Association of Postoperative Hyperglycemia With Outcomes Among Patients With Complex Ventral Hernia Repair

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**IMPORTANCE** Patients with medically complex conditions undergoing repair of large or recurrent hernia of the abdominal wall are at risk for early postoperative hyperglycemia, which may serve as an early warning for delays in recovery and for adverse outcomes.

**OBJECTIVE** To evaluate postoperative serum glucose level as a predictor of outcome after open ventral hernia repair in patients with major medical comorbidities.

**DESIGN, SETTING, AND PARTICIPANTS** We performed a retrospective medical record review of 172 consecutive patients who underwent open ventral hernia repair at Penn State Milton S. Hershey Medical Center, an academic tertiary referral center, from May 1, 2011, through November 30, 2013. We initially identified patients by medical complexity and repair requiring a length of stay of longer than 1 day.

**MAIN OUTCOMES AND MEASURES** Postoperative recovery variables, including time to the first solid meal, length of stay, total costs of hospitalization, and surgical site occurrence.

**RESULTS** Postoperative serum glucose values were available for 136 patients (79.1%), with 130 (95.6%) obtained within 48 hours of surgery. Among these patients, Ventral Hernia Working Group grade distributions included 8 patients with grade 1, 79 with grade 2, 41 with grade 3, and 8 with grade 4. Fifty-four patients (39.7%) had a postoperative glucose level of at least 140 mg/dL, and 69 patients (50.7%) required insulin administration. Both outcomes were associated with delays in the interval to the first solid meal (glucose level, ≥140 vs <140 mg/dL: mean [SD] delay, 6.4 [5.3] vs 5.6 [8.2] days; P = .01; ≥2 insulin events vs <2: 6.5 [5.5] vs 5.4 [8.4] days; P = .02); increased length of stay (glucose level, ≥140 vs <140 mg/dL: mean [SD], 8.0 [6.0] vs 6.9 [8.2] days; P = .008; ≥2 insulin events vs <2: 8.3 [6.1] vs 6.5 [8.4] days; P < .001); increased costs of hospitalization (glucose level, ≥140 vs <140 mg/dL: mean [SD], $31 307 [$20 875] vs $22 508 [$22 531]; P < .001; ≥2 insulin events vs <2: $31 943 [$22 224] vs $20 651 [$20 917]; P < .001); and possibly increased likelihood of surgical site occurrence (glucose level, ≥140 vs <140 mg/dL: 37.5% [21 of 56 patients] vs 22.5% [18 of 80 patients]; P = .06; ≥2 insulin events vs <2: 36.4% [24 of 66 patients] vs 21.4% [15 of 70 patients]; P = .06). Not all patients with diabetes mellitus developed postoperative hyperglycemia or needed more intense insulin therapy; however, 46.4% of the patients who developed postoperative hyperglycemia were not previously known to have diabetes mellitus, although most had at least 1 clinical risk factor for a prediabetic condition.

**CONCLUSIONS AND RELEVANCE** Postoperative hyperglycemia was associated with outcomes in patients in this study who underwent complex ventral hernia repair and may serve as a suitable target for screening, benchmarking, and intervention in patient groups with major comorbidities.
Despite recent advances in materials and operative approaches for repair of large or recurrent hernias of the abdominal wall, rates of surgical site infection and recurrence remain high. Postoperative surgical site infection and recurrence are significant components of the morbidity and costs of care at the time of operation as well as risk factors for long-term failures of repair. Consistently cited among the risk factors for adverse outcomes in patients undergoing ventral hernia repair (VHR) is diabetes mellitus (DM). Patients with DM who undergo surgery carry an increased risk for infection and other complications at the surgical site, such as seroma, poor incisional healing, and early recurrence. In individual reports, however, an influence of DM on outcomes has not been detected or could not be distinguished easily from the influence of other comorbid conditions, such as obesity, smoking, chronic obstructive pulmonary disease, or immunosuppression.

