A Pharmacist-Led Practice to Improve Perioperative Glycemic Control in Elective Surgery

Nathaniel P. Morin

Quality Improvement Success Stories are published by the American Diabetes Association in collaboration with the American College of Physicians and the National Diabetes Education Program. This series is intended to highlight best practices and strategies from programs and clinics that have successfully improved the quality of care for people with diabetes or related conditions. Each article in the series is reviewed and follows a standard format developed by the editors of *Clinical Diabetes*. The following article describes an effort to facilitate the timely identification and treatment of pre- and postoperative hyperglycemia in people with diabetes having elective surgery at a tertiary care hospital in Calgary, Alberta, Canada.

Describe your practice setting and location.

The South Health Campus (SHC) is a tertiary care hospital located in Calgary, Alberta, Canada. It has ~275 inpatient beds and multiple outpatient clinics serving Calgary and Southern Alberta. SHC has team-based pharmacy services coverage, through which the same pharmacist team will cover an inpatient unit and that unit's corresponding outpatient clinic. For example, the inpatient cardiology pharmacist team also works in the hospital's outpatient cardiology clinic and the inpatient neurology pharmacist team also works in the neurology outpatient clinic.

Surgical pharmacist team members split their time between the inpatient surgical unit and the outpatient pre-admission clinic (PAC). In the PAC, people with planned surgery are seen by a team of internists, anesthesiologists, nurses, and pharmacists if they have complex medical conditions (e.g., coronary artery disease, inflammatory bowel disease on biologic drug therapy, active cancer, or an indication for anticoagulation therapy). This pre-surgery process is to ensure that patients are medically optimized before surgery and to provide recommendations for perioperative care to the surgeons.

In the PAC, patients with diabetes are given standardized recommendations based on internal guidelines pertaining to which oral antidiabetic medications should be taken or held on the morning of surgery and, if applicable, how to adjust their long-acting insulin the day of or night before surgery.

Describe the specific quality gap addressed through the initiative.

Before the initiative, the hospital's process for perioperative glycemic management for elective surgery was for patients with diabetes to have their blood glucose checked on arrival preoperatively with a point-of-care device at the same time check-in vital signs were recorded. If a patient's blood glucose was >10 mmol/L (180 mg/dL), indicating hyperglycemia during check-in, the admitting nurse would page the patient's anesthesiologist a notification and await treatment guidance. Regardless of hyperglycemia treatment, once the patient had surgery, the responsibility for postoperative glycemic management would pass to the patient's surgeon. A visual map of this process is provided in Supplementary Figure S1.

Alberta Health Services, Calgary, Alberta, Canada

Corresponding author: Nathaniel P. Morin, Nathaniel.Morin@ahs.ca

This article contains supplementary material online at https://doi.org/10.2337/figshare.21966665.

https://doi.org/10.2337/cd21-0139

This process of paging, waiting for call-back, and then passing the responsibility for glycemic management to a different practitioner resulted in low rates of treatment for preoperative hyperglycemia and delayed treatment of postoperative hyperglycemia. Often, the anesthesiologist being paged about a patient's preoperative hyperglycemia was actively managing a different patient in the operating room and unable to take the time to properly review the situation and treat the next hyperglycemic patient. Furthermore, different anesthesiologists had different opinions about what level of preoperative hyperglycemia warranted treatment and even how to treat preoperative hyerglycemia, which contributed to low rates of preoperative hyperglycemia treatment.

Postoperatively, treatment of hyperglycemia was sometimes delayed because the common practice of the surgeon teams was to order a correction scale for insulin from the hospital's basal-bolus insulin therapy (BBIT) order set, which instructed nursing staff to check blood glucose and correct hyperglycemia three times daily with meals. Depending on the time of day surgery ended and when this order was entered into a patient's electronic chart, a patient could have a blood glucose check immediately postoperatively, up to 6 hours later at the next meal, or not at all if the patient was discharged before the next meal.

Thus, the quality gap we identified and addressed in this initiative was that glycemic management on the day of surgery was reactive, fragmented, not evidence-based, and not standardized.

How did you identify this quality gap? In other words, where did you get your baseline data?

Surgical pharmacist team members identified the gap in perioperative glycemic management through their experience working in both the PAC and the inpatient surgery unit. They frequently saw the same patients before and after surgery, reviewed their own recommendations for day-of-surgery glycemic management, and noted that those recommendations had not been implemented.

