/or stress hyperglycemia. To reduce bias, several capillary blood glucose measurements were excluded from the following: obstetrics/gynecology unit and palliative care units, given different glycemic targets; psychiatry unit and emergency rooms, given disproportionate paucity of collectable data; and intensive care units, given clinical preference for tighter control with more frequent use of intravenous insulin.

Outcome Measures

The primary outcome of interest was glycemic control, as defined by proportion of all capillary blood glucose