Rationalization, Development, and Implementation of a Preoperative Diabetes Optimization Program Designed to Improve Perioperative Outcomes and Reduce Cost

Tracy Setji,[1] Thomas J. Hopkins,[2] Maria Jimenez,[2] Erin Manning,[2] Michael Shaughnessy,[2] Rebecca Schroeder,[2] Sergio Mendoza-Lattes,[3] Susan Spratt,[1] Julie Westover,[2] and Solomon Aronson,[2] on behalf of the Duke Perioperative Enhancement Team (POET)

Diabetes is an increasingly common medical condition affecting ~29 million people (8 million of whom are undiagnosed), or 9% of the U.S. population. The estimated health expenditures to prevent and treat diabetes and associated direct and indirect complications totaled $245 billion in 2012, and this cost is on a trajectory to double by 2030 (1,2). An estimated 25% of patients with diabetes will require surgery (3). Twenty-eight percent of patients with diabetes are unaware that they have the disease (2). Furthermore, 5–10% of patients presenting for surgery are found to have previously unrecognized diabetes (4,5). This is particularly important because patients who are unaware of their diabetes have higher preoperative blood glucose levels (4) and a higher risk of perioperative mortality compared to patients who are aware of their diabetes (5).

Diabetes is a well-known risk factor for postoperative infection, acute renal failure, ileus, and prolonged hospital stay (6–9). Poor preoperative glycemic control portends poor intraoperative glycemic control, which is an established risk factor for perioperative morbidity (10,11). Surgical patients with perioperative hyperglycemia (with and without underlying diabetes) have a greater risk for infection and related adverse outcomes after surgery compared to patients without hyperglycemia. Patients with diabetes are more prone to these surgical complications due to the microangiopathy (e.g., nephropathy and neuropathy) and macroangiopathy (e.g., atherosclerosis) intrinsic to the disease and also have mortality rates significantly greater than those of patients without diabetes (12–16). When patients with poorly controlled diabetes present for surgery, they impose a significant financial health resource burden, including prolonged ventilator dependence, longer hospital stay, and greater postoperative loss of productivity.

As the prevalence of diabetes increases, optimal screening, management, and timing of elective surgery for patients with diabetes has become a matter of increasing importance and proactive discussion and remains a population health challenge. Although analysis of the cost-effectiveness of postponing scheduled surgery to treat poor glycemic control in presurgical populations is crucial for enhancing the value proposition of the decision to have surgery, the optimal preoperative care delivery model for diabetes management remains unclear (17–23). We describe here a methodology for the rationalization, development, and implementation of a preoperative diabetes optimization program using a systematic approach and strategy developed by the Duke Perioperative Enhancement Team (POET) that can be easily adapted to serve the needs of other health care institutions.

POET Formation and Role

In early 2013, Duke Anesthesiology, with support from other health system stakeholders, created POET to

[1]*Department of Medicine (Endocrinology Division), Duke University Medical Center, Durham, NC*

[2]*Department of Anesthesiology, Duke University Medical Center, Durham, NC*

[3]*Department of Orthopedic Surgery, Duke University Medical Center, Durham, NC*

Corresponding author: Tracy Setji, tracy.setji@dm.duke.edu

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enhance the value of perioperative care through a disciplined care reengineering process. The collective competencies of strategy, operations, finance, workflow, project management, electronic health record (EHR) integration, and clinical outcomes data analysis are brought together to redesign existing clinical care processes.

The process begins with generative discussion and a supportive business case rationalization to implement care design change. Once the clinical outcome improvement and financial return analysis is completed and judged to be compelling, multidisciplinary leaders are engaged to help redesign work streams with the assistance of an assigned clinical lead and project manager to facilitate operational changes. At the same time, clinical metrics are developed and informatics resources are leveraged to enable continuous data tracking. In our experience, the steps required for developing and implementing a preoperative care design process and diabetes clinic include:

