

ORIGINAL RESEARCH & CONTRIBUTIONS

Pharmacist Glycemic Control Team Improves Quality of Glycemic Control in Surgical Patients with Perioperative Dysglycemia

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Abstract

Context: Perioperative hyperglycemia is a risk factor for increased morbidity and mortality. Improved glycemic control has been demonstrated to reduce surgical site infections, reduce perioperative morbidity, and reduce length of stay. However, safe and effective perioperative glycemic control can be limited by expert clinician availability.

Objective: To improve quality by reliably providing safe and effective glycemic control to surgical patients with diabetes or stress hyperglycemia.

Design: A designated group of pharmacists, the Glycemic Control Team (GCT), worked under protocol, on a consultation basis, to manage perioperative dysglycemia during hospitalization.

We used a pre-post, observational study design to assess the effectiveness of the intervention and implementation of the GCT.

Main Outcome Measures: The proportion of patients pre- and postintervention with good glycemic control and with hypoglycemia were measured and compared. We defined good glycemic control as having all, or all but one, point-of-care blood glucose values between 70-180 mg/dL in each 24-hour period. We defined hypoglycemia as having any point-of-care test glucose value <70mg/dL in any of the 3 days evaluated.

Results: During the preimplementation period, 77.4% of postoperative patient days demonstrated good glycemic control. In the postimplementation period, this percentage increased to 90.3%. Over the same period, the rate of hypoglycemia decreased from 8.6% to 4.6%.

Conclusion: Implementation of a pharmacist team to manage glycemic control in hospitalized, postoperative patients led to safer and better quality of glycemic care as measured by improved glycemic control and lower rates of hypoglycemia.

Introduction

Patients with diabetes and stress hyperglycemia are hospitalized frequently for surgical procedures.¹ Although the primary reason for hospitalization is not related to acute glycemic problems, these patients require attention to safe and effective glycemic control care throughout hospitalization.² Improved glycemic control has been demonstrated to reduce surgical site infections, reduce perioperative morbidity, and reduce length of stay (LOS).³ Increasing evidence points to an association between hospital hyperglycemia and surgical outcomes.⁴⁻⁸ There is strong evidence that patients with hyper-

glycemia undergoing cardiac surgery and admitted to the Intensive Care Unit have an increased rate of deep sternal wound infection, hospital complications, and mortality,^{9,10} and that hospital complications, LOS, and mortality may be reduced with improved glycemic control. Also, after noncardiac surgery, perioperative hyperglycemia has been associated with postoperative infections,⁶⁻⁸ increased LOS, hospital complications, and mortality.¹ Although the benefits of intensive insulin therapy (targeting 80-110mg/dL) in critical care patients have recently come into question,¹¹⁻¹³ there is general agreement that moderate glycemic control targets are

beneficial and that surgical patients may be a population at lower risk for hypoglycemia and therefore potentially able to benefit more from moderate glucose control.¹⁴⁻¹⁷ One randomized controlled trial has recently reported that, in general surgery patients, the use of basal-bolus insulin regimens led to reductions in a composite of postoperative complications including wound infection, pneumonia, bacteremia, respiratory failure, and acute renal failure.¹⁸

Unfortunately, patients admitted to hospitals primarily for surgical services may not have optimal attention paid to glycemic control. Expertise in the recommended processes of care, and in prescribing and adjusting appropriate insulin regimens in patients with rapidly changing needs, may not be readily available to all surgical patients.

