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).

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Effect of a computerized order template

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.

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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References
1. Umpierrez GE, Smiley D, Zisman A, Prieto LM, Palacio A, Ceron M, Puig A, Mejia R. Randomized study of basal-bolus insulin therapy in the inpatient management of patients with type 2 diabetes (RABBIT 2 trial). Diabetes Care 2007;30:2181–2186
2. Moghissi ES, Korytkowski MT, DiNardo M, Einhorn D, Hellman R, Hirsch IB, Inzucchi SE, Ismail-Beigi F, Kirkman MS, Umpierrez GE, American Association of Clinical Endocrinologists, American Diabetes Association. American Association of Clinical Endocrinologists and American Diabetes Association consensus state-

| 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 (%)            | 17 (27) | 13 (20) | 0.8 |
| Cardiac                             | 10 (16) | 10 (15) |    |
| GI or liver disease                 | 9 (14)  | 9 (14) |    |
| Pulmonary (including pneumonia)     | 7 (11)  | 11 (17) |    |
| Infection, nonpneumonia             | 2 (3)   | 3 (5) |    |
| Diabetes                            | 18 (29) | 19 (29) |    |
| Other                               |         |             |    |
|                                    |         |             |    |
| 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 χ² or Fisher exact test for categorical variables. GI, gastrointestinal.
3. Wexler DJ, Meigs JB, Cagliero E, Nathan DM, Grant RW. Prevalence of hyper- and hypoglycemia among inpatients with diabetes: a national survey of 44 U.S. hospitals. Diabetes Care 2007;30:367–369

4. Maynard G, Lee J, Phillips G, Fink E, Renvall M. Improved inpatient use of basal insulin, reduced hypoglycemia, and improved glycemic control: effect of structured subcutaneous insulin orders and an insulin management algorithm. J Hosp Med 2009;4:3–15

5. Donihi AC, DiNardo MM, DeVita MA, Korytkowski MT. Use of a standardized protocol to decrease medication errors and adverse events related to sliding scale insulin. Qual Saf Health Care 2006;15:89–91

6. Murphy DM, Vercruysse RA, Bertucci TM, Wall MJ, Schrierer AE, Nabhan FA, Barron WM, Emanuele MA. Reducing hyperglycemia hospitalwide: the basal-bolus concept. Jt Comm J Qual Patient Saf 2009;35:216–223

7. Schnipper JL, Ndumele CD, Liang CL, Pendergrass ML. Effects of a subcutaneous insulin protocol, clinical education, and computerized order set on the quality of inpatient management of hyperglycemia: results of a clinical trial. J Hosp Med 2009;4:16–27

8. Guerra YS, Das K, Antonopoulos P, Borkowsky S, Fogelfeld L, Gordon MJ, Pa-
lal BM, Witsil JC, Lacuesta EA. Compu-
terized physician order entry- based hyperglycemia inpatient protocol and glycemic outcomes: The CPOE-HIP study. Endocr Pract 2010;16:389–397

9. Schnipper JL, Liang CL, Ndumele CD, Pendergrass ML. Effects of a computerized order set on the inpatient management of hyperglycemia: a cluster-randomized controlled trial. Endocr Pract 2009;16:209–218

10. Noschese M, Donihi AC, Koerbel G, Karslioglu E, Dinardo M, Curl M, Korytkowski MT. Effect of a diabetes order set on glycaemic management and control in the hospital. Qual Saf Health Care 2008;17:464–468

11. Chekati V, Osburne RC, Jameson KA, Cook CB. Perceptions of resident physicians about management of inpatient hyperglycemia in an urban hospital. J Hosp Med 2009;4:E1–8

12. Cook CB, Jameson KA, Hartsell ZC, Boyle ME, Leonhardt BJ, Farquhar-Snow M, Beer KA. Beliefs about hospital diabetes and perceived barriers to glucose management among inpatient midlevel practitioners. Diabetes Educ 2008;34:75–83

13. Rubin DJ, Moshang J, Jabbour SA. Diabetes knowledge: are residents physicians and nurses adequately prepared to manage diabetes? Endocr Pract 2007;13:17–21

14. Inzucchi SE. Clinical practice. Management of hyperglycemia in the hospital setting. N Engl J Med 2006;355:1903–1911

15. Goldberg PA, Bozzo JE, Thomas PG, Mesmer MM, Sakhrova OA, Radford MJ, Inzucchi SE. “Glucometrics”—assessing the quality of inpatient glucose management. Diabetes Technol Ther 2006;8:560–569