ABSTRACT

As the prevalence of diabetes continues to increase in the United States, a higher proportion of elective surgical candidates will require specific preoperative education and guidelines to maximize patient outcomes and reduce the costs of care. The purpose of this article is to review the current literature to determine how preoperative glycemic control affects the lengths of hospital stays, postoperative complications, and mortality in people living with type 1 and 2 diabetes. Additional recommendations are provided for preoperative hypo- and hyperglycemia, the use of insulin pumps or continuous glucose monitors, and day-of-surgery management of insulin and oral hypoglycemic agents. Gaps in medical evidence are acknowledged and future directions in research are proposed to provide high-quality guidelines for the preoperative care of adult patients with diabetes.
INTRODUCTION

As the prevalence of diabetes increases in the United States, practicing physicians must be able to educate and manage these patients in the preoperative setting. With 29.1 million (9.3% of the U.S. population) Americans living with diabetes today, nearly 1 in 10 surgical candidates may have diabetes and require special recommendations before surgery [1].

While the 2011 Joint British Diabetes Societies Inpatient Care Group (JBDS) created guidelines for the preoperative management of patients with diabetes undergoing elective surgery, many physicians in the U.S. may not know these guidelines exist [2]. In a 2014 study on preoperative hemoglobin A1C (A1C) and its effect on clinical outcomes for patients undergoing surgery, the authors say “there are no standards of care for optimal A1C levels before surgery”[3]. A letter to the editor in response to this article stated that there are, indeed, standards for optimal A1C from the 2011 JBDS. The original authors responded to the letter with, “We were not aware of these guidelines and believe that most surgeons and anesthesiologists in the U.S. are not aware of them either” [3-5]. Despite the available evidence, there is a need for a practical set of guidelines that physicians can use to manage surgical candidates with diabetes safely and effectively in the preoperative setting to improve patient outcomes and reduce the costs of care.

This article seeks to review the current literature for preoperative glycemic control in adult patients with type 1 and 2 diabetes undergoing elective surgery. We will review the specific needs of patients with diabetes in the preoperative setting, such as A1C monitoring, pharmacologic alterations in oral and injectable glycemic agents, managing morning-of-surgery hypo- or hyperglycemia, and the costs associated with glycemic control.

PREOPERATIVE GLYCEMIC CONTROL

Hemoglobin A1C (A1C)

The A1C is a measure of the average blood glucose over a two to three month period, and has been used by surgeons as a risk assessment tool in the preoperative assessment of patients with diabetes who require elective surgery. The American Diabetes Association (ADA) has not provided recommendations for the optimal A1C in patients undergoing elective surgery, but generally recommends an A1C less than 7% to avoid the long-term complications of type 1 and 2 diabetes [6-10]. Several studies have shown associations between the preoperative A1C and increased morbidity of surgery, which raises questions regarding the ideal A1C range patients and surgeons should strive to achieve before agreeing on elective surgery.

Hospital length of stay after surgery is a reliable indicator of both patient morbidity and cost of care, as each additional day in the hospital costs more than two thousand dollars [11]. A 2014 study from Brigham and Women’s Hospital looked at nearly 450 individuals with diabetes from the National Surgical Quality Improvement Program (NSQIP) database to determine the relationship between preoperative A1C and the length of hospital stay [3]. The authors showed an A1C greater than 8% was associated with a significantly longer length of hospital stay and greater costs of medical care, but an A1C between 6.5% and 8% was comparable to individuals without diabetes. Another study showed longer hospital stays and increased healthcare costs in spine surgery patients with previously undiagnosed diabetes and an elevated A1C [12].

Beyond the increased length of hospital stay and cost of care, other studies have looked at how preoperative A1C affects complication and death rates after surgery in patients with diabetes. One study of nearly five hundred patients showed an A1C less than 7% was significantly associated with lower infections after non-cardiac surgery, which included pneumonia, wound infections, urinary infections, or systemic infections [13]. A similar A1C cutoff was observed in patients with diabetes undergoing bypass surgery, as an A1C greater than or equal to 7% was associated with a reduced five-year survival [14] and increased unfavorable events, including renal failure, stroke, and surgical wound infection [15].

While current research indicates that lowering a patient’s A1C prior to elective surgery may lead to shorter hospital stays, reduced costs, and improved clinical outcomes, no research compares patients who reduce their A1C before surgery to those who do not. Current evidence points toward a recommended preoperative A1C somewhere between 7% and 8.5% [2], the benefits of which should be discussed with patients in the preoperative setting despite a lack of official guidelines.
Hyperglycemia

Despite the lack of A1C recommendations in the perioperative setting, the ADA recommends perioperative glycemic control between 80 to 180 mg/dL [16], and advises against intensive insulin therapy due to the lack of benefit and potential for increased hypoglycemic episodes [17]. While hyperglycemia can be dangerous and patients may be tempted to aim for higher blood glucose during fasting, hyperglycemia in the preoperative setting has been described as a risk factor for poor surgical outcomes. A recent, large review showed diabetes is an independent risk factor for surgical site infection (SSI), and further showed hyperglycemia in the preoperative setting doubles the SSI risk [18]. In addition to the increased risk for SSI, perioperative hyperglycemia has been shown to increase the length of hospital stay and associated healthcare costs [19]. This highlights the importance of maintaining the ADA’s recommended perioperative glycemic recommendations and properly educating patients before surgery.

