Perioperative Management of Diabetes

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Diabetes affects from 2% to 5% of the American population. Diabetic patients are more likely to undergo surgery during their lifetime than are people without diabetes because of an increased risk of infections, as well as vascular, ocular, and renal disease. Morbidity and mortality rates during the perioperative period are higher in diabetic patients because of a heightened incidence of coronary artery disease, the frequency of impaired renal function, and the propensity to fluid and electrolyte imbalance. Furthermore, hypoglycemia can directly affect perioperative morbidity, and persistent hyperglycemia may increase the risk of postoperative infections and poor wound healing. Consequently, perioperative management of the diabetic patient is a common, challenging problem. By effectively stabilizing the diabetic state, the risks related to surgery can be minimized and perioperative outcomes improved.

Aims for perioperative control of the blood glucose level in the diabetic patient include: 1) avoidance of hyperglycemia (blood glucose levels over 250 mg/dL with intravenous dextrose infusing or over 200 mg/dL measured just before oral nourishment), and 2) prevention of hypoglycemia (blood glucose levels below 100 mg/dL with intravenous dextrose infusing or below 80 mg/dL measured just before oral nourishment). Other usual markers for diabetes control including levels of hemoglobin A1c, plasma lipids, or urinary glucose are irrelevant during periods of short-term stress; however, significant ketosis should be avoided by adequate use of insulin and carbohydrate.

Traditionally, patients have been managed by receiving 50% of their usual morning dose of intermediate-acting (NPH or Lente) insulin on the morning of surgery and then using subcutaneous regular insulin on a sliding-scale basis (guided by monitored blood glucose levels) along with an intravenous infusion of 5% dextrose and water. At times no intermediate insulin is given; instead, intermittent regular insulin is used alone in an amount related to the monitored blood glucose level and the estimated degree of insulin sensitivity.

A better understanding of the physiologic responses in diabetic patients to the stress of surgery has led to the incorporation of protocols which utilize an intermediate-acting insulin concomitant with continuous intravenous regular insulin infusions at a dose sufficient to blunt the effect of the counter-regulatory hormones. Such management, as well as the use of accurate reflectance meters for blood glucose monitoring, will lessen the liability of the diabetes control. The blood glucose concentration is now easier to stabilize, the incidence of ketoacidosis and undetected hypoglycemia has significantly decreased, and, as a result, perioperative morbidity and mortality rates have improved.

The following general principles and specific protocols will help the practitioner care for diabetic patients in the perioperative period and during labor and delivery.

I. General Principles

A. Most patients scheduled for elective surgery will undergo medical clearance preoperatively. At that time, the state of the diabetes control will be assessed.

B. Goals for clearance for elective surgery are:

1. Fasting blood glucose below 150 mg/dL.
2. No symptoms of uncontrolled diabetes.
3. General anabolic state.

C. If these goals are not met, elective surgery may be postponed until the diabetes is more stable.

D. Under emergency surgical situations, stabilization of the diabetes can be achieved promptly, although diabetic ketoacidosis should be treated for several hours in order to correct the metabolic acidosis prior to surgery. Only an exsanguinating hemorrhage or equally emergent situation would take precedence.

II. Noninsulin-Requiring Diabetes

A. Minor Surgery

1. For patients with diet-controlled diabetes:

   a) The evening before surgery, eat a regular meal
   b) Before surgery, take 150 grams of carbohydrate
   c) Check blood glucose
   d) Check serum ketones
   e) If blood glucose is below 80 mg/dL, give glucose

2. For patients with insulin therapy:

   a) Insulin dose to be given before surgery
   b) Monitor blood glucose
   c) Adjust insulin as necessary

III. Insulin-Requiring Diabetes

A. Major Surgery

1. If it is possible, the last insulin injection should be given 2-3 hours before surgery.

2. If surgery is necessary for emergent reasons, give an additional short-acting insulin injection 1 hour before surgery and begin an insulin infusion 1 hour after surgery.

   a) The evening before surgery, eat a regular meal
   b) Before surgery, take 150 grams of carbohydrate
   c) Check blood glucose
   d) Check serum ketones
   e) If blood glucose is below 80 mg/dL, give glucose

   1) In the case of patients who are not hypoglycemic:
      a) The evening before surgery, eat a regular meal
      b) Take regular insulin 1 hour before surgery
      c) Check blood glucose
      d) Adjust insulin as necessary

   2) In the case of patients who are hypoglycemic:
      a) The evening before surgery, eat a regular meal
      b) Take regular insulin 1 hour before surgery
      c) Check blood glucose
      d) Adjust insulin as necessary

