

Anaesthesia and the diabetic patient

J. A. ROELOFSE, F. R. ERASMUS

Summary

Since it is estimated that 1 out of every 2 diabetic patients will require surgery at some point in his lifetime, it is imperative that the anaesthetist should understand the disease process as well as the anaesthetic problems associated with it. This article emphasizes the medical, surgical and anaesthetic aspects of the treatment of patients with diabetes mellitus.

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Greek and Roman physicians used the term diabetes to refer to conditions in which the cardinal finding was a large volume of urine output. Two types were distinguished: (i) diabetes mellitus (DM) in which the urine tasted sweet; and (ii) diabetes insipidus in which the urine was tasteless. Today the unmodified term diabetes is used as a synonym for DM. DM describes a class of disease characterized by chronically elevated blood glucose concentrations, often accompanied by other clinical and biochemical abnormalities. Most abnormalities can be traced to reduced entry of glucose into various peripheral tissues and increased liberation of glucose into the circulation from the liver. The end result is an excess of extracellular glucose but an inability to transport this glucose into the intracellular compartment. This leads to 'starvation in a sea of plenty'. The disease may vary in its expression from totally asymptomatic to rapidly lethal.

The more descriptive and informative terms 'insulin-dependent' and 'non-insulin-dependent' DM have replaced the old terms 'maturity onset' and 'juvenile onset'. The present classification has been widely adopted and is likely to stand for many years.¹ The usual symptoms and signs of DM are well known and related to hyperglycaemia and/or keto-acidosis. It is as well to remember that keto-acidosis can present with severe abdominal pain, and on examination the patient may have a rigid abdomen.² When symptoms of thirst, polyuria with glycosuria and weight loss are present, a single blood glucose measurement is usually all that is required to establish the diagnosis. A clearly raised fasting blood glucose concentration, in excess of 8 mmol/l or a postabsorptive blood glucose level in excess of 11 mmol/l unequivocally establish the diagnosis.

The last decade has seen remarkable advances in our understanding and management of DM. There are three principal aims in the treatment of the diabetic patient: (i) to restore the disturbed metabolism to as near normal as is consistent with comfort and safety; (ii) to prevent or delay progression of the short- and long-term hazards of the disease; and (iii) to provide the diabetic with the knowledge, motivation and means

to undertake his own care. The basic treatment of DM is a low-carbohydrate, sucrose-excluding diet together with insulin in the insulin-dependent diabetic who is liable to ketosis. The non-insulin-dependent diabetic's condition is usually controlled on diet alone, but sometimes oral hypoglycaemic agents or insulin are also required.³ Oral hypoglycaemic agents are being used by 30% of all diabetics. In addition to their well-known side-effects,⁴ they can provoke mild or even severe hypoglycaemia. The sulphonylureas are generally preferred to the biguanides because they are more potent and have fewer side-effects. The effects of the sulphonylureas may be potentiated by drugs such as probenecid, mono-amine oxidase-inhibitors, clofibrate, propranolol, phenylbutazone and methotrexate.⁴ The biguanides are still on the market and are used quite often. The risk of lactic acidosis is greatest with phenformin, although that associated with methformin cannot be ignored. Oral hypoglycaemics should not be used during pregnancy. There are various types of insulin preparations available.¹ The choice depends largely on personal preference as much as on the response of the patient. It must be remembered that the half-life of insulin in the circulation is less than 10 minutes. A decrease in the blood glucose concentration is noticed within 30 minutes of intravenous and 2-3 hours of subcutaneous injection.

Anaesthetic considerations

Anaesthetists may be called on to: (i) control the pre-operative blood sugar level in previously undiagnosed cases; (ii) advise on the treatment regimen for a known diabetic undergoing planned surgery; (iii) plan for an emergency procedure in an uncontrolled case; (iv) evaluate the pre-operative risk of diabetes-associated disease; and (v) assist in the intensive care management of patients with coma and severe biochemical abnormalities. Optimum management of the patient is dependant upon communication and co-ordination between physician, surgeon and anaesthetist. Ideally the patient should be admitted to hospital 1 or 2 days before surgery. This should allow adequate time for assessment and, if necessary, correction of metabolic disturbances. It is important to remember that 50% of all diabetics will require surgery and that 25% are diagnosed *de novo* in the surgical ward. Fields of surgery where the anaesthetist may come across diabetics are: (i) infections (abscess, gangrene); (ii) ophthalmology (cataracts, retinal detachment); (iii) vascular surgery (arterial grafts, amputations); (iv) obesity (cholecystitis); (v) 'acute abdomen' (keto-acidosis); (vi) renal failure (repeated urinary tract infections, chronic pyelonephritis); (vii) pancreatic diseases (pancreatitis, carcinoma of the pancreas); and (viii) obstetrics (history of big babies and foetal death). It is also known that DM can be a cause of coma. Other conditions such as hypo- and hyperglycaemia, lactic acidosis, hyperosmolar non-ketotic coma, cerebrovascular accidents and head injuries can also cause coma. The diabetic is thus not exempt from other causes of coma!