There are no official guidelines for cancelling elective surgeries based on preoperative hyperglycemia. Some have proposed, however, that a preoperative blood glucose between 300 to 500 mg/dL is an indication to cancel surgery [20]. More definitive recommendations to cancel surgery include severe dehydration, diabetic ketoacidosis (DKA), and hyperosmolar hyperglycemic nonketotic syndrome (HHNS) [21]. One U.S. hospital (Boston Medical Center) uses a preoperative blood glucose of 300 mg/dL as a cutoff for when to screen patients for potential DKA and HHNS, but there is no evidence to support this screening method [20]. There is a need for high-quality prospective studies to determine the ideal glycemic cutoff to undergo elective surgery, as operating room time is costly at $62 per minute and surgical outcomes are concerns for both patients and physicians [22].

Hypoglycemia

A dearth of evidence exists for the management of preoperative hypoglycemia the day of elective surgery, but certain patient-centered recommendations will help ease this potential burden on fasting diabetes patients. NPO status (withholding of oral food and fluids) in preoperative setting is concerning given the results from a patient survey presented at a national conference that showed a knowledge gap in key principals to avoid hypoglycemia in type 2 diabetes patients [23]. While NPO status after midnight is important to prevent the risk of aspiration during surgery and subsequent pneumonia [24], it may increase the risk of hypoglycemia in patients with diabetes. For this reason, patients with diabetes should be scheduled as the first case to reduce the NPO time and missed meals [2]. Contrary to what most patients are told for preoperative planning, the 2011 American Society of Anesthesiologists practice guidelines for preoperative fasting allow for clear fluids, which include sugary drinks and fruit juices without pulp, up to 2 hours before a surgical procedure [24]. This is an important and often overlooked aspect of preoperative education for patients with diabetes who may fear low blood glucose the morning of surgery.

To monitor for hypoglycemia, the ADA recommends finger sticks every 4 to 6 hours while NPO [16]. This is especially important in patients with hypoglycemic unawareness, a loss of the signs of hypoglycemia, due to long-standing diabetes [25]. Alternatively, patients achieving the 80-180 mg/dL perioperative standard may experience hypoglycemic symptoms if they generally have uncontrolled diabetes, and thus, should closely monitor their blood glucose [25]. One study looked at fasting diabetes patients who had hypoglycemic symptoms while driving to have routine labs drawn, and found a 68% reduction in risk when patients were properly educated on fasting precautions [26]. While surgical patients are typically accompanied by another individual to drive them to the hospital, similar guidelines should become standard to prevent hypoglycemia in the preoperative setting.

A growing trend in glycemic monitoring for people living with type 1 diabetes is the use of continuous glucose monitors (CGMs), which can alert patients to decreasing glucose trends in the absence of hypoglycemic symptoms [27]. While CGMs are not yet meant to drive glucose decision-making, and should be supplemented with self-monitoring of blood glucose, clinical trials are currently underway to answer this question [10]. It should be noted, however, that CGM use in conjunction with acetaminophen may lead to falsely elevated glucose readings that could be significant for the NPO diabetes patient [28]. This effect is most pronounced up to eight hours after acetaminophen ingestion, and is likely due to interactions of acetaminophen at the CGM sensing electrode [28]. This further highlights the ADA’s recommendations to monitor blood glucose in the preoperative setting, and not to rely solely on CGM measurements [10, 16].
Insulin and Oral Hypoglycemic Agents

The ADA has limited guidelines for managing insulin and oral hypoglycemic agents in the preoperative setting, but does recommend stopping oral hypoglycemic agents the morning of surgery and taking half the intermediate insulin dose or the full long-acting insulin dose [16]. A consensus statement from the Society for Ambulatory Anesthesiology and the JBDS guidelines recommend stopping short-acting insulin the day of surgery due to NPO status [2, 21]. While seemingly simple, there are other considerations patients with diabetes may wish to know before the day of surgery, such as the use of insulin pumps during surgery and specific medication guidelines.

Several studies have demonstrated that insulin pumps in the surgical setting are reasonable alternatives to standard insulin injections, but pumps must be well-documented to ensure the hospital staff is aware of their use [29]. One study found insulin pump use in the perioperative setting had no increased medical expenditures and had similar patient outcomes as standard insulin injections [30]. Some protocols recommend reducing the basal insulin by 20% at midnight before surgery when using an insulin pump, but no consensus has been agreed upon [20]. The current authors believe another reasonable option is to maintain the patient’s basal insulin without bolusing starting at 10:00 PM the evening before surgery. Other considerations for insulin pump use should surround the placement of the pump away from the surgical site, but no guidelines are available to further clarify preoperative pump site placement.

