

**KEY WORDS**

Diabetes, Surgery, Perioperative management, Insulin, Hyperglycemia in ICU

**INTRODUCTION**

Hyperglycemia has shown strong association with worse outcomes in critically ill hospitalized patients.<sup>1</sup> Hyperglycemia in patients following stroke have poor functional recovery and higher mortality.<sup>2</sup> Critically ill patients with high blood glucose, who had myocardial infarction are more likely to have congestive heart failure, cardiogenic shock or death during hospitalization.<sup>3</sup> Perioperative hyperglycemia in surgical patients, increases the risk of postoperative mortality, and cardiovascular, respiratory, neurologic, and infectious morbidity.<sup>4</sup> Hyperglycemia increases morbidity and increased length of stay, irrespective of admission specialty, which increases the inpatient costs. This is a particular problem in surgical patients where the excess bed days were estimated to be 45% greater than for people with diabetes admitted to medical wards.<sup>5</sup> The peri-operative mortality rate is reported to be up to 50% higher than that of the non-diabetic population.<sup>6</sup> Hyperglycemia might be due to pre-existing diabetes or it might get first detected just on admission. While hospitals often have standard protocols in place to manage those known to have diabetes, these previously known diabetics are just a fraction of those at risk for abnormal inpatient glycemic control. The other dysglycemic patients, especially undiagnosed diabetes and those with stress-induced hyperglycemia (SIH), may be unexpected, unrecognized, difficult to differentiate from each other in the inpatient setting, and not well understood, present a big challenge in perioperative care.

**INPATIENT HYPERGLYCEMIA: DEFINITIONS**

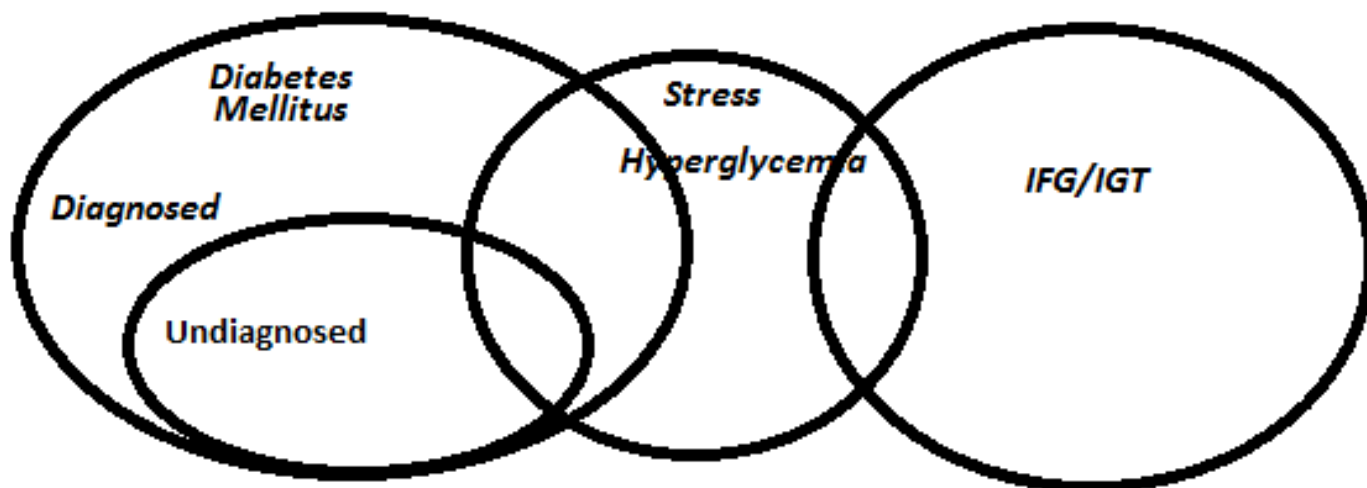
The American Diabetes Association (ADA) classifies three categories of inpatient dysglycemia.<sup>7</sup> The first category is being those with a known case of diabetes. May be type 1 DM, type 2 DM, pre-existing IFG (Impaired fasting glucose) and IGT (Impaired Glucose Tolerance) or a case of GDM. The second category, unrecognized diabetes, includes patients with inpatient hyperglycemia which persists even after discharge. However, because inpatient blood glucose values should not be used routinely to make a diagnosis of diabetes, this population is difficult to define accurately in the acute care setting. Hemoglobin A<sub>1c</sub> (HbA<sub>1c</sub>) is a suitable screening test for diabetes<sup>8</sup> may simplify the inpatient diagnosis of diabetes if drawn preoperatively. The third category, hospital-related hyperglycemia, or stress-induced hyperglycemia (SIH), defines patients with inpatient hyperglycemia