An alternative hypothesis is that, rather than DM per se, the severity of a postoperative imbalance of glucose levels drives delays in recovery, early adverse events, and possibly long-term recurrences in patients undergoing VHR. Hyperglycemia is increasingly recognized as a marker of poor clinical outcomes in patients with different forms of acute illness, injury, and surgical stress; this association is stronger and more consistent in patients without than in those with DM. Among different populations of patients undergoing surgery, the likelihood of postoperative hyperglycemia can vary from 20% to 50%, with such variation potentially attributable to the blend of population characteristics, type and intensity of the illness or injury, and the metabolic requirements for healing and recovery. To our knowledge, no study has examined the relationship between early postoperative hyperglycemia and outcome in patients undergoing open VHR for large defects or recurrent hernia, a population characterized by multiple comorbidities. Thus, our primary goals in this study were to determine the prevalence of postoperative hyperglycemia in a patient population with complex comorbidities who are undergoing VHR and to test the hypothesis that early postoperative hyperglycemia predicts delays in recovery, increased costs of hospitalization, and early adverse outcomes in these patients. An additional goal was to identify attributes of the patient group or of the conduct of the operation that might predict early postoperative hyperglycemia, thereby offering insight into opportunities for intervention.

Methods

We performed a retrospective medical record review on all adult patients who underwent elective open complex VHR from May 1, 2011, through November 30, 2013, at Penn State Milton S. Hershey Medical Center. This study was approved by the internal review board of Penn State Milton S. Hershey Medical Center. All patient data were deidentified. Patients were identified using Current Procedural Terminology codes for elective open VHR with or without separation of components that included at least 1 of the following 4 codes: 49560, 49565, 15734, and 49568. We identified patients with complex medical conditions and hernia from hospital records as those requiring open repair and a length of stay (LOS) greater than or equal to 7 days. Patients were graded according to Ventral Hernia Working Group (VHWG) definitions, as summarized in Table 1. We abstracted operative notes to verify the type of hernia and method of repair, including primary repair with no synthetic or biological mesh in 11 patients, bridge or interposition mesh in 12 patients, overlay mesh with closure of fascia in 37 patients, and underlay mesh with closure of fascia in 76 patients. All patients maintained normothermia (36°C-38°C) perioperatively. All patients were given preoperative antibiotics just before or at the time of incision and intraoperatively according to institutional clinical practice guidelines. Patients with mesh placed and drains present received additional doses of antibiotics for at least 24 hours. Drains were placed in 105 patients and were removed routinely when daily outputs were less than 30 to 40 mL.

The primary marker of interest was the first postoperative serum glucose (POG) level, defined as the first serum glucose level measured after skin closure within 48 hours after operation.

<table>
<thead>
<tr>
<th>Factor</th>
<th>No. of Patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade 1</td>
<td>8</td>
</tr>
<tr>
<td>Low risk and no history of wound infection</td>
<td>8</td>
</tr>
<tr>
<td>Grade 2</td>
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<td>Smoker</td>
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<td>Obesity</td>
<td>71</td>
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<td>T2DM</td>
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<tr>
<td>Immunosuppression</td>
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<td>COPD</td>
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<td>Grade 3</td>
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<td>T2DM</td>
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<td>Immunosuppression</td>
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<td>COPD</td>
<td>4</td>
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<tr>
<td>Prior wound infection</td>
<td>14</td>
</tr>
<tr>
<td>Stoma</td>
<td>17</td>
</tr>
<tr>
<td>GI tract violated</td>
<td>17</td>
</tr>
<tr>
<td>Grade 4</td>
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<td>Obesity</td>
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<td>T2DM</td>
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<td>Immunosuppression</td>
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<td>COPD</td>
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<td>Prior wound infection</td>
<td>8</td>
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<tr>
<td>Infected mesh</td>
<td>7</td>
</tr>
<tr>
<td>Septic dehiscence</td>
<td>1</td>
</tr>
</tbody>
</table>

Abbreviations: COPD, chronic obstructive pulmonary disorder; GI, gastrointestinal; T2DM, type 2 diabetes mellitus.

a Some patients had more than 1 factor.

b Indicates distribution of criteria met for prior grades.
surgery. Serum glucose values were used with the exception of 13 patients who had only point-of-care glucose level measurements. Postoperative hyperglycemia was defined as a first POG level of at least 140 mg/dL (to convert to millimoles per liter, multiply by 0.0555), in accordance with recommendations for monitoring glycemia in non–critical care settings. A second POG level was obtained within 96 hours of surgery, and we calculated the difference. A secondary marker of interest included the number of insulin events, defined as the number of times insulin was administered postoperatively during the hospital stay.