Delineation of Local Problem

At Kaiser Sunnyside Medical Center (KSMC), our data indicates that, since implementing universal screening for hyperglycemia of all patients admitted, approximately 40% have either a previous diagnosis of diabetes, or have at least 2 blood glucose tests >140 during their first 24 hours in the hospital. KSMC participates in the American College of Surgeons National Surgical Quality Improvement Program (NSQIP), the first nationally validated, risk-adjusted, outcomes-based program to measure and improve the quality of surgical care.¹⁹ In reviewing local NSQIP data, it was noted that our hospital had an unacceptably high rate of complications in patients with diabetes as opposed to patients without diabetes. A surgeon hypothesized that increased attention to screening for diabetes,

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prediabetes, and stress hyperglycemia with subsequent appropriate inpatient management of patients identified would improve rates of complications. In late 2006 and early 2007, KSMC implemented improved intraoperative and postoperative glycemic control in collaboration with the Anesthesiology Department, which led to an 81% reduction in all 30-day NSQIP-measured postoperative complications in general and vascular surgery diabetics, and a 50% reduction in these complications in “nondiabetics,” most of whom were found to have “prediabetes” (James Schwarz, MD; personal communication; 2011 Dec 21).⁴ However, provision of safe and effective glycemic control after patients were transitioned out of the care of anesthesiologists in the Post-Anesthesia Care Unit (PACU), was outside the scope of practice of most surgeons and the prior initiative. Hospitalist consultation for the volume of surgical patients in need of glycemic control was impractical, and, even when available, these consultants demonstrated practice variability in ordering safe and effective glycemic control regimens.

KSMC formed a multidisciplinary glycemic control workgroup (GCWG) in December 2006, to address the complex needs of hospitalized patients with diabetes or hyperglycemia. The GCWG is composed of pharmacists, hospitalists, surgeons, anesthesiologists, nursing representatives, administrators, dietitians, and inpatient certified diabetes educators. During the implementation period, we targeted overall clinical awareness and treatment of hospital hyperglycemia through staff and physician educational programs, guidelines, and order sets, as well as ongoing advocacy by local physician champions in the Hospitalist and Surgery Departments. Patients with diabetes and stress hyperglycemia continued to receive suboptimal care and our quality analyses identified a number of perceived barriers. Using continuous quality improvement methodology, barriers were explored further and generally fell into the categories of “insufficient clinical knowledge or experience with prescribing insulin regimens” or “insufficient time to pay attention to the complex and often-changing needs of patients with diabetes and/or hospital hyperglycemia.”

Methods

To directly address these barriers, the GCWG explored various options and, in collaboration with the Hospitalist, Surgery, and Anesthesia Departments, and the Pharmacy and Therapeutics Committee developed a group of inpatient pharmacists under the auspices of the Glycemic Control Team (GCT). The team primarily was designed to provide glycemic control consultation to surgeons.

Protocol Development and Training of the Glycemic Control Team Pharmacists

The GCT protocol²⁰ was created by the pharmacy clinical coordinator who worked closely with physicians experienced in inpatient diabetes management from the Endocrinology, Hospitalist, and Surgery Departments, using principles defined by guidelines from the medical literature.^{2,17,21-23} The protocol was designed to direct the safe and appropriate use of intravenous and subcutaneous insulin in surgical and medical patients with diabetes, or at risk for or demonstrating hospital hyperglycemia. Important components of the protocol included recommendations on when to begin and discontinue intravenous insulin, how to transition from intravenous therapy, how to calculate subcutaneous insulin doses, how to adjust insulin doses, when to resume oral agents, how to manage patients on tube feedings and total parental nutritional, and discharge planning. The GCT protocol allows the GCT pharmacist to provide comprehensive inpatient glycemic management. In addition to writing and adjusting daily insulin orders, the GCT can also order relevant labs (eg, serum creatinine, HbA_{1c}), place consultation requests for the registered dietitian and the certified diabetes educator, and via verbal collaboration with clinicians place outpatient orders for insulin and diabetic supplies (glucometer, lancets, test strips, insulin syringes). The protocol was approved by the hospital Pharmacy and Therapeutics Committee and is regularly reviewed and updated to reflect current evidence from the medical literature, current practice and systems issues, expanded services, full scope of practice, and additional needed details (Inpatient Pharmacy Manual: Glycemic Control Protocol [2/12] available online at: [\[tejournal.org/files/Winter2012/Inpatient-PharmacyManual.pdf\]\(http://tejournal.org/files/Winter2012/Inpatient-PharmacyManual.pdf\)\).²⁰](http://www.thepermanen-</p>
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Training of the GCT pharmacists was completed through lectures by physicians (endocrinologist, surgeon, and hospitalists) and various online resources (presentations, lectures, and articles). Training included: how to manage inpatient hyperglycemia with subcutaneous and intravenous insulin and provided an in depth review of diabetes, stress- and steroid-induced hyperglycemia and hypoglycemia management, and the evidence supporting prevention and treatment of inpatient hyperglycemia. All GCT pharmacists completed a competency examination, developed by the lead GCT pharmacist, to ensure they were competent to prescribe inpatient insulin regimens.

