Anesthetists are concerned with the blood glucose levels of their diabetic patients. This study was performed to determine the changes in the blood glucose values of the nondiabetic when the patient is faced with the stress of surgery, intravenous fluids, anesthesia and recovery.

With complaints of epigastric pain, nausea and vomiting, a patient visits his doctor only to find out he needs to be admitted to the hospital for tests. He probably can anticipate gallbladder surgery. Worries that traverse his mind include what the tests will show, the separation from home and family, missing time at work, the actual surgical procedure and its effects, the anesthetic and even the possibility of death. How is his body reacting to this trauma and stress?

The normal response of the body to stress ultimately raises the blood glucose, which increases the need for insulin. Glucose is the only nutrient that the brain, retina and germinal epithelium use to provide them with survival energy in response to stress. A normal patient is able to handle the gluconeogenesis (dumping of glucose by the liver) because the beta cells of the islets of Langerhans produce and release insulin into the circulatory system. The insulin increases the transport of glucose across the cell membrane tenfold. When a normal patient comes to surgery, this stress response is put into play.

During a stressful situation, the body mobilizes the stress response for survival and adaptation to the stressing factor. This stress response can be caused by any trauma, infection, extreme heat or cold, injection of sympathetic drugs, surgery, debilitating disease or fear. Any patient undergoing surgery is exposed to a triple level of stress: (1) anxiety about the operation, (2) the metabolic effect of anesthesia and (3) the surgical procedure. The amount of stress induced by the surgery depends on the duration and magnitude of the procedure, with intrabdominal procedures being the most stressful to the body. Because the stress of surgery causes the gluconeogenesis along with the dextrose in the intravenous solutions (that are used to regulate blood pressure and prevent dehydration), can the nondiabetic patient's system handle the rapid increase of blood glucose?

Normal stress response

In the fasting state, the normal nondiabetic patient's blood glucose concentration is narrowly controlled by the body between a range of 80-90 mg/dl. Following a meal the blood sugar will rise for approximately one hour to a level of 120-140 mg/dl. Within two hours after the absorption of the last carbohydrate, the glucose concentration will return to the premeal range because of the function of insulin carrying glucose into the cells.

Stimulation of the sympathetic nervous system releases epinephrine at the sympathetic nervous system terminals. The hormonal response to stress
is mediated mainly by the increased secretion of epinephrine and glucocorticoids, which causes a rise in blood sugar and fatty acids as well as a fall in circulating insulin. Epinephrine produces hyperglycemia by (1) stimulating the breakdown of glycogen by the liver, (2) decreasing the uptake of glucose by the muscles and (3) inhibiting the release of insulin by the pancreas. Cortisol release is another way of increasing the amount of glucose available to the body to produce energy during stress. Once cortisol is released, an increase in the transport of amino acids is noted from the extracellular fluids into intracellular fluids of the liver cells. This increases the availability of amino acids for conversion into glucose by enzymes also found in the liver.

Cortisol also causes mobilization of amino acids from extrahepatic cells such as muscle. More amino acids become available in the plasma to enter into glyconeogenesis and promote formation of glucose. Utilization of fatty acids for energy and the mobilization of fatty acids from adipose tissue are increased with cortisol. Cortisol decreases the cell utilization of glucose by decreasing glucose transport into the cells and decreases the oxidation of NADH in glycolysis. Glucocorticoids also decrease glucose uptake by adipose tissue, causing the need for an increase of endogenous or exogenous insulin.

The liver is an important blood glucose buffer, since it is able to take up large quantities of glucose in insulin when found in excess in the blood stream. In the absence of insulin, or when the blood glucose concentration falls, the liver can release glucose into the circulatory system—the process of glucogenesis.

**Blood glucose in diabetes**

The blood glucose level at any given time is determined by the balance between the amount of glucose entering and leaving the blood stream. Determinants of this level are dietary intake, rate of entry into cells and glycostatic activity of the liver. In the diabetic patient less insulin is available, which decreases the utilization of glucose by body cells. The blood glucose level rises, thereby causing an increase in mobilization of fats from fat stores to supply energy for the cells. Because of the lack of energy supplied by the decrease of glucose intracellularly, there is less production of proteins, causing cellular weakening and breakdown.

**Diabetics and surgery**

Surgery is more common in patients with diabetes than in patients without diabetes. There are more surgical complications and higher mortality rates in diabetic patients as compared with nondiabetic patients. Galloway reported 115 incidences of postoperative morbidity in 667 cases. Seventy percent of the reported surgical complications are septic in nature. Infection was present in 90% of the patients considered in the mortality and morbidity figures in Galloway's study. Infection was the cause of 60% of the deaths that occurred after surgery in the diabetic patients.

