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ORIGINAL ARTICLE

Clinical Inertia during Postoperative Management of Diabetes Mellitus: Relationship between Hyperglycemia and Insulin Therapy Intensification

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Abstract

Objective:

Our objective was to assess the application of insulin regimens in surgical postoperative patients with diabetes.

Methods:

A chart review was conducted of patients with diabetes who were hospitalized postoperatively between January 1 and April 30, 2011. Analysis was restricted to patients hospitalized for ≥3 days and excluded cases with an endocrinology consult. Insulin regimens were categorized as "basal plus short acting," "short acting only," or "none," and the pattern of use was evaluated by hyperglycemia severity according to tertiles of both mean glucose and the number of glucose measurements >180 mg/dl.

Results:

Among cases selected for analysis (n = 119), examination of changes in insulin use based on tertiles of mean glucose showed that use of basal plus short-acting insulin increased from 10% in the lowest tertile (mean glucose, 120 mg/dl) to 18% in the highest tertile (mean glucose, 198 mg/dl; $p < .01$); however, 70% of patients in the highest tertile continued to receive short-acting insulin only, with 12% receiving no insulin. Intensification of insulin to a basal plus short-acting regimen was also seen when changes were evaluated by the number of measurements >180 mg/dl ($p < .01$), but 70% and 12% of patients in the highest tertile still remained only on short-acting insulin or received no insulin, respectively.

Conclusions:

Use of basal plus short-acting insulin therapy increased with worsening hyperglycemia, but many cases did not have therapy intensified to the recommended insulin regimen—evidence of clinical inertia. Strategies should be devised to overcome inpatient clinical inertia in the treatment of postoperative patients with diabetes.

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Introduction

Postoperative hyperglycemia has been associated with worse morbidity and mortality in patients hospitalized following surgery. Postoperative hyperglycemia has been associated with an increased incidence of wound infections, morbidity and mortality, and length of stay.[1–6] Available data indicate that treating postoperative hyperglycemia can improve outcomes in some groups of surgical patients.[7–9] Current guidelines suggest that fasting glucose should not exceed 140 mg/dl and that random glucose should not be higher than 180 mg/dl in hospitalized patients.[10,11]

Insulin therapy is now regarded as the optimal treatment for hyperglycemia for hospitalized, noncritically ill patients during the postoperative period.[10,11] The use of correction insulin—the so-called sliding scale—without concurrent use of basal insulin in the hospital results in ineffective control of hyperglycemia.[12,13] In noncritically ill medical and surgical inpatients, the most efficacious insulin program to treat glucose levels above recommended targets consists of a combination of long-acting basal insulin and short-acting insulin with meals when the patient is eating, supplemented by correction doses for high glucose values.[14–16]

Clinical inertia is defined as the failure to intensify therapy when needed.[17] We first described clinical inertia in the hospital with regards to insulin administration in 2006,[18] with further evidence found subsequently.[19] Others have also observed clinical inertia in the treatment of inpatient diabetes.[20–22] Although clinical inertia has been shown to occur in the management of a general population of hospitalized patients with diabetes, this has not been studied specifically in surgical patients with diabetes. We hypothesized that surgical teams rely on antiquated insulin programs and fail to intensify insulin regimens despite significant hyperglycemia. We then examined treatment strategies used among inpatients with diabetes who were hospitalized following a surgical procedure.

Methods

Case Selection

The postoperative period was defined as the date and time from admission after surgery to patient discharge. Patients discharged with an ICD-9-CM (International Classification of Diseases, 9th Revision, Clinical Modification) diagnosis code for diabetes (ICD-9-CM code 250.xx) were identified in a search of the hospital's electronic billing records as described previously.[19] Adult patients (≥18 years old) with a diagnosis of diabetes who were undergoing a surgical procedure between January 1 and April 30, 2011, were identified from discharge data. The institutional review board approved this study. As some patients may have had more than one procedure and postoperative admission, the unit of analysis was the hospital stay.

