Diabetes mellitus: anaesthetic management

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Summary
As the incidence of diabetes mellitus continues to increase in the United Kingdom, more diabetic patients will present for both elective and emergency surgery. Whilst the underlying pathophysiology of type 1 and type 2 diabetes differs, there is much good evidence that controlling the blood glucose to > 10 mmol.l\(^{-1}\) in the peri-operative period for both types of diabetic patients improves outcome. This should be achieved with a glucose–insulin–potassium regimen in all type 1 diabetics and in type 2 diabetics undergoing moderate or major surgical procedures. After surgery, a decrease in the catabolic hormone response resulting from good analgesia and the avoidance of nausea and vomiting should allow early re-establishment of normal glycaemic control.
The peri-operative management of patients with diabetes mellitus is important and will become increasingly so as more people both in the UK and worldwide are diagnosed with diabetes. The diagnosis of diabetes is made according to World Health Organization guidelines [1, 2] when random plasma glucose is >11.1 mmol.l\(^{-1}\) or when fasting plasma glucose is >7.0 mmol.l\(^{-1}\) on two separate occasions. Anaesthetists will be involved in the peri-operative care of more diabetics as these patients will inevitably present in increasing numbers for operative procedures.

Currently, 3% of the UK population are known to be diabetic (1.8 million people) and it is estimated that a further 1 million people have undiagnosed type 2 diabetes [3]. The incidence is predicted to increase as the UK population is ageing. Furthermore, the UK has the fastest increase in the rate of obesity in the developed world, and the risk of type 2 diabetes rises 10-fold in people with a body mass index (BMI) >30 kg.m\(^{-2}\)[3]. Diabetes shortens life expectancy by 20 years for type 1 and 10 years for type 2, with 80% of diabetics dying from cardiovascular disease [3]. It is apparent from these figures that diabetes will be an increasing part of the workload of healthcare professionals.

In early studies it was suggested that diabetic patients undergoing elective surgery were at greater risk of morbidity from myocardial ischaemia, wound infection, renal ischaemia and cerebrovascular infarction but this has not been confirmed in later studies. However, there are consistent data showing that diabetic patients have a 50% increase in early mortality following coronary artery bypass grafting (CABG) [4, 5]. Diabetic patients undergoing cardiac surgery have an increased morbidity that results from worse myocardial function, a higher incidence of sternal wound infection, an increased likelihood of postoperative renal failure, an increased likelihood of delayed stroke and a longer hospital stay [6].

Type 1 diabetes results from a failure of insulin secretion, whereas type 2 diabetes is due to an insulin resistance that is usually associated with defective insulin secretion. There are common misconceptions that type 2 diabetes is a ‘mild’ form of diabetes, that it is easy to treat and that tight metabolic control is unnecessary. The two types of diabetes present difficult metabolic challenges and both types of diabetic patient are subject to the adverse effects of hyperglycaemia. The complete absence of insulin secretion in type 1 diabetes results in lipolysis, proteolysis and ketogenesis, but gross catabolism is rare in type 2 diabetes as such metabolic changes are inhibited by minimal levels of insulin secretion. However, these problems can occur in type 2 diabetes in the presence of other physiological stresses such as sepsis and dehydration [7]. Untreated diabetes results in dehydration (due to the osmotic diuretic effect of glycosuria), acidaemia (due to the accumulation of ketones and lactate), weight loss, fatigue and muscle wasting.

In general, type 1 diabetics always require exogenous insulin whereas although type 2 diabetics may require insulin, often good glycaemic control can be achieved by a combination of diet and/or oral hypoglycaemic drugs. Oral hypoglycaemic drugs can be divided into three main groups:

- **sulphonylureas** such as glibenclamide and gliclazide, which act on the pancreas to increase \(\beta\)-cell sensitivity and so augment insulin secretion;
- **biguanides** such as metformin, which act on the liver to decrease glucose output and on extrapancreatic sites to increase glucose utilisation;
- **thiazolidinediones** such as pioglitazone and rosiglitazone, which act on extrapancreatic sites to increase insulin sensitivity and on the liver to inhibit gluconeogenesis.
Long-term intensive control of blood glucose has been shown to decrease microvascular complications (such as proliferative retinopathy and diabetic nephropathy) in type 1 [8] and type 2 [9] diabetes. Unfortunately, intensive glucose control has not been shown to reduce macrovascular disease (such as atherosclerotic disease), diabetes-related mortality or all-cause mortality.

Aims of peri-operative management

Surgery, critical illness and trauma are all associated with an