Hyperglycemia as a Risk Factor in the Perioperative Patient

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ABSTRACT

Bodily injury and stress associated with surgical interventions increase glucose levels not only in individuals diagnosed with diabetes mellitus but also in patients without a preoperative diagnosis of diabetes. Whatever the cause, hyperglycemia is becoming an increasingly important indicator of perioperative patient outcomes. An elevated blood glucose level affects the body’s defense systems and the body’s ability to heal after surgical intervention. Perioperative nurses should closely monitor the patient’s blood glucose levels and watch for signs of hyperglycemia throughout the perioperative experience. Perioperative nurses should work collaboratively with other perioperative team members to identify and treat perioperative hyperglycemia. AORN J 95 (March 2012) 352-361. © AORN, Inc, 2012. doi: 10.1016/j.aorn.2011.06.010

Key words: hyperglycemia, diabetes of injury, stress diabetes, diabetes mellitus.

Individuals undergoing a surgical procedure are at risk for complications of hyperglycemia even in the absence of a diagnosis of diabetes mellitus.¹ Complex metabolic and endocrine changes, including the disruption of glucose metabolism, occur as a result of an individual’s preoperative health status, the condition requiring surgery, the surgical intervention, and postoperative processes. The disruption of glucose metabolism results in hyperglycemia (ie, blood sugar level greater than 200 mg/dL).² It is important for perioperative nurses to understand the pathophysiological process that drives hyperglycemia, the effects that hyperglycemia has at the cellular and systemic levels, research correlations between hyperglycemia and patient complications in the perioperative setting, and recommended patient care practices that disrupt the pathological process and improve patient healing and outcomes.

According to Berkers et al,³ bodily injury and stress associated with surgical interventions increase glucose levels in individuals diagnosed with diabetes mellitus. However, patients without diabetes also may experience postoperative hyperglycemia. Regardless of the reason for hyperglycemia, increased glucose levels have led to impaired healing in the surgical patient.⁴ The National Nosocomial Infections Surveillance
System risk index included hyperglycemia as a leading risk factor for surgical site infections. In the past, stress diabetes, or diabetes of injury (ie, a transitory increase of blood glucose level in response to the stress of an illness or injury), was considered to be a beneficial adaptive response that promotes healing and positive postoperative outcomes. Generally, postoperative blood glucose levels were left untreated unless the levels were greater than 200 mg/dL. However, recent research has correlated normoglycemia in the perioperative patient with decreased morbidity and mortality. Evidence suggests that nurses should closely monitor the patient’s blood glucose levels and watch for signs of hyperglycemia throughout the perioperative experience. Therefore, it is important for perioperative nurses to understand the pathophysiology related to surgical insult and resulting hyperglycemia in patients with or without diabetes mellitus.

**PATHOPHYSIOLOGY**

There are several similarities between diabetes mellitus and diabetes of injury. Diabetes mellitus is a pancreatic failure that results in the body’s inability to produce or use insulin. Diabetes of injury is the result of the stress imposed by surgical intervention or critical illness. Both conditions can induce profound hyperglycemia. Thus, nondiabetic patients can experience significant durations of hyperglycemia that present unique challenges for perioperative nurses.

Hyperglycemia is the end product of many bodily responses and dysfunctions that result in two altered metabolic conditions: abundant endogenous glucose production and impaired glucose uptake in peripheral insulin-dependent tissues. High glucose levels mute the innate immune response and disrupt the inflammatory mechanism.

Surgical tissue trauma and associated stress activate the endocrine system. Resultant increased hepatic production of glucose, inhibited insulin secretion or action, and insulin resistance produce hyperglycemia (Figure 1). Stimulation of the adrenal cortex causes the release of cortisol, which causes hyperglycemia as a result of muscle proteolysis, glycogenolysis, and excessive hepatic gluconeogenesis (Figure 2). Normally, there is

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**Figure 1. Sympathoadrenergic stimulation in response to surgical tissue trauma and stress.**
a feedback mechanism and response to help reduce hyperglycemia, but the stimulation of catecholamines interferes with this process. As hyperglycemia develops or is exacerbated, the immune system is compromised and healing is impaired (Figure 3).¹⁰

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**Figure 2. Hypothalamic-pituitary axis response to surgical tissue trauma and stress.**