As part of the quality improvement (QI) process, data were collected starting 3 months before the pharmacists implemented their new practice process as a baseline.

Summarize the initial data for your practice (before the improvement initiative).

For patients with type 1 or type 2 diabetes having planned day surgery within 6 months of being seen in the PAC, only 8% of those with preoperative hyperglycemia received treatment, 54% of patients had their blood glucose checked postoperatively, and 16% of those with postoperative hyperglycemia received treatment for it.

What was the time frame from initiation of your QI initiative to its completion?

This QI initiative had no defined time frame and is ongoing to further improve perioperative glycemic control at SHC. This assessment encompasses the period from November 2018 to September 2021.

Describe your core QI team. Who served as project leader, and why was this person selected? Who else served on the team?

The pharmacist who championed this new practice process acted as project leader and involved the other surgical pharmacists, the site's anesthesia and surgery department lead physicians, PAC internal medicine and anesthesia lead physicians, the day surgery and post-anesthesia recovery unit clinical nurse educators and managers, as well as pharmacy services management.

Describe the *structural* changes you made to your practice through this initiative.

In 2017, after obtaining stakeholder approval, the surgery pharmacist team created a process to proactively manage perioperative blood glucose for PAC patients with diabetes. This practice relied on the pharmacists' expanded scope of practice in Alberta, Canada, to prescribe medication, as well as their expertise in perioperative medicine. All patients having planned surgery at SHC were admitted through the day surgery department, but may have either been moved postoperatively back to the day surgery department for same-day discharge, admitted to one of three inpatient units depending on their type of surgery, or moved to the intensive care unit, if needed. The pharmacist team felt that it was important to design the new practice process to fit into current workflows across all locations to reduce the need for additional staff education or new certifications. During the creation and initial implementation of the process, the pharmacist team held meetings and educational sessions as well as distributed educational materials to surgical, anesthesiology, PAC, nursing, and pharmacy stakeholders. This was to ensure buy-in and seamless integration of the new practice. Copies of these materials are available upon request.

In November 2018, the surgery pharmacist team members working in the PAC started their new practice of prescribing one-time preoperative insulin correction scales (pre-op scale practice) for any patients with diabetes they saw in the PAC who they judged to be at risk for having preoperative blood glucose levels >10 mmol/L (180 mg/dL). To assess patients, the pharmacists reviewed each patient's baseline blood glucose control based on their A1C trend in the previous 12 months and their antidiabetic medications, with the knowledge of which medications would be held for surgery based on internal guidelines. The pharmacists then interviewed patients in the clinic to assess their typical fasting blood glucose levels, eating habits, hypoglycemia history, medication changes, and other relevant factors. Based on their assessments, the pharmacists relied on their professional judgment to prescribe pre-op scales as needed, after obtaining patients' informed consent.

A research project was also completed in the PAC to assist in pharmacist decision-making regarding their pre-op scale practice (1). During the PAC appointments, patients' insulin correction scales were prescribed into their future surgery's electronic chart to activate on their arrival. To determine the correction scale insulin dose, the pharmacists first calculated their patients' insulin sensitivity using the American Association of Clinical Endocrinologists/American College of Endocrinology Insulin Pump Management Task Force formula of 1,700/total daily insulin dose (TDD) converted to standard international units (94/TDD) and then rounded for ease of use to 100/TDD (2). The dose calculation then used the TDD calculation from the RABBIT 2 (Randomized Study of Basal Bolus Insulin Therapy in the Inpatient Management of Patients with Type 2 Diabetes Undergoing General Surgery) clinical trial (3), resulting in a final insulin sensitivity formula of 100/(0.5 × total body weight in kg).

After calculating a patient's insulin sensitivity, the pharmacists prescribed a dose of rapid-acting insulin sufficient to target 9 mmol/L (160 mg/dL) if the patient had a blood glucose level >10 mmol/L (180 mg/dL) on admission for surgery. For example, if someone had a calculated insulin sensitivity of 2 mmol/L (36 mg/dL) per unit of insulin, that patient would get 1 unit of insulin if blood glucose was 10–11.9 mmol/L (180–200 mg/dL), 2 units if blood glucose was 12–13.9 mmol/L (215–230 mg/dL), 3 units if blood glucose was 14–15.9 mmol/L (250–270 mg/dL), and so forth. Insulin aspart was chosen to standardize the insulin type in the practice and was added to all surgical and postoperative ward stock locations to optimize nursing and dispensary workflows.