that normalizes when the counter-regulatory hormone surge and excessive pro-inflammatory state abate. Stress hyperglycemia seem to be different than hyperglycemia secondary to diabetes, in that it confers an increased risk of mortality. Rady and colleagues have shown higher mortality in patients without diabetes requiring insulin versus patients with known diabetes (10% vs 6%) in a retrospective single institution intensive care unit (ICU), despite lower average glucose values in the group without diabetes.<sup>9</sup> In their retrospective cohort, Egi et al have found that hyperglycemia was associated with increased mortality in patients without diabetes, but not in patients with known diabetes, suggesting that high blood glucose in this group may represent a different pathophysiology and natural history than in patients with known diabetes.<sup>10</sup>

Current recommendations for glycemic control do not differentiate patients with diabetes from those with hyperglycemia attributable to stress, but it is not known currently whether glycemic targets should, in fact, be the same.<sup>12</sup> Unfortunately, very little is currently known about SIH in general, including its natural history and risk for developing overt diabetes mellitus in the future. (Figure 1)

**WHY IS MANAGEMENT OF DIABETES IMPORTANT IN THE SURGICAL SETTING?**

On average, diabetics require more hospitalizations, longer durations of stay, and cost more to manage than non-diabetics. The estimated cost of managing known diabetes in 2012 was \$245 billion, a 41% increase from the 2007 estimate, with the largest percentage (43% of the total medical cost) being spent on inpatient hospital care.<sup>13</sup> Furthermore, diabetics undergo certain procedures and surgeries more commonly than non-diabetics and have higher morbidity and mortality when acutely compromised or ill.<sup>14</sup> Surgical procedures may result in various metabolic consequences, which can alter normal glucose homeostasis. The resulting hyperglycemia is a risk factor for postoperative sepsis,<sup>15</sup> endothelial dysfunction<sup>16</sup> cerebral ischemia<sup>17</sup> and impaired wound healing.<sup>18</sup> Moreover, the stress response may trigger diabetic ketoacidosis<sup>19</sup> (DKA) or hyperglycemic hyperosmolar syndrome<sup>20</sup> (HHS) during surgery or postoperatively. Nevertheless, new data suggests that meticulous control of blood glucose in patients undergoing major surgeries, like cardiac<sup>21</sup> and orthopedic<sup>22</sup> procedures may minimize the above-mentioned negative sequel and promote better outcomes.



**Fig. 1: Relationship of In-hospital Hyperglycemia<sup>11</sup>**

### HOW DOES SURGERY AFFECTS METABOLISM (FIGURE 2)

The surgery-associated trauma results in increased production of stress hormones, cortisol and catecholamine, which reduce the insulin sensitivity, while heightened sympathetic activity reduces insulin secretion. Simultaneously there is increase in growth hormone and glucagon secretion also.<sup>23</sup> Amongst diabetics, insulin production is already marginalized; the metabolic changes that occur during surgery cause a marked catabolic state. Changes in normal metabolic patterns due to surgery trigger gluconeogenesis, glycogenolysis, proteolysis, lipolysis, and ketogenesis eventually resulting in hyperglycemia and ketosis.<sup>24</sup>

### PRE-OPERATIVE ASSESSMENT

Preoperative identification of patients with DM, or those at risk for perioperative dysglycaemia, provides a potential opportunity to reduce morbidity and mortality. Early identification facilitates timely intervention and allows arrangement of appropriate perioperative and long-term follow-up.<sup>26</sup> In any hyperglycemic inpatient who did not have a prior diagnosis of diabetes but with fasting glucose  $\geq 100$  mg/dl or random glucose  $\geq 180$  mg/dl, we should get HbA<sub>1c</sub> done to determine the presence or absence of pre-existing diabetes. HbA<sub>1c</sub> values  $>5.7\%$  is suggestive of prediabetes, while HbA<sub>1c</sub> of  $>6.5$  endorsed the diagnosis of diabetes. Given the implication of undiagnosed diabetes on poor wound healing, every effort should be made to establish the diagnosis prior to discharge. Such patients should be considered high risks for and should also receive appropriate ambulatory follow-up.