**Figure 3. Effects of hyperglycemia on the healing process.**
RESEARCH
Several quantitative observational and randomized controlled studies have associated abnormal glucose levels with increased lengths of hospital stay, intensive care unit admissions, surgical site infections, neurological events, and mortality (Table 1).6,11-16 Although some recent studies purport that a glucose control range that is too low (ie, < 110 mg/dL) can cause hypoglycemic events and the accompanying consequences,13,16 most studies have emphasized

- the magnified effect of hyperglycemia as an indicator of patient risk,
- its correlation with negative patient outcomes, and
- the positive effects of some level of glucose control with insulin.4,9,14,17,18

<table>
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<th>Authors</th>
<th>Research design</th>
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<tr>
<td>Bagry et al (2008)1</td>
<td>Prospective Randomized controlled trial</td>
<td>1,548 surgical intensive care unit patients</td>
<td>46% reduction in bacteremias and 41% decrease in renal failure in patients who had insulin titrate blood glucose levels &lt; 110 mg/dL versus a control group of patients who had insulin titrate blood glucose levels &lt; 215 mg/dL</td>
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<tr>
<td>Jones et al (2008)2</td>
<td>Retrospective Correlational Descriptive</td>
<td>2,297 coronary artery bypass patients</td>
<td>Early postoperative hyperglycemia correlated with increased morbidity and mortality independent of diabetes mellitus</td>
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<td>Malmstedt et al (2008)3</td>
<td>Cohort study Correlational Descriptive</td>
<td>1,840 coronary artery bypass patients</td>
<td>Significant increase in ipsilateral amputations in patients with diabetes versus patients without diabetes</td>
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<tr>
<td>NICE-SUGAR Study Investigators, Finfer et al (2009)4</td>
<td>Randomized controlled study Correlational Descriptive</td>
<td>6,104 intensive care unit patients</td>
<td>Patients whose glucose control was &lt; 180 mg/dL had lower mortality than patients whose glucose control was 81 mg/dL to 108 mg/dL</td>
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<tr>
<td>Ouattara et al (2005)5</td>
<td>Prospective cohort study Correlational Descriptive</td>
<td>200 patients undergoing heart surgery with diabetes</td>
<td>Multivariate analysis identified poor glycemic control as an independent risk factor for morbidity; tight control of glucose yielded significantly better outcomes than traditional control</td>
</tr>
<tr>
<td>Turnia et al (2005)6</td>
<td>Retrospective Correlational Descriptive</td>
<td>516 trauma patients</td>
<td>Correlated glucose levels of &gt; 200 mg/dL with higher rates of infection and mortality</td>
</tr>
<tr>
<td>Weiner et al (2008)7</td>
<td>Meta-analysis</td>
<td>8,432 critically ill patients</td>
<td>Tight glucose control resulted in more hypoglycemic episodes than reduced patient mortality</td>
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Study results conflict regarding the optimal glucose control range to prevent hypoglycemic crisis as well as to avoid hyperglycemic risks. Research has yet to correlate outcomes with either glycated hemoglobin (HbA1c) results (ie, average plasma glucose concentration over prolonged periods) or hospital stay average blood glucose levels.

**IMPLICATIONS**
Research results have a number of implications for perioperative nurses (Table 2). It is recommended that nurses obtain a baseline blood glucose level for the patient. Patients without known diabetes can demonstrate symptoms that should alert the perioperative nurse to the risk of hyperglycemia or developing perioperative hyperglycemia. These symptoms may include somnolence, fruity breath, itchy skin, and confusion.

Some hospitals have instituted admission testing that includes an initial blood glucose level for all patients, regardless of preexisting diseases. The Agency for Healthcare Research and Quality recommends preoperative glycemic screening and subsequent control measures depending on the findings. A study by Gurkan and Wenz supported maintaining preoperative glycemic levels < 200 mg/dL. A protocol for perioperative glucose management developed and instituted by the Ohio State University Medical Center recommends reviewing a preoperative HbA1c test that was obtained within the past 30 days; if the result is greater than 9%, the referring physician is contacted and consideration is given to postponing a nonemergent procedure until glucose levels improve. In addition, the protocol recommends maintaining a target glucose level of 120 mg/dL to 150 mg/dL intraoperatively.

When evaluating a patient’s blood glucose level, it is important to know whether the patient is taking any antidiabetic medications. If so, knowledge of the last dose, onset, peak, and duration of that medication can give the nurse insight into the direction that the blood glucose level is likely to follow.

Identifying factors that can compound stress hyperglycemia is an important part of nursing assessment, judgment, and perioperative care. Corticosteroids, catecholamines, anabolic agents, and other medications increase blood glucose levels. Furthermore, patients who have central visceral obesity are particularly prone to insulin resistance. The excessive adipose tissue around the abdomen works as an endocrine organ and is an indication of dysfunctional cellular metabolism that contributes to hyperglycemia.