Data Abstraction

The electronic medical record for each patient was reviewed. Demographics were recorded. Also extracted were type of diabetes, self-reported year of diabetes diagnosis, outpatient diabetes therapy, body mass index, hemoglobin A1c, type of surgery, surgical service, and whether an inpatient endocrinology consulting service was involved with the case. Data were linked to the laboratory information system and pharmacy databases to obtain point-of-care bedside blood glucose levels and mode of inpatient hyperglycemia therapy, as previously described.[19] None of the patients required an intensive care unit stay or received intravenous insulin.

Assessment of Glucose Control

For consistency with our previous methods of assessing clinical inertia in our hospital, assessment of glucose control was derived from analysis of bedside point-of-care glucose data. The patient stay mean glucose was calculated by averaging all the bedside glucose measurements for the entire length of stay for each patient, then calculating the composite average for all hospital cases ($BedGluc_{avg}$).[19] The percentage of hyperglycemic and hypoglycemic measurements in the bedside glucose measurement data were calculated by dividing the number of values per patient by the total number of bedside measurements per patient and then multiplying by 100. Results were then stratified into >180, >200, >250, >300, or >350 mg/dl and into <40, <50, <60, or <70 mg/dl, respectively, as previously described.[19]

Definitions of Inpatient Hyperglycemia Treatment

In examining inpatient hyperglycemia therapy, we determined only what was actually administered to the patient. Long-acting insulin (glargine or neutral protamine Hagedorn in our facility) was termed "basal." A rapid-acting insulin (regular or aspart in our hospital) was defined as "short acting" if provided either as a prandial dose and/or a correction dose. Patterns of insulin administration were then classified as "none," "basal only," "short acting only," or "basal plus short acting." If a patient was receiving premixed insulin, it was placed in the basal plus short-acting category.[19]

Data Analysis

Because it is not clear if there is value to escalating glycemic control therapy in cases with short stays, we restricted the analysis to ones that had a length of stay ≥3 days.[19] Additionally, we included only those cases that did not have an endocrinology consultation. The relationship of changes in inpatient therapy with respect to hyperglycemia was assessed in two ways. $BedGluc_{avg}$ values were divided into three groups based on tertile cut points, as previously described.[19] Practitioners providing care for inpatients typically make decisions on hyperglycemic therapy on the basis of bedside glucose measurements. Therefore, we also examined changes in therapy according to the number of bedside glucose measurements >180 mg/dl, stratifying the data into three groups based on tertile cut points as for $BedGluc_{avg}$.

After the $BedGluc_{avg}$ values were divided into three groups, the differences in insulin treatment regimen were compared across groups using the χ^2 test. Similar analysis was performed according to the number of point-of-care glucose values >180 mg/dl. The expectation was that there would be greater use of basal plus short acting among the highest tertiles of hyperglycemia. Data were reported as mean (standard deviation) or as number and percentage.

Results

Patient Characteristics

A total of 258 patients who underwent 267 surgical procedures and were hospitalized postoperatively were identified. Of these, 69% were hospitalized ≥3 days and 20% were comanaged by endocrinology, yielding 114 patients with 119 postoperative cases for final analysis. Most were male, white, and obese and had type 2 diabetes (**Table 1**). The mean self-reported duration of diabetes was 12 years. Preoperative glucose control was fair based on available mean hemoglobin A1c. Most patients were treated as outpatients with oral hypoglycemic agents only, followed by insulin monotherapy, then diet alone, and then combinations of insulin and oral agents. Most procedures were elective surgeries (**Table 1**). The three most common surgical specialties were orthopedic (36/119, 30% of cases), urologic (18/119, 15%), and general surgical (17/119, 14%), whereas others included a variety of other specialties (e.g., vascular, cardiothoracic, transplant; not shown).