### PREOPERATIVE EVALUATION

In elective surgical procedures, potential problems should be identified, corrected, and stabilized before surgery. Preoperative evaluation includes assessment of metabolic control and any diabetes-associated complications, including cardiovascular disease, autonomic neuropathy, and nephropathy, which could affect the surgical outcome. Asymptomatic cardiac ischemia occurs relatively often in patients with diabetes.<sup>27</sup> The presence of cardiovascular risk factors should prompt a thorough evaluation. At minimum, resting electrocardiography should be

performed, but a stress test is often justified if there is suspicion for cardiovascular disease. Cardiac autonomic neuropathy may predispose patients to perioperative hypotension,<sup>28</sup> so the presence of resting tachycardia, orthostatic hypotension, peripheral neuropathy, and loss of normal respiratory heart rate variability should be sought. Serum creatinine levels should be measured, but they are not a sensitive indicator of early renal dysfunction, which is usually advanced before an elevation in creatinine develops. Kidney function can be estimated by using eGFR formulas but, if a high index of suspicion for renal impairment exists, a measured creatinine level from a 24-hour urine collection is the best gauge of renal function. Diabetic patients with proteinuria or abnormal creatinine clearance have a greater risk of developing acute renal failure.

### STANDARDS FOR PERIOPERATIVE CARE INCLUDE THE FOLLOWING:<sup>26</sup>

1. Target glucose range for the peri-operative period should be 80–180 mg/dL.
2. Preoperative risk assessment for patients at high risk for ischemic heart disease and those with autonomic neuropathy or renal failure.
3. The morning of surgery, hold any oral hypoglycemic agents and give half of NPH dose or full doses of a long-acting analog or pump basal insulin.
4. Monitor blood glucose every 4–6 h while NPO and give short-acting insulin as needed.

A review found that tight perioperative glycemic control did not improve outcomes and was associated with more hypoglycemia<sup>29</sup> therefore, in general, tighter glycemic targets than mentioned above are not advised.

### PERIOPERATIVE MANAGEMENT

Transition from tight to reasonable glucose control: Van den Berghe and colleagues in 2001 published their single-centered prospective randomized study of 1548 surgical ICU patients and have reported a lower risk of blood stream infections, renal failure, blood transfusions, critical illness polyneuropathy, shorter requirement for mechanical ventilation, and a 30% decrease in mortality,