IV. Postoperative Management

A. Medium- and Large-Surgery Patients

1. Monitor blood glucose at least every 2 hours.
2. Adjust insulin as necessary.

3. Check urine for ketones.

B. Minor-Surgery Patients

1. Monitor blood glucose at least every 4 hours.
2. Adjust insulin as necessary.

3. Check urine for ketones.

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The fasting blood glucose should be less than 150 mg/dL if not begin insulin therapy preoperatively. (See section II.A.3.)

b) Begin an intravenous infusion of 5% dextrose and water to deliver 6 grams of glucose per hour (120 mL/hr) or 100 to 150 grams of glucose per 24 hours.

c) Check the blood glucose every two hours during surgery. If the blood glucose exceeds 200 mg/dL, then give insulin. (See section II.A.3.)

d) Check the blood glucose every two to four hours after surgery until it is stable and then measure a daily fasting blood glucose thereafter.

e) Resume the usual diet when appropriate.

2. For patients taking an oral hypoglycemic agent:

a) Hold the sulfonylurea on the day of surgery.

b) The fasting blood glucose should be below 150 mg/dL if not begin insulin therapy preoperatively. (See section II.A.3.)

c) Begin an intravenous infusion of 5% dextrose and water to deliver 6 grams of glucose per hour (120 mL/hr) or 100 to 150 grams of glucose per 24 hours.

d) Check the blood glucose every two hours during surgery. If the blood glucose exceeds 200 mg/dL, then give insulin. (See section II.A.3.)

e) Check the blood glucose every two to four hours postoperatively until it is stable and then measure a daily fasting blood glucose thereafter.

f) Resume the usual diet and the oral hypoglycemic agent when appropriate.

3. When insulin therapy is required:

Give 5 units of regular insulin subcutaneously for a blood glucose of 200 to 250 mg/dL, plus 1 unit of regular insulin for every 50 mg/dL blood glucose over 250 mg/dL. For subsequent blood glucose give regular insulin by this same formula as follows: less than 80 mg/dL → 0 units; 80 to 120 mg/dL → 2 units; 121 to 150 mg/dL → 3 units; 151 to 200 mg/dL → 4 units; 201 to 250 mg/dL → 5 units; 251 to 300 mg/dL → 6 units; etc.

Example: For a blood glucose of 282 mg/dL, initially give 6 units of regular insulin subcutaneously followed by regular insulin based on the outlined scale no more than four hours. Absolute amounts of regular insulin given should be adjustable as one observes the response of the blood glucose to the initial amounts of insulin.

B. Major Surgery

1. If the blood glucose is not controlled (i.e., fasting blood glucose is greater than 150 mg/dL), change to intravenous insulin therapy protocol as outlined in section III.A; otherwise follow the protocol outlined under section II.A.1. or II.A.2.

2. After the operation, when the patient is eating, give subcutaneous regular insulin on a sliding-scale basis prior to each meal as suggested above (see section II.A.3.).

3. If the patient’s total daily insulin requirement exceeds 20 units for several consecutive days, chronic insulin therapy will likely be needed. Institute a mixture of regular insulin and intermediate (NPH, Lente) insulin based upon the amount of insulin required by the patient during those days. Of the total daily dose of insulin, give two-thirds of the dose in the morning before breakfast and one-third in the evening before dinner. Of that insulin used in the morning and in the evening, give two-thirds as an intermediate-acting insulin and one-third as regular insulin. Example: An average of 36 units of sliding-scale insulin are used daily. To institute a mixed regular and intermediate insulin regimen, give 24 units of insulin in the morning (8 units regular with 16 units of NPH) and give 12 units of insulin before dinner (4 units regular with 8 units of NPH).

III. Insulin-Requiring Diabetes

A. All Operations

1. Stabilize the blood glucose prior to surgery as well as possible.

2. Advise the patient to inject the usual daily dose of insulin on the day prior to the planned operation.

3. Administer one-half of the usual total daily dose of insulin as intermediate (NPH, Lente) insulin in equal amounts every 12 hours on the day of surgery.

4. Prior to the surgery, begin an intravenous solution containing 100 units of regular insulin dissolved in 500 mL of normal saline at 1 to 2 units of insulin (5 to 10 mL) per hour. Simultaneously infuse 5% dextrose and water at 120 mL/hr (6 grams glucose/hr).