Additional considerations for managing oral medications relates to metformin and the use of intravenous (IV) contrast in the surgical setting. IV contrast was previously thought to increase the likelihood of dreaded metformin complications resulting from kidney damage and accumulation of lactic acid in the blood [31]. New guidelines have since emerged that allow for more liberal use of metformin in the setting of IV contrast, and do not require stopping metformin with type I-III chronic kidney disease. Metformin should, however, still be stopped prior to undergoing elective surgery, and may be restarted after surgery as long as patients with acute kidney injury or severe chronic kidney disease did not receive IV contrast [32].

TRANSLATION TO CLINICAL PRACTICE

Despite the preoperative glycemic guidelines created by the JBDS, many physicians are unaware of their existence and studies have shown various barriers to adopt guidelines into clinical practice. One qualitative study identified various barriers that prevent the adoption of clinical guidelines, noting a lack of incentive to incorporate guidelines into physician practices as a major barrier [33]. Such incentives to adopt guidelines that improve patient outcomes while reducing costs are emerging through negative incentives for provider preventable conditions (as defined by the Centers of Medicare and Medicaid Services), including manifestations of poor glycemic control [34, 35]. The researchers also highlighted the importance of recognizing the interactions between patients, physicians, and systems that allow the integration of guidelines into practice, and found a lack of education and a preference for clinical experience were reasons to forgo practice guidelines [33].

Integrated care pathways facilitate the translation of practice guidelines into local protocols that overcome barriers to utilize evidence-based care as the standard of care [36]. Such an approach was utilized by researchers at Boston University and Yale University hospitals in the creation of a perioperative glycemic control program [20]. By implementing local protocols based on the evidence available for perioperative glycemic control, researchers were able to install system-wide practices to better manage diabetes surgical candidates with evidence-based medicine. Similarly, researchers at the Mayo Clinic developed a protocol to improve documentation of insulin pump use in patients with diabetes undergoing elective surgery to increase medical team awareness of pump use [37]. Figure 1 demonstrates an algorithm that incorporates the available evidence in the literature to make surgical decisions based on preoperative glycemic control in patients with diabetes undergoing elective procedures.
Figure 1. Algorithm for preoperative glycemic control

Preoperative recommendations for glycemic control in patients with diabetes undergoing elective surgical procedures based on current evidence and previous protocols [20, 29]. A1C, hemoglobin A1C; DKA, diabetic ketoacidosis; HHNS, hyperosmolar hyperglycemic nonketotic syndrome; OR, operating room.

Preoperative Office Visit (1 week before surgery)

A1C

>8.5%

Postpone surgery if possible to improve A1C

≤7%

Weigh risks and benefits of surgery relative to A1C

7-8.5%

Postpone surgery to improve A1C

PATIENT EDUCATION NIGHT BEFORE SURGERY

- NPO at midnight: allow clear fluids up to 2hrs before
- Insulin: 1/2 intermediate or full long-acting dose at 10pm, no bolusing while NPO
- Oral hypoglycemics: stop night before
- Pump: keep away from surgical site and consider surgical positioning
- Encourage friend/family member to drive patient to hospital
- Schedule as first case to reduce NPO

Glycemic control unlikely to improve without surgery

Morning of Surgery

Finger Stick

181-300

300-500

≤180

Evidence of:
- Severe dehydration
- DKA
- HHNS

Initiate IV insulin with dextrose

Proceed to OR

Cancel surgery
CONCLUSIONS AND OUTLOOK

This review illustrates the current evidence available for preoperative glycemic control in adult patients with diabetes undergoing elective surgical procedures. While evidence is available for using the A1C and preoperative blood glucose to assess a patient’s risk of surgical complications and mortality, no consensus has determined how these variables should alter a patient’s surgical care. A multidisciplinary collaborative approach between the medical personnel involved in the preoperative care of patients with diabetes should consider implementing more patient-centered recommendations to address specific needs surrounding glycemic control. Notably, expanding awareness of anesthesia guidelines that allow patients to drink clear, sugary drinks without pulp (e.g., apple juice) up to two hours before surgery would ease patient concerns of hypoglycemia while NPO. Recommendations regarding insulin pumps and continuous glucose monitors in the preoperative setting further enhance the patient-centered education that should take place to improve patient care and surgical outcomes.

This information serves as a basis to educate patients with diabetes before surgery and identify gaps in the literature that should be filled with high-quality clinical trials. The cost implications associated with glycemic control in the preoperative setting are clearly illustrated by hospital length of stay, complications, and the surgical cancellations that may result from inadequate glycemic management. It remains unclear how patient outcomes and medical costs are affected by delaying surgery to improve glycemic control, but this is a topic of interest for future research.

CONFLICT OF INTEREST DISCLOSURES

All authors have completed and submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest. Mr. Weir has no disclosures to report. Dr. Deeb reports grants and personal fees from Novo Nordisk, outside the submitted work.

REFERENCES


