Effectiveness of a Computerized Insulin Order Template in General Medical Inpatients With Type 2 Diabetes

A cluster randomized trial

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OBJECTIVE — To determine whether an electronic order template for basal-bolus insulin ordering improves mean blood glucose in hospitalized general medical patients with hyperglycemia and type 2 diabetes.

RESEARCH DESIGN AND METHODS — We randomly assigned internal medicine resident teams on acute general medical floors to the use of an electronic insulin order template or usual insulin ordering. We measured diabetes care parameters for 1 month on all patients with type 2 diabetes and blood glucose <60 mg/dl or >180 mg/dl treated by these physicians.

RESULTS — Intervention group patients (n = 65) had mean glucose of 195 ± 66 mg/dl. Control group patients (n = 63) had mean glucose of 224 ± 57 mg/dl (P = 0.004). In the intervention group, there was no increase in hypoglycemia.

CONCLUSIONS — Access to a computer insulin order template was associated with improved mean glucose levels without increasing hypoglycemia in patients with type 2 diabetes.

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Physiological, basal-bolus insulin prescribing is safe, effective (1), and the standard of care in hospitalized patients with type 2 diabetes and hyperglycemia (2). Yet only about half of such patients are prescribed basal insulin in the hospital (3). Order templates to support basal-bolus insulin prescribing (usually as part of a comprehensive inpatient diabetes quality improvement program) have been effective in improving glycemia in observational trials (4–8). Randomized trials have shown more modest effects (9,10). Knowledge of appropriate insulin ordering is a barrier to ordering basal-bolus insulin among inpatient providers (11–13).

We tested the hypothesis that giving internal medicine residents access to an electronic insulin order template would be more effective than usual insulin ordering in lowering mean blood glucose in medical inpatients with type 2 diabetes.

RESEARCH DESIGN AND METHODS

— We piloted a simple electronic insulin order template based on previously studied protocols (1,4,14) and internal review by diabetologists and pharmacists at a tertiary care medical center with a proprietary computerized order entry system. The template presents sequential screens linking to a weight-based insulin dose calculator and facilitating prescription of a total daily dose of insulin of 0.5 units/kg, half in basal glargine and half in prandial aspart, with supplemental aspart (supplementary Appendix 1, available at http://care.diabetesjournals.org/cgi/content/full/dc10-0964/DC1).

Using a computerized coin toss, we randomly assigned seven teams of providers (42 internal medicine residents) working in general medical acute care units to have the option to use the order template (intervention group) or to use usual insulin ordering (control group). All residents received a 30-min educational session and a two-page pamphlet on how to prescribe and titrate basal-bolus insulin (supplementary Appendix 1).

We identified all patients prescribed insulin by these providers during the study period (30 April 2009 to 27 May 2009). We excluded patients with type 1 diabetes (n = 11) and type 2 diabetes with blood glucose between 60 and 180 mg/dl because the order set was designed to apply to hyperglycemia in patients with type 2 diabetes without other risks for hypoglycemia (i.e., liver or renal failure). Diagnosis of type 2 diabetes was confirmed by chart review. We determined age, sex, race, length of stay, and primary diagnosis of the patients from the medical record. Glycemic parameters were calculated from point-of-care glucose values, using mean glucose as the main outcome for its easy interpretability and similarity to other metrics (15). Secondary outcomes included the rate of prolonged hyperglycemia (three consecutive glucose values >240 mg/dl); hospital-stay rate of hypoglycemia (any glucose value <60 mg/dl or <40 mg/dl); the rate of use of sliding scale insulin alone (having sliding scale insulin orders without any other insulin orders at any point during admission); rate of initial prescription of basal insulin (any order for long-acting insulin within 1 day of hospital admission); and basal insulin at any time (any order for long-acting insulin at any time during the hospital stay).

The study had 80% power to detect a difference in mean glucose of 30 mg/dl between groups, assuming SD of 60 mg/dl. We performed Student t tests and Wilcoxon rank sum tests to determine differences between means and medians of continuous and non-normally distributed variables and performed χ^2 or Fisher

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exact tests for categorical variables. We repeated mean glucose estimates accounting for repeated (glucose) and correlated (provider) measures and adjusting for baseline glucose (supplementary Appendix 2). All analyses were performed with SAS version 9.1. The protocol was approved by the Partners Healthcare Institutional Review Board.