During the pre-operative evaluation some diabetes-related problems of importance to the anaesthetist must be looked for and ruled out or, if present, suitable therapy instituted to achieve an optimal pre-operative condition. Diabetics have a high incidence of atherosclerosis, nephropathy, hypertension and ischaemic heart disease. The insulin-dependent diabetic

Department of Anaesthesia, Tygerberg Hospital and University of Stellenbosch, Parowallei, CP

J. A. ROELOFSE, M.MED. (ANAES.), PH.D. (MED.)

F. R. ERASMUS, M.MED. (ANAES.), F.F.A. (S.A.)

subject commonly develops coronary artery disease and, if myocardial infarction occurs, the mortality associated with it is markedly increased. There is also a higher incidence of autonomic and peripheral neuropathy. Sudden cardiac arrest has been described in patients with autonomic neuropathy. It is possible that motor neuropathies, especially if associated with muscle wasting, may increase the risk of hyperkalaemia after the administration of succinylcholine. In addition, motor neuropathy may make the evaluation of neuromuscular blockade difficult. If a peripheral nerve stimulator is used, care must be taken to test uninvolved muscle. The anaesthetist must also be careful not to miss respiratory tract infections, to which the diabetic patient has a high sensitivity. The diabetic patient is very susceptible to nerve injuries during the intra-operative period, so that positioning on the operating table should be done very carefully if injury to exposed nerve trunks (ulnar, peroneal) and plexuses is to be avoided.

Planning

The following aspects must be considered when planning the anaesthetic approach in a diabetic patient.

Medical factors. Pre-operative assessment should be as for any anaesthetic, with emphasis on systems that are important to anaesthesia and known to be adversely effected by DM. This assessment includes performance of all the relevant special investigations, where time permits. A chest radiograph and ECG should be performed and urea and electrolyte levels determined, and a full blood count should be obtained. Optimal pre-operative control of all systems involved must be achieved and drug interactions and premedication must be considered.

Surgical factors. The anaesthetist may be called on to administer an anaesthetic under the following conditions: (i) as an emergency procedure; (ii) as an elective operation; and (iii) for a complication of DM.

Anaesthetic technique

A properly conducted regional technique results in the least metabolic disturbances. Monitoring is mandatory. Assessment of intra-operative blood sugar control has been greatly aided by the facility of immediate, reasonably accurate capillary blood glucose measurements, either using one of the many meters now available or the direct-reading Haemo-Glukotest (Boehringer Mannheim). Laboratory estimations of blood glucose concentrations can also be performed. The major hazard in the management of DM is the problem of hypoglycaemia, which can be rapid and fatal, and it is preferable if the blood sugar level is slightly above normal. However, some clinicians believe that short-term hyperglycaemia can result in troublesome side-effects.⁵ Acute exposure to hyperglycaemia (> 14 mmol/l) can result in: (i) disturbance of host defence mechanisms; (ii) extracellular fluid depletion and electrolyte imbalance; (iii) intracellular dehydration; and (iv) impaired surgical wound healing. Other authors feel that one should strive to avoid hyper- as well as hypoglycaemia. A normal blood glucose level of 4–8 mmol/l is highly desirable. The 'nil per os' patient should be covered with a dextrose infusion. Outpatients are sometimes instructed to take nothing by mouth, but often continue to take their oral hypoglycaemic agents. The symptoms of hypoglycaemia are due to glucose lack in the central nervous system. The onset may be rapid or slow, depending on the type of antidiabetic therapy. When the onset is rapid, cortical symptoms such as confusion, weakness, hunger and hypothermia may be present. Symptoms due to increased secretion of catecholamines such as sweating, palpitations, tachycardia, pallor and tremors, may also be found. When there is a slow onset of hypoglycaemia the patient may complain of headache, blurred vision, fine tremors and coldness. During