The primary outcomes of interest were (1) time to the first solid meal, used as a surrogate marker for resolution of postoperative ileus and defined as the period from skin closure to the order of a regular, cardiac-prudent, or carbohydrate-consistent diet; (2) LOS; (3) total costs of hospitalization; and (4) surgical site occurrence (SSO), defined as the occurrence of seroma, hematoma, surgical site infection, nonhealing wound, or a hernia recurrence within the first 90 days after surgery. We used Wilcoxon rank sum tests to compare means and medians for continuous outcome variables between groups and Fisher exact tests for comparisons of categorical variables. Logistic regression was used to determine whether the POG level was associated with wound occurrence and whether certain patient characteristics were associated with the occurrence of postoperative hyperglycemia. An exact logistic regression was used when small cell counts violated the assumptions of asymptotic logistic regression. A fixed-effects model was used to adjust for covariates with time to the first solid meal, LOS, and total costs of hospitalization. These outcome variables were log-transformed before this analysis because their distributions were not normal. We performed all statistical analysis using commercially available software (SAS, version 9.3; SAS Institute Inc).

Results

Prevalence of Postoperative Hyperglycemia

We identified a total of 172 consecutive patients who underwent open hernia repair from May 1, 2011, through November 30, 2013, at Penn State Milton S. Hershey Medical Center. Postoperative serum glucose values were available for 136 patients (79.1%), with 130 of these (95.6%) obtained within 48 hours of surgery. Fifty-six patients (41.2%) had a first POG level of at least 140 mg/dL. Twenty-six of the 56 patients with postoperative hyperglycemia (46.4%) had no known history of symptoms or diagnosis of DM and no documentation of treatments for hyperglycemia. Of those who were not known to have DM preoperatively, 4 were overweight (body mass index [BMI] [calculated as weight in kilograms divided by height in meters squared] 25–30), and the remainder met criteria for obesity (BMI >30). All had resolution of hyperglycemia and were not discharged with medications for control of serum glucose levels.

Surgical Site Occurrences

Of the 136 patients in whom POG levels were recorded, 39 (28.7%) developed at least 1 SSO within 90 days of surgery. The 50 total SSOs in these 39 patients included 16 seromas, 15 surgical site infections, 13 failures of wound healing without cellulitis, 3 hematomas, and 3 early recurrences recognized within 90 days. Recognition of the initial SSO occurred during the initial hospital stay in 6 patients, within 30 days of surgery in 28 patients, and 30 to 90 days after surgery in 5 patients.

Table 2 summarizes the attributes of the patient group obtained from preoperative evaluation and the intraoperative course and analyzed according to influence on 90-day SSOs. Patient characteristics that were not significantly associated with 90-day SSOs on logistic regression included sex, recurrent hernia, use of components separation in the repair, use of mesh, coronary artery disease, hypertension, and preoperative corticosteroid use. Placement of drains (105 patients) and drainage output were not clearly associated with changes in outcome (VHWG grades were not equivalent and no valid analysis could be performed when the VHWG grade was taken into account). Factors significantly associated with SSOs included greater BMI, longer procedure duration, and a preoperative diagnosis of DM (type 2 DM [T2DM] in all).

Influence of Postoperative Hyperglycemia

Table 3 shows the influence of postoperative hyperglycemia on the likelihood of an SSO. Using bivariate analysis, patients with SSOs were more likely to have had preoperative hyperglycemia, to have been given insulin, and to have had more insulin events. As shown in Table 4, patients with hyperglycemia and those who had an increased insulin requirement were more likely to have delays in the interval to the first solid meal, to have increased LOS and costs of hospitalization, and to develop an SSO. By treating POG level as a continuous variable, we found that it correlated mildly with increased LOS (r = 0.26; P = .01), time to the first solid meal (r = 0.29; P = .004), and total cost (r = 0.26; P = .01) in the group without DM. Such associations were not observed in the group with DM.

To understand more clearly whether disturbances in POG levels might be independently predictive of outcomes, we performed a multivariable analysis using logistic regression for SSOs with all of the variables (P < .01) from Tables 2 and 3 as covariates for adjustment in addition to postoperative hyperglycemia. The most significant of these covariates were age, BMI, duration of the procedure, a history of DM, postoperative insulin use, and the number of insulin events. The adjusted model, including all covariates (P = .91) and only those that were significant (P = .71), did not yield a statistically significant result for a POG level of at least 140 mg/dL. However, because the presence of a diabetic condition drives POG levels and because the number of postoperative insulin events is driven by POG levels, we excluded these 2 covariates in the analysis. Nevertheless, the POG level was still not an independent predictor of SSOs (P = .45).