Acute pain, blood loss, and lengthy surgical

<table>
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<th>Admission blood glucose level</th>
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<td>&lt; 100 mg/dL</td>
<td>No specific preoperative measures</td>
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<tr>
<td>100 mg/dL ≤ 220 mg/dL</td>
<td>Review creatinine test results and a baseline electrocardiogram obtained within the previous 12 months</td>
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<td></td>
<td>Monitor blood pressure closely</td>
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<td>&gt; 220 mg/dL</td>
<td>Consider referring the patient to an endocrinologist after surgery</td>
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<tr>
<td></td>
<td>Consider postponing nonemergent surgery until better glycemic control is obtained</td>
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<td></td>
<td>Perform a blood glucose test at induction and consider insulin drip intervention if surgery lasts longer than 1 hour</td>
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<th>Interim outcome statement</th>
<th>Outcome statement</th>
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| Risk of electrolyte imbalance | - Identifies baseline endocrine status by interviewing the patient and reviewing the medical record for a history of endocrine disorders (eg, diabetes).  
- Performs a diabetic assessment to include  
  - identifying types of diabetes (ie, type I, type II, gestational, diabetes of injury) and  
  - identifying means of diabetes control, such as  
    - diet,  
    - exercise,  
    - use of oral glycemic agents, and  
  - type of insulin taken if applicable (ie, name, dose, route, date of last dose).  
- Identifies physiological status.  
- Verifies presence of prosthetics or corrective devices (eg, insulin pump).  
- Assesses baseline skin condition.  
- Reports deviation in diagnostic study results (eg, blood glucose level, glycated hemoglobin).  
- Communicates physiological health status (eg, verbal reports, patient record) to appropriate team members.  
- Collaborates with other health care providers regarding diagnostic study results or assessment findings.  
- Administers prescribed medications by  
  - reviewing the medication reconciliation sheet for current medications, medication allergy interactions, contraindications, and medication-medication or herbal supplement-medication interactions;  
  - validating order as prescribed;  
  - verifying the medication label;  
  - anticipating the need for and availability of equipment and supplies based on the patient’s needs (eg, insulin drip pump);  
  - selecting equipment and supplies in an organized and timely manner | Laboratory values (eg, blood glucose levels) are within expected ranges immediately after surgery. | The patient’s endocrine status is maintained at or improved from baseline levels. |
procedures also can induce insulin resistance as well as decrease glucose disposal.6

RECOMMENDATIONS
Glucose level is often considered the sixth vital sign.24 The first step in preventing the complications of perioperative hyperglycemia is to improve clinical assessment with admission testing of glucose level and HbA1c (Table 3). If the patient’s blood glucose level is > 180 mg/dL, the nurse should consult with medical staff members. Perioperative nurses should follow these recommendations:

- Initiate and become part of a collaborative effort to develop a hospital protocol for glucose control in surgical patients with and without diabetes to maintain a blood glucose level of < 140 mg/dL. 
- Collaborate to set a specific glycemic target of > 80 mg/dL for scheduled nonemergent surgical interventions.
- Perform blood glucose checks every two hours during surgery if surgery lasts longer than two hours and if the patient’s preoperative blood glucose level was > 110 mg/dL.

- Be prepared to implement an insulin drip if needed.
- Perform postoperative blood glucose checks with initial vital signs on all patients in the postanesthesia care unit.
- Develop postoperative monitoring protocols for patients with a blood glucose level of > 180 mg/dL.
- At discharge, provide patient teaching about signs and symptoms of increased hyperglycemia and infection or nonhealing that would require medical attention.
- Consider obtaining a referral to an endocrinologist if necessary.19

CONCLUSION
There is a consensus among experts and researchers that hyperglycemia is a risk factor for negative surgical outcomes.2,3,6,11,14 However, experts disagree on target blood glucose levels
Perioperative Hyperglycemia

Overview
Hyperglycemia means the amount of glucose (sugar) in your blood is too high. This may happen if your pancreas does not make enough insulin, which controls blood sugar. However, hyperglycemia can also happen if your body is stressed by illness, injury, or undergoing surgery. Hyperglycemia can cause problems during surgery and can interfere with wound healing after surgery.