anaesthesia many or all of these signs will be masked. The blood glucose level must be monitored frequently. If a patient does not wake up after an anaesthetic the blood sugar level must be measured. Selection of an anaesthetic agent or agents does not appear to be a major factor in the safe outcome of a surgical procedure in a diabetic patient. No agent is categorically contraindicated in and none is specifically beneficial for diabetic patients. The choice of anaesthetic agent depends entirely on the experience and preferences of the anaesthetist. It is based on the type of surgery, the medical status of the patient, and the surgical risks involved.

Peri-operative management

Peri-operative management is based on an understanding of the normal endocrine pancreas as well as the alterations that are induced by the disease process. Optimal management should begin with detailed pre-operative assessment and preparation. This same degree of attention and expert care must then be carried into the peri- and postoperative periods. The prime objective should be the prevention of hypoglycaemia and, secondary to this, prevention of diabetic keto-acidosis. The success or failure of any treatment regimen may depend on monitoring of biochemistry, flexibility and awareness of the individual needs of each patient. Provision should be made for those patients controlled by diet and/or oral hypoglycaemic agents and those controlled by insulin. The uncontrolled patient with a very high blood sugar level or ketosis or who is in a coma must also be catered for. The anaesthetist may also have to cope with patients scheduled for minor surgery (the patient will eat on the day of the operation), major surgery (the patient will not be given food by mouth, possibly for several days) or emergency procedures.

A stabilized patient should have no ketosis or acidosis, normal urea and electrolyte levels, a blood sugar level of 5–10 mmol/l, and should be normovolaemic. The urine sugar level can be used as a guide to controlling the patient's condition if the following are kept in mind: (i) the renal sugar threshold must be known; (ii) the patient should be catheterized; (iii) the bladder must be emptied 1 hour before each sample is taken; (iv) urine monitoring is retrospective — the urine sugar level can reflect what went on in the blood up to 2 hours previously; and (v) surgery and anaesthesia may alter the urine flow and renal threshold. At one time it was popular to monitor glucose by checking urine samples. It is now recognized, however, that there are disadvantages with this technique. It is also important to remember that the measurement of urine glucose will *never* show hypoglycaemia. If in doubt, the blood sugar level must be measured. The diabetic patient should undergo his operation early in the morning if possible. Oral glucose must never be given to the patient since it is hypertonic, stimulates gastric juice secretion and delays gastric emptying. When an emergency procedure is necessary it is best to play for time — 3 hours can allow for reasonable control and stabilization. Patients who are scheduled for elective surgery should be given nothing orally for 6 hours before the operation.

There are various suggestions in the literature on how much insulin the diabetic patient should be given. Unfortunately, great controversy exists as to the methods of administration and amounts of insulin that should be given during the peri-operative period. Most regimens have disadvantages as well as advantages. The blood glucose sliding-scale system comprises 6-hourly subcutaneous injections of soluble insulin according to the blood glucose concentration. If the blood glucose level is < 8 mmol/l no insulin is given, if 8–10 mmol/l 5 U are given, if 10–12 mmol/l 10 U, if 12–15 mmol/l 15 U, and if > 15 mmol/l 20 U. If ketones are present an extra 5 U insulin is given. The use of a constant intravenous infusion of insulin and glucose was initially described in the treatment of diabetic

keto-acidosis, but more applications are found for this method in the management of the diabetic patient.⁶ This technique can safely be used in diabetics admitted for emergency operations. It entails the administration of a fixed amount of glucose per hour according to the basic fluid requirements of the patient.⁷ The average adult should get 100-150 g glucose per day (equivalent to 2-3 ml/kg/h 5% dextrose in water). Insulin is infused intravenously to maintain the blood glucose concentration at 10 mmol/l.

According to Nel *et al.*⁷ the constant intravenous infusion of insulin and glucose should be given as described below.