Preoperative hyperglycemia was chosen as the target of the initiative because it is an independent risk factor for poor postoperative outcomes in people with diabetes (4–6), and untreated preoperative hyperglycemia leads to intra- and then postoperative hyperglycemia, which are also risk factors for poor postoperative outcomes (7). In early 2020, the pre-op scale practice was expanded; rather than only prescribing a pre-operative insulin correction scale for use before surgery, the pharmacists implemented a new practice of prescribing insulin correction scales that start preoperatively and continue every 4 hours (Q4H scale practice) during the day of surgery.

In the new Q4H scale practice, intraoperative blood glucose management was left unchanged and continued to be left to the discretion of patients' anesthesiologist. However, if there was an intraoperative blood glucose check, then the next Q4H scale blood glucose check would occur 4 hours after the intraoperative check rather than the preoperative check. The expansion to the Q4H scale practice also changed from using calculated insulin sensitivity to using the corresponding insulin correction scale in the hospital's BBIT order set, using a TDD of 0.5 units/kg/day to improve standardization with all inpatients. For example, a 100-kg person would have a calculated TDD of 50 units (100 kg × 0.5 units/kg/day), and the corresponding insulin correction scale in the BBIT order set for a TDD of 50 units/day would be prescribed. On the BBIT order set, there are different correction scale categories based on TDD of <30, 31–50, 51–80, and >80 units. Copies of these order sets can be found online at www.BBIT.ca.

Describe the most important changes you made to your *process* of care delivery.

The most important change to our PAC and surgical practices was the move from a reactive approach to a proactive one using standardized, evidence-based treatment and follow-up before patients even arrive for a surgical procedure. This change was in contrast to the previous method of notifying anesthesiologists of patients' preoperative hyperglycemia and waiting for them to react and either treat the hyperglycemia or cancel the surgery at their discretion.

Another important aspect of the change to care delivery was the standardization of patient blood glucose surveillance, hyperglycemia treatment, and follow-up

across multiple patient locations (e.g., day surgery, post-anesthesia recovery, and several inpatient units). Furthermore, the new practice streamlined the hyperglycemia treatment process for nursing staff, who no longer had to page a physician, wait for a callback, discuss the situation, and then wait for the type of insulin ordered to be sent from the hospital's dispensary if it was not in the ward stock. Now, they now simply check blood glucose and administer insulin per the correction insulin scale order, if one is present in the electronic chart. A process map for the workflow changes can be seen in Supplementary Figure S1.

Summarize your final outcome data (at the end of the improvement initiative) and how they compared with your baseline data.

Between September 2018 and September 2021, there were 845 day surgery visits by patients who were seen in the PAC and then had surgery within 6 months and had their blood glucose checked during their admission. Among these patients, pharmacists prescribed 155 insulin correction scales, which included 52 one-time pre-op scales prescribed from November 2018 to April 2020, and 103 Q4H insulin correction scales prescribed from April 2020 to September 2021. This left 689 patients between September 2018 and September 2021 who had no pharmacist-prescribed insulin correction scale of any kind and passed through the traditional care pathway (Supplementary Figure S1).

Because insulin correction scales were prescribed during patients' PAC visit weeks or months before surgery, no day surgery patients had a pharmacist-prescribed insulin correction scale between September 2018 and early November 2018. These patients were put into a group identified as "before any pharmacist-prescribed correction scale started" (Supplementary Table S1). The group identified as "after any pharmacist-prescribed correction scale practice started" included all patients seen starting from the surgery date of the first patient whose chart contained a pharmacist-prescribed pre-op scale (in early November 2018) until September 2021, when data collection ended. During this time, patients in the after group may have had a pre-op scale, a Q4H scale, or no pharmacist-prescribed insulin correction scale (i.e., following the traditional care pathway).

Similarly, any patient having surgery from September 2018 through March 2020 were put into a subgroup identified as "before the Q4H scale practice started," and all patients after the date when the first patient's orders contained a Q4H scale (April 2020 until September 2021) were organized into a group identified as "after the Q4H scale practice started" to evaluate the current SHC PAC pharmacist insulin correction scale practice compared with everything that came before it. Thus, patients in the before-Q4H group included those who received a pharmacist-prescribed pre-op scale and those on the traditional care pathway. The after-Q4H group contained a few patients with pre-op scales (because their PAC visit took place before the pharmacist changeover, but their surgery occurred after the change to the Q4H practice). The rest of the patients in the after-Q4H group were those prescribed a Q4H scale and those on the traditional care pathway.

