Pharmacists' Impact on Glycemic Control Among Surgical Patients at a Large Academic Institution

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Hyperglycemia has been associated with poor outcomes in several large studies. Repeated or prolonged hyperglycemia has been linked to an increased risk of adverse outcomes, including limb amputation, acute myocardial infarction, prolonged length of hospital stay, and increased mortality, in various populations (1–4). Suspension of oral antidiabetic agents in anticipation of procedures for which oral nutritional intake is contraindicated, along with insulin resistance resulting from acute illness, often leaves patients without proper glucose control when admitted to the hospital.

The National Quality Forum (NQF), a not-for-profit organization, supports evidence-based consensus standards to achieve better health outcomes. NQF endorses many Centers for Medicare & Medicaid Services (CMS) quality measures, which often affect reimbursement. This attempts to hold institutions accountable for providing quality patient care. Among these measures are standards focusing on patients presenting with heart failure, acute myocardial infarction, and pneumonia. Currently, serum glucose–related CMS measures have been developed but are not yet implemented; these measures include the average percentage of hyperglycemic and hypoglycemic hospital days. More information about these measures can be found on the NQF's website (http://www.qualityforum.org).

With an increasing focus on quality and outcomes measures, the need exists to quickly identify hyperglycemic patients and initiate appropriate interventions. Optimization of insulin therapy requires careful assessment of multiple patient-specific factors, including nutritional intake, prior insulin requirements, and concomitant medications (5). With knowledge of drug therapy, drug preparation, and dispensing, pharmacists are well situated to be involved in many aspects of glycemic management in the inpatient setting (6). Clinical pharmacist participation in rounds and surveillance of prescribing patterns can optimize serum glucose management (5–7). This single-center, prospective, observational cohort study aimed to evaluate the impact of dedicated clinical pharmacy services on serum glucose management among high-risk surgical inpatients.

Methods

At the University of California, San Francisco (UCSF) Medical Center, clinical pharmacists are asked to review an online educational module developed by the UCSF Diabetes Committee and pass a multiple-choice competency exam. The educational module includes information regarding diabetes, serum glucose goals for hospitalized patients with diabetes, various types of insulin, and adjustment of insulin doses, as well as case examples and interactive case studies. Service-based clinical pharmacists participate in interdisciplinary rounds for most services. Among the surgical services, Orthopedic Surgery, Neurosurgery,

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and General Surgery Services have dedicated clinical pharmacist participation on acute and intensive care units; Vascular, Urology, and Plastic Surgery services have dedicated clinical pharmacist participation only if patients are admitted to the intensive care unit (ICU). Rounding pharmacists provide verbal recommendations daily to primary teams. However, documentation of such recommendations is optional, not required.

At UCSF Medical Center, serum glucose monitoring and insulin may be prescribed in the electronic medical record utilizing a variety of insulin management orders. Patients receiving parenteral or enteral nutrition receive serum glucose monitoring every 4 hours. Among patients taking nutrition orally, serum glucose is monitored five times per day—before meals, at bedtime, and at 2:00 a.m. In addition to an insulin sliding scale with doses varying based on insulin sensitivity, fixed doses of mealtime insulin may also be ordered.

Patients ≥18 years of age with persistent hyperglycemia from 26 November 2012 to 21 January 2013 were eligible for inclusion if they were admitted to a surgical service with a dedicated clinical pharmacist and did not have a formal endocrinology consult within the first 72 hours of evaluation. Persistent hyperglycemia was defined as two or more episodes of serum glucose >180 mg/dL within a 24-hour period. Patients were followed for up to 7 days after inclusion or for <7 days if they received a formal endocrinology consultation, were discharged, or were transferred to another service.

The primary endpoint was the proportion of serum glucose values >180 mg/dL per day over time. Secondary endpoints included the number of patients with a daily median serum glucose value >180 mg/dL, the proportion of serum glucose values >225 mg/dL per day over time, the number of hypoglycemic events, and the number of documented pharmacist recommendations. A hypoglycemic event was defined as a serum glucose value <70 mg/dL and/or administration of dextrose or glucose for symptoms of hypoglycemia. Pharmacist recommendations included verbal recommendations to initiate, discontinue, or adjust insulin or oral antidiabetic agents. However, documentation of pharmacist recommendations remained optional throughout the study, and the specific types of recommendation made were not captured.

Categorical variables were compared using the Fisher's exact test or Pearson's χ^2 test, as appropriate. A linear mixed-effects model was used to assess the proportion of serum glucose values >180 and >225 mg/dL over 7 consecutive days (8).

