

# Perioperative Glucose Control in Patients With Diabetes Undergoing Elective Surgery

Vinaya Simha, MD; Pankaj Shah, MD

**Hyperglycemia in the perioperative period** is associated with several adverse outcomes including wound infection, pneumonia, sepsis, and cardiovascular events.<sup>1</sup> **Limited evidence** suggests that **good glucose control** is likely to be **beneficial** in **reducing** postoperative **mortality**, **length** of hospital stay, and cardiovascular **complications** such as stroke.<sup>2</sup> Guidelines for achieving good perioperative glucose control are available but lack sufficient detail.<sup>3</sup> In this JAMA Insights article, we outline an **easy-to-adopt approach** for safe and effective perioperative management of hyperglycemia.

## Preoperative Assessment

Hemoglobin A<sub>1c</sub> (HbA<sub>1c</sub>) should be checked preoperatively in all patients with diabetes to assess glucose control. Although higher levels are associated with unfavorable outcomes, **no evidence** shows that **postponing surgery** to improve glucose control is **beneficial**. **Perioperative glucose levels** have been shown to **influence** surgical **outcomes more** than HbA<sub>1c</sub>.<sup>4</sup> However, it is reasonable to defer elective surgery in patients with **HbA<sub>1c</sub> above 8%** if the situation will intensify diabetes management strategies. Severe hyperglycemia (glucose >250 mg/dL), with or without metabolic decompensation, warrants postponement of elective surgery.

During the preoperative evaluation of patients with diabetes, it is important to review current glycemic control and pharmacotherapy and provide the patient with written instructions on how to adjust medications the day before and the morning of surgery. In general, on the day before surgery, **patients can continue all medications including metformin**. Concerns about **metformin-induced lactic acidosis** or other adverse effects, when this drug is administered before surgery, are largely **unfounded**.<sup>5</sup> The **only medication** that may need dose **adjustment** the day before surgery is **long-acting basal insulin** administered at **night**. If patients take inappropriately high doses of **basal insulin (>60%** of total daily dose of insulin), predisposing to **hypoglycemia** during a prolonged fast, the **dose should be reduced by 50% to 75%**. This is especially relevant for patients with malnutrition or other concomitant illnesses such as renal and hepatic insufficiency, which increase the risk for hypoglycemia. A recent observational study in patients with type 2 diabetes indicated that the **optimal basal insulin dose** on the **evening before surgery** is about **75%** of the **normal** dose.<sup>6</sup>

The **Figure** presents a possible approach for adjustment of insulin dose on the morning of surgery. Although not formally validated, this approach is used extensively at Mayo Clinic with good results. In patients with **type 1 diabetes**, it is important to **not interrupt basal insulin** delivery to prevent the occurrence of diabetic ketoacidosis. **No adjustments in the dose of long-acting insulin** are required if its current dose is appropriate (no hypoglycemia on prolonged fasting). In patients with **type 2 diabetes**, it is often reasonable to administer **half the dose of basal insulin** in the **morning of surgery**. Similarly, the **dose of intermediate-acting insulin** should be reduced by **half** in all patients because it **provides prandial coverage** for the **midday meal**, which will likely be **skipped** on the day of surgery. **All short-acting prandial insu-**

**lin doses are stopped until** the patient **resumes oral food intake**, as also are **noninsulin antidiabetic agents**. For patients treated with premixed insulin preparations who have satisfactory fasting blood glucose levels, **half the basal component dose** can be administered as **intermediate-acting insulin (NPH)**. However, **if patients have fasting hyperglycemia (>200 mg/dL)**, **half the morning dose** of premixed insulin can be administered before surgery.

When patients report for surgery in the morning, their blood **glucose** and **time and dose of last diabetes medication** should be recorded. **Hypoglycemia** (glucose <70 mg/dL) should be treated with glucose **tablets** or gel if food or drink is not allowed. For patients taking insulin or a sulfonylurea, it is desirable that blood glucose be **greater than 100 mg/dL** before the start of surgery. If blood glucose is **greater than 180 mg/dL**, a supplemental correction dose of **rapid-acting insulin** is often administered. **Intravenous insulin infusion** may need to be initiated in some conditions (eg, severe hyperglycemia or **type 1 diabetes** with **prolonged surgery**). A standard protocol for **subcutaneous** supplemental correction insulin dose and also for **intravenous** insulin infusion rates should be adopted.

To the extent possible, elective surgery for patients with diabetes should be scheduled early in the morning to help limit the duration of fasting. When this is unavoidable, **basal insulin** and **supplemental** correction insulin should be administered as outlined previously, and appropriate prandial coverage should also be provided if the patient is allowed to eat early in the day.

## Intraoperative Glucose Management

Intraoperative hyperglycemia has been associated with a variety of undesirable surgical outcomes, but the **benefits of stringent glucose control** during this period are **uncertain**. A randomized trial of **intensive** insulin infusion therapy to maintain blood glucose in the normal range of **80 to 100 mg/dL** was **not** found to favorably **influence** postoperative **complications** and may be associated with greater harm.<sup>7</sup> It is therefore advisable to maintain blood glucose **less than 180 mg/dL** without causing hypoglycemia. This can be achieved either by **subcutaneous** supplemental doses of **rapid-acting insulin** administered **every 2 hours** or by intravenous insulin **infusion** with blood **glucose monitoring** every **1 to 2 hours**.

