



# Duke University Medical Center Perioperative Diabetes Management Program

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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 a project at an academic tertiary-care medical center aimed at identifying surgical patients with uncontrolled diabetes early in the preoperative process to improve their perioperative glycemic control and surgical outcomes.

## Describe your practice setting and location.

Duke University Medical Center is an academic, tertiary-care setting in Durham, NC, that serves a broad referral base. The PASS (Perioperative Anesthesia and Surgical Screening) Clinic is a specialized preoperative clinic with a focus on perioperative value enhancement by individualized presurgical screening, situational risk assessment, and optimization of chronic comorbid medical conditions. The PASS Clinic serves as the central referral corridor for the Perioperative Diabetes Management Program, a part of the Perioperative Enhancement Team (POET), through

which the Endocrinology Department receives notice of patients with unknown or poorly managed diabetes who require rapid access to presurgical diabetes care. POET was initially formed in 2013 to enhance overall perioperative care through a disciplined care reengineering process. As described in more detail by Setji et al. (1), POET underwent a series of steps in designing this program, including starting with a supportive discussion followed by a business case rationalization and multidisciplinary workstream redesign. This effort included plans for improvements to the electronic health record (EHR) system and its integration with continuous data monitoring capabilities.

## Describe the specific quality gap addressed through the initiative.

Inadequate control and management of diabetes in the perioperative period is common and associated with impaired perioperative outcomes. The purpose of this quality improvement (QI) project was to identify surgical patients with uncontrolled diabetes earlier in the preoperative process, expedite access to diabetes management by the Endocrinology Department, and improve perioperative glucose control and surgical outcomes.

Both known and undiagnosed diabetes are common in the surgical population and have been associated with important and possibly preventable surgical complications. A recent meta-analysis that included studies involving all types of surgical procedures reported a prevalence of previously diagnosed diabetes of 17% (1), and up to 25% of coronary artery bypass patients were found to have known diabetes (2). Apart from diagnosed diabetes, undiagnosed diabetes has been seen in up to 10–12% of surgical and inpatient populations (3–5), and perioperative hyperglycemia has been reported in 20–40% of general surgery patients and 80% of cardiac surgery patients (6). Perioperative hyperglycemia has been strongly linked with mortality, as well as many surgical

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complications such as urinary tract infection, ileus, and surgical site infection (7). Furthermore, the severity of these complications is often much worse in patients with perioperative hyperglycemia but undiagnosed diabetes (5). This evidence highlights the need for preoperative diabetes screening programs, since uncontrolled diabetes, whether known or undiagnosed, is a potentially modifiable risk factor. Improvement in perioperative glucose control may therefore lead to improved outcomes in surgical patients.

Although strong associations have been established between the presence of poorly controlled diabetes and adverse postoperative outcomes, what is not known is how to most effectively screen and define best practices to optimize these known high-risk patients both pre- and perioperatively (8). The primary objective of the POET Diabetes Perioperative Diabetes Management Program was to test the hypothesis that elective surgical patients with poorly controlled diabetes (defined as an A1C >7.5%) could be identified and managed proactively and effectively to achieve improved perioperative glucose control. A secondary hypothesis was to test whether fast-tracked endocrinology referral was a feasible and sustainable model for this program.

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

The Duke POET diabetes pathway was planned based on the importance of excellent perioperative glucose control and the reported incidence of poor glucose control observed at Duke University Medical Center (1) and in the wider literature. Baseline data were identified by performing a comparison query of the electronic medical record. Patients who participated in the pathway were matched one to one to non-pathway control subjects with diabetes during the same time period using variable optimal matching on the basis of demographics, surgical procedure, laboratory values, and comorbidities (Table 1). Preoperative A1C was matched within  $\pm 0.5\%$  to each pathway patient's preoperative A1C within the preceding 3 months. Surgical procedure was matched based on Current Procedural Terminology (CPT) code groupings defined by the American College of Surgeons' National Surgical Quality Improvement Program list of similar surgical procedures where possible and manual CPT review of similar surgical procedures by the investigation team for all others. Patients were also matched for creatinine and albumin levels, age, sex,

and race. Data from these two groups of patients were then compared.