1. An intravenous solution of 10% dextrose in water is started at 18h00 on the evening before the operation. The aim is to maintain the blood glucose concentration at 10 mmol/l. Before starting the insulin infusion the blood glucose level must be determined. To prepare the infusion 20 U insulin is injected into a plastic bag containing 200 ml normal saline. Insulin is administered via a microdrip set (60 drops/min) according to the blood glucose concentration. If the blood glucose level is > 25 mmol/l give 3 U/h (30 drops/min), if 15-25 mmol/l 2 U/h (20 drops/min), if 10-15 mmol/l 1 U/h (10 drops/min), if 8-10 mmol/l 0,5 U/h (5 drops/min), and if < 8 mmol/l no insulin is given. The preparation of insulin and normal saline must be renewed 12-hourly.

2. It is necessary to repeat the blood glucose estimation at 22h00. The insulin infusion must then be adjusted to maintain the blood glucose level at 10 mmol/l. A repeat blood glucose determination is required on the morning before the operation and insulin should be given according to the guidelines above.

3. It is important not to stop the infusion of insulin and glucose during the operation; insulin is given according to the blood glucose level.

4. Postoperatively the aim is to keep the blood glucose level at 10 mmol/l. Insulin must be given according to the blood glucose level.

The non-insulin-dependent diabetic (stabilized on oral hypoglycaemic agents)

In the case of minor surgery, if the patient is receiving a long-acting sulphonylurea, change to a short-acting preparation 1 week pre-operatively. Biguanides should be stopped. On the day of the operation no tablets are given. The blood glucose level must be measured before and 4 hours after the operation. If the blood glucose level is < 7 mmol/l no extra treatment is indicated, if > 7 mmol/l a constant intravenous infusion of insulin should be given initially. Postoperatively a short-acting sulphonylurea should be given with the first meal. If control is unsatisfactory pre-operatively, the operation must be postponed.

In the patient who is to undergo major surgery, if control is unsatisfactory pre-operatively he should be started on insulin before the operation. In the stabilized patient a constant intravenous infusion of insulin can be used on the day of the operation and during the postoperative period.

The insulin-dependent diabetic

The chief principle of diabetic management through any crisis in which patients cannot eat or drink is to continue insulin administration. There are many different regimens for treating the diabetic pre-operatively. The patient's condition should be stabilized on a short-acting insulin 3 days before the operation. Insulin can also be given by a constant intravenous infusion (as described). A baseline blood glucose level must be obtained on the day of the operation. At Tygerberg Hospital some anaesthetists use the regimen involving the setting up of an intravenous 'cocktail' solution. No insulin is given on the

morning before the operation. The 'cocktail' solution consists of 1 litre of 10% dextrose in water with 20 U insulin added and 1 g potassium chloride and calcium, magnesium and vitamin supplements if needed. The composition of the 'cocktail' solution must be adjusted according to the blood glucose and serum potassium levels. If the blood glucose level is 5-10 mmol/l use the 'cocktail' solution as above, if < 5 mmol/l decrease the insulin content to 10 U, if > 10 mmol/l increase the insulin content to 30 U, and if > 20 mmol/l, increase the insulin content to 40 U. If the serum potassium level is < 4 mmol/l, the potassium chloride content must be increased to 2 g, if > 4 mmol/l it must be omitted. The intravenous 'cocktail' solution can be a sideline of the main infusion. The blood glucose level must be measured at 1-2-hourly intervals, depending on the type of surgery. The rate of infusion in the average adult should be \pm 100 ml/h. Until the question of insulin adsorption by containers has been resolved, we recommend a fresh 'cocktail' solution every 4 hours. This solution can also be used during the postoperative period. The blood glucose and potassium levels must be measured regularly. The 'cocktail' solution can be stopped as soon as oral intake is well established. Insulin administration can then be resumed as on the last pre-operative day. If the patient is taking steroids or suffering from an infectious process the insulin requirements should probably be raised by 20% — depending again on the blood glucose estimation. If no oral feeding is possible after 48 hours, intravenous hyperalimentation must be considered. The secret of success depends on flexibility, blood glucose and potassium estimations as often as required, control of infection, maintenance of a normal blood volume and correction of dehydration and acid-base abnormalities.

