Full Case:

A 45-YEAR-OLD WOMAN has a known history of diabetes for 30 years. Her diabetes is normally controlled with a combination regimen of neutral protamine hagedorn (NPH) and regular insulin: NPH 32 units and regular 16 units before breakfast, and NPH 12 units and regular 12 units before dinner. She is scheduled for emergency surgery for ovarian abscess. Her blood glucose level is 350 mg per dL.

Questions:

What are the principles of management of diabetic ketoacidosis?

Diabetic ketoacidosis is an acute medical emergency characterized by an absolute or relative deficiency of insulin, resulting in an accumulation of ketone acids in the blood. The main disturbances are hyperglycemia, glucosuria, intracellular dehydration, acidosis, and electrolyte imbalance. Conventionally, severe ketoacidosis implies levels of ketone acids in the blood of generally more than 7 mmol per L, a decrease in serum bicarbonate to less than 10 mEq per L, or a decrease in pH level to less than 7.25. The initial physical examination should be supported with urinalysis, venous blood analysis for glucose, electrolytes and determination of anion gap, serum ketone estimation, urea nitrogen level, and complete blood cell count. Reagent strips maybe used to electronically determine the blood glucose and ketones quickly so therapy can be initiated. An arterial blood gas sample should be analyzed to determine acid-base imbalance. The mainstay of treatment includes fluids, insulin, bicarbonate, and potassium.

Fluids: Most patients are dehydrated and the loss of water exceeds that of salt. Therefore hypotonic saline solution (0.45% sodium chloride) is considered optimal. Five percent dextrose should be instituted once the serum glucose level falls to less than 300 mg per dL to prevent hypoglycemia secondary to insulin therapy. A central venous pressure measurement and Urine output are good guidelines for fluid therapy.
Insulin: All patients in ketoacidosis are in immediate need of insulin. Therefore, a rapid-onset short-acting insulin should be employed to attain better control. Insulin, 10 to 20 units, can be given intravenously initially, and an infusion of insulin at a rate of 1 to 2 units per hour may be started depending on blood glucose levels. Initial bolus dose may be repeated depending on the severity of ketoacidosis and hyperglycemia, as well as the glucose-lowering response to the initial dose. Blood glucose level should be reduced at a rate of no more than 50 mg/dl/hour, as a faster reduction rate can lead to cerebral edema.

Bicarbonate: Sodium bicarbonate should be used to correct severe metabolic acidosis (with a pH level of <7.20) as guided by determinations of arterial blood pH level. PaO2, and bicarbonate overcorrection should be avoided.

Potassium: After acidosis, osmotic diuresis, and vomiting, body potassium stores are depleted by 5 to 10 mEq per kg of body weight. Serum potassium level, although initially normal usually decreases as a result of hemodilution, and because the correction of hyperglycemia and acidosis results in movement of potassium from extracellular space to intracellular space. Therefore, potassium should be added to the intravenous infusion 3 to 4 hours after initiating the therapy, provided the renal function is adequate. Frequent laboratory data and clinical findings should dictate the dose and frequency regimen of the treatment. Supportive therapy for associated problems should continue, and overcorrection should be avoided.


**What is nonketotic hyperosmolar coma?**

Nonketotic hyperosmolar coma is a syndrome of profound dehydration usually seen in patients with type 2 DM when they are unable to drink enough to keep up with urinary fluid losses secondary to glycosuria. No ketoacidosis is present. Patients present with extreme hyperglycemia, hyperosmolality, volume depletion, and mental status changes. Plasma glucose level is generally approximately 1,000 mg per dL, approximately twice the value seen in diabetic ketoacidosis. The mortality rate is greater than 50%. The most important aspect of treatment is rapid administration of large amounts of intravenous fluid, but as with diabetic ketoacidosis, insulin, dextrose, and potassium are necessary as well.


**What are the signs and implications of autonomic neuropathy in the diabetic patient?**

Autonomic neuropathy occurs in approximately 1 of every 10 diabetic patients. In the older population, especially those with coexisting hypertension, the incidence increases fourfold to fivefold. Signs of autonomic neuropathy include lack of sweating, early satiety, orthostatic hypotension, gastric reflux, and lack of change in pulse rate with deep inspiration. Impotence and urinary symptoms of dysautonomic bladder may be evident.

The implication of autonomic neuropathy is increased morbidity and mortality. Orthostatic hypotension in the peri operative period is common and may be severe immediately postoperatively. Myocardial ischemia is often painless with risks of cardiorespiratory arrest. Gastroparesis predisposes these patients to nausea, vomiting, regurgitation, and aspiration.

How would you prepare this patient for anesthesia and surgery?

The preoperative evaluation will determine the preparation of this patient, the principles of which are as follows:

Hydration
- Poor oral intake secondary to malaise and abdominal pain, concomitant vomiting (if present), and osmotic diuresis resulting from glucosuria will make dehydration quite likely in this patient. Any dehydration that is present, therefore, should be rapidly corrected. Normal or half-normal saline is a preferred intravenous solution because the blood glucose level is already elevated in this instance.

Insulin
- Infection and stress are known to increase insulin requirements, which explains hyperglycemia in this patient. Insulin can be given to this patient either in small doses (5-10 units intravenously) every hour or as a continuous infusion at 1 to 2 units per hour using a pump. Hourly blood and urine glucose and acetone measurements should be used to adequately monitor this therapy. Add-base and electrolyte correction should be carried out as dictated by blood test results.