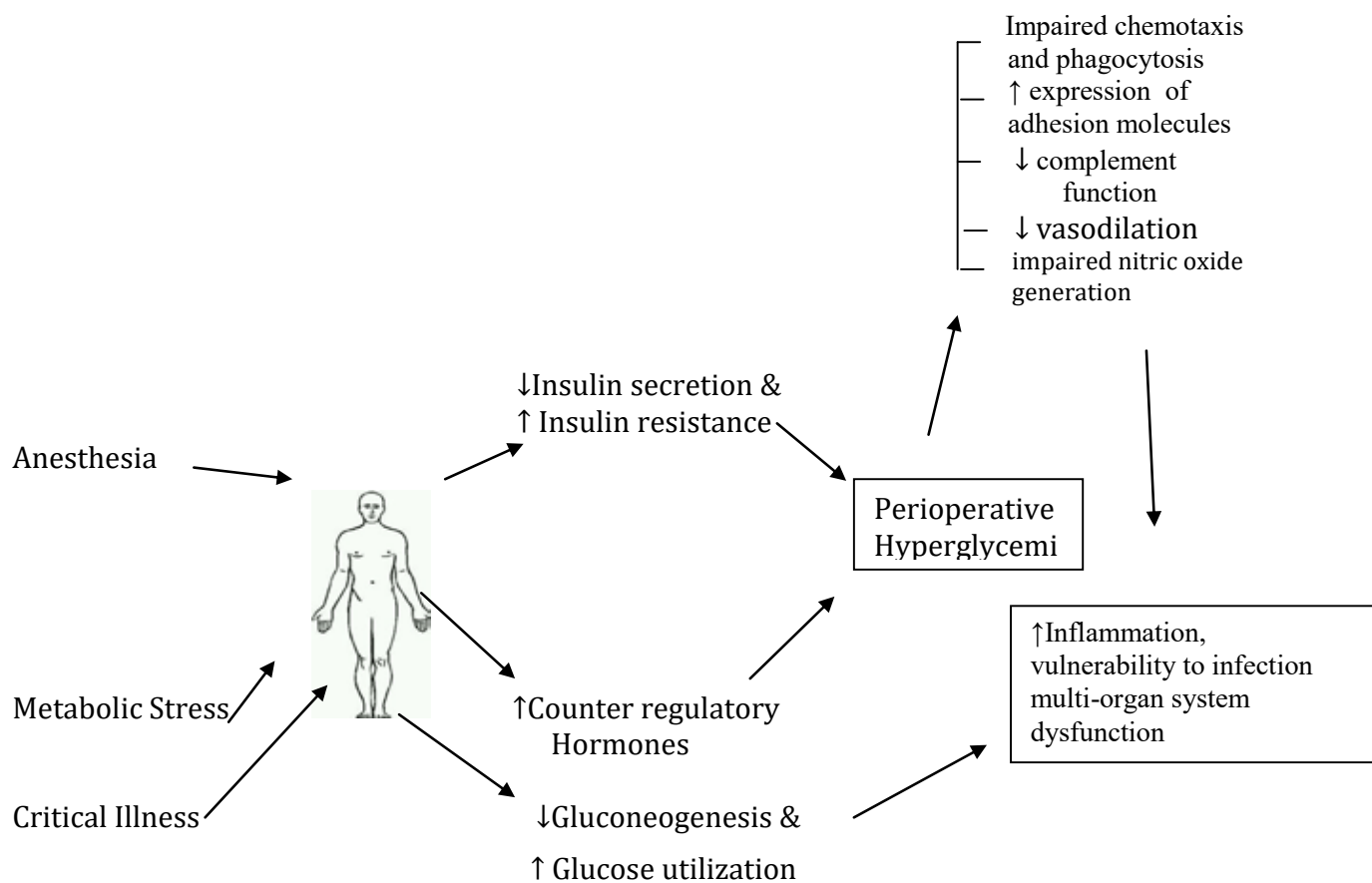


Fig. 2: How Surgery affects Metabolism?<sup>25</sup>

which was reduced in patients given an insulin infusion to control blood glucose to 80–110 mg/dl compared to 180–200 mg/dl, most of whom had recent cardiac surgery. This is also referred as “tight” glucose control. The results from this investigation were met with great enthusiasm, and tight glucose control became the standard of care in many institutions.<sup>30</sup> However, a meta-analysis of 29 randomized controlled trials found no difference in mortality between “tight” glucose control (<110 mg/dL) and “moderately tight” (<150 mg/dL) control.<sup>31</sup> Importantly the largest prospective multinational, multidisciplinary Normoglycemia in Intensive Care Evaluation and Survival Using Glucose Algorithm Regulation (NICE-SUGAR) trial in 6104 ICU patients reported increased mortality in patients randomized to achieve a blood glucose level of 81–108 mg/dl versus <180 mg/dl.<sup>32</sup> Thereafter, updated, comprehensive recommendations for inpatient glycemic control were issued by the American Association of Clinical Endocrinologists (AACE) and the ADA. They emphasize the need for “reasonable, achievable, and safe” glycemic goals and recommended in-hospital intensive care unit targets to 140–180 mg/dl and have suggested 100–180 mg/dl as a guideline for general care medical and surgical wards.<sup>33</sup>

### SHOULD SURGERY BE DELAYED TO OPTIMIZE HEMOGLOBIN A<sub>1</sub>C OR ACUTE HYPERGLYCEMIA?

It is also unclear whether shorter term improvement in glucose control (hours to days) could improve perioperative outcomes. Observational evidence shows that patients with acutely elevated preoperative glucose

fare worse than those with normoglycemia,<sup>34</sup> although there have been no randomized, prospective trials to date investigating whether acute preoperative glycemic correction carries any benefit. At this time, it seems prudent to control blood glucose to a reasonable level preoperatively, but recommendations for exact targets cannot be made. In addition, a delay in surgery is not practical for many patients requiring urgent or emergent procedures. At this point, glycemic correction of elevated HbA<sub>1c</sub> prior to elective surgery is not recommended.