When a diabetic patient is admitted to be prepared for surgery, the preoperative assessment must include the functional age of the patient. For example, if the patient is 40 chronologic years old with a diabetic history of 15 years, the physiologic age of this individual is 55, based on the physiologic changes associated with the disease process. These changes require more consideration in the assessment of the diabetic patient than in a 40-year-old nondiabetic patient. Diabetic patients need to be admitted to the hospital one to two days preoperative to access the renal threshold for glucose, fasting blood sugar baseline and general health. When the diabetic patient whose condition is normally controlled by oral hypoglycemics is admitted for major surgery with general anesthesia, control with insulin may be necessary as well.

There are three ways commonly employed to control the diabetic's blood glucose under anesthesia. The split dose technique divides the normal dose. One half the patient's normal insulin is given the morning of surgery, an IV of D5 H2O at a rate of 200 cc/hour is given during surgery and at least one blood glucose level is checked in postanesthesia recovery after surgery. If the patient's blood glucose is above 200 mg/dl at 6 a.m. the day of surgery, two thirds the usual dose is given preoperatively, and the remaining dose is given in postanesthetic recovery.

The second method is employed best when the patient's normal insulin dose is above 20 units of NPH per day. This patient is given the regular insulin by continuous infusion administered IV at 2 units/hour, rather than the usual subcutaneous administration of two thirds the patient's usual constant infusion of 1 unit/hour, providing the patient with equivalent diabetic control as did the subcutaneous administration of two thirds the patient's normal dose. The study by Taitelman et al demonstrated that 90% of the insulin given by IV infusion actually was delivered to the patient, contrasting with studies that stated that the insulin remained in the bottle when given using a constant infusion pump with either glass, plastic IV bottles or tubing.
Anesthesia and the diabetic

Agents used to produce anesthesia can alter carbohydrate metabolism when combined with stress.\(^7\) Anesthesia has a hyperglycemic effect on all patients.\(^7\) The selection of agents does not seem to affect the safe outcome of the surgical procedure in diabetic patients. None of the anesthetic agents is contraindicated and none is particularly beneficial to the diabetic patient. The choice of agents depends on the anesthetist's experience, his/her preferences, the type of surgeries anticipated, medical status of the patient and the surgical risks.\(^7\)

Studies done by Podolsky of the nondiabetic patient undergoing anesthesia showed that the agents with the least effect on the blood glucose levels were nitrous oxide, thiopental and halothane (isoflurane was not studied). He also reported an observed normal rise in blood glucose which consists of only 10 to 15 mg/dl and reported that this factor should not be a consideration in the type of anesthetic the patient receives.\(^9\) In the diabetic patient the overall goal is to promote early ingestion of carbohydrates and decrease nausea and vomiting during the postoperative period.\(^7\)

Anesthetic agents and the diabetic patient

General anesthesia also is very well tolerated by the diabetic patient as described below.\(^7\)

**Intravenous agents.** Thiopental combined with inhalation of 70% nitrous oxide and 30% oxygen causes no change in the blood glucose; however, glucose tolerance was depressed. There is some evidence that it partially inhibits or delays the effects of the operation on metabolism.\(^7\)

**Inhalation agents.** Halothane does not seem to affect the plasma insulin nor significantly affect blood glucose levels during anesthesia.\(^7\)

Enflurane (Ethrane\(^\circ\)) does not change the blood glucose level, regardless of what was originally found in early research on the agent.\(^7\)

Isoflurane with oxygen at 1.3 MAC without surgery significantly increases the blood glucose levels and growth hormone but causes no significant change in insulin or cortisol.\(^7\)

**Local agents.** Properly administered local anesthetics have no effect on carbohydrate metabolism. Field block, spinal and epidural anesthesia produce little disturbance in metabolic status.\(^7\) Local anesthesia is more effective than general anesthesia, resulting in fewer changes in blood glucose, growth hormone and cortisol caused by the operation. There is a decrease in blood flow in the muscle and an increase in the blood lactate found during epidural anesthesia.\(^7\)

Research

Special care is given diabetic patients with regard to regulation of the blood glucose levels during surgery. What happens to the normal patient undergoing the normal stress response during surgery and anesthesia? How does that patient's pancreas handle the glucose load that is released into his or her system?