5. During surgery check the blood glucose every one to two hours and adjust the intravenous insulin and/or the intravenous dextrose delivery rate to maintain the blood glucose between 100 to 200 mg/dL. Adjust the insulin delivery rate by 0.5 units per hour for every 50 mg/dL change in glucose as follows:

<table>
<thead>
<tr>
<th>Blood Glucose (mg/dL)</th>
<th>Insulin (U/hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 80</td>
<td>0</td>
</tr>
<tr>
<td>81–100</td>
<td>0.5</td>
</tr>
<tr>
<td>101–150</td>
<td>1.0</td>
</tr>
<tr>
<td>151–200</td>
<td>1.5</td>
</tr>
<tr>
<td>201–250</td>
<td>2.0</td>
</tr>
<tr>
<td>251–300</td>
<td>2.5</td>
</tr>
<tr>
<td>301–350</td>
<td>3.0</td>
</tr>
<tr>
<td>351–400</td>
<td>3.5</td>
</tr>
<tr>
<td>401–450</td>
<td>4.0</td>
</tr>
</tbody>
</table>

6. Postoperatively, the above protocol can be continued in the recovery room and in an intensive care unit.

7. Check the level of serum potassium every four to eight hours since an effect of insulin is to lower the serum potassium level by intracellular transfer.

8. For patients who do not go to an intensive care unit, administer regular insulin subcutaneously approximately 30 minutes before the anticipated completion of surgery or discharge from the recovery room. The intravenous insulin infusion may be discontinued 30 minutes later and the intravenous dextrose infusion rate decreased to 50 to 100 mL/hr.

9. Continue the use of intermittent regular insulin subcutaneously every four to six hours and dextrose intravenously until the patient tolerates oral intake. Initiate intermediate insulin as the patient’s clinical state stabilizes.
IV. Diabetes and Pregnancy: Management for Delivery

The metabolic goal is a blood glucose between 70 to 100 mg/dL in order to lessen the risk of neonatal hypoglycemia.

A. Diabetes Prior to Pregnancy

1. Women in labor and those scheduled to undergo labor induction or cesarean section will be fasting.
2. Begin an intravenous infusion of 5% dextrose and one-fourth normal saline at 125 to 150 mL/hr.
3. Give one-fourth of the current intermediate-acting (NPH or Lente) insulin dose on the morning of anticipated delivery.
4. Monitor the blood glucose hourly prior to delivery, immediately postdelivery, and then at least every six hours postpartum.
5. If the blood glucose is greater than 100 mg/dL, begin an insulin infusion as 100 units of regular insulin dissolved in 500 mL of normal saline at 1 to 2 units of insulin (5 to 10 mL) per hour.
6. Adjust the intravenous insulin and dextrose infusion rates to maintain the blood glucose between 70 to 100 mg/dL throughout labor and delivery.
7. Discontinue both the insulin and dextrose infusions when the patient is tolerating oral intake, then administer one-half the prepartum sliding-scale regular insulin subcutaneously every six hours appropriate to the monitored blood glucose.
8. In preparation for discharge, discuss metabolic goals with the patient. She may be placed back on her prepregnancy insulin regimen unless judged otherwise.

B. Gestational Diabetes Mellitus (diabetes first identified during this pregnancy)

1. Women in labor and those scheduled to undergo labor induction or cesarean section will be allowed no oral intake.
2. Begin an intravenous infusion of 5% dextrose and one-fourth normal saline at 125 to 150 mL/hr.
3. Since the patient was not taking insulin prior to pregnancy, intermediate-acting insulin is not routinely given prior to delivery. However, it may be necessary in some severe cases of gestational diabetes mellitus.
4. Administer one-half the prepartum sliding-scale dose of regular insulin every four to six hours based on the blood glucose level until delivery of the baby. If any blood glucose level is greater than 100 mg/dL, initiate treatment with a simultaneous intravenous insulin infusion (see section IV.A.).
5. Discontinue the intravenous infusions postpartum when appropriate.
6. Although no further postpartum insulin will be required in most patients, some will require it. Therefore, blood glucose should be monitored closely for 48 hours postpartum.

V. General Observations

1. Sepsis always increases insulin requirement.
2. Slender diabetic patients are more sensitive to insulin than are obese diabetic patients.
3. Patients undergoing coronary artery bypass surgery or renal transplant surgery usually require larger amounts of insulin than do patients who undergo other operations.
4. If diabetic ketoacidosis is present prior to surgery, all but the most emergent operations should be delayed for approximately 6 to 12 hours, if possible, to allow time for control of the ketoacidotic state.
5. Diabetic patients should be scheduled for surgery in the morning whenever possible.