### HOW TO MINIMIZE THE RISKS OF EMERGENCY SURGERY IN PATIENTS WITH DIABETES

- Metabolic status: immediate measurement of plasma glucose, pH, creatinine, BUN, electrolytes
- Volume status: check for orthostasis, elevated BUN and/or creatinine, urine output
- Cardiac status: ECG
- Delay surgery if possible until metabolic control and volume status are stabilized.
- Maximize glucose, electrolyte, and acid-base status. Insulin and glucose infusions.
- Saline infusion if volume is depleted, depending on renal function and cardiac status.
- Potassium infusion if renal function is normal and serum potassium is normal or low. Bicarbonate infusion only in patients with severe acidosis

## WHAT PHARMACOLOGIC AGENTS ARE RECOMMENDED?

Insulin remains the standard of care for inpatient glycemic control. In the ICUs, insulin infusions are the preferred, as the half-life of intravenous insulin is in minutes, allowing for rapid titration in the setting of changing clinical status. Insulin infusions are also useful on general care wards, allowing rapid titration at a time when steroids may taper, the counter regulatory hormone surge declines, and diet is advanced. However, because insulin infusion is labor-intensive, and is not available on many general care units, subcutaneous insulin, including basal, bolus, and correction, is the recommended alternative to using correction regimens alone. As a general rule, correction or “sliding scale” insulin should not be used as a single modality.<sup>35</sup>

## ORAL ANTI-DIABETIC DRUGS

Preoperatively, oral hypoglycemic agents, especially sulfonylurea and meglitinide, have potential for producing hypoglycemia during fasting prior to surgery. In addition, the long half-life of many of these drugs makes titration in the setting of rapidly changing clinical parameters difficult. Thus, oral antidiabetic drugs should be continued up to the night prior to surgery, then held on the morning of surgery, with consideration of the fact that stopping antidiabetic therapy too early may compromise glucose control. Maintenance of preoperative glucose concentrations of 140 to 180 mg/dL or less is a reasonable goal. Oral drugs should not be restarted, until the patient has resumed adequate and regular oral intake. Until adequate oral intake occurs, short- or medium duration insulin may be used to treat hyperglycemia until oral antihyperglycemic drugs can be restarted. Insulin therapy allows an improved ability to titrate to changing glucose concentrations compared with oral hypoglycemic agents. Sulfonylurea agents should be held for 24 hours prior to elective surgery because of the risk of adverse effects resulting from closure of the cardiac  $K_{ATP}$  channels, which may increase the risk for myocardial ischemic injury by blocking an intrinsic mechanism of cardio-protection, termed “ischemic preconditioning”. Ischemic preconditioning provides myocardial protection by the application of brief episodes of ischemia, which renders the myocardium more resistant to injury.<sup>36</sup> Because the meglitinides (nateglinide, repaglinide), act by a similar mechanism involving closure of the  $K_{ATP}$  channels, it is recommended that these drugs should also be held for 24 hours prior to surgery.

Chemically metformin has similarities to its predecessor, phenformin, which was associated with high risk of lactic acidosis and approximately 50% mortality<sup>37</sup> thus, concern has been raised of the possibility of life-threatening lactic acidosis occurring with metformin. In addition, surgical patients are already at increased risk for lactic acidosis because of predisposing conditions, including renal insufficiency, congestive heart failure, hypoxemia and hypovolemia. Perioperative metformin-associated lactic acidosis has been reported;<sup>38</sup> thus it is recommended that metformin to be discontinued for 24 hours or more prior to surgery. Metformin may be restarted following surgery after adequate oral intake has resumed. Metformin should

not be restarted in patients with renal insufficiency, hepatic impairment, or heart failure because of the increased risk of metabolic acidosis.<sup>39</sup> Oral agents have class-specific limitations for inpatient use and, except for the most stable general care patients approaching discharge, should not be used routinely. An elevated preoperative HbA<sub>1c</sub> can provide information that a significant adjustment in preoperative medication may be needed at discharge, including continuing of inpatient insulin for patients that were first placed on it in the hospital.<sup>11</sup>

## INSULIN THERAPY

Insulin is the drug of choice for most of the patients subjected for surgery, especially during any major surgical procedures. The best protocol is basal-bolus regimen. Use of insulin analogues (Rapid acting: Aspart, Lispro, Glulisine and Long acting: Glargine, detemir) is preferred over regular & NPH insulin. Endocrine society clinical practice have given the most simplified recommendations as below:

Example of a basal bolus insulin regimen for the management of non-critically ill patients with type 2 diabetes<sup>41</sup>

