Glucose monitoring of patients with diabetes mellitus receiving general anesthesia: A study of the practices of anesthesia providers in a large community hospital

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Surgical stress causes hyperglycemia with potential complications (e.g., impaired granulocytic function and delayed wound healing) particularly when glucose levels exceed 250 mg/dL. Standards of care for patients with diabetes undergoing surgery may vary by geographic locale, type of surgical procedure, and type of diabetes. We explored whether anesthesia providers monitor glucose levels in patients with diabetes.

Records of 100 patients with diabetes who underwent surgery under general anesthesia (length of procedure: range, 1.9-11.8 hours) were reviewed. Demographic information, glucose levels, frequency of glucose monitoring, and treatment used for diabetes management preoperatively, intraoperatively, and postoperatively were recorded.

There were 46 males and 54 females, aged 62 ± 13 years (55% currently treated with insulin). Of the study cohort, 89% had preoperative, 23% had intraoperative, and 54% had postoperative glucose monitoring performed. As expected, postoperative glucose concentrations were significantly higher than preoperative glucose levels (mean difference, 99 mg/dL, P < .01). The mean postoperative glucose level was 262 ± 89 mg/dL with 30 of the 54 monitored patients having a postoperative glucose level greater than 250 mg/dL. Individuals treated with insulin and those who underwent major surgery were more likely to have glucose levels monitored. These results suggest that better strategies for monitoring glucose levels during the surgical period are needed.

Key words: Anesthesia, diabetes mellitus, glucose monitoring.

Introduction

It has previously been estimated that individuals with diabetes mellitus have a 50% chance of needing surgery at least one time in their lives. Surgery has the potential for significant morbidity or mortality for all patients. The primary causes of intraoperative mortality among individuals with diabetes are cardiovascular complications. In addition, individuals with diabetes are likely to be obese and may have renal impairment. Thus, meticulous anesthetic care may be required, with particular attention to metabolic normalization during the preoperative, intraoperative, and postoperative periods.

Surgical stress causes increased secretion of catecholamines, glucagon, cortisol, and growth hormone, as well as inhibition of insulin secretion. This, in turn, causes activation of gluconeogenic precursors and increased gluconeogenesis, glycolysis, and protein degradation, with resulting hyperglycemia. Osmotic diuresis can result because of the elevated glucose levels, thus further concen-
trating the counterregulatory hormones and develop-
ing a state of exaggerated insulin resistance. Hy-
perglycemia is associated with increased neurologic
ischemia, delayed wound healing, predisposition to in-
fecition (probably secondary to decreased white
blood cell function), hyperkalemia, and other prob-
els such as changes in drug metabol-
ism.

Stress hyperglycemia has been shown by many
investigators in individuals with and without
abetes. Several regimens have, therefore, been
suggested for managing glucose levels of patients
with diabetes during surgery. Some of these
clude injecting 1/2 to 2/3 of the usual insulin dose
subcutaneously or infusing various concentrations
of insulin and glucose intravenously. Intravenously
administered insulin has the advantage over insu-
lin given subcutaneously because it allows more
rapid responsiveness to changing insulin needs.
Despite the technical ability to nearly normalize
glucose levels, it can still be difficult because of the
lack of established predictors of insulin needs in-
traoperatively and postoperatively. Thus any man-
agement strategy requires careful monitoring of
glucose levels during the preoperative, intraopera-
tive, and postoperative periods.

The major objective of this study was to deter-
cine to what extent anesthesia providers monitor
glucose levels in patients with diabetes during the
preoperative, intraoperative, and postoperative pe-
riods. In addition, we examined whether the type
of current diabetes therapy and the type of surgical
procedures influenced the frequency of glucose
monitoring.

Methods

 Patients. Medical records of 100 patients with
diabetes who underwent surgery in a large com-
nunity hospital under general anesthesia for a mini-
imum of 2 hours were randomly selected and re-
viewed over a 12-month period. All patients had
received general anesthesia for a minimum of 2
hours, with the exception of one patient for whom
the length of the procedure was 1.9 hours. Records
of patients younger than 18 years of age; patients
who received anesthesia under monitored anesthe-
sia care, local, or regional anesthesia; and patients
who underwent cardiovascular surgery were ex-
cluded from this review.

 Chart review. Each record, including the an-
esthesia record, postanesthesia care unit flow sheet,
intravenous fluid flow sheet, preoperative record,
nurses notes, and progress notes, was carefully re-
viewed by one of us and the following information,
when available, was recorded: age, gender, height,
weight, duration of diabetes, type of diabetes, dia-
abetes therapy (e.g., insulin or oral medication), pre-
operative, intraoperative, and postoperative blood
levels, frequency of glucose monitoring, anesthesia providers, and treatment used for dia-
etes management preoperatively, intraoperatively,
and postoperatively.