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

Before the improvement initiative, preoperative diabetes care was not formalized. Surgical patients with diabetes were instructed to return to their primary care provider, or a new referral to an endocrinologist was made if it was felt that their diabetes was unmanaged or partially treated. There were no particular A1C triggers followed by surgeons or the staff of the PASS Clinic for referral, and the decision to proceed to surgery rested mainly with the surgical team, with varying thresholds for glucose control.

As shown in Table 1, the matched control group ( $n = 30$ ) had a median age of 67.5 years (interquartile range [IQR] 60–71 years), 53% were male, and most patients had an American Society of Anesthesiologists (ASA) Physical Status Classification System score of 3. The surgical breakdown included 40% general surgery, 33% orthopedics, 24% spine, and 3% cardiac. The most commonly recorded comorbidities in both the matched control and the diabetes pathway intervention groups were coronary artery disease (6–10% of patients), hypertension (10–13%), and hyperlipidemia (13–17%). The median A1C value in the matched control group was 8.7%. The matched control group had a median day-of-surgery fasting blood glucose value of 168 mg/dL (IQR 105–247 mg/dL,  $P = 0.21$ ) and a median glucose value on postoperative day 1 of 190 mg/dL (IQR 147–225 mg/dL,  $P = 0.06$ ). Roughly 40% of patients in both groups received steroids pre- or intraoperatively for prophylaxis of postoperative nausea and vomiting. No patients had sepsis, cardiac arrest, respiratory failure, or surgical site infection listed as a postoperative complication.

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

This pathway was initially launched in February 2016 for spine surgical patients because of the strong mutual interest of the surgeons in this service line to better control perioperative blood glucose levels and improve the perioperative infection rate. Starting with one service line also allowed for pilot testing before expanding the project. A few months later, orthopedics and surgical oncology patients were added to the program. The processes of the pathway were continually reviewed to identify implementation barriers. Data evaluation was completed in spring of 2019.

**TABLE 1** Demographic and Clinical Variables of Diabetes Pathway Patients Versus Matched Control Subjects

	Diabetes Pathway Patients (n = 30)	Matched Control Subjects (n = 30)	Total (n = 60)
Age, years	64.5 (58-72)	67.5 (60-71)	66.5 (59-72)
Sex			
Female	14 (46.7)	14 (46.7)	28 (46.7)
Male	16 (53.3)	16 (53.3)	32 (53.3)
Race			
Black or African American	13 (43.3)	13 (43.3)	26 (43.3)
Caucasian	17 (56.7)	17 (56.7)	34 (56.7)
ASA score			
2	1 (3.4)	3 (10.0)	4 (6.8)
3	25 (86.2)	24 (80.0)	49 (83.1)
4	3 (10.3)	3 (10.0)	6 (10.2)
BMI, kg/m <sup>2</sup>	31.9 (27.2-36.6)	31.7 (27.8-37.1)	31.7 (27.3-36.8)
Coronary artery disease	2 (6.7)	3 (10.0)	5 (8.3)
Chronic obstructive pulmonary disease	1 (3.3)	0 (0.0)	1 (1.7)
Hypertension	4 (13.3)	3 (10.0)	7 (11.7)
Heart failure	1 (3.3)	1 (3.3)	2 (3.3)
Hyperlipidemia	4 (13.3)	5 (16.7)	9 (15.0)
Alcohol abuse	0 (0.0)	0 (0.0)	0 (0.0)
History of tobacco use	0 (0.0)	0 (0.0)	0 (0.0)
Current tobacco use	0 (0.0)	2 (6.7)	2 (3.3)
End-stage renal disease	0 (0.0)	0 (0.0)	0 (0.0)
Cerebrovascular disease	1 (3.3)	0 (0.0)	1 (1.7)
Chronic kidney disease	2(6.7)	1 (3.3)	3 (5.0)
Steroids pre- or intraoperatively	13 (43.3)	12 (40.0)	25 (41.7)
A1C, %	8.4 (7.8-9.9)	8.7 (7.5-9.8)	8.6 (7.5-9.9)
Albumin, g/dL	3.7 (3.3-4.2)	3.9 (3.6-4.1)	3.8 (3.6-4.1)
Creatinine, mg/dL	1.1 (0.8-1.3)	1.0 (0.8-1.2)	1.0 (0.8-1.3)

Data are median (IQR) for continuous variables and n (%) for categorical variables.