We implemented the GCT in January 2009. A GCT pharmacist was available by pager or electronic order entry 7 days a week, 10 hours a day, to all surgical patients in need of perioperative glycemic control. On average they were able to consult on 15 to 20 patients per day. After-hours consults were deferred until the following morning. The inpatient pharmacy GCT initially trained 5 full-time GCT pharmacists and 1 part-time GCT pharmacist, who would rotate to the glycemic control service. By June 2010, the GCT had grown to 6 full-time pharmacists, 2 part-time pharmacists, and an additional 5 cardiovascular pharmacists. During the first several months, the GCT received consultation requests on just a few patients a day, which increased to 25 to 30 patients a day after 4 to 6 months, and a second 10-hour GCT pharmacist shift was added. Physicians noticed the work of the GCT and wanted their patients' hyperglycemia managed by the GCT. At this point, inclusion/exclusion criteria were developed to help limit the number of inappropriate consultation requests, which created a more manageable workload to provide safe and effective care. The team currently sees 20 to 35 patients in a typical day. Some other surgical patients are seen instead by the physicians in the Hospitalist or Critical Care Departments.

Daily Duties and Workflow

After reviewing the patient's chart and meeting with the patient's nurse, the GCT pharmacist enters insulin orders into the

electronic medical record (EMR) order entry system. Kaiser Permanente (KP) has a developed EMR that integrates inpatient and outpatient records, thus simplifying chart review. All of the following are available to the GCT pharmacist: the point-of-care-test (POCT) glucose results, laboratory test values, electronic medication administration record, all clinician notes, and outpatient records (including medication orders, chart notes, and laboratory test results). After entering necessary orders for all patients, the GCT pharmacist meets with most of the patients to obtain important history from new patients or, especially for patients without known diabetes, to explain why blood glucose is tested, and why they are receiving insulin during their hospitalization. The GCT pharmacist also gathers home blood glucose control information and identifies barriers to good outpatient control. Education is provided to patients with newly diagnosed diabetes or patients at high risk of developing diabetes. The certified diabetes educator, dietician, and the patient's nurse are involved when appropriate. Finally, the GCT pharmacist documents a structured daily electronic progress note on each patient.

Discharge from the Hospital

Discharge glycemic control needs are addressed as early in the hospitalization as clinically feasible to allow for needed patient education and planning patients' transition regimens. Patients without discharge needs (ie, patients without diabetes or with resolved stress hyperglycemia, or patients with known diabetes with good control on their prior-to-admission regimen) are discharged without novel GCT interventions. Patients who have discharge needs (eg, patients with new insulin starts or patients with poor control) receive intervention by the GCT pharmacist and coordination of care with the health care team. Patients receive extensive education from the GCT pharmacist, the patient's nurse, the registered dietician, and the certified diabetes educator, as needed. In general, the GCT is responsible for: communicating the discharge plan to the patient; providing basic education and reviewing signs or symptoms of hypoglycemia and its management; constructing a discharge instruction sheet for new insulin starts or if

significant changes were made to the home insulin regimen; obtaining authorization from the attending physician regarding the discharge plan; entering discharge orders for outpatient regimens when indicated; electronically routing progress notes to the primary care physician, communicating with floor nurses to provide glucometer teaching (if indicated); and communicating with the certified diabetes educator who provides more in-depth, individualized diabetes education to the patient and/or caregiver when needed.