- A. Basal insulin orders: Discontinue oral diabetes drugs and non-insulin injectable diabetes medications upon hospital admission. Starting insulin: calculate the total daily dose as follows:
  - 0.2 to 0.3 U/kg of body weight in patients: aged >70 yr and/or e-GFR less than 60 ml/min.
  - 0.4 U/kg body weight/day for patients not meeting criteria above & have BG of 140–200 mg/dl.
  - 0.5 U/kg body weight/day for patients not meeting the criteria above & have BG 201–400 mg/dl.
  - Distribute total calculated dose as approximately 50% basal insulin and 50% nutritional insulin.
  - Give basal insulin once (glargine/detemir) or twice (detemir/NPH) daily, at same time each day.
  - Give rapid-acting (prandial) insulin in three equally divided doses before each meal. Hold prandial insulin if patient is not able to eat.
  - Adjust insulin dose(s) according to the results of bedside BG measurements.
- B. Supplemental (correction) rapid-acting insulin analog or regular insulin.

## SUPPLEMENTAL INSULIN ORDERS

- If a patient is able and expected to eat all or most of his/her meals, give regular or rapid-acting insulin before each meal and at bedtime following the “Usual” column (Section C below).
- If a patient is not able to eat, give regular insulin every 6 h (6–12–6–12) or rapid-acting insulin every 4 to 6 h following the “Sensitive” column (Section C below).
- Supplemental insulin adjustment.
- If fasting and premeal plasma glucose are persistently above 140 mg/dl in the absence of

**Table 1: Perioperative blood glucose management in patients with diabetes undergoing ambulatory surgery<sup>40</sup>**

- Determine level of glycemic control
- Discontinue metformin prior to surgery in patients with renal dysfunction and who will receive IV contrast
- Avoid oral agents and noninsulin injectables the day of surgery
- Base perioperative use of insulin on safety concerns and maintenance of adequate glucose control
- Use basal (long intermediate-acting or continuous SQ rapid acting)- prandial/supplemental (short or rapid acting) insulin
- Avoid alterations of long acting basal insulin (glargine or detemir) the day before surgery unless there is report of hypoglycemia and in patients on diet restriction preoperatively. The day of surgery, may use 75% to 100% of daily long – acting insulin dose.
- Reduce evening dose of intermediate – acting insulin(NPH) the day before surgery to 75%. The day of the surgery use 50% to 75% of morning dose.
- Withhold prandial insulin while patient is fasting
- Consider the level of preoperative glycemic control when planning for preoperative insulin use
- Postpone surgery in patient with significant dehydration ketosis and hyperosmolar nonketotic states
- Consider presence of comorbidities and potential risks of surgical complication in chronically poorly controlled patient
- Maintain intraoperative blood glucose levels between 100 to 180mg/dl
- Consider using rapid -acting insulin over regular insulin in the postoperative period
- Favor SQ administration of insulin to achieve and maintain target glucose level rather than IV insulin in ambulatory patients undergoing short procedures. IV insulin is the most favorable treatment for patient undergoing long procedures.
- Avoid respective doses of subcutaneously administered insulin to prevent insulin “stacking”
- Consider perioperative use of insulin for insulin naïve patients with significant hypoglycemia if able to monitor blood glucose level at home.
- Schedule patients with diabetes as the first case of the day when possible to minimize disruption of their routine.
- Request patients to bring their insulin and hypoglycemia treatment to the facility
- Instruct adequate preoperative hydration and administer at adequate intraoperative crystalloid infusion provide that there are no contraindications
- Obtain blood glucose level on the patient arrival before surgery the before discharge home
- Monitor intraoperative blood glucose 1-2 h depending upon the duration of the procedure and type of insulin used
- Corroborate significantly low glucose levels with central laboratory tests. May treat first or while waiting for results to avoid adverse sequelae in patient with altered consciousness under anesthesia
- Suspect , prevent, identify, and manage hypoglycemia promptly
- Observe patient in and ambulatory facility until hypoglycemia from perioperatively administered insulin is excluded.
- Provide clear and consistent instructions regarding plans to return to preoperative antidiabetic regime and management of potential hypoglycemia
- Instruct patient to travel with hypoglycemia treatment to and from the surgical facility

hypoglycemia, increase insulin scale of insulin from the insulin-sensitive to the usual or from the usual to the insulin-resistant column.

- If a patient develops hypoglycemia BG <70 mg/dl, decrease regular or rapid-acting insulin from the insulin-resistant to the usual column or from the usual to the insulin-sensitive column.