What are signs and symptoms of hyperglycemia?
If you have hyperglycemia, you may have increased thirst, dry mouth, decreased appetite, fatigue, blurred vision, fruity breath, itchy skin, nausea or vomiting, abdominal pain, frequent urination, or confusion.

How is hyperglycemia diagnosed?
Your health care provider will test your blood.

What are my treatment options?
Sometimes hyperglycemia can be treated by controlling the amount and type of food you eat, or you may need medicine to control your blood sugar. This medicine may be taken by mouth or may be given as a shot or through an IV directly into your blood.

What will the preoperative care include?
Health care providers may ask you questions about signs and symptoms of hyperglycemia and any treatment you are currently using, such as eating a diabetic diet or taking medicine for high blood sugar.

A health care provider may draw blood to test your blood sugar level or test your urine for ketones. Ketones are a by-product of the body using fat for energy instead of glucose when insulin is not present in sufficient quantities.

You may need hyperglycemia medicine before surgery.

What happens during surgery?
Health care providers will watch you closely for any symptoms of hyperglycemia during surgery. They may draw your blood and may give you hyperglycemia medicine if your blood sugar level gets too high.

What will postoperative care include?
After surgery, you will be admitted to the recovery area and monitored closely.

A nurse may draw your blood to test your blood sugar level and may give you hyperglycemia medicine, if needed.

Before you go home, a nurse will teach you and your designated support person about watching for signs and symptoms of high blood sugar levels; how to test your blood for high sugar levels, if needed; and how to give yourself hyperglycemia medicine, if needed.

What are possible complications of high blood sugar levels during and after my surgery?

Your wound may not heal well.
You may get an infection in your wound.
If hyperglycemia is left untreated, you may experience problems with your eyes, kidneys, nerves, and heart; infections in your mouth, skin, or feet; poor circulation; diabetic coma; or even death. These may be prevented by controlling your blood sugar level.

What happens after I go home?
Eat healthy and stay active.
Keep the incisions dry for the first 7 to 10 days. Then wash your incisions daily with mild, perfume-free soap and gently pat dry; do not put any lotion or powder directly on your incisions until they are completely healed.

Watch for signs and symptoms of high blood sugar.
Monitor your blood sugar and urine as instructed by your doctor.
Take hyperglycemia medicine if ordered by your doctor.

Call your doctor immediately if you experience any of the following:

shortness of breath or sudden dizziness or weakness;
increased redness, swelling, or drainage at your incision sites;
fever greater than 101°F (38.3°C) or chills;
nausea or vomiting that is not relieved with medication;
growing or ongoing diarrhea;
high blood glucose levels that are persistently above 240 mg/dL with ketones in your urine;
trouble keeping your blood glucose within the desired range.

Resources

and duration and methods of intervention to achieve optimal patient safety and healing. Previous trends toward tight glycemic control have been shown to produce hypoglycemic events that generate unintended negative patient outcomes. Consequently, in combination with evidence that hyperglycemia can be a real predictor of surgical site infections and increased morbidity and mortality, many hospitals are producing glucose management protocols geared toward a more moderate control level. Regardless, hyperglycemia is a surgical risk that demands attention and careful monitoring by perioperative nurses.

References
Resources

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Hyperglycemia as a Risk Factor in the Perioperative Patient

PURPOSE/GOAL
To educate perioperative nurses about the risks of complication from perioperative hyperglycemia in patients with and without a diagnosis of diabetes.

OBJECTIVES
1. Explain the causes of hyperglycemia.
2. Discuss the effects of hyperglycemia.
3. Identify symptoms of hyperglycemia.
4. Describe interventions that nurses should consider to treat perioperative hyperglycemia.

The Examination and Learner Evaluation are printed here for your convenience. To receive continuing education credit, you must complete the Examination and Learner Evaluation online at http://www.aorn.org/CE.

QUESTIONS
1. Individuals undergoing a surgical procedure are at risk for complications of hyperglycemia even in the absence of a diagnosis of diabetes mellitus.
   a. true  
   b. false

2. Stress diabetes, or diabetes of injury, was formerly considered to be a beneficial adaptive response that promotes healing and positive postoperative outcomes.
   a. true  
   b. false

3. Hyperglycemia
   1. causes abundant endogenous glucose production.
   2. disrupts the inflammatory mechanism.
   3. impairs glucose uptake in peripheral insulin-dependent tissues.
   4. is the end product of many bodily responses and dysfunctions that result in altered metabolic conditions.
   5. mutes the innate immune response.
   a. 4 and 5  
   b. 1, 2, and 3  
   c. 1, 2, 3, and 4  
   d. 1, 2, 3, 4, and 5