Table 1.
Characteristics of 114 Patients with Diabetes Requiring 119 Hospitalizations after a Surgical Procedure (January–April 2011)

Characteristic	Value[a]
Age, years	68 (11)
Male sex	66 (58)
White	99 (87)
Body mass index, kg/m^2	31.4 (7.5)
Type 2 diabetes mellitus	110 (96)
Duration of diabetes, years	12 (12)[b]
Hemoglobin A1c, %	7.0 (1.6)[c]
Length of stay, days	6.7 (4.4)
Home diabetes medication regimen	
Oral agents	71 (62.2)
Insulin	29 (25.4)
Diet	9 (7.9)
Oral and insulin	5 (4.4)
Surgery type	
Elective	74 (71)
Urgent	30 (25)
Emergent	5 (4)

[a] Values are mean (standard deviation) or number (percentage).
[b] Recorded in 61 patients.
[c] Obtained in 79 patients.

Glycemic Control

$BedGluc_{avg}$ was 157 mg/dl (35 mg/dl). Over a quarter of per-patient glucose measurements exceeded 180 mg/dl. More severe hyperglycemia (glucose >350 mg/dl) occurred but was not very common (**Figure 1A**). The frequency of hypoglycemia, and especially severe hypoglycemia, was rare (**Figure 1B**).