## Postoperative Management

Upon arrival to the postoperative care area, blood glucose must be rechecked and intraoperative insulin administration reviewed. Intravenous insulin infusion should be continued in patients who received it intraoperatively and initiated if subcutaneous insulin injections have not been effective in controlling blood glucose levels. **Intensive insulin** therapy in the **postoperative period** has been associated with **lesser risk of infection** and overall **morbidity and mortality**, but ideal glucose **targets** are **not clear**. Based on studies in other hospitalized patients (both surgical and nonsurgical), it seems reasonable to target preprandial blood glucose between **100 and 140 mg/dL** and random

Figure. Suggested Administration of Insulin and Other Diabetes Medications on the Morning of Surgery

Patient due for elective surgery	Medication plan for morning of surgery		
No known type 1 diabetes and no similar clinical features	Hold	50% Dose	Continue normal therapy
▶ Noninsulin therapies only	●		
Combination of insulin and noninsulin therapies		●	
▶ Long- and intermediate-acting insulin		●	
▶ Short- or rapid-acting insulin and noninsulin therapies	●		
Known type 1 diabetes or similar clinical features present <sup>a</sup>	Continue basal insulin therapy		
Combination of short- or rapid-acting and intermediate-acting insulin	●		
▶ Short- or rapid-acting insulin	●		
▶ Intermediate-acting insulin		●	
Combination of short- or rapid-acting and long-acting insulin	●		
▶ Short- or rapid-acting insulin	●		
▶ Long-acting insulin (appropriate dose)			●
▶ Long-acting insulin (inappropriately high dose)		●	
Indications for inappropriately high long-acting insulin dose: Frequent hypoglycemia, especially at night or early morning Steep overnight decline in blood glucose (>40 mg/dL) Patient requires bedtime snack to avoid hypoglycemia Long-acting insulin dose is >60% of total daily insulin dose		●	
Insulin pump therapy	●	Discontinue insulin pump and start intravenous insulin infusion therapy	
▶ Continued perioperative insulin pump use is not indicated	●	Discontinue insulin pump and start intravenous insulin infusion therapy	
▶ Continued perioperative insulin pump use is indicated			●
Indications for continued perioperative use: Patient has good glucose control and is adept at pump usage Short surgery duration (<2 h) and quick recovery expected No hemodynamic compromise Pump infusion site is not close to surgical field			●
			Reduce to 25% if basal rate is inappropriately high

Insulins by method of performance are categorized as long-acting (glargine, detemir, and degludec), intermediate-acting (NPH insulin), and short-acting (regular human insulin) insulins, and rapid-acting insulin analogues (insulin aspart, lispro, and glulisine).

<sup>a</sup> Examples of patient characteristics: needing multiple doses of insulin and if 1 dose of insulin is skipped, the next monitored glucose level is very high; small changes in insulin doses lead to big changes in glucose concentration; history of severe hyperglycemia or ketoacidosis without a major stress; high within-day glucose variability; recurrent hypoglycemic episodes; patients with postpancreatectomy diabetes.

blood glucose between 100 and 180 mg/dL. A basal-bolus regimen has been shown to be more effective than supplemental correction sliding-scale insulin alone in surgical patients<sup>8</sup> and should be adopted once patients resume oral nutrition.

### Use of Insulin Pump in the Perioperative Period

Continuous subcutaneous insulin infusion through an insulin pump, with or without glucose sensor augmentation, is becoming increasingly popular and can be used to perioperatively deliver basal insulin in appropriate conditions (Figure). Use must be limited to patients capable of self-management who are undergoing a relatively short surgery. Basal rate reduction should be considered similar to

adjustment of basal injection dose (as discussed previously). Few studies have examined the reliability of continuous glucose monitoring in hospitalized patients, and therefore, use in the perioperative period should be restricted only to research settings at this time.

### Conclusions

Hyperglycemia represents significant risk to surgical patients, and effective management has the potential to improve surgical outcomes in patients with diabetes. A comprehensive program from preoperative evaluation through surgery and postoperative care and culminating in clear discharge instructions about diabetes medications is necessary to accomplish this goal.

#### ARTICLE INFORMATION

**Author Affiliations:** Division of Endocrinology, Diabetes, and Metabolism, Mayo Clinic, Rochester, Minnesota.

**Corresponding Author:** Vinaya Simha, MD, Division of Endocrinology, Diabetes, and Metabolism, Mayo Clinic, 200 First St SW, Rochester, MN 55905 (simha.aj@mayo.edu).

**Published Online:** January 7, 2019.  
doi:10.1001/jama.2018.20922

**Conflict of Interest Disclosures:** None reported.

#### REFERENCES

1. Kwon S, Thompson R, Dellinger P, et al. Importance of perioperative glycemic control in general surgery. *Ann Surg.* 2013;257(1):8-14.

2. Buchleitner AM, Martínez-Alonso M, Hernández M, et al. Perioperative glycaemic control for diabetic patients undergoing surgery. *Cochrane Database Syst Rev.* 2012;(9):CD007315.

3. American Diabetes Association. Diabetes care in the hospital. *Diabetes Care.* 2018;41(suppl 1):S144-S151.

4. van den Boom W, Schroeder RA, Manning MW, et al. Effect of A<sub>1c</sub> and glucose on postoperative mortality in noncardiac and cardiac surgeries. *Diabetes Care.* 2018;41(4):782-788.

5. Duncan AI, Koch CG, Xu M, et al. Recent metformin ingestion does not increase in-hospital morbidity or mortality after cardiac surgery. *Anesth Analg.* 2007;104(1):42-50.

6. Demma LJ, Carlson KT, Duggan EW, et al. Effect of basal insulin dosage on blood glucose concentration in ambulatory surgery patients with type 2 diabetes. *J Clin Anesth.* 2017;36:184-188.

7. Gandhi GY, Nuttall GA, Abel MD, et al. Intensive intraoperative insulin therapy versus conventional glucose management during cardiac surgery. *Ann Intern Med.* 2007;146(4):233-243.

8. 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(2):256-261.