- Identification of a pilot population (e.g., patients needing spine surgery)
- Determination of a procedure-specific A1C trigger for preoperative diabetes management optimization
- Determination of clinic volume projections at the A1C threshold for workflow analysis
- Financial modeling of the preoperative diabetes clinic's impact for resource analysis
- Development of a comprehensive diagnostic and treatment plan
- Clinic workflow design
- Staff planning and staff training requirements
- Physical space arrangement planning
- Integration of laboratory ordering into an EHR order set
- Integration of scheduling and care team communication into the EHR
- Identification of patient education needs
- Institutional introduction of the preoperative diabetes management program
- Continuous institutional communication of ongoing status and success of the program

Institutional Rationalization

One of POET's early objectives was to explore ways to enhance perioperative management of diabetes in surgical patients at high risk for perioperative complications. All the described steps (from planning to clinic operation) took just over 6 months from conception to implementation. Patients with preexisting diabetes or at high risk for undiagnosed diabetes who were undergoing elective procedures with the potential for significant postsurgical adverse events were identified and matched to utilization data by case mix. We used our internal EHR and University Health System Consortium data to explore opportunities to affect this target population.

Because guidelines for defining tolerable perioperative glucose thresholds, as well as the index case mix protocol for management of preoperative diabetes, vary among institutions, we chose historic clinical variables to reflect real-world experiences, recognizing that the medical decision of how best to manage hyperglycemia before, during, and after surgery is complex and best served by a pragmatic and best-practice approach.

Value Proposition

Surgical site infections overall are one of the most common types of health care–associated infections, accounting for 20–30% of all health care–associated infections among hospitalized patients (24–27), and they remain a substantial cause of morbidity, prolonged hospitalization, and death. The odds of patients with diabetes having surgical site infections are 1.5 times greater than those without diabetes (28). In addition to postoperative infectious complications, postoperative myocardial ischemia is increased among patients with diabetes who undergo cardiac or noncardiac surgery (29–31). Surgical site infections extend primary surgical lengths of stay by 10 days and contribute to readmission days of care. The estimated cost per infection ranges from $7,000 to $38,000, with an estimated total cost in the United States of $1.6 billion annually (32). Therefore, reducing surgical site infections in patients with diabetes could have a significant effect on resource utilization.

Determining a Target Population

The ideal target patient population for a preoperative diabetes program should have significant rates of poorly controlled diabetes amenable to treatment and a surgical team amenable to interventions aimed at improving patient safety and outcomes, even if that means potentially delaying elective surgery once a patient is declared surgical. Data suggest that surgical site infection rates are increased in patients with elevated A1C undergoing spine surgery (33,34), and unplanned 30-day hospital readmissions after lumbar spine surgery are related to wound complications. Thus, in collaboration with the Spine Surgery co-management team, Duke University's Department of Anesthesiology, the Department of Medicine's Endocrinology Division, and the Departments of Orthopedic and Neurosurgery, POET determined that patients presenting for spine surgery were an appropriate group in which to pilot this program. POET then partnered with the hospital administration to launch the preoperative diabetes optimization program. Since launching the program in spine surgery, we are expanding the target population to include oncological, vascular, and joint surgery clinics.

Developing Screening Criteria

One of the first considerations for designing a clinical workflow in an otherwise busy surgical clinic fo-

cused on the sensitivity and specificity of screening criteria to test patients deemed to be at high risk. Approximately one in four people with diabetes in the United States and approximately half of Hispanic and Asian Americans with diabetes are undiagnosed (35). Several algorithms have been described to help guide the screening of patients for diabetes. The American Diabetes Association suggests screening for diabetes in all adults who are ≥45 years of age and for younger adults whose BMI is ≥25 kg/m^2 with at least one additional risk factor (36). The BMI cut point is suggested to be lower in Asian Americans. The U.S. Preventive Services Task Force recommends screening for abnormal blood glucose as part of cardiovascular risk assessment in adults aged 40–70 years who are overweight. In addition, medications such as glucocorticoids, thiazide diuretics, and atypical antipsychotics increase the risk of diabetes and should be considered when screening algorithms are developed.