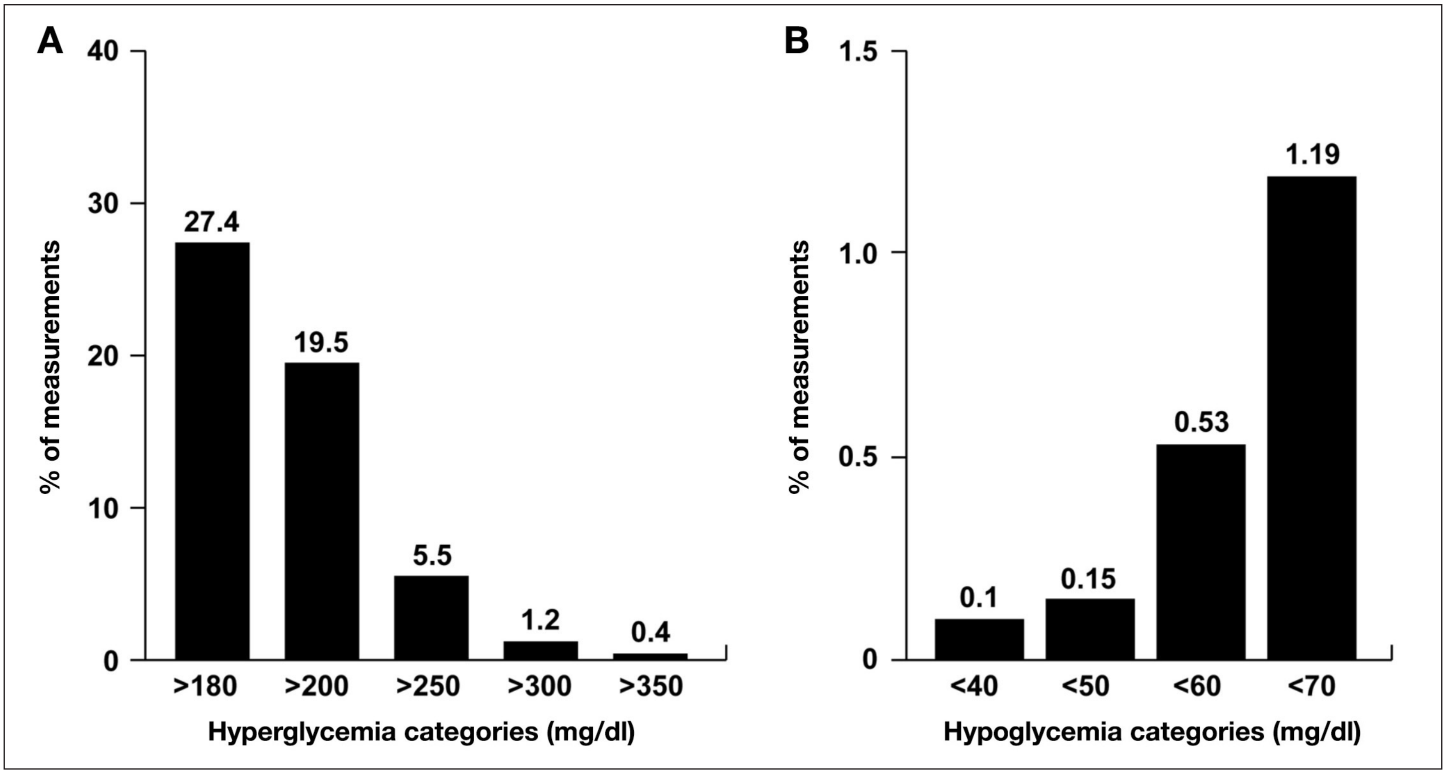

Figure 1. Percentage of per-person bedside glucose measurements with hyperglycemia **(A)** and with hypoglycemia **(B)**.

Overview of Hyperglycemia Therapy

Nearly 90% of cases were on insulin while hospitalized (**Table 2**). However, over one-third did receive oral agents as well, either alone or in combination with insulin, and a minority received no treatment for hyperglycemia. Among those on insulin therapy, the majority were managed with short-acting insulin only (**Table 2**).

Relationship of Insulin Therapy to Severity of Hyperglycemia

Changes in hyperglycemia treatment were evaluated according to the severity of glucose control as defined by tertile cut points. First we examined changes in insulin regimen that occurred in response to increasing frequency of glucose measurements >180 mg/dl (**Figure 2**A). A significant change in the use of insulin was detected as the average number of hyperglycemic values increased ($p < .01$). Specifically, use of the basal plus short-acting insulin regimen increased from 8% in the first tertile to 18% in the third. However, despite this greater delivery of basal plus short-acting insulin to cases with more frequent hyperglycemia, nearly 70% of cases in the highest tertile remained on short-acting insulin alone and 12% received no insulin therapy.

A similar pattern of insulin use was detected when data were analyzed according to $\text{BedGluc}_{\text{avg}}$ (**Figure 2B**), with significant differences in regimens detected across groups ($p < .01$). Although a basal plus short-acting insulin program increased from 10% to 18% from the first to third tertiles of hyperglycemia, 70% of cases still remained on short-acting insulin only and 12% received no insulin.

For cases in the highest tertile and on short-acting insulin alone, all but one case was on correction insulin only, with the remaining one on prandial plus correction. Use of

Table 2.
Overview of Inpatient Hyperglycemia Treatment Strategies for 119 Postoperative Surgical Cases with Diabetes

Treatment strategy	Number (%)
Therapy type (n = 119)	
None	12 (10)
Oral	3 (3)
Oral plus insulin	37 (31)
Insulin	67 (56)
Insulin regimen (n = 104)	
Short acting only	83 (80)
Basal plus short acting	21 (20)