VI. Case Examples

Patient A is a thin, insulin-dependent diabetic male scheduled to undergo an appendectomy. He usually takes 4 units of regular insulin with 20 units of NPH insulin in the morning and 6 units of regular insulin with 10 units of NPH insulin before dinner. His blood glucose control is fair with a hemoglobin A1c level under 10.0%. On the day of surgery, oral intake is withheld. His blood glucose is 150 mg/dL. He is given 10 units of NPH insulin subcutaneously, and a 5% dextrose and water infusion at 120 mL/hr is started along with a simultaneous insulin infusion at 1 unit/hr (see section III.A.). His blood glucose is monitored hourly and appropriate action taken:

<table>
<thead>
<tr>
<th>Time</th>
<th>Blood Glucose</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 hr</td>
<td>140 mg/dL</td>
<td>Continue the initial infusion.</td>
</tr>
<tr>
<td>2 hr</td>
<td>200 mg/dL</td>
<td>Increase the insulin rate to deliver 1.5 U/hr.</td>
</tr>
<tr>
<td>3 hr</td>
<td>75 mg/dL</td>
<td>Discontinue the insulin drip and increase the dextrose infusion rate to 150 mL/hr.</td>
</tr>
<tr>
<td>4 hr</td>
<td>160 mg/dL</td>
<td>Resume the insulin infusion at 1.5 U/hr.</td>
</tr>
<tr>
<td>5 hr</td>
<td>260 mg/dL</td>
<td>Increase the insulin delivery rate to 2.5 U/hr.</td>
</tr>
<tr>
<td>6 hr</td>
<td>145 mg/dL</td>
<td>Patient is now in the recovery room, awake and alert, able to take some sips of liquid. Decrease the dextrose delivery rate to 75 mL/hr. Give 10 units of NPH insulin subcutaneously and discontinue the intravenous insulin 30 minutes later.</td>
</tr>
<tr>
<td>10 hr</td>
<td>240 mg/dL</td>
<td>Administer 6 units of regular insulin subcutaneously. Continue sliding-scale regular insulin every four to six hours (see section II.A.3.).</td>
</tr>
</tbody>
</table>

Patient B, an obese (approximately 120 kg [264 lb]) male with a gangrenous ulcer of the foot, is scheduled to undergo femoral-popliteal bypass surgery. He has been requiring 15 units of regular insulin and 20 units of NPH insulin before dinner or fluids of any kind. Administration of insulin: Start 50 units NPH insulin. Start an intravenous infusion of 100 units regular insulin dissolved in 500 mL normal saline at 125-150 mL/hr. Draw blood 1 hr, 2 hr, and 3 hr. In preparation for surgery, adjust doses to lower insulin requirements. Adjust according to plasma insulin levels. Do not stop insulin. Give 100 units of regular insulin immediately postdelivery, and then at least every six hours postpartum. If surgery is anticipated, an alternative management would be to administer a dose of subcutaneous regular insulin on the morning of surgery dependent on the monitored blood glucose and repeated every four to six hours. Another alternative is the use of one-fourth of the total 24-hour insulin dosage as regular insulin every six hours with adjustments appropriate to the blood glucose response.

With resumption of the patient’s usual diet, discontinue the postoperative insulin regimen and intravenous fluids and gradually resume the usual insulin regimen.

Note: Diabetic patients should be scheduled for surgery in the morning whenever possible. However, if surgery later in the day is anticipated, an alternative management would be to administer a dose of subcutaneous regular insulin on the morning of surgery dependent on the monitored blood glucose and repeated every four to six hours. Another alternative is the use of one-fourth of the total 24-hour insulin dosage as regular insulin every six hours with adjustments appropriate to the blood glucose response.
units of regular insulin and 50 units of NPH insulin in the morning and 20 units of regular insulin and 40 units of NPH insulin before dinner. On the morning of surgery he is allowed no food or fluids orally and his blood glucose is 310 mg/dL.

Administer 25 units of NPH insulin subcutaneously.

Start 5% dextrose and water at 120 mL/hr intravenously.

Start an intravenous insulin infusion at 3.0 units/hr (see section II.A.).

His blood glucose is monitored hourly and appropriate action taken:

<table>
<thead>
<tr>
<th>Time (hr)</th>
<th>Blood Glucose (mg/dL)</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>200</td>
<td>Decrease insulin infusion rate to deliver 1.5 U/hr.</td>
</tr>
<tr>
<td>2</td>
<td>70</td>
<td>Increase intravenous fluid infusion rate to 150 mL/hr and decrease the insulin infusion rate to 1.0 U/hr.</td>
</tr>
<tr>
<td>3</td>
<td>125</td>
<td>Continue intravenous insulin infusion at 1.0 U/hr.</td>
</tr>
</tbody>
</table>

This pattern can be continued throughout the operation and carried over into the surgical intensive care unit until the patient can tolerate oral intake.

Suggested Reading