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

Two physicians partnered to share the role of project leader—an endocrinologist champion with a special interest in perioperative care and an anesthesiologist with a background in administration, perioperative medicine, and cardiac anesthesia. It was felt that this was a good opportunity for partnership between the two disciplines to optimally deliver the model of this pathway; thus, the two physicians shared the role of project leader. Other key team members included a perioperative medicine fellow, the medical director of the PASS Clinic, a statistician,

endocrinologists and advanced practice providers (APPs) who agreed to see fast-tracked perioperative patients, and clerical staff to help with scheduling and implementation. Process workflows were optimized with the help of the Spine Clinic providers at the beginning of the project and included input from different surgical service lines as the project evolved.

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

No new physical structure was built to accommodate this initiative. The project focused on care process remodeling

leveraging existing clinical clinics, personnel, and time. In terms of personnel, two scheduling clerical staff members (patient access coordinators) were instrumental in helping to expedite the endocrinology visits. They received alerts through the EHR system (Epic) each time a POET diabetes referral was made to endocrinology for preoperative diabetes optimization. They then prioritized contacting these patients and expediting their preoperative endocrinology clinic appointment.

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

Elective surgical patients with a known A1C >7.5% were referred to endocrinology through a specialized presurgical care pathway directly by surgeons or PASS Clinic preoperative providers. Early in the process, more patients were referred directly by surgeons. Over time, the PASS Clinic evolved to become more robust in its screening and referral potential in that all surgical patients were scheduled for either a telephone or in-person visit. This process added the ability for the PASS Clinic to identify and refer more patients. Preoperative visits done by patients' primary care providers were not relied on, as all patients were evaluated by the PASS Clinic. The exact number of referrals from surgeons compared with the PASS Clinic was not recorded.

To better identify patients with uncontrolled diabetes, A1C testing was highly encouraged in patients who had a history of type 1 or type 2 diabetes or a history of using insulin or oral antihyperglycemic agents and did not have a recent A1C result from the preceding 3 months. To help identify those with undiagnosed diabetes, a screening A1C prior to referral was also encouraged for patients with a BMI >25 kg/m<sup>2</sup> and age >40 years or another risk factor for diabetes (e.g., family history, cerebrovascular disease, hypertension, polycystic ovarian syndrome, or acanthosis nigricans) or a random blood glucose >140 mg/dL in the patient's EHR record. A full care process workflow is described elsewhere (1). In these cases, an A1C test was ordered to assess diabetes status, and patients were referred if their A1C was >7.5%. Surgeons and APPs in the PASS Clinic were strongly encouraged to screen and refer patients to this pathway, and it was left to their clinical discretion to screen and order A1C testing based on the criteria outlined above.

A special order set in the EHR system was created to facilitate referral with the appropriate diagnosis code; however, PASS APPs did not have a formal checklist or specific EHR reminder. Any questions or clarifications on

the process were handled by an attending anesthesiologist present in the PASS Clinic daily. Once a referral was placed from either the PASS Clinic or a surgeon, an Epic in-basket message was sent to a patient access coordinator, who facilitated scheduling of high-priority endocrinology appointments. If an eligible patient preferred to work with an existing endocrinologist or primary care provider, appropriate care communication was made to this individual regarding urgent diabetes management. This subset of patients was not included in the data analysis.

A select group of endocrinologists and endocrinology APPs with specialized knowledge of perioperative diabetes care management worked with the POET diabetes pathway patients. Direct communication via the EHR among the endocrinology team, the PASS Clinic, and the surgical team was an expectation regarding patients' preoperative diabetes management progress, and decisions to delay or cancel surgery were made on a case-by-case basis. Further, the endocrinology team communicated among themselves via detailed notes in the EHR that addressed outpatient and inpatient care considerations. The focus of the preoperative endocrinology care was largely to safely improve patients' preoperative diabetes control. The endocrinology team followed guidelines set forth by the American Diabetes Association for outpatient and inpatient diabetes treatment, with blood glucose goals of 80–180 mg/dL for most patients. Outpatient medication regimens were tailored based on individual patient needs. Many patients had medication regimen changes before surgery, but specifics were not identified in this study.