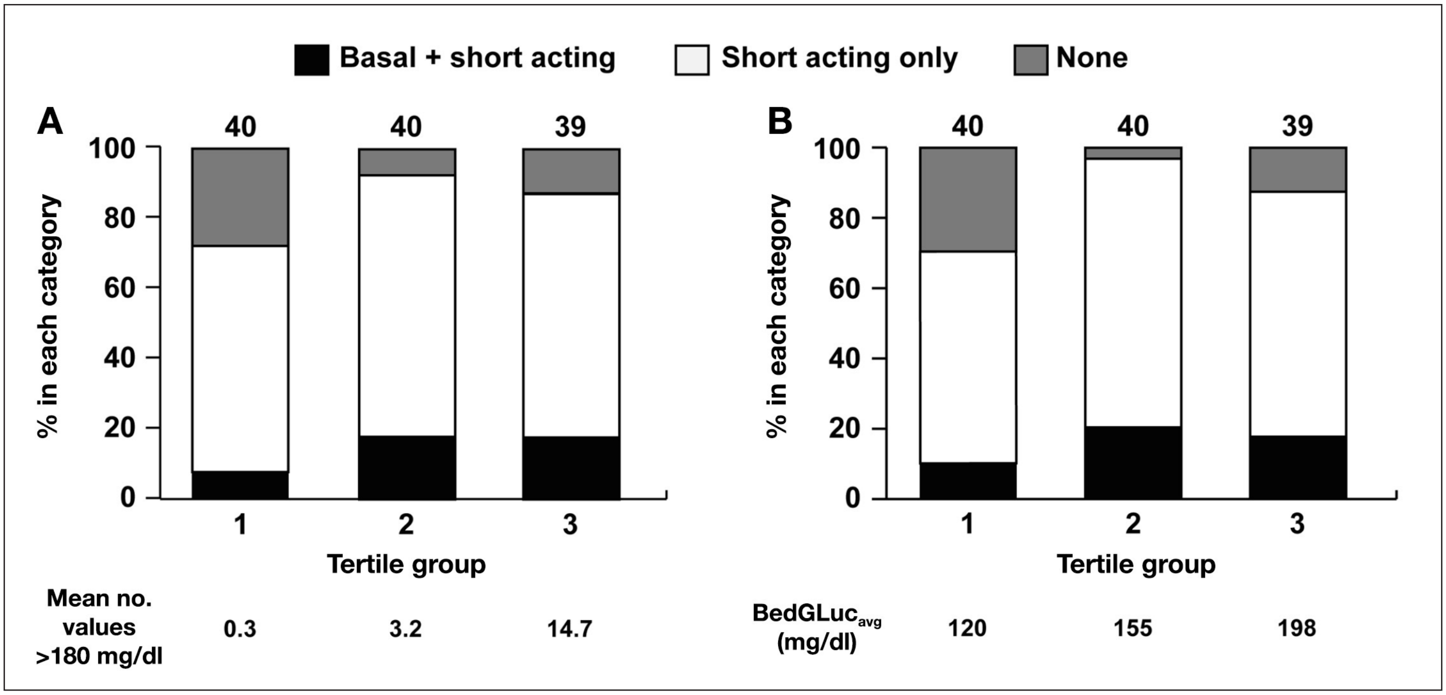

Figure 2. Changes in insulin regimen according to tertiles based on the number of bedside glucose measurements >180 mg/dl **(A)** and according to the patient stay mean point-of-care glucose (BedGluc$_{avg}$; **B**). Numbers on top of bars indicate numbers of cases in each tertile.

oral agents remained constant across tertiles ($p > .3$), with 34% of cases in the highest tertiles of hyperglycemia receiving oral agent therapy for hyperglycemia.

Discussion

Current recommendations advocate use of basal insulin in conjunction with a short-acting insulin to compensate for meals and high glucose levels.[10,11] Even when not eating, and regardless of cause of hyperglycemia (e.g., steroid use, enteral feeding), patients with glucose values above recommended levels should have a basal insulin to control hyperglycemia. The surgical patient population with diabetes is of particular interest given the relationship between hyperglycemia and patient outcomes.[1–6] Data on how surgical services are applying insulin therapy in the postoperative patients, however, is limited.

This analysis demonstrated that hyperglycemia is common among those patients with a length of stay ≥3 days and solely managed by the surgical teams, with over one quarter of glucose values being >180 mg/dl. Overall, there was a move toward using insulin to treat hyperglycemia during the postoperative period. Review of outpatient treatment revealed that approximately 60% of patients were managed with oral agents, either alone or in combination with insulin, whereas approximately one-third of the patients received insulin. Once patients were hospitalized, use of oral agent therapy decreased to about one-third of cases during hospitalization, whereas overall insulin administration increased to nearly 90%. These were positive therapeutic changes that, in general, moved toward guidelines on limiting the use of oral hypoglycemic medications among hospitalized patients with diabetes and substituting with insulin therapy instead. At the same time, measured hypoglycemic events were extremely rare, with only approximately 1% of per-patient glucose measurements being <70 mg/dl.