#### C. Supplemental insulin scale (Table 2)<sup>41</sup>

The numbers in each column of *Section C* indicate the number of units of regular or rapid-acting insulin analogs

per dose. “Supplemental” dose is to be added to the scheduled insulin dose. Give half of supplemental insulin dose at bedtime. If a patient is able and expected to eat all or most of his/her meals, supplemental insulin will be administered before each meal following the “Usual” column dose. Start at insulin-sensitive column in patients who are not eating, elderly patients, and those with impaired renal function. Start at insulin-resistant column in patients receiving corticosteroids and those treated with more than 80 U/d before admission.

### Approaches to insulin therapy during Enteral Nutrition (EN)<sup>41</sup>

Continuous EN: Administer basal insulin once (glargine, detemir) or twice (detemir/NPH) a day in combination with a short- or rapid-acting insulin analog in divided doses every 4 h (lispro, aspart, glulisine) to 6 h (regular insulin).

### CYCLED FEEDING

- Administer basal insulin (glargine, detemir, or NPH) in combination with short- or rapid-acting insulin analog at the time of initiation of EN.

- Repeat the dose of rapid-acting insulin (lispro, aspart, glulisine) at 4-h intervals or short-acting (regular) insulin at 6-h intervals for the duration of the EN. It is preferable to give the last dose of rapid-acting insulin approximately 4 h before and regular insulin 6 h before discontinuation of the EN.

**Bolus feeding:** Administer short-acting regular or rapid-acting insulin analog (lispro, aspart, glulisine) before each bolus administration of EN.

### BEDSIDE BLOOD GLUCOSE MONITORING

Bedside point of care (POC) blood glucose (BG) monitoring guides insulin dosing. In the patient receiving nutrition, glucose monitoring should be performed before meals to match food ingestion. In the patient not receiving nutrition, BG monitoring is advised every 4–6 h.<sup>42</sup> More frequent BG testing ranging from every 30 min to every 2 h is required for patients receiving intravenous insulin. Safety standards should be established for BG monitoring that prohibit the sharing of finger-stick lancing devices, lancets, needles, and pens to reduce the risk of transmission of blood-borne diseases.

**Limitations in the Hospital Setting:** POC meters have limitations for measuring BG. Although the U.S. Food

**Table 2: Supplemental insulin scale**

BG (mg/dl)	Insulin-sensitive	Usual	Insulin-resistant
>141-180	2	4	6
181-220	4	6	8
221-260	6	8	10
261-300	8	10	12
301-350	10	12	14
351-400	12	14	16
>400	14	16	18

**Table 3: Insulin dosing for enteral/parenteral feedings<sup>41</sup>**

Situation	Basal	Bolus
Continuous enteral feedings	Glargine q.d. or NPH/detemir b.i.d.	SQ rapid-acting correction every 4 hours
Bolus enteral feedings	Continue prior basal; if none, consider 10 units NPH or glargine insulin to TPN IV bottle	SQ rapid-acting insulin with each bolus feeding to cover the bolus feeding and to correct for hyperglycemia
Parenteral feedings	Regular insulin to TPN IV bottle	Rapid-acting insulin SQ every 4 hours to correct for hyperglycemia

IV, intravenous; SQ, subcutaneous; TPN, total parenteral nutrition.

**Table 4: Intravenous Insulin Infusion protocol<sup>44</sup>**

Variable Rate Intravenous Insulin Infusion	
Mix 100 U short-acting insulin in 100 mL normal saline (1 U = 1 mL) Start insulin infusion at 0.5 to 1 U per hour (0.5 to 1 mL per hour)* Start a separate infusion of 5 percent dextrose in water at 100 to 125 mL per hour Monitor blood glucose hourly (every two hours when stable) and adjust insulin infusion rate according to the following algorithm:	
Blood glucose level, mg per dL (mmol per L)†	Action
Below 70 (30.89)	Turn off insulin infusion for 30 minutes, recheck blood glucose level. If blood glucose level is still below 70, give 10 g glucose and recheck blood glucose level every 30 minutes until the level is above 100 (5.56), then restart infusion and decrease rate by 1 U per hour.
71 to 120 (3.94 to 6.67)	Decrease insulin infusion rate by 1 U per hour
121 to 180 (6.72 to 10.0)	Continue insulin infusion as is
181 to 250 (10.1 to 13.89)	Increase insulin infusion rate by 2 U per hour
251 to 300 (13.94 to 16.67)	Increase insulin infusion rate by 3 U per hour
301 to 350 (16.72 to 19.4)	Increase insulin infusion rate by 4 U per hour
351 to 400 (19.5 to 22.2)	Increase infusion rate by 5 U per hour
Above 400 (22.2)	Increase insulin infusion rate by 6 U per hour

\*—Glucose infusion rate can also be increased if tendency toward hypoglycemia persists. †—Target blood glucose range is 120 to 180 mg per dL (6.67 to 10 mmol per L).