Evaluation of Effectiveness

When implementation dates of the GCT were determined, we developed a plan to collect and analyze data on its effectiveness in the surgical population in collaboration with researchers and analysts from KP's sister institution, the Center for Health Research. Our evaluation question was: Would implementing a consultation-based, pharmacist-staffed GCT improve glycemic control measures in surgical patients at KSMC?

We used a pre-post, observational study design to test the effectiveness of the intervention. The preimplementation period included the 12 months before the GCT implementation: January 1, 2008 through December 31, 2008. The postimplementa-

tion period, after the GCT team was fully implemented at KSMC, included the 12 months from July 1, 2009 through June 30, 2010. A 6-month, January-to-July 2009 gap was chosen to increase internal validity. The target population was identified by including all patients with 2 or more POCT glucoses during each index PACU admission. Thus we identified a study population of surgical patients at risk for perioperative dysglycemia at KSMC. This design should generate high external validity at managed care organizations structured like KSMC, but the results may not generalize to other populations or care delivery settings.

We conducted an observational, data-only quantitative analysis. All data elements used for the analysis were obtained from the KP Northwest EMR, which produces valid and reliable information and has been used extensively in quality evaluations and research published in peer-reviewed journals. We used χ^2 analysis to assess differences in glycemic control metrics between the postimplementation period versus the preimplementation period. We defined good glycemic control as having all, or all but one, POCT blood glucose values of 70 mg/dL to 180 mg/dL in each 24-hour period with day 1 defined as the

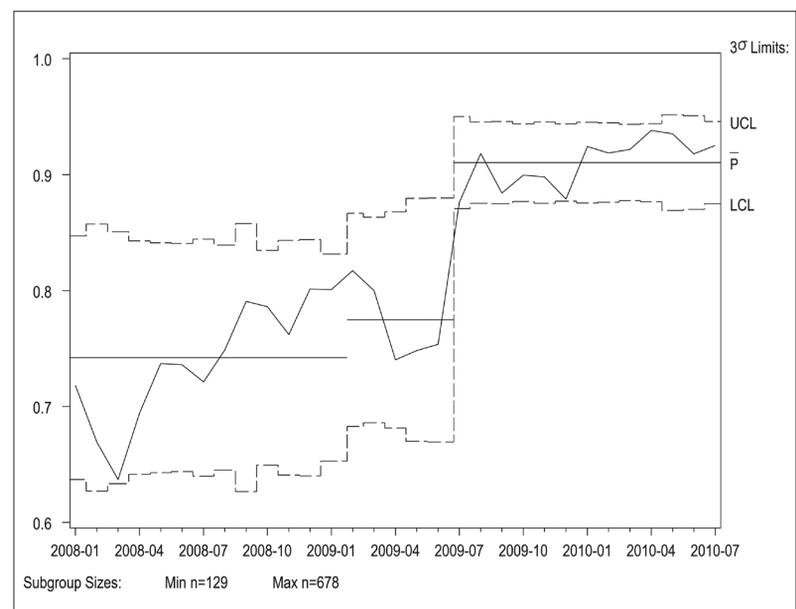


Figure 1. Proportion of postoperative patients with good control (70 mg/dL to 180 mg/dL) before, during (ramp-up period), and after implementation of the Glycemic Control Team at the Kaiser Sunnyside Medical Center.