Before any pharmacist-prescribed correction scales started, 93% of all patients had their preoperative blood glucose checked, compared with 94% after the pharmacist-prescribed correction scale practice started (Supplementary Table S1). Sixteen percent of all patients had preoperative hyperglycemia before any pharmacist-prescribed correction scale practice started, compared with 12% after the pharmacist-prescribed correction scale practice started (Supplementary Table S1). Before any pharmacist-prescribed correction scale started, 8% of the preoperative hyperglycemic patients were given insulin to treat preoperative hyperglycemia, compared with 34% after the pharmacist-prescribed correction scale practice started. Postoperatively, 54% of patients had their blood glucose checked before any pharmacist-prescribed correction scale practice started, increasing to 69% ($P < 0.05$) after the pharmacist-prescribed correction scale practice started. Forty-three percent of the patients who had their blood glucose checked postoperatively had postoperative hyperglycemia before any pharmacist-prescribed correction scale practice started, compared with 26% ($P < 0.05$) after the pharmacist-prescribed correction scale practice started. Finally, 16% of those postoperative hyperglycemic patients received insulin before any pharmacist-prescribed correction scale practice started, compared with 31% after the pharmacist-prescribed correction scale practice started (Supplementary Table S1).

When comparing before and after the current pharmacist-prescribed Q4H scale practice was implemented, 92% of patients had their blood glucose checked preoperatively before the Q4H scale, compared with 95% after the Q4H scale. Eleven percent of patients had preoperative hyperglycemia before the Q4H scale, compared with 12% after the Q4H scale, with 21% of preoperative hyperglycemic patients receiving insulin before the Q4H scale, compared with 38% after the Q4H scale. Postoperatively, 57% of patients had their blood

glucose checked before the Q4H scale, improving to 75% (P <0.05) after the Q4H scale. Twenty-nine percent of patients in whom postoperative blood glucose was checked had hyperglycemia before the Q4H scale, compared with 26% after the Q4H scale. Of these hyperglycemic patients, 19% were given insulin before the Q4H scale, improving to 35% after the Q4H scale (P <0.05) (Supplementary Table S1).

When comparing blood glucose monitoring and hyperglycemia treatment in terms of the specific insulin correction scale pathways and organizing patients into groups containing people passing through the traditional care pathway, the pre-op scale pathway, or the Q4H scale pathway (Supplementary Table S2), 92% of patients in the traditional care pathway had their blood glucose checked preoperatively, compared with 100% in both the pre-op scale and Q4H scale pathways. Nine percent of people in the traditional care pathway had preoperative hyperglycemia, with 3% of hyperglycemic patients receiving insulin, compared with 19% in the pre-op scale pathway (P <0.05), with 70% of hyperglycemic patients receiving insulin (P <0.05), and 26% in the Q4H scale pathway (P <0.05), with 81% of hyperglycemic patients receiving insulin (P <0.05). Postoperatively, 64% of patients in the traditional care pathway had their blood glucose checked compared with 75 and 89% (P <0.05) in the pre-op scale and Q4H scale pathways, respectively. Twenty-three percent of the patients who had their blood glucose checked in the traditional care pathway had postoperative hyperglycemia, with 13% receiving insulin treatment, compared with 33% of patients in the pre-op scale pathway (P <0.05), with 38% receiving insulin (P <0.05), and 43% of patients in the Q4H scale pathway (P <0.05), with 68% receiving insulin (P <0.05) (Supplementary Table S2).

For evaluation of the time it took to administer insulin to patients once they were found to have hyperglycemia (Supplementary Table S3), we assessed the difference in time between when a blood glucose level >10 mmol/L (180 mg/dL) was recorded in a patient's electronic chart and when insulin administration was recorded in the patient's electronic chart. Before any pharmacist-prescribed correction scale practice started, the median time to insulin administration after hyperglycemia being recorded in the patient's electronic chart was 2 hours, 12 minutes, improving to 28 minutes after any pharmacist-prescribed correction scale practice started (P <0.05). When comparing the traditional care pathway, pre-op scale pathway, and Q4H scale pathway, the median time to insulin administration when hyperglycemia improved from 2 hours, 12 minutes in the traditional care pathway to 16 minutes in the pre-op scale pathway and 26 minutes in the Q4H scale pathway (P <0.05 compared with the traditional care pathway).

What are your next steps?