**Table 5: Summary<sup>45</sup> Broad management goals across the perioperative timeline. Overall goals: (i) reduce patient morbidity & mortality, (ii) avoid clinically significant hyper- or hypoglycemia, (iii) maintain acid/base, electrolyte, & fluid balance, (iv) prevent ketoacidosis, (v) Achieve blood glucose target less than 180 mg/dL in critical patients and less than 140 mg/dL in stable patients.**

Preoperative management key points	Intraoperative management key points	Postoperative management key points
<ul style="list-style-type: none"> <li>i. Verify target blood glucose concentration with frequent glucose monitoring</li> <li>ii. Use insulin therapy to maintain glycemic goals</li> <li>iii. Discontinue biguanides, alpha glucosidase inhibitors, thiazolidinediones, sulfonylureas, and GLP-1 agonists</li> <li>iv. Consider cancelling nonemergency procedures if patient presents with metabolic abnormalities (DKA, HHS, etc.) or glucose reading above 400-500 mg/dL</li> </ul>	<ul style="list-style-type: none"> <li>i. Aim to maintain intraoperative glucose levels between 140 and 170 mg/dL</li> <li>ii. Physicians must take length of surgery into account when determining an intraoperative glucose management strategy</li> <li>iii. For minor surgery, preoperative glucose protocols may be continued</li> <li>iv. IV insulin infusion is being promoted as a more efficient method of glycemic control for longer or more complex surgeries</li> </ul>	<ul style="list-style-type: none"> <li>i. Target postoperative glycemic range between 140 and 180 mg/dL</li> <li>ii. In the event a patient is hypoglycemic after surgery, begin a dextrose infusion at approximately 5-10 g/hour</li> <li>iii. Ensure basal insulin levels are met, especially in type 1 diabetic patients</li> <li>iv. Postprandial insulin requirements should be tailored according to the mode in which the patient is receiving nutrition</li> <li>v. Supplemental insulin can be used to combat hyperglycemia and restore blood glucose values back to target range</li> </ul>

Please note that the information presented in this table has been referenced in the text.

and Drug Administration (FDA) has standards for blood glucose meters used by lay persons, there have been questions about the appropriateness of these criteria, especially in the hospital and for lower BG readings.<sup>43</sup> Significant discrepancies between capillary, venous, and arterial plasma samples have been observed in patients with low or high hemoglobin concentrations and with hypoperfusion. Any glucose result that does not correlate with the patient's clinical status should be confirmed through conventional laboratory glucose tests. The FDA established a separate category for POC glucose meters for use in health care settings and has released a draft on in-hospital use with stricter standards. Before choosing a device, consider the device's approval status and accuracy.

#### HYPOGLYCEMIA MANAGEMENT PROTOCOL:<sup>41</sup>

For treatment of BG below 70 mg/dl:

In a patient who is alert and able to eat and drink, administer 15–20 g of rapid-acting carbohydrate such as 15–30 g glucose 4–6 ounces orange or apple juice, 6 ounces “regular” sugar sweetened soda or 8 ounces skim milk.

In an alert and awake patient who is NPO or unable to swallow, administer 20 ml dextrose 50% solution IV and start IV dextrose 5% in water at 100 ml/h.

In a patient with an altered level of consciousness, administer 25 ml dextrose 50% (1/2 amp) and start IV dextrose 5% in water at 100 ml/h.

In a patient with an altered level of consciousness and no available iv access, give glucagon 1 mg IM. Limit, two times.

Recheck BG and repeat treatment every 15 min until glucose level is at least 80 mg/dl.

#### CONCLUSION

Perioperative management of hyperglycemia is more an art than clinical science. Glucose homeostasis at various circumstances remains highly variable and unpredictable. Intravenous insulin infusion is suppose to be the best, but is expensive and often cumbersome. Moreover, infusion might not be necessary for all surgical cases. Clinical acumen plays a vital role for achieving the set glycemic and other targets during pre, intra and postoperative period of a diabetic person subjected for any surgery.

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