Based on the above criteria, as well as the patient population and workflow at the Duke Spine Center, high-risk criteria for the preoperative diabetes optimization program were proposed (Table 1). Patients who meet these screening criteria during their clinic visit in the Duke Spine Center undergo a brief chart review by the certified medical assistant for evidence of an A1C within a 3-month window of the day they are determined to be a surgical candidate. If there is no record of an A1C available in their EHR, then a point-of-care A1C test is performed in the clinic at the time of the visit. Point-of-care testing with an A1C analyzer (Siemens Health Care USA, Malvern, Pa.) in the surgery clinic represented the optimal approach to patient identification, particularly in light of its ease of use, accuracy, and low cost. The point-of-care evaluation of diabetes was coordinated to occur in the existing preoperative anesthesia testing laboratory immediately after a patient's appointment in the orthopedic clinic to avoid the need for a separate trip to a medical facility. When laboratory results are available, evaluation and entry into an appropriate protocol treatment algorithm is undertaken using the preoperative anesthesia testing clinic workspace. Alternatively, if insurance does not cover screening A1C testing, a screening glucose measurement is obtained.

TABLE 1. Screening Criteria for the Diabetes Optimization Program

- History of diabetes (type 1 or type 2)
- History of taking insulin or an oral hypoglycemic agent
- BMI >28 kg/m^2

Protocol Workflow and Operationalization in the Clinic

Clinic workflow design, staffing requirements, physical space arrangement, and plans for medical oversight were incorporated from multiple stakeholders, including surgeons, operational directors of the surgery clinics, nurse managers, the preoperative anesthesia testing clinic medical director, and appropriate diabetes clinic staff. This effort sought to maximize the efficiency and effectiveness of appropriate patient identification, diabetes treatment, patient convenience, and staff satisfaction, while minimizing staff workflow disruption, communication errors, patient loss to follow-up, and cost.

After the initial diagnosis of poorly controlled diabetes is confirmed, a series of events commences simultaneously to permit laboratory evaluation, patient education, appropriate surgical scheduling (≥6 weeks from the declaration of need for surgery because this is the typical scheduling window for nonurgent surgeries), appropriate referral to primary care and specialty care as needed, and initiation, monitoring, and titration of a treatment and management strategy (Figure 1). All steps in the protocol are guided by order sets and best-practice alerts in the EHR. The process requires a patient tracking system and careful attention to communication needs between primary and specialty care clinics for scheduling coordination and communication among providers and patients. The process to ensure that all patients are diverted as needed to have their modifiable comorbidity attended to before their procedure is similar to making sure a plane is not allowed to land until its wheels are down and flaps are engaged. To continue this analogy, tracking patients while they are optimized for surgery is essential, just as tracking a plane is imperative as it circles the airport in a holding pattern before being permitted to land. These essential components were made possible by the development and implementation of an advanced clinical informatics support infrastructure that features discrete order entry, patient tracking, clinical decision support, and comprehensive data management.

Patients with preexisting uncontrolled diabetes (defined as an A1C >7.5%) or a new diagnosis of diabetes are identified for intervention. The A1C cutoff of 7.5% was chosen after much discussion of the literature and to be consistent with the practices of some of the surgeons. It is worth noting that, although many studies demonstrate increased perioperative complications in patients with elevated A1C values, not all studies demonstrate this finding (37,38), and it may be that immediate perioperative glycemic control is most important (38).

Nonetheless, our practice often finds that excellent perioperative and postoperative glycemic control is often easier to achieve in patients who have a stable diabetes regimen before surgery, particularly if the duration of hospitalization is short. The patients identified for intervention receive immediate patient education, educational materials, and an initial introduction to the