Antibiotics
- Antibiotics should be instituted once appropriate culture samples are obtained.


What is the effect of anesthesia and surgery on insulin and glucose metabolism?

Both sevoflurane and isoflurane impair glucose tolerance to the same degree, independent of surgical stimulation. No studies have examined the effects of nitrous oxide on glucose tolerance.

Surgery results in a stress response, accompanied by a catabolic state. The extent of this metabolic response is related to the severity of the operation and other concomitant factors, such as sepsis in this patient and shock, if present. The well-recognized hormonal changes include increased catecholamines, adrenocorticotropic hormone, and cortisol secretions, as well as plasma cyclic adenosine monophosphate and glucagon levels. As a result, blood glucose level are known to increase during surgery, whereas plasma insulin levels remain constant. There is also a phase of relative insulin resistance after surgery. All these changes increase insulin requirements acutely in the diabetic patient.

Insulin treatment started before surgery, along with a glucose infusion to maintain normoglycemia, results in lowering of cortisol levels immediately after surgery. Epidural block also reduces the release of stress hormones.

Breaking the preoperative fasted state shortly before surgery with liquid oral carbohydrates has been shown to reduce postoperative insulin resistance. The benefits of such intake should be weighed against the increased risk of aspiration.


Tanaka T, Nabatame H, Tanifuji Y. Insulin secretion and glucose utilization are impaired under general anesthesia with sevoflurane as
How would you treat hyperglycemia intraoperatively?

Intraoperative hyperglycemia (blood glucose level >250 mg/dL) should be treated with intravenous regular insulin. Small doses (up to 10 units) of insulin may be used reliably and effectively as single intravenous injections. In adults, a useful rule of thumb is that each unit of regular insulin lowers the blood sugar level by approximately 30 mg per dL. Blood sugars monitored every 1 to 2 hours further dictate the continuation of therapy. Although the half-life of intravenous insulin is short, hypoglycemia as late as 3 hours after an injection has been observed.

Another way to control hyperglycemia intraoperatively is to use a continuous infusion of insulin, starting at 1 unit per hour; if preoperatively, the patient requires 20 units or less of NPH insulin daily. In this patient, a starting rate of 2 units per hour, further dictated by frequent blood and urine glucose estimations, will be a reasonable regimen. The use of an infusion pump with a plastic syringe affords a 90% recovery of insulin due to limited adsorption. The keystone to intraoperative diabetes management is the measurement of blood glucose concentration.


How would you recognize and treat hypoglycemic shock intraoperatively?
It is virtually impossible to differentiate hypoglycemic shock from other forms of shock intraoperatively unless supported by low blood glucose concentrations measured concomitantly.

Treatment lies in administration of glucose, which may be given as a bolus of 50% glucose, followed by a 10% dextrose-insulin infusion. Blood sugar level increases approximately 30 mg per dL for each 7.5-g bolus of dextrose in a 70-kg adult.


What are the common postoperative complications you expect in a diabetic patient?

In addition to the usual complications, the common problems in a diabetic patient include poor diabetes control and infection. Hyperglycemia is associated with delayed wound healing, decreased leukocyte function, and greater likelihood of brain damage in the setting of cardiorespiratory arrest. A higher incidence of cardiovascular and renal problems, in combination with autonomic neuropathy, can also result in postural hypotension and urinary retention. Overall morbidity and mortality are increased.


Does diabetes increase perioperative risk? Is it necessary to achieve tight perioperative control of blood glucose?

Diabetes itself may not be as important to perioperative outcome as its end-organ effects. Diabetic and nondiabetic patients who are matched
for type of surgery, age, sex, weight and complicating diagnoses have similar complication rates. Diabetic patients have complicating diagnoses much more frequently than nondiabetic patients, particularly obesity. Therefore, the average diabetic patient presents a higher perioperative risk than the average nondiabetic patient. Sepsis and complications of atherosclerosis are the leading causes of death in these patients. Other changes, such as nephropathy and autonomic neuropathy (e.g., urinary retention, gastroparesis, and painless myocardial ischemia), contribute to increased morbidity. Episodes of hyperglycemia, hypoglycemia, and diabetic ketoacidosis, conditions not generally encountered in the healthy population, carry a higher than normal risk of perioperative morbidity.

Glycemic control, particularly in the diabetic patient taking insulin, is a critical factor in the perioperative outcome. Although controversy has existed in the past about how tightly blood sugar levels should be controlled chronically in diabetic patients, the preponderance of recent data suggests that the long-term benefits of such tight control include delayed onset and limitation of complications of diabetes. It is also known that hyperglycemia may worsen neurologic outcome after intraoperative cerebral ischemia. Studies also suggest that hyperglycemia with a blood glucose level of more than 250 mg per dL inhibits polymorphonuclear cell activity. Increased incidence of infection, decreased wound healing, and a higher incidence of end-organ damage should prompt us to achieve tight perioperative control of blood sugar in diabetic patients. In this population, patients with poor intraoperative glycemic control (four consecutive blood glucose measurements >200 mg/dL despite insulin therapy) during cardiac surgery have been shown to have higher rate of cardiovascular, respiratory, infectious, renal, and neurologic complications following surgery.