In addition, we asked how the POG level and the number of insulin events ranked as predictors of all outcomes with other preoperative risk factors and decisions or events at the time of the operation. We created a full model for each outcome (time to the first solid meal, LOS, total cost, and 90-day SSOs) that included all of the variables in Tables 2 and 3 but excluded the change in trajectory of glucose levels because that
variable is calculated using the first POG level. We then created a reduced model by stepwise elimination, treating all variables equally, and found that the most consistent predictors for delays in recovery (time to the first solid meal and LOS) and increases in cost were the duration of the procedure ($P < .001$ for each outcome) and the number of insulin events ($P < .002$ for each outcome), with variable contributions from other attributes (eTable 1 in the Supplement).

**Preoperative Predictors of Postoperative Hyperglycemia**

Higher BMI (odds ratio, 1.67 [95% CI, 1.23-2.26]; $P < .001$), longer procedure duration (OR, 1.04 [95% CI, 1.01-1.07]; $P = .004$), higher American Society of Anesthesiologists class (OR, 3.32 [95% CI, 1.57-7.00]; $P = .001$), hypertension (OR, 2.24 [95% CI, 1.07-4.67]; $P = .03$), postoperative insulin use (OR, 4.56 [95% CI, 2.16-9.59]; $P < .001$), number of insulin events (OR, 1.25 [95% CI, 1.10-1.42]; $P < .001$), and preoperative oral hypoglycemic use (OR, 9.53 [95% CI, 2.02-44.94]; $P = .004$) were all associated with a higher likelihood of developing postoperative hyperglycemia (eTable 2 in the Supplement).

Twenty-six of 56 patients who had poor control of glucose levels (46%) were not known to have DM preoperatively. Twenty-two of the 42 patients with known DM had a measurement of hemoglobin A1c levels before the date of operation; when these levels were elevated, the operation was often deferred until better control was obtained. Among the 94 patients without DM, 51 (54%) had hypertension, 94 (100%) were overweight/obese (BMI $\geq$ 25), and 80 (85%) were older than 45 years. Prior studies have suggested that perioperative use of corticosteroids is associated with hyperglycemia at higher doses (eg, 8 to 10 mg) but not at lower doses (eg, 4 mg) that are still effective in reducing perioperative nausea. In this cohort, use of perioperative dexamethasone sodium phosphate (at a standard adult dose of 4 mg) was not associated with a significantly increased risk for postoperative hyperglycemia.

### Table 2. Demographics and Preoperation Attributes of Study Groups

<table>
<thead>
<tr>
<th>Variable</th>
<th>Patient Groupa</th>
<th>90-d SSO (n = 39)</th>
<th>No 90-d SSO (n = 97)</th>
<th>P Valueb</th>
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<td>Age, mean (SD), y</td>
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<tr>
<td>Male</td>
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<td>18 (46)</td>
<td>38 (39)</td>
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<tr>
<td>BMI, mean (SD)</td>
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<td>Procedure duration, mean (SD), min</td>
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<td>Recurrent hernia</td>
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<tr>
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<td>38 (97)</td>
<td>93 (96)</td>
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</table>

Abbreviations: ASA, American Society of Anesthesiologists; BMI, body mass index (calculated as weight in kilograms divided by height in meters squared); SSO, surgical site occurrence; T2DM, type 2 diabetes mellitus.