We believe this practice can be implemented easily at any Alberta Hospital that uses electronic charting and has pharmacist coverage of a PAC as part of a team-based approach to perioperative glycemic management in people with diabetes. We plan to discuss our findings with provincial leadership with this hope in mind.

What lessons did you learn through your QI process that you would like to share with others?

Through this QI process, we found that the SHC PAC pharmacists play an important role in the perioperative management of diabetes, especially when they have an expanded scope of practice that allows them to prescribe insulin. Because PAC pharmacists manage PAC patients' diabetes, this practice also allows the PAC physicians and nurses to spend more time assessing patients' other medical conditions such as those that require physical assessment. Furthermore, because the pre-op scale and Q4H scale pathways had significantly more hyperglycemic surgical patients than the traditional care pathway, these results show that the surgery pharmacist team accurately identified patients at risk for pre- or postoperative hyperglycemia. However, overall pre- and postoperative hyperglycemia treatment rates remain below 50% in day surgery patients. Even when patients had an insulin correction scale active in their profile (i.e., the Q4H scale), the postoperative hyperglycemia treatment rate was still only 68%, showing that further action is needed that the surgery pharmacist team operating in the PAC may not be able to address. One possibility is that, despite continued postoperative hyperglycemia, scheduled discharge occurred too soon after the postoperative blood glucose check for nursing staff to feel comfortable administering insulin.

Another important lesson we learned from this QI process is that having a standardized protocol of blood glucose surveillance and hyperglycemia treatment is more successful in finding and treating hyperglycemia than having a standardized protocol of notification and waiting for guidance. The Q4H scale pathway yielded a preoperative hyperglycemia treatment rate of 81% and a postoperative hyperglycemia treatment rate of 68% compared with the traditional care pathway treatment

rates of 3 and 13% for pre- and postoperative hyperglycemia, respectively. This finding highlights the benefit of having a "what to do" rather than a "who to notify" protocol. Furthermore, given that no patients had hypoglycemia, this initiative demonstrated that, with a standardized, evidence-based hyperglycemia treatment protocol in place, physician involvement may not be necessary for nursing staff to start treatment of perioperative hyperglycemia (i.e., a "treat first and notify afterward" approach can be feasible).

Finally, although this practice does not fully solve the problem of untreated day-of-surgery hyperglycemia, it is an important part of the SHC's ongoing work to improve perioperative glycemic management.

ACKNOWLEDGMENT

The author acknowledges the assistance of Kevin Lonergan, lead analyst of clinical information system analytics for Alberta Health Services Data & Analytics, for his help in collecting and organizing patients' electronic information.

DUALITY OF INTEREST

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

AUTHOR CONTRIBUTIONS

As the sole author of this article, N.P.M. is the guarantor of this work and, as such, had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

REFERENCES

1. Van Herk P, Morin N, Dersch-Mills D, Roedler R, Ang B, Olivieri L. Risk factors for preoperative hyperglycemia in surgical patients with diabetes: a case-control study. Can J Hosp Pharm 2022;75:34–40

2. Grunberger G, Abelseth JM, Bailey TS, et al. Consensus statement by the American Association of Clinical Endocrinologists/American College of Endocrinology Insulin Pump Management Task Force. Endocr Pract 2014;20: 463–489

3. Umpierrez GE, Smiley D, Jacobs S, et al. Randomized study of basal-bolus insulin therapy in the inpatient management of patients with type 2 diabetes undergoing general surgery (RABBIT 2 Surgery). Diabetes Care 2011; 34:256–261

4. Noordzij PG, Boersma E, Schreiner F, et al. Increased preoperative glucose levels are associated with perioperative mortality in patients undergoing noncardiac, nonvascular surgery. Eur J Endocrinol 2007;156: 137–142

5. Abdelmalak BB, Knittel J, Abdelmalak JB, et al. Preoperative blood glucose concentrations and postoperative outcomes after elective non-cardiac surgery: an observational study. Br J Anaesth 2014;112:79–88

6. Duncan AE, Abd-Elsayed A, Maheshwari A, Xu M, Soltesz E, Koch CG. Role of intraoperative and postoperative blood glucose concentrations in predicting outcomes after cardiac surgery. Anesthesiology 2010;112:860–871

7. Wang YY, Hu SF, Ying HM, et al. Postoperative tight glycemic control significantly reduces postoperative infection rates in patients undergoing surgery: a meta-analysis. BMC Endocr Disord 2018;18:42