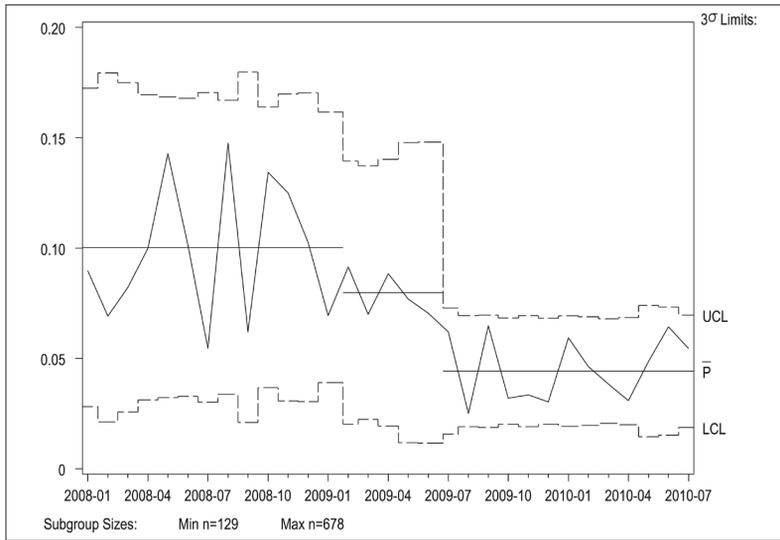


Figure 2. Proportion of postoperative patients with hypoglycemia (<70 mg/dL) before, during (ramp-up period), and after implementation of the Glycemic Control Team at the Kaiser Sunnyside Medical Center.

date of the surgical procedure. We defined hypoglycemia as having any POCT glucose value <70mg/dL in any of the 3 days evaluated. The unit of analysis for glycemic control measures occurred at the POCT level.

To account for the effect of potential confounders, we further performed logistic regression to measure the independent effect of the GCT intervention on glycemic control. Using our pre-post quality evaluation, we used multivariate modeling to assess the efficacy of the GCT intervention, adjusting for potential confounders identified by EMR extraction including: age, gender, severity of illness (constructed via Charlson Comorbidity Index²⁴), health care use, race and ethnicity (approximated via census information), poverty status (approximated via census information), surgery

type (eg, general, orthopedic, urology, etc), and LOS of index hospital admission. This quality-improvement project was reviewed and approved by the Center for Health Research institutional review board.

Results

A total of 1294 unique patients in the preintervention period and 4842 unique patients in the postintervention period were analyzed to assess glycemic control. During the preimplementation period, 77.4% of patient days of patients admitted to the PACU during their hospitalization were in good glycemic control (70mg/dL to 180 mg/dL) on postoperative days 1 to 3. In the postimplementation period, this percentage increased to 90.3% (Figure 1). During the same period, rates of hypoglycemia (<70 mg/dL) decreased, from

8.6% to 4.6% of patient days (Figure 2). The number of severe hypoglycemia (<40mg/dL) events was very low, at 1.5% of patient days preintervention, but also fell in the postimplementation period to 1.0% of patient days.

Table 1 summarizes the multivariate logistic regression analysis for the post-implementation versus the preimplementation periods adjusted for age, gender, severity of illness (constructed via Charlson Comorbidity Index), health care use, race and ethnicity (approximated via census information), poverty status (approximated via census information), surgery type (eg, general, orthopedic, urology, etc), and LOS of index hospital admission. The logistic regression demonstrated persistence of improved glycemic control when adjusting for potential confounders; a higher proportion of perioperative patients achieved good glycemic control on day 1 (odds ratio [OR] 3.10, 95% confidence interval [CI] 2.62, 3.67), and day 2 (OR 1.65, 95% CI 1.34, 2.04) after implementation of the GCT. Similarly, the modeling demonstrated that fewer patients experienced hypoglycemia (OR 0.34, CI 0.28, 0.40) during the postimplementation period.

The results of our analysis demonstrate that after implementation of a pharmacist-run GCT, measures of glycemic control improved and hypoglycemia events decreased in surgical patients. These results demonstrate that the GCT is meeting its goal of improving the safety and quality of care in patients with glycemic issues in the postoperative setting.