**Methods and techniques**

Female patients between 25 and 50 years old undergoing abdominal surgery were studied.

### Table 1

Blood glucose measurements in nondiabetic surgical patients

<table>
<thead>
<tr>
<th>Operation</th>
<th>Agents used</th>
<th>% levels before induction</th>
<th>15 minutes after incision</th>
<th>30 minutes after incision</th>
<th>15 minutes after entering PAR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scope tubal</td>
<td>fentanyl</td>
<td>58</td>
<td>106</td>
<td>106</td>
<td>104</td>
</tr>
<tr>
<td>Abdominal hysterectomy</td>
<td>enflurane</td>
<td>85</td>
<td>102</td>
<td>106</td>
<td>97</td>
</tr>
<tr>
<td>Scope tubal</td>
<td>fentanyl</td>
<td>70</td>
<td>160</td>
<td>160</td>
<td>160</td>
</tr>
<tr>
<td>Abdominal hysterectomy</td>
<td>enflurane and fentanyl</td>
<td>90</td>
<td>129</td>
<td>126</td>
<td>123</td>
</tr>
<tr>
<td>Exploratory laparotomy</td>
<td>isoflurane and fentanyl</td>
<td>80</td>
<td>104</td>
<td>104</td>
<td>100</td>
</tr>
<tr>
<td>Scope tubal</td>
<td>isoflurane</td>
<td>120</td>
<td>117</td>
<td>117</td>
<td>119</td>
</tr>
<tr>
<td>Scope tubal</td>
<td>fentanyl</td>
<td>54</td>
<td>120</td>
<td>123</td>
<td>119</td>
</tr>
<tr>
<td>Diagnostic scope</td>
<td>isoflurane</td>
<td>94</td>
<td>134</td>
<td>134</td>
<td>100</td>
</tr>
<tr>
<td>Vaginal hysterectomy</td>
<td>isoflurane and fentanyl</td>
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<td>240</td>
<td>181</td>
<td>186</td>
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<tr>
<td>Abdominal hysterectomy</td>
<td>fentanyl</td>
<td>97</td>
<td>116</td>
<td>117</td>
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</tr>
<tr>
<td>Scope tubal</td>
<td>isoflurane</td>
<td>91</td>
<td>116</td>
<td>116</td>
<td>136</td>
</tr>
</tbody>
</table>
These patients had no history of diabetic problems, were within 15% of their ideal weight (to rule out any borderline diabetics) and were generally in good health.

Capillary blood glucose levels were measured with the Accuchek Glucometer™ and Chemstrip bG™ (both by Bio Dynamics). The patients were treated as if they had diabetes with regard to regulating their fluids. The first blood glucose measurement was taken when the IV was started. An IV of D5LR was started on the morning of surgery and run at a rate of 1.6 cc/kg/hour. Lactated Ringers solution without glucose was used to administer normal surgical fluids, agents and drugs required for the anesthetic and to regulate the blood pressure when indicated. Blood glucose measurements were taken 15 and 30 minutes after incision and 15 minutes after the patient was received in the postanesthesia recovery room.

Results
A total of 11 patients were included in the study, and the summary of the results can be found in Table I.

The normal range established both pre- and post-prandial is 80 to 140 mg/dl for comparison. When studying the results, only two patients (1.8%) maintained a blood glucose above the normal range. The preoperative blood glucose range fell below the established normal range five times or 45% of the time.

The agents used were isoflurane, enflurane, and fentanyl (alone or in combination with an inhalation agent). A comparison of the findings of the different agents in the study reveals a minimal difference in the blood glucose levels of the patients.

Conclusion
A study involving 11 patients is not large enough to use to draw a definite conclusion, but a pattern was found to exist in most of the patients. The study showed that a nondiabetic patient's system can handle the gluconeogenesis and the stress encountered before, during and after surgery and anesthesia.

This study showed that with the stress of surgery causing gluconeogenesis, and the glucose given IV with the surgical fluids, the nondiabetic patient can handle the rapid increase of glucose in his system.

REFERENCES

AUTHOR
Debra Schwaninger Topp, CRNA, BS, graduated from Bryan Memorial School of Nursing in 1978. She worked in the operating room for five years in Kansas City and Lincoln, Nebraska. She graduated from Nebraska Wesleyan-Bryan Memorial School of Anesthesia in August of 1984, and is presently a staff anesthetist at Bryan Memorial Hospital and St. Elizabeth's Hospital in Lincoln, Nebraska. This paper was written when the author was a senior nurse anesthesia student.