The anesthesiologist on the day of surgery was responsible for placing inpatient endocrine consult requests, and a specific best practice advisory and smart order set in the EHR was created to streamline this process. Most patients were seen on the afternoon of the day of their surgery by an APP from the inpatient endocrinology team. Patients with surgery scheduled late in the afternoon were seen the next morning; however, the inpatient endocrinology team helped the primary inpatient team establish overnight care plans. Patients were otherwise managed with standard anesthesia and surgical care throughout the pre- and intraoperative period at the discretion of the attending anesthesiologist. A perioperative workflow that included recommendations for blood glucose monitoring and insulin therapy for patients with perioperative glucose levels above goal was created and shared with the anesthesiology and endocrinology teams. However, care management decisions were still variable among providers.

**TABLE 2** Perioperative Outcomes

	Diabetes Pathway Patients (n = 30)	Matched Control Subjects (n = 30)	Total (n = 60)	P
Fasting day-of-surgery glucose, mg/dL	131 (102-182) 153 (68.2)	168 (105-247) 181 (87.3)	145 (102-240) 167 (78.8)	0.2082
Median postoperative glucose, mg/dL	155 (134-195) 167 (38.6)	174 (150-189) 180 (50.3)	168 (135-194) 173 (44.9)	0.4871
Median glucose postoperative day 1, mg/dL	152 (136-194) 165 (45.9)	177 (147-225) 190 (56.4)	171 (142-204) 178 (52.6)	0.0618
Preoperative hypoglycemia, <80/<50 mg/dL	6 (20.0)/0 (0.0)	6 (20.0)/1 (3.3)	12 (20.0)/1 (3.3)	1.000
Preoperative day-of-surgery insulin	4 (13.3)	0 (0.0)	4 (6.7)	0.1124
Intraoperative insulin	6 (20.0)	8 (26.7)	14 (23.3)	0.7611
Hospital length of stay, days	3 (1-5) 3.4 (2.6)	3 (1-5) 4.1 (4.3)	3 (1-5) 3.8 (3.5)	0.7310
30-day readmission	10 (33.3)	9 (30.0)	19 (31.7)	1.000
90-day readmission	19 (63.3)	14 (46.7)	33 (55.0)	0.2993
30-day emergency department admission	4 (13.3)	3 (10.0)	7 (11.7)	1.000
90-day emergency department admission	5 (16.7)	4 (13.3)	9 (15.0)	1.000
Discharge disposition				0.0105
Home health service	1 (3.3)	5 (16.7)	6 (10.0)	
Home or self-care	25 (83.3)	15 (50.0)	40 (66.7)	
Rehab facility	1 (3.3)	0 (0.0)	1 (1.7)	
Skilled nursing facility	3 (10.0)	10 (33.3)	13 (21.7)	

Data are median (IQR) on the first line and mean (SD) on the second line for continuous variables and n (%) for categorical variables.

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

The average number of days of optimization (time period between referral to endocrinology and date of surgery) was 41.6, with a wide range of variability from 2 to 177 days. Although not statistically significant, fasting blood glucose values on the day of surgery were generally lower and had a smaller range than in the pathway group (median glucose 131 mg/dL [IQR 102–182 mg/dL] vs. 168 mg/dL [IQR 105–247], *P* = 0.21) (Supplementary Figure S1). Patients in the pathway group also trended toward lower postoperative day 1 median glucose values (165 mg/dL [IQR 136–194 mg/dL] vs. 190 mg/dL [IQR 147–225 mg/dL], *P* = 0.06). Similar to day-of-surgery values, postoperative day 1 glucose values showed less variability than the control group, as shown by the tighter IQR; 75% of the pathway group were recorded as having a median glucose value <200 mg/dL (Supplementary Figure S1).

Discharge disposition varied greatly between groups; fewer patients in the pathway group were discharged to a skilled nursing facility (10 vs. 33%) or needed home

health services (3 vs. 17%, *P* = 0.01) (Table 2). It is difficult to ascertain and largely unknown why the discharge disposition difference emerged within our current data set with a small number of patients. However, it is possibly a signal of improved perioperative coordinated care within the realm of glucose management, which may have been a small contributing factor in the decision to pursue postoperative skilled nursing care. Although care was taken to match the groups by procedure type (CPT code) and comorbidities, it is possible that the matched group had similar but more extensive surgery and had more extensive medical comorbidities, which may have contributed to this difference. Data are continuing to be collected for this project to reach higher numbers of participants for stronger statistical significance in the future.

A total of 13 of the 30 pathway patients had inpatient postoperative endocrinology consultations. In chart review of the pathway patients, the majority of patients who did not receive an inpatient consultation were found to have had controlled blood glucose levels postoperatively and were discharged early on



postoperative day 1. Unfortunately, the number of patients discharged on postoperative day 1 in the matched cohort was not tracked. These data could have helped shed light on the difference in discharge to a skilled nursing facility based on surgical acuity.