Discussion

The work of quality improvement seeks to minimize the “Implementation Gap,” or the observed difference between scientific understandings of what “should” happen to manage a specific disease state and what actually occurs during an episode of patient care. The National Quality Forum prioritized inpatient glycemic control as one of the 34 Safe Practices it recommends to optimize hospital care of patients, admonishing hospitals to “Take actions to improve glycemic control by implementing evidence-based intervention practices that prevent hypoglycemia and optimize the care of patients with hyperglycemia and diabetes.”²⁵

Table 1. Multivariate logistic regression for postimplementation Glycemic Control Team vs preimplementation Glycemic Control Team

Outcome Measure	Postimplementation GCT vs Preimplementation GCT		
	Odds Ratio	95% CI	P value
Glycemic Control Measures			
Good glycemic control (Day 1; N = 5888)	3.10	2.62, 3.67	<0.0001
Good glycemic control (Day 2; N = 2763)	1.65	1.34, 2.04	<0.0001
Good glycemic control (Day 3; N = 1941)	1.21	0.96, 1.54	0.1129
Hypoglycemia (any POCT < 70, Day 1-3; N = 5935)	0.34	0.28, 0.40	<0.0001

CI = confidence interval; GCT = Glycemic Control Team; POCT = point of care test

Our institution identified a typical quality problem: implementation of known best practices was suboptimal because of systemic barriers, which were only revealed by continuing to engage in quality-improvement processes (such as keeping run charts of glycemic control metrics, walk-throughs, root cause analyses, and interviews with frontline staff and physicians). KSMC's GCWG actively sought a solution to further improve the quality

of care for the dysglycemic surgical population. We sought to break down the barriers of limited time and expertise in inpatient glycemic management of surgical patients. The results of our analysis demonstrate that perioperative and postoperative dysglycemia can be better managed by developing a specific team of pharmacists whose sole task is to focus on inpatient glycemic management.

It is known that optimizing inpatient glycemic control can be expensive, labor intensive, and require significant effort in coordination of the services of many hospital divisions.^{26,27} However, this incremental expense has previously been shown to be cost-effective in a variety of settings.²⁸⁻³⁰ Given the current focus on efficiency in health care, it will be important to determine whether the improvements in glycemic control measures in the current study will result in measurable improvements in patient outcomes and utilization.

In the postimplementation period, there were many more patient days included per month. During the preimplementation period, approximately 175 patient-days were recorded each month; in the postimplementation period, the monthly volume was closer to 500 patient days. During the study period, the hospital did experience growth, particularly in operating room capacity, which explains some of the larger sample size in the postimplementation period. However, increasing attention to the benefit of perioperative glucose control led the hospital to begin POCT glucose testing on all patients in the PACU, so increased POCT testing to include a larger segment of the post-surgical population is a likely factor. As testing increased, it is possible that more patients who were already in good control

were included in the postimplementation group, inflating the overall average. This possibility, however, is not well supported by internal quality data later collected hospitalwide. In November 2010, KSMC implemented a policy to complete screening glucose testing on all patients. When the entire hospital rolled out universal glucose testing for all admitted patients, the hospital's rate of patient-days with good glucose control actually decreased, suggesting that it was not only patients in good control who were being newly tested. In the 10 months before universal hyperglycemia screening, the hospital as a whole averaged 73% of inpatients screened, and in-control patient-days averaged 72.7% hospitalwide. In the 3 months after implementing universal hyperglycemia screening protocols, the hospital screened 98% of all inpatients, and the overall level of control remained approximately stable at 71.3% in-control (Inpatient Pharmacy Manual: Glycemic Control Protocol [2/12] available online at: www.thepermanentejournal.org/files/Winter2012/InpatientPharmacyManual.pdf).²⁰