*Unless otherwise indicated, data are expressed as number (percentage) of patients.*

*Logistic regression is used to compare all variables.*
Interface of VHWG Grade and Postoperative Disturbance of Glucose Levels
The VHWG grading system\(^1\) has been proposed as a tool for standardizing the reporting of medical complexity and outcomes, particularly with respect to SSOs. The utility of the system depends on its focus on preoperative and perioperative events, such as contamination at the time of operation. As shown in Table 1, this patient group is medically complex, with 79 (58%) assigned a VHWG grade 2; 41 (30%), grade 3; and 8 (6%), grade 4. In Table 3 in the Supplement, outcomes are presented as a function of VHWG grade, including a breakdown of the individual types of SSO (hematoma, surgical site infection, nonhealing wound without infection, seroma, and recurrence). Based on the data in the 2 most common grades (2 and 3), we asked whether the presence of postoperative hyperglycemia (POG level, ≥140 mg/dL) or disturbance in the control of glucose levels (≥2 insulin events) might influence the percentage of patients exceeding the expected outcomes in each category (interval to the first solid meal ≥5 days, LOS ≥6 days, total cost ≥$25,000, or any SSO). As shown in the Figure, variables of disturbance in glucose levels are associated with suboptimal outcomes within each grade, perhaps providing an additional useful discriminator of outcome.

Characteristics of the Patients Lacking Measurement of POG Level
Thirty-six patients (20.9%) were excluded from the main analysis because they did not have records of POG level measurements. We compared the groups with and without POG level measurements. Patients without POG level measurements had significantly shorter LOS (\(P < .001\)) and were more likely than patients with POG level measurements to have fewer preoperative comorbidities (eTable 4 in the Supplement). Six of the excluded patients (16.7%) developed a wound occurrence within 90 days after surgery.

Discussion
In this study, we evaluated the relationship between POG levels and outcomes in a comorbidity-rich population undergoing VHR. Postoperative hyperglycemia was a significant predictor of increased time to the first solid meal, LOS, and cost in patients with ventral hernia and correlates with SSO rates. Postoperative hyperglycemia is associated with an increased risk for SSOs in populations of patients undergoing varied general surgical procedures.\(^6,21,22,33,34\) To our knowledge, this re-

### Table 3. Variables of Imbalance of Serum Glucose Levels

<table>
<thead>
<tr>
<th>Variable</th>
<th>Patient Group(^a)</th>
<th>P Value(^b)</th>
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<td></td>
<td>90-d SSO ((n = 39))</td>
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</tr>
<tr>
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<td>No 90-d SSO ((n = 97))</td>
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</tr>
<tr>
<td>Preoperative oral hypoglycemic use</td>
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</tr>
<tr>
<td>Yes</td>
<td>6 (15)</td>
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<tr>
<td>No</td>
<td>33 (85)</td>
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<tr>
<td>Postoperative insulin use</td>
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<tr>
<td>No</td>
<td>13 (33)</td>
<td>.03</td>
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<td>No. of insulin events, mean (SD)</td>
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<td>No</td>
<td>2.0 (3.1)</td>
<td>.03</td>
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<td>First POG level &gt;140 mg/dL</td>
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<td>Yes</td>
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<td>No</td>
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<td>ΔPOG level &gt;20 mg/dL</td>
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<td>19 (49)</td>
<td>.06</td>
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### Table 4. Influence of Postoperative Hyperglycemia on Indexes of Recovery\(^a\)

<table>
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<tr>
<th>Variable</th>
<th>Outcome(^b)</th>
<th>P Value(^b)</th>
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<td>LOS, d</td>
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<td>8.0 (6.0)</td>
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<td>&lt;140</td>
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<td>≥2</td>
<td>6.5 (5.5)</td>
<td>8.3 (6.1)</td>
</tr>
<tr>
<td>&lt;2</td>
<td>5.4 (8.4)</td>
<td>6.5 (8.4)</td>
</tr>
<tr>
<td>P value</td>
<td>.02</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>

Abbreviations: Δ, difference; POG, postoperative serum glucose; SSO, surgical site occurrence. Si conversion factor: To convert POG to millimoles per liter, multiply by 0.0555.

\(^a\) Unless otherwise indicated, data are expressed as number (percentage) of patients.

\(^b\) Logistic regression is used to compare all variables.