Although these latter findings suggest that practitioners were responding to the severity of hyperglycemia by changing pharmacotherapy, further examination of the data suggests that a substantial number of patients did not have insulin therapy intensified to the more effective basal plus short-acting regimen despite evidence of ongoing hyperglycemia—evidence of clinical inertia. A substantial number of cases in the highest tertile of glucose values were treated with correction insulin alone, and approximately one-third remained on oral agents—both antiquated and ineffective regimens to control hyperglycemia, particularly severe hyperglycemia.[12,13] The findings in this study are consistent with earlier observations on the general inpatient diabetes population at our institution,[19] and now specifically confirm them among surgical patients with diabetes.

The findings in this analysis must be taken in the context of the institution's overall efforts at improving inpatient glucose control. For instance, a multidisciplinary subcommittee has been promoting guidelines for inpatient diabetes care and providing related educational activities to all hospital staff since 2006, including access to an online simulation course on inpatient diabetes management for use by internal medicine and surgical residents.[23] Studies by others have shown that a combination of structured insulin orders combined with staff education to partially alleviates clinical inertia in the hospital.[24–29] Our facility implemented computerized order entry in 2007 that includes provisions to order basal, prandial, and correction insulin treatment that are accessible to all practitioners. However, despite all these efforts at our institution, clinical inertia remains evident among the inpatient surgical practices.

Consequently, other strategies to assist the surgical services in the management of inpatient hyperglycemia are needed. Previous studies have proposed and shown the benefit of a specialized care team in the management of inpatient diabetes and of overcoming clinical inertia.[30–32] Given the impending shortfall in the U.S. endocrinology workforce,[33] other medical specialties may not be able to depend in the future on the availability of these experts to assist with the management of their inpatient diabetes cases. The type of strategies introduced to assist physicians in overcoming clinical inertia in the hospital may depend on the specialty or type of service, as experience or expertise will vary.

Another approach to improve inpatient diabetes care could be to train a cadre of advanced level practitioners trained in diabetes management to provide support specifically to the surgical services.[34–37] Beginning May 2012, we implemented a quality improvement program using a nurse practitioner trained in inpatient diabetes management who is dedicated to the surgical services, with the aim of increasing use of basal and short-acting insulin regimen. Final data collection was completed March 2013.

There are some limitations to this analysis. In addition to the small size of the final analytic sample, the retrospective review of electronic records does not allow assessment of the reasons underlying the decision-making behavior of clinicians (e.g., why they did or did not change therapy). Guidelines propose targets for both preprandial glucose (<140 mg/dl) and random glucose (<180 mg/dl) in the hospital.[10,11] However, the varying nature of nutritional support used in the hospital that can change from day to day or even throughout the day make preprandial and postprandial glucose measurements difficult to differentiate in retrospective electronic data. Consequently, we chose to analyze treatment changes according to glucose measurements >180 mg/dl (the random target cutoff) and according to the patient stay mean ($BedGluc_{avg}$) values.

Finally, these data are specific to our institution. Nonetheless, it does serve as a baseline against which we can measure the impact of our quality-improvement efforts. It has been recommended that institutions develop standardized methods of assessing insulin use.[9] There is no consensus as to how to evaluate clinical inertia in the hospital. Given the lack of such guidance, the method of dividing the data into tertile groups and examining corresponding insulin use provides a useful approach to evaluating the extent of clinical inertia.[18,19] The analytic approach here is one method of assessing clinical inertia, but others should be developed and evaluated.

In addition to providing further data on one method for assessing clinical inertia, it also outlines a model to examine quality of care in this high-visibility group of patients. Additionally, these data have provided important insights into the characteristics of surgical patients with coexisting diabetes, their level of inpatient metabolic control, and the therapeutic strategies currently in use by surgical services for management of hyperglycemia. Use of a recommended basal plus short-acting insulin therapy modestly increased with worsening hyperglycemia, but a substantial number of cases remained on an antiquated short-acting regimen despite hyperglycemia. Strategies for overcoming inpatient clinical inertia in the postoperative patient with diabetes need to be devised so that glucose control can be improved and outcomes optimized.

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