The type of surgical procedure was classified as
minor/moderate or major. This classification
scheme was in accordance with the surgery depart-
ment's policy for determining the acuity level of
care and was set according to the complexity of
the procedure. Examples of procedures classified as
minor/moderate are scalenectomy, shoulder
acromioplasty, ulcer débridement, plastic recon-
struction of lower extremity, and hemorrhoidoc-
tomy. Examples of procedures classified as major
are abdominal aortic aneurysm repair, lumbar lam-
inctomy, carotid endarterectomy, femoral-popliteal
bypass, total hip replacement, colon resection, and
total abdominal hysterectomy.

 Data analysis. For analysis of continuous data,
the Student's t test was applied except when the data
were not normally distributed as determined by
Kolmogorov-Smirnov Goodness of Fit test (e.g.,
length of procedure). In this case, the data were
analyzed by the Mann-Whitney U test. The chi-
square test for contingency tables was used to ana-
lyze dichotomous variables.

Results

One hundred medical records of patients with
diabetes were reviewed in this study. Table I reveals
the characteristics of this study cohort by gender.

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<thead>
<tr>
<th>Table I</th>
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<td>Characteristics of study cohort</td>
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<tr>
<td>Age (years) (n = 100) (n = 46) (n = 54)</td>
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<td>Height (m) (n = 68) (n = 29) (n = 39)</td>
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<td>Weight (kg) (n = 89) (n = 39) (n = 50)</td>
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<td>Body mass index (kg/m²) (n = 68) (n = 29) (n = 39)</td>
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<tr>
<td>Current treatment (%)</td>
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<tr>
<td>Insulin</td>
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<td>Oral hypoglycemic agent and/or diet</td>
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Values are mean ± SD
NS—Nonsignificant
There were 46 males and 54 females aged 62 ± 13 years (mean ± SD). The body mass index of the study cohort was 28 ± 6 kg/m² but this represents only 68% of the individuals studied as height was a frequently missing variable from the medical record. Of the patients, 55% were currently being treated with insulin, while 45% were being treated with oral hypoglycemic agents, diet, or both. The majority of them (69%) underwent major surgery compared with 31% who underwent minor/moderate procedures. All patients, with the exception of one, received general anesthesia for a minimum of 2 hours (average length of procedure, 3.6 ± 2 hours; range, 1.9-11.8 hours). The length of procedures was longer for patients who underwent major surgery compared with patients who had minor/moderate procedures (4.1 ± 2.1 versus 2.5 ± 0.6 hours; P < .05).

Of the study cohort, 11% did not have a preoperative glucose level performed. For the remaining 89%, the mean preoperative glucose level was 167 ± 74 mg/dL. The mean preoperative glucose was higher (i.e., 175 ± 85 mg/dL) for individuals currently treated with insulin than for those currently treated with oral hypoglycemic agents, diet, or both (i.e., 156 ± 53 mg/dL), but the difference was not statistically significant. Table II reveals that 42 patients received some form of treatment for diabetes preoperatively. Of those, 15 individuals, with a mean glucose of 127 ± 40 mg/dL (range 57-176 mg/dL), were treated with IV fluids containing dextrose only. Because four of the 15 were never tested preoperatively, it may indicate that standard treatment by some anesthesia providers is routine administration of dextrose-containing fluids, perhaps being more concerned with preventing hypoglycemia than hyperglycemia.

Only 23% of the study cohort had at least one intraoperative glucose determination, with 18 monitored once, four twice, and one person four times. Six of these 23 individuals were treated during surgery (Table II). An individual's preoperative blood glucose level did not seem to explain why patients were or were not monitored during surgery as there was no significant difference between the preoperative glucose levels of those tested intraoperatively and those not tested intraoperatively (147 ± 66 versus 173 ± 75 mg/dL; P = .14).

Postoperatively, 54% of the cohort was tested. The mean glucose level was 262 ± 89 mg/dL, with 30 of the 54 patients having a postoperative glucose level greater than 250 mg/dL. A postsurgical response was apparent for these individuals, as the postoperative glucose concentrations were significantly higher than the preoperative glucose levels (mean difference, 99 mg/dL; P < .01). This response may have been due to a number of different factors, including hypermetabolism, dehydration, or administration of IV dextrose. Comparing postoperative glucose levels for individuals who currently treat their diabetes with insulin to those who currently treat their diabetes with oral hypoglycemic agents, diet, or both revealed significantly higher postoperative glucose concentrations for the former group (279 ± 92 versus 227 ± 75 mg/dL; P < .05).