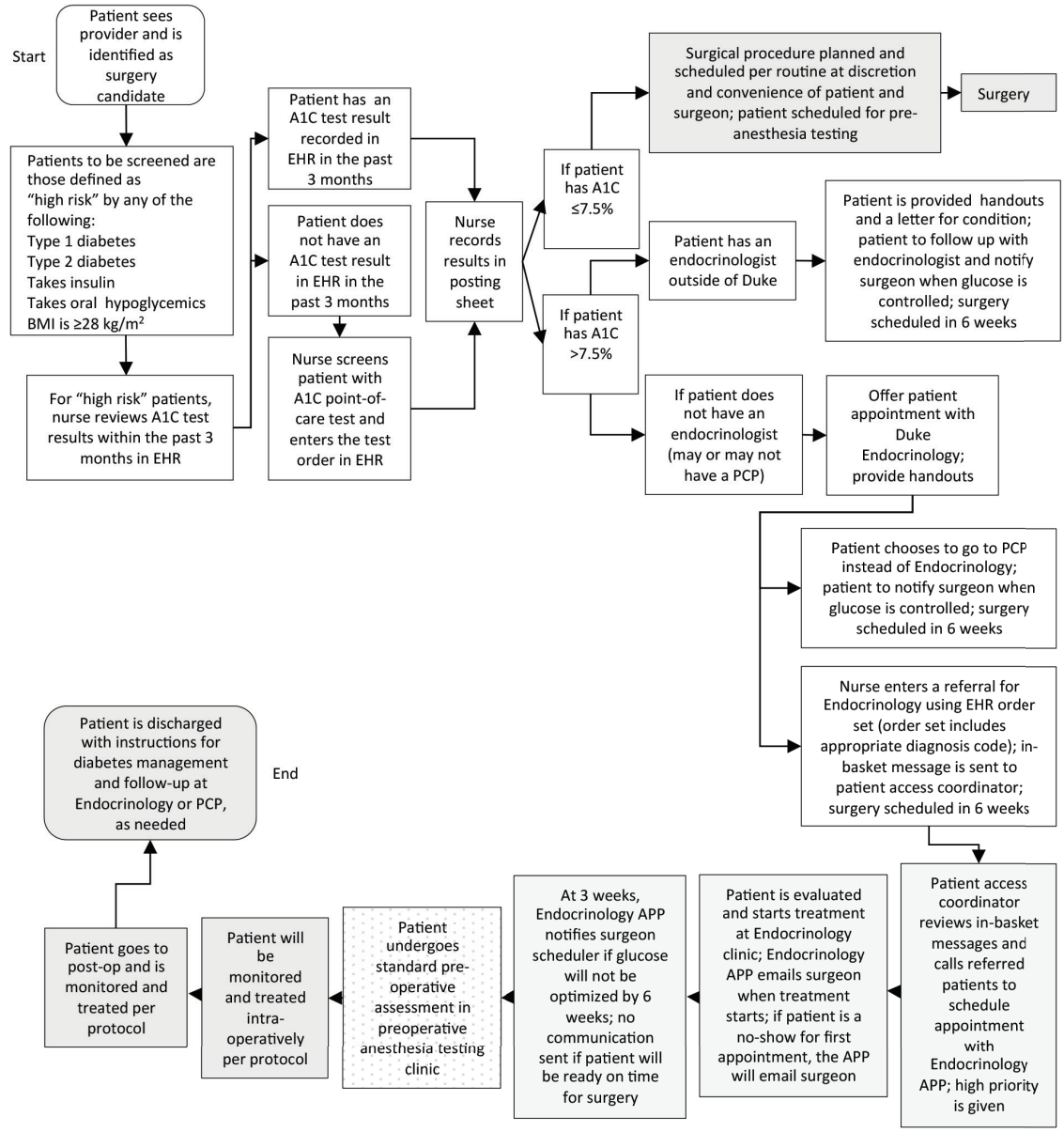