The pregnant patient

It is estimated that DM occurs in 1-2% of all pregnancies.⁸ Most of these patients have gestational diabetes — only 10% of pregnant patients are diabetic before pregnancy. The 20th century has been a remarkable era as regards advancement in the care of the diabetic woman who becomes pregnant. At the beginning of the century diabetic women suffered from infertility, and the rare woman who achieved pregnancy faced a dismal prognosis. Maternal death was a real threat, and the perinatal survival rate a mere 40%. The availability of insulin restored fertility and virtually abolished maternal mortality. All patients should be controlled by insulin administration. Epidural analgesia during labour may be important because there is less tendency for fluctuations in blood glucose levels due to pain during labour. The blood glucose levels must be kept at 3-7 mmol/l until the birth of the child. Reactive hypoglycaemia is prevented in the newborn. A constant intravenous infusion of insulin can be used during labour and the operative procedure.

In caring for the diabetic patient, it must be remembered that no single protocol can be expected to manage all patients. In addition, certain factors that are present in the pre-operative period (obesity, infections, pregnancy, exogenous glucocorticoids) can be expected to markedly increase insulin requirements. Removal of a stressful situation, such as by delivery, drainage of an intra-abdominal abscess, or removal of a gangrenous limb, will suddenly and markedly reduce insulin requirements. Constant monitoring of the blood glucose level is the key to optimum management.

Lactic acidosis

A diabetic patient may present with either type A or type B lactic acidosis. The causes of type A lactic acidosis are hypo-

tension and conditions causing poor tissue perfusion.⁹ The blood lactate level is usually > 5 mmol/l and the pH 7.25 or less. Type B1 lactic acidosis is caused by DM, renal failure, liver disease and leukaemia. The causes of type B2 lactic acidosis are usually drugs and toxins such as biguanides, parenteral nutrition agents (fructose, sorbitol, xylitol and ethanol), salicylates and methanol. A blood lactate level of 2 mmol/l is a common finding in patients taking biguanides, and is not important unless the liver metabolism and clearance of lactate is decreased or the blood biguanide levels are increased due to drug interactions or decreased hepatic and renal clearance. The mortality rate in type A lactic acidosis is 80%, in type B it is 50%. The results of treatment are very disappointing. The cause must be eliminated. Alkalinization must be undertaken, and a massive amount of bicarbonate (more than 2500 mmol) is sometimes necessary. A patient with sodium overload may require dialysis. Insulin and glucose may be necessary — especially if the blood glucose concentration is > 15 mmol/l. Dichloro-acetate is sometimes used. It is important to correct dehydration. A central venous pressure monitor will be of great help. The serum potassium concentration must also be monitored.

Keto-acidosis

Keto-acidosis usually results from lack of insulin. The clinical onset occurs over hours or days. Symptoms of uncontrolled DM such as drowsiness, dehydration, overbreathing, acetone on the breath, hypotension and gastric splash may be present. The diagnosis can be confirmed by special investigations such as measurement of the blood glucose level (may show extreme hyperglycaemia), acid-base (pH may range from normal to 6.9) and plasma ketone evaluations, blood counts (white cell count often raised) and measurement of serum electrolytes (serum potassium level usually raised, sodium concentration normal or reduced, urea and creatinine concentrations raised).

Treatment consists of the following:

1. A nasogastric tube must be passed.
2. Intravenous saline (0.9%) must be administered. The intravenous infusion must be changed to a dextrose-saline infusion once the blood glucose concentration has fallen to < 10 mmol/l.

3. Intravenous insulin administration by starting a constant infusion (as previously described).

4. Potassium and sodium bicarbonate administration as required. The potassium infusion must only be started once the serum potassium concentration is known. It should be withheld if oliguria or anuria are present, or if the serum potassium concentration remains > 5 mmol/l. If the serum potassium level is normal or < 4 mmol/l, 20 mmol potassium chloride should be added to each litre of saline. If the serum potassium value falls to < 3 mmol/l, 40 mmol of potassium chloride should be added to each litre of saline. An ECG monitor should be set up; there is, however, no substitute for serial potassium measurements. When the pH value is < 7.1 or if the patient is shocked, sodium bicarbonate should be given.

5. Underlying conditions such as respiratory or urinary tract infections must be treated.

Aketic hyperosmolar states

It is usually the elderly patient suffering from non-insulin-dependent DM who develops this condition. Patients usually have very high blood glucose levels, are dehydrated and sometimes are admitted in shock. Management is the same as for keto-acidosis, except that 0.45% saline is given (if the serum sodium concentration is > 150 mmol/l) and a lower rate of insulin infusion (3 U/h) is often sufficient. A central venous pressure monitor is especially important in older people.

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