Eighteen of 23 patients whose glucose concentration was checked during surgery were also tested postoperatively. Glucose levels were lower for those 18 patients compared with the other 36 patients who were tested postoperatively (234 ± 74 versus 277 ± 94 mg/dL; P < .10), but the difference was not statistically significant.

To determine whether persons who were currently treating their diabetes with insulin were monitored more often than persons who were using oral hypoglycemic agents, diet, or both, we compared the type of current treatment of diabetes with preoperative, intraoperative, and postoperative glucose testing (Table III). Table IV gives results of the comparison of the classification of surgery with glucose monitoring. Clearly, glucose monitoring was performed more often if individuals were using insulin and if they underwent major surgery.

Although the frequency of glucose monitoring could differ by type of anesthesia provider, a team approach is used in our operating rooms, thus making individual analysis (e.g., anesthesiologist versus nurse anesthetist) impossible.

**Discussion**

The goal of optimal treatment for patients with diabetes undergoing surgery is to prevent hypoglycemia, hyperglycemia, ketoacidosis, and severe fluid loss. Thus, the maintenance of euglycemia during surgery is of critical importance. Medical
evaluation preceding surgery should include an assay of the glucose concentration for all patients. If the glucose concentration is extremely elevated, surgery may need to be delayed until the glucose level is lower. In this study cohort, no knowledge of increased blood glucose levels would have been realized in 11% of the patients.

Some recommend that during surgery blood glucose levels should be maintained at 150 to 200 mg/dL with glucose levels checked at least every 2 hours, whereas others advise hourly testing. In our study, because testing was not performed on 67% of the patients during surgery, whether glucose levels were maintained at this level is unknown. Many regimens for intraoperative glucose management have been suggested, but no matter what the regimen, monitoring of glucose levels is vital.

Roelofse and Erasmus recommended that the aim of postoperative glucose management should be around 180 mg/dL. Blood glucose monitoring at the bedside is still required, with some suggesting every 2-4 hours as appropriate time intervals.

The data in this study suggest that many-patients with diabetes were not managed optimally during the surgical period (preoperative, intraoperative, and postoperative). It appeared that individuals currently treated with insulin and those undergoing major surgery were more likely to have the glucose level monitored.

Rossini suggested that there is a reduced desire for aggressive approaches toward maintaining blood glucose levels at or near normal because of the risk of precipitating a serious complication (e.g., cerebral vascular accident due to hypoglycemia). It is recognized that tight glycemic control may increase the risk of hypoglycemic events. Therefore, standards of care appropriate to risk, such as more frequent and regular glucose monitoring for patients undergoing surgery, may be required. In recent years, perhaps the most notable advancement in the management of patients with diabetes has been the availability of methods that allow frequent blood glucose measurements with a rapid turnaround time. If these methods are used in the operating room, all staff must be taught to perform the measurements accurately. We recommend that specific guidelines for monitoring glucose levels for all patients with diabetes be developed by anesthesia providers. These should include preoperative glucose measurements for all individuals with diabetes, with monitoring every 1-2 hours as suggested by others through the postoperative period until blood glucose levels are stabilized.

The prevention of hyperglycemia for the surgical patient is important for several reasons besides the obvious consequences of ketoacidosis, electrolyte imbalance, and dehydration. For example, impaired wound healing is associated with hyperglycemia, and the healing process depends on well-functioning granulocytes. Reduction in blood glucose levels below 250 mg/dL has been shown to improve granulocytic function (e.g., phagocytosis and chemotaxis). The problem in convincing individuals that meticulous control of glucose concentrations is important comes from the lack of ability to perform a definitive study that clearly reveals the benefits of maintaining adequate glycemic control for the surgical period. There is, however, sufficient circumstantial evidence to warrant levels that approach euglycemia.

Keeping blood glucose levels within a specific range represents a compromise between minimizing risks of hyperglycemia and protecting against hypoglycemia. Establishing glucose stability may spare the patient of metabolic decompensation catabolism, thus aiding in a quicker recovery with decreased morbidity and/or mortality.

These cross-sectional observations were based on the medical records of a large community hospi-
tal (the 13th largest nonfederal, nonstate hospital in the United States) and could have some unrecognized biases. If these results, however, are representative of practices at other institutions, they suggest that better strategies for improving glucose monitoring of all patients with diabetes who are undergoing surgery is warranted.

REFERENCES


AUTHORS

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