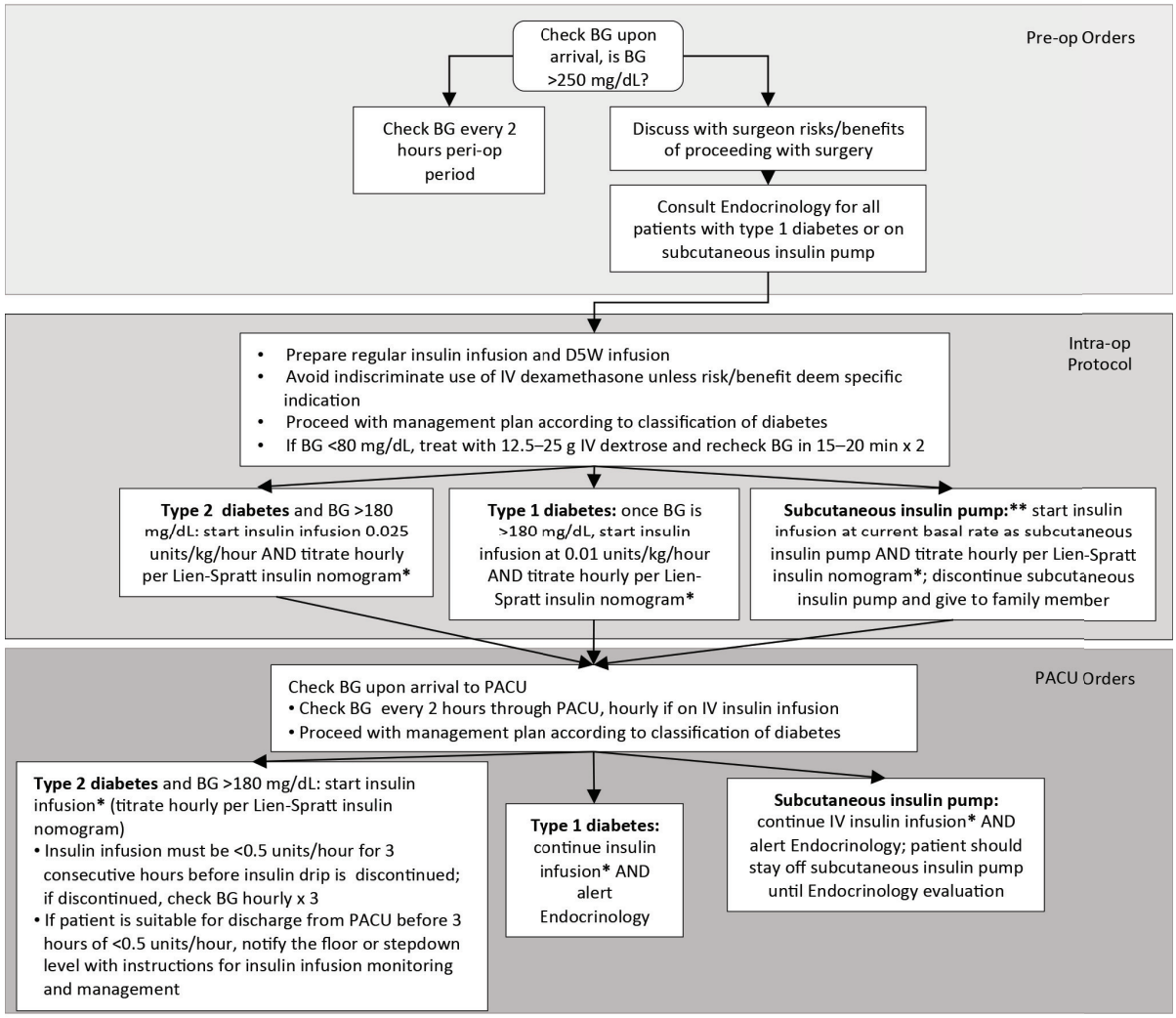