4. Stimulation of the adrenal cortex causes release of cortisol, which causes hyperglycemia as a result of
   1. muscle proteolysis.
   2. glycogenolysis.
   3. excessive hepatic gluconeogenesis.
   4. enzymatic glycosylation.
   a. 1 and 3  
   b. 2 and 4  
   c. 1, 2, and 3  
   d. 1, 2, 3, and 4
5. Stimulation of catecholamines interferes with a feedback mechanism and response that is intended to help reduce hyperglycemia.
   a. true  b. false

6. Studies have associated abnormal glucose levels with
   1. increased lengths of hospital stay.
   2. increased intensive care unit admissions.
   3. surgical site infections.
   4. neurological events.
   5. mortality.
      a. 1 and 3  b. 2, 3, and 4
      c. 1, 2, 4, and 5  d. 1, 2, 3, 4, and 5

7. Symptoms that should alert the perioperative nurse that the patient may have or be developing perioperative hyperglycemia include
   1. confusion.
   2. fruity breath.
   3. itchy skin.
   4. somnolence.
      a. 1 and 3  b. 2 and 4
      c. 1, 2, and 4  d. 1, 2, 3, and 4

8. Excessive adipose tissue around the abdomen
   1. contributes to hyperglycemia.
   2. is an indication of dysfunctional cellular metabolism.
   3. diverts blood flow from the pancreas.

9. To prevent the complications of perioperative hyperglycemia, nurses should
   1. consult with medical staff members if the patient’s preoperative blood glucose level is > 180 mg/dL.
   2. perform blood glucose checks every two hours during surgery and if the patient’s preoperative blood glucose level was > 110 mg/dL.
   3. be prepared to implement an insulin drip if needed.
   4. perform postoperative blood glucose checks with initial vital signs on all patients in the postanesthesia care unit.
   5. provide patient teaching about signs and symptoms of increased hyperglycemia and infection or nonhealing that would require medical attention.
   6. consider obtaining a referral to an endocrinologist if necessary.
      a. 1, 3, and 5  b. 2, 4, and 6
      c. 2, 3, 5, and 6  d. 1, 2, 3, 4, 5, and 6

10. Experts and researchers have not come to a consensus regarding whether hyperglycemia is a risk factor for negative surgical outcomes.
    a. true  b. false

The behavioral objectives and examination for this program were prepared by Rebecca Holm, MSN, RN, CNOR, clinical editor, with consultation from Susan Bakewell, MS, RN-BC, director, Perioperative Education. Ms Holm and Ms Bakewell have no declared affiliations that could be perceived as posing potential conflicts of interest in the publication of this article.
Hyperglycemia as a Risk Factor in the Perioperative Patient

This evaluation is used to determine the extent to which this continuing education program met your learning needs. Rate the items as described below.

OBJECTIVES
To what extent were the following objectives of this continuing education program achieved?

1. Explain the causes of hyperglycemia.
   Low 1. 2. 3. 4. 5. High
2. Discuss the effects of hyperglycemia.
   Low 1. 2. 3. 4. 5. High
3. Identify symptoms of hyperglycemia.
   Low 1. 2. 3. 4. 5. High
4. Describe interventions that nurses should consider to treat perioperative hyperglycemia.
   Low 1. 2. 3. 4. 5. High

CONTENT
5. To what extent did this article increase your knowledge of the subject matter?
   Low 1. 2. 3. 4. 5. High
6. To what extent were your individual objectives met? Low 1. 2. 3. 4. 5. High
7. Will you be able to use the information from this article in your work setting?
   1. Yes 2. No

8. Will you change your practice as a result of reading this article? (If yes, answer question #8A. If no, answer question #8B.)

8A. How will you change your practice? (Select all that apply)
   1. I will provide education to my team regarding why change is needed.
   2. I will work with management to change/implement a policy and procedure.
   3. I will plan an informational meeting with physicians to seek their input and acceptance of the need for change.
   4. I will implement change and evaluate the effect of the change at regular intervals until the change is incorporated as best practice.
5. Other: ____________________________

8B. If you will not change your practice as a result of reading this article, why? (Select all that apply)
   1. The content of the article is not relevant to my practice.
   2. I do not have enough time to teach others about the purpose of the needed change.
   3. I do not have management support to make a change.
   4. Other: ____________________________

9. Our accrediting body requires that we verify the time you needed to complete the 2.1 continuing education contact hour (126-minute) program: ____________________________