In the pathway group, it remains unclear whether the day-of-surgery anesthesiologist did not order the inpatient consultations as expected or whether the primary inpatient team cancelled the consultations because they felt they did not need the extra input. Furthermore, a few patients were involved in the program before the specific workflow reminder was in effect to remind day-of-surgery anesthesiologists to request an inpatient endocrinology consultation. One podiatry patient with poorly controlled blood glucose postoperatively did not receive a postoperative endocrinology consultation but would have greatly benefitted from one, whereas all other patients who did not receive a postoperative consultation had relatively controlled postoperative blood glucose based on chart review. More recently, in an effort to address hyperglycemia in podiatry patients elsewhere in the hospital, there now exists an automatic endocrinology consultation for podiatry patients with uncontrolled diabetes.

A total of 20 of the 30 pathway patients had outpatient postoperative endocrinology follow-up. There was no specific protocol for postoperative follow-up, which was left to the discretion of the inpatient endocrinologist and surgical team. Of those who did not have postoperative diabetes follow-up care, reasons varied from no-show status to instructions given for follow-up as needed before discharge.

The endocrinology team at Duke University Medical Center did not experience an overwhelming number of referrals from this pathway that the existing staff could not manage. However, this is an academic medical center with a full diabetes team on staff and thus probably was able to absorb more consultations than other community-based settings may have been able to handle. If an endocrinology team were to be overwhelmed at Duke or in other settings, possible options could include hiring more endocrinology providers if the program is deemed an important perioperative initiative, using personnel from other specialties such as internal medicine to help care for these patients, or further risk-stratifying patients and identifying more stringent trigger and referral criteria.

### What are your next steps?

The PASS Clinic was recently reorganized to focus on complete identification of all presurgical patients, improved triage, and earlier upstream notification to promote more robust preoperative optimization. We hope to continue to

improve screening for patients with diabetes with timely A1C testing and quick diabetes care through the existing pathway, with more time for disease optimization. Additionally, it was expected that most or all of the patients would have postoperative inpatient endocrinology consultations and postoperative follow-up care; however, this expectation was not fully realized. Further work to improve this process in Plan-Do-Study-Act cycles can include improving adherence to ordering inpatient endocrinology consultations and working toward a greater proportion of patients having follow-up care postoperatively. Although it is definitely possible that the inpatient endocrinology team may become overwhelmed with pathway patient consultations, currently this has not been an issue, and certain triggers or inclusion/exclusion criteria could be considered in the future should this issue arise.

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

We showed that improved perioperative glycemic control is possible for elective surgical patients with poorly controlled diabetes using a fast-tracked referral process to endocrinology colleagues in established clinics. This approach offers another possible avenue in addition to those that have already proven useful, such as a nested diabetes clinic within a preoperative clinic (9–11). Further, the flagging of these high-risk patients in the EHR allowed for prompt endocrinology involvement on the day of surgery. We feel this postoperative inpatient endocrinology follow-up was an important aspect of achieving improved glucose control on postoperative day 1, which is typically the hardest time period in which to manage blood glucose levels before patients resume a regular diet after surgery.

Challenges to this model of care included an irregular pattern of time to optimization (ranged from 2 to 177 days), which suggests avoidable care variability. A more robust protocol with more stringent process criteria could be used to reduce this variability while still maintaining a focus on individual patient needs. Strict trigger criteria based on recent A1C values, as well as a central hub for patient referrals (PASS Clinic versus relying solely on surgeon referral) helped to identify more patients who could benefit from such care. Finally, focusing especially on care transitions with EHR help can improve the number of patients who receive both an inpatient endocrinology consultations and complete postoperative follow-up.

### DUALITY OF INTEREST

T.E.M. is a consultant for Mallinckrodt. No other potential conflicts of interest relevant to this article were reported.

## QUALITY IMPROVEMENT SUCCESS STORY

### AUTHOR CONTRIBUTIONS

T.A.L. wrote the manuscript and researched data. J.W., S.A., and T.S. reviewed/edited the manuscript and contributed to the discussion. T.E.M. reviewed/edited the manuscript. M.F. completed the statistics for the project. T.A.L. 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.

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