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Figure. Influence of Postoperative Hyperglycemia on Outcome Outliers Within Patients With Ventral Hernia Working Group Grades 2 (n=79) and 3 (n=41)

<table>
<thead>
<tr>
<th>A</th>
<th>Postoperative serum glucose level</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>≤140 mg/dL</td>
</tr>
<tr>
<td></td>
<td>Patients (%)</td>
</tr>
<tr>
<td>P</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Time to First Solid Meal ≥5 d</td>
<td>0.007</td>
</tr>
<tr>
<td>LOS ≥6 d</td>
<td>0.004</td>
</tr>
<tr>
<td>Cost, ≥$25 000</td>
<td>0.13</td>
</tr>
<tr>
<td>SSO</td>
<td>0.13</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>B</th>
<th>Insulin events</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0 or 1</td>
</tr>
<tr>
<td></td>
<td>Patients (%)</td>
</tr>
<tr>
<td>P</td>
<td>0.04</td>
</tr>
<tr>
<td>Time to First Solid Meal ≥5 d</td>
<td>0.04</td>
</tr>
<tr>
<td>LOS ≥6 d</td>
<td>0.03</td>
</tr>
<tr>
<td>Cost, ≥$25 000</td>
<td>0.03</td>
</tr>
<tr>
<td>SSO</td>
<td>0.03</td>
</tr>
</tbody>
</table>

A, Comparison between groups with postoperative serum glucose levels of less than 140 vs at least 140 mg/dL (to convert to millimoles per liter, multiply by 0.0555). B, Comparison between groups with 0 or 1 vs 2 or more insulin events, defined as the number of times insulin was administered postoperatively during the hospital stay. Comparisons were performed using Fisher exact test. Surgical site occurrence (SSO) is defined as the occurrence of seroma, hematoma, surgical site infection, a nonhealing wound, or a hernia recurrence. LOS indicates length of stay.

Our findings raise 3 additional issues for discussion. First, in this study, we recorded SSOS to 90 days after operation. Recommendations and practices for the reporting of wound occurrences after elective abdominal operations and specifically for VHR have often focused on the 30-day interval after the operation. In some reports focusing on patients with complex hernia, the length of follow-up for SSOS is implied (but not necessarily stated explicitly) as the overall length of follow-up of the cohort. In our study, approximately one-third of the SSOS were documented outside the 30-day window, confirming the need in this particular patient group for extended follow-up beyond the 30-day window practiced in many registries and large cooperative data sets. Our data also suggest that the costs of complex VHR associated with postoperative hyperglycemia may be affected not only by resource use during the hospital stay but also by care and charges outside the hospital setting.

Second, although this study suggests that acute postoperative hyperglycemia serves as a reporter or predictor for potential delays in recovery or adverse outcomes, the extent to which its effects can be mitigated by aggressive efforts at normalization of POG levels remains unclear. Hyperglycemia is a serious risk in the effort to regulate serum glucose levels within too narrow a range in hospitalized patients, especially in the critically ill but also in the noncritically ill. Recent reports, however, have demonstrated the effectiveness of standardized protocols for managing acute hyperglycemia in the inpatient surgical population that obviate unwanted episodes of hypoglycemia while reducing adverse outcomes, at least in some populations undergoing surgery. These considerations provide optimism that early recognition and careful but not overly aggressive management of perioperative hyperglycemia may benefit surgical patient groups such as the group described herein.

Last, nearly half the patients in this cohort with poor glucose control (POG ≥140 mg/dL) were not known to have DM preoperatively. Patients with newly diagnosed hyperglycemia are known to have a higher mortality rate and lower functional outcome owing to illness or major operations than patients with a known history of DM or normoglycemia. Thus, Umpierrez et al have recommended that all inpatients with known DM or hyperglycemia (glucose level, >140 mg/dL) undergo measurement of hemoglobin A1c levels if that measurement has not been performed in the preceding 3 months. At the same time,
current clinical practice recommendations do not include routine screening for DM in all patients undergoing major abdominal operations.29 Such routine screening is difficult but not impossible30 to justify given the variability among different patient groups undergoing different procedures. Our report links a specific population that has a high incidence of T2DM and attributes associated with T2DM to a potentially high risk for stress hyperglycemia.

At the same time, whether stress hyperglycemia is simply a form or precursor of T2DM or whether stress hyperglycemia in a patient with DM can be viewed simply as a poorly controlled episode in T2DM management remains unclear. The hereditary component of T2DM is increasingly well recognized35-38 and is an observation that underscores the increasing relevance of family history in assessing the risk for glucose intolerance.

Conclusions

A number of factors may contribute to the appearance of stress hyperglycemia after major surgery or sepsis, including genetic factors distinct from or only weakly connected to T2DM.47,48 These considerations emphasize that patients being considered for complex VHR represent a relevant, high-risk population for testing hypotheses about approaches to screening, benchmarking, and intervention in this important perioperative problem.