RESULTS — During the 4-week study period, 144 insulin-treated patients with type 2 diabetes were admitted to the seven study teams. Mean glucose was 186 ± 56 mg/dl in intervention patients and 206 ± 61 mg/dl in control patients ($P = 0.004$). Excluding 16 patients whose point-of-care glucose values were between 60 and 180 mg/dl left a study sample size of 128; 127 had at least one value >180 mg/dl and 1 had a glucose value <60 mg/dl. Sixty-three patients were treated by providers with access to the order template (intervention group), and 65 were treated by providers who received the pamphlet and brief teaching session alone (control group). There were no significant differences between groups in patient age, sex, race, length of stay, or primary diagnosis. Mean glucose was significantly better in the intervention group (194 ± 66 mg/dl vs. 224 ± 57 mg/dl, $P = 0.004$) (Table 1). The rates of basal insulin orders, any hypoglycemia, and severe hypoglycemia did not differ between groups.

Table 1—*Baseline characteristics and results*

	Control	Intervention	*P**
n	63	65	
Age (years)	70 ± 13.6	68 ± 14.3	0.4
Male subjects, *n* (%)	34 (54)	40 (61)	0.4
White subjects, *n* (%)	37 (84)	39 (80)	0.6
Length of stay (days), median (IQR)	5 (3–11)	6 (3–10)	0.6
Primary diagnosis, *n* (%)			
Cardiac	17 (27)	13 (20)	0.8
GI or liver disease	10 (16)	10 (15)	
Pulmonary (including pneumonia)	9 (14)	9 (14)	
Infection, nonpneumonia	7 (11)	11 (17)	
Diabetes	2 (3)	3 (5)	
Other	18 (29)	19 (29)	
Results			
Mean glucose (mg/dl)	224 ± 57	194 ± 66	0.004
Sliding scale alone, %	35	38	0.7
Basal insulin, day of admission, %	31	30	0.9
Basal insulin at any time, %	65	61	0.7
Prolonged hyperglycemia (3 consecutive glucose >240 mg/dl), %	38	26	0.2
Hypoglycemia (<60 mg/dl at any time), %	14	12	0.7
Severe hypoglycemia (<40 mg/dl), %	1	0	0.5
Basal insulin dose (units), median (IQR)	16 (10–34)	18 (10–28)	0.4

Data are means ± SD, median (interquartile range [IQR]), percent, or *n* (%). *Student *t* test for continuous variables, Wilcoxon rank sum test for length of stay and mean insulin dose, and χ^2 or Fisher exact test for categorical variables. GI, gastroinestinal.

CONCLUSIONS — In this randomized trial of a computer order template to support basal-bolus insulin prescribing for general acute medical inpatients with type 2 diabetes, we found an improved mean glucose level in patients of providers given access to the order template.

Mean glucose levels in both groups were higher than the goal for inpatient glucose levels in noncritically ill patients (2), and mean basal insulin doses were low, consistent with persistent inadequate treatment. The rate of basal insulin ordered at admission was low and increased equivalently in both groups to a rate over 60%; this compares favorably to a rate of 43% in a national sample of insulin-treated inpatients with type 2 diabetes (3). The rate of sliding scale insulin alone (35%) was equivalent to that of a comparable national sample (35%) (3). Given the efficacy of basal-bolus treatment, it seems even a low rate of appropriate insulin ordering may be associated with modest improvement in mean glucose levels. Use of the order template may have been limited by its optional use and the minimal support for the order set, in contrast to similar programs at other centers (9,10).

In conclusion, access to an electronic basal-bolus insulin order template was associated with a significant improvement in glycemic control among patients with type 2 diabetes without increasing the rate of hypoglycemia but did not substantially change insulin ordering behavior. A "smarter" template with alerts based on glucose levels and nutritional status and forced rather than optional use, coupled with more intensive implementation support, might further improve the care of hospitalized patients with type 2 diabetes.

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E.C. conceived of the project. E.C. and D.J.W. designed the study. E.C., D.J.W., and S.M.B. developed the order template. E.C., D.J.W., and S.M.B. executed the study. P.S. managed the data and conducted the repeated-measures analysis. D.W. performed the remainder of the data analysis. D.J.W. drafted the manuscript. E.C., P.S., and S.M.B. reviewed/edited the manuscript. D.J.W. had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

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