The pre-post design of our study was chosen because we did not think it would be desirable or ethical to randomize patients to receive attention from the team. A retrospective design was also considered, but we were concerned about selection bias in that it was likely that the GCT would be consulted more frequently on "sicker" or more "problematic" patients than on those "easy to control." Therefore, our study is limited as expected by its design, in that there are potential secular factors other than the intervention affecting the "post" period. Other quality-improvement activities, mainly spearheaded by the GCWG, were ongoing during the same period as implementation of the GCT. For instance, several physician and nurse education sessions were held. We publicized an Inpatient Glycemic Control Practice Resource and physician pocket card. We implemented Glycemic Nurse Champions, a group of nurses who participate in quarterly educational meetings and serve as nurse resource experts for each unit. Universal screening for hyperglycemia went live in November 2010. Finally, though it would be impossible to measure, we feel the "culture" of the institution has essentially changed in its attention to and appropriate

response to inpatient hyperglycemia. It is therefore likely that not all of the improvements measured preimplementation to postimplementation reflect solely the effect of the GCT pharmacists' work.

Lessons Learned

There were a few lessons learned as expected with any new program or clinical service. We intentionally did not initially communicate the existence of the GCT to all hospital staff because we wanted to start the program slowly to avoid being inundated with consultation requests and unable to manage high numbers of patients safely and effectively. There were several nuisances that arose because of lack of advertisement. Only a handful of surgeons and anesthesiologists knew of the program initially. Sometimes physicians would adjust insulin subcutaneous orders, not knowing that the GCT was managing the patient. Surgeons and their residents would sometimes inappropriately discontinue insulin infusion orders, not knowing that the GCT had been consulted, and this led to rebound hyperglycemia. We realized the scope of practice and protocols for the team must be clearly defined and disseminated. For example, maintenance intravenous fluids are out of the scope of practice for GCT pharmacists and orders for these were not included in the protocol, although surgeons sometimes assumed otherwise. We recommend optimizing communication to all stakeholders before implementation as an essential part of this type of quality-improvement intervention.

Future Directions

Currently there are plans to spread the learnings at KSMC regarding inpatient glycemic control to the rest of the Northwest Region. Our goal is to optimize the integrated nature of the KP system to provide consistent and standardized glycemic control care to all patients through the spectrum of their care experiences. The issue of safe transitions in developing a patient's glycemic control care plan is a next priority for the GCWG. We wish to optimize the opportunity to provide truly "seamless" medical care, leveraging resources such as our communications systems, integrated EMR, and outpatient care management programs. The ideal situa-

The GCT protocol allows the GCT pharmacist to provide comprehensive inpatient glycemic management.

tion of various team members being able to access and execute an individualized glycemic control plan from the preoperative setting (primary care physician's office or preoperative clinic visit), to the surgical preparatory unit, the operating room, the PACU, the floor, and to hospital discharge, has yet to be realized. Work is ongoing to attempt to hardwire appropriate transition processes surrounding the use of insulin in the perioperative setting as well as other transitions in the hospital (such as moving from critical care to the floor). The GCT pharmacists will continue to be key stakeholders in implementing improved processes to guide the patient through each of these transitions and in arranging the necessary continued care and follow-up after hospital discharge.

Because of good initial results, the GCT is being expanded and the roles are being redefined to allow each member of the health care team to maximally use their skills. We are proceeding with efforts to more clearly delineate each team member's role in patient education and engagement, including nurses, certified diabetes educators, registered dietitians, GCT pharmacists, and physicians to avoid duplication of effort and confusion for each patient. The GCT may then be able to expand work to manage some non-surgical patient populations with unmet glycemic control management needs in the hospital, such as oncology patients on high-dose steroid regimens.

Conclusion

Important components of implementation of the GCT included robust detection of hyperglycemia, knowledge of outpatient regimens and data via an integrated EMR, protocols surrounding use of insulin in various clinical situations, and ongoing cycles of process improvement involving input from a multidisciplinary group when problems are identified. Implementation of a pharmacist GCT improves the quality of inpatient glycemic control in perioperative patients, improving the proportion of patients in good control and reducing the rate of hypoglycemia. This improvement persists when adjusted for patient level factors such as demographics and severity of illness. ❖

^a Retired General Surgeon from Northwest Permanente.

Disclosure Statement

The author(s) have no conflicts of interest to disclose.

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