Results

Eighty patients were included. These patients included a high proportion of patients admitted to the ICU (42.5%) and receiving parenteral nutrition (12.5%), enteral nutrition (12.5%), or systemic corticosteroids (35%) (Table 1). On the day of inclusion (day 0), the average serum glucose among all patients was 208 mg/dL, and 63.8% of patients had a median serum glucose >180 mg/dL (Table 2). By the end of the fol-

TABLE 1. Baseline Characteristics

Parameter	Patients (*n* = 80)
Age (median years [IQR])	65.5 (56.8–73.3)
Female (*n* [%])	27 (34)
Average BMI (kg/m^2 [IQR])	28.6 (25.4–35.6)
Service (*n* [%])	
Orthopedic	13 (16)
Neurosurgery	13 (16)
General surgery	20 (25)
ICU	34 (43)
Dialysis (*n* [%])	3 (4)
Parenteral nutrition (*n* [%])	10 (13)
Enteral nutrition (*n* [%])	10 (13)
Systemic corticosteroids (*n* [%])	28 (35)
Parenteral or enteral nutrition or systemic corticosteroids (*n* [%])	42 (53)
Baseline serum glucose (mean mg/dL [SD])	208 (46)

IQR, interquartile range

TABLE 2. Serum Glucose Characteristics Over Time

	Evaluable Patients (*n*)	Patients With Serum Glucose >180 mg/dL (*n* [%])	Average Serum Glucose (mg/dL [SD])
Day 0	80	51 (64)	208 (45.6)
Day 1	80	39 (49)	189 (43.3)
Day 2	80	28 (35)	177 (41.7)
Day 3	76	24 (32)	176 (40.7)
Day 4	61	19 (31)	175 (44.0)
Day 5	55	18 (33)	179 (47.4)
Day 6	48	16 (33)	176 (44.7)
Day 7	42	8 (19)	165 (32.8)

low-up period, 33 patients had been discharged, 4 had received an endocrinology consultation, and 1 was transferred to a nonsurgical service, leaving 42 evaluable patients on day 7. The average serum glucose among patients with a dedicated clinical pharmacist decreased by 5.0 mg/dL per day (P <0.01) (Table 2). Over 7 days, the average proportion of serum glucose values >180 mg/dL decreased 4.5% per day (P <0.01), and the average proportion of serum glucose values >225 mg/dL decreased 2.2% per day (P <0.01).

A total of 2,893 serum glucose values were recorded for all patients. Of these, there were 15 discrete hypoglycemic events among 12 patients, equivalent to 2.85 hypoglycemic events per 100 patient-days. Eight of the 12 patients were in the ICU during the hypoglycemic event. Five patients were receiving parenteral or enteral nutrition. Of these five patients, three hypoglycemic events were related to discontinuation of parenteral or enteral nutrition without adjustment of standing insulin orders.

Documentation of pharmacist recommendations was not required. However, pharmacists documented 39 recommendations. Of the 39 recommendations, 28 (71.8%) were accepted. Twenty-one (53.8%) of these recommendations occurred within the first two days of inclusion in the study. Eight patients received more than one documented recommendation, and 64 patients had no documented pharmacist recommendations. The majority of documented recommendations (76.9%) were for patients in the ICU. Types of recommendations and reasons for rejection of recommendations were not captured. No hypoglycemic events were directly linked to a documented pharmacist recommendation. Subgroup analyses of recommendations were not possible because of the low number of documented recommendations relative to patient-days.

Discussion

This study demonstrates the potential effect of clinical pharmacist participation in the management of serum glucose in the inpatient setting. The proportion of serum glucose values >180 mg/dL per day decreased over time among this high-risk patient population. Parenteral nutrition, enteral nutrition, and systemic corticosteroids are factors that have been associated with inpatient hyperglycemia, and patients receiving these represent a population requiring careful serum glucose monitoring and therapy adjustment (9–11). Despite these factors, patients on services with a dedicated clinical pharmacist still had a statistically significant improvement in serum glucose over time. This observation may be a result of pharmacist collaboration with providers and nurses, which has been well documented (7,12–15).

There were several limitations to our study. First, given the service-based nature of the pharmacy model, we were unable to provide an appropriate control group. Surgical services at UCSF without a dedicated clinical pharmacist include acute care patients on the Urology, Plastic Surgery, and Vascular services. These services are vastly different from services with a dedicated clinical pharmacist. The admitting diagnoses of many of the General Surgery patients included such issues as necrotizing pancreatitis, pancreatic carcinoma, and morbid obesity, whereas most patients on the Urology, Plastic Surgery, or Vascular services were admitted for elective procedures. Because an appropriate comparator group was not present, the study's ability to directly assess the role of pharmacists was limited. Additionally, there was limited information captured with regard to pharmacy-specific recommendations; we were only able to capture recommendations documented in the pharmacy intervention database. Because documentation of recommendations was not required, the true number of recommendations may have been higher than the number of those recorded. Finally, the linear mixed-effects statistical model was unable to account for potential variations in serum glucose between readings. Consequently, the average or median serum glucose values reported may not accurately represent the patients' serum glucose levels throughout the study period.

As hospitals shift their attention to improving processes and patient outcomes, administrators will need to allocate resources appropriately to ensure that performance measures are achieved. Hospitals can maximize their efforts by identifying patients at risk for hyper- and hypoglycemia. Pharmacists are well trained to focus on performance measures related to serum glucose. By tasking pharmacists with initiatives that aim to improve the management of serum glucose, resource-limited hospitals can maximize the role of their pharmacists.

Despite having a complicated patient population among services with a dedicated clinical pharmacist, our study observed a significant decrease in the proportion of serum glucose values >180 and >225 mg/dL per day. Standardizing and focusing pharmacist recommendations on serum glucose control among high-risk populations may help to improve patient care. Further studies assessing the direct impact of pharmacists' recommendations on changes in serum glucose are required.

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Duality of Interest

No potential conflicts of interest relevant to this article were reported.

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