FIGURE 1. Preoperative diabetes optimization workflow.

preoperative diabetes management program by their surgeon (or his or her surrogate). These patients are then offered an expedited evaluation by an endocrinology advanced practice provider (APP). All patients referred to the endocrine clinic are offered expedited visits within a few days of their surgical appointment. If they decline the endocrinology referral, they are referred back to their primary care provider (PCP) with a form letter outlining appropriate work-up and follow-up. The endocrinology visit is comprehensive and includes basic diabetes teaching of glucose monitoring, diet, exercise (if appropriate), and medication initiation and titration. In some cases, a referral also may be made to a nutritionist or diabetes educator. Subsequent visits or telephone encounters with the endocrinology APP assess the blood glucose response to the intervention, and further adjustments are made as needed.

In addition to identifying at-risk patients and optimizing preoperative management in the near short-term before surgery, it was also recognized that identified high-risk patients would require close follow-up of their diabetes perioperatively and at discharge from the hospital. Therefore, patients presenting to the endocrinology clinic before surgery receive personalized instructions from the endocrinology provider regarding their diabetes therapies before surgery. These plans are generally consistent with the perioperative diabetes guidelines created by the Endocrinology



*If insulin infusion required, start D5W at 40 mL/hour AND titrate insulin hourly per Lien-Spratt nomogram.
**Therapy guidelines for same-day surgery.

FIGURE 2. Intraoperative diabetes optimization workflow. BG, blood glucose; D5W, dextrose 5% water; intra-op, intraoperative; IV, intravenous; PACU, post-anesthesia care unit; peri-op, perioperative; pre-op, preoperative.

Department that are used in the anesthesiology preoperative clinic but may be fine-tuned as appropriate. During hospitalization, intraoperative protocols have been established for treating perioperative hyperglycemia with insulin therapy and most often intravenous insulin because of its short half-life and efficacy and widespread experience with it at our institution (Figure 2). However, there are many individualized protocols available in the literature, and discussion of intraoperative management is beyond the scope of this article. Postoperatively, the surgery residents consult Endocrinology for management of identified patients based on predefined criteria. Perioperative blood glucose targets are 4.44–9.99 mmol/L (80–180 mg/dL) per American Diabetes Association guidelines (22). Furthermore, close follow-up with Endocrinology after discharge is facilitated to optimize glycemic control during recovery from surgery.

Integrating Workflow Into the EHR

To be effective, innovative care redesign initiatives must be integrated into clinical workflow as well as the enterprise EHR; operational success can be facilitated by an effective user interfacing and provider workflow. The clinical informatics strategy was outlined at the commencement of the project and customized to the needs as the plan for the clinic developed (including adding electronic ordering of A1C testing, an electronic order set to facilitate efficient ordering of laboratory studies, and modifications of the electronic scheduling system to accommodate appointment requests). Before deployment, these features were tested, and after deployment, validation and modifications were performed at predefined time intervals.

Results to Date and Outcome Collection

Since implementation of the program, we have identified 27 patients with uncontrolled or newly diagnosed diabetes, and 23 have been treated at Duke for their diabetes. Of these, 13 have undergone their designated surgical procedure, four are scheduled for surgery within a month of this writing, and six are currently not scheduled for surgery (three subsequently were not felt to be surgical candidates for other nondiabetes reasons, two did not follow up with the surgeon or Endocrinology, and one has a pending appointment with his surgeon). Of the four who did not seek care at Duke, three followed up with their PCP, and one had a local endocrinologist. We are collecting data on baseline characteristics and perioperative glycemic control and surgical complications (infection rate, length of stay, readmission, need for repeat surgery, and mortality). We also will be performing cost/benefit analyses for identifying and intervening on patients with uncontrolled diabetes before surgical intervention.

Discussion

The decision to treat diabetes by traditional intraoperative and postoperative standards incorporates institutional and provider bias regarding sensitivity toward preoperative patient needs, perioperative complications ascribed to hyperglycemia, and health care resource utilization impact. Nonetheless, a patient's A1C before surgery may be associated with adverse outcomes and therefore should influence management decision-making. By developing and implementing a preoperative diabetes program to screen, diagnose, and treat underappreciated diabetes or poorly controlled diabetes in patients presenting for elective surgery, we aim to decrease complication rates, improve patient outcomes, and decrease costs.

This multidisciplinary plan provides value to multiple beneficiaries. We anticipate that we will have decreased complication rates, which will drive down costs for the health system. The surgical departments will likely benefit from fewer case cancellations resulting from unmanaged perioperative diabetes, decreased patient lengths of stay, and improved perioperative outcomes. Finally, and most importantly, patients will benefit from avoidance of complications and their associated morbidity and mortality and potential overall improvement in longer-term health by achieving better glycemic control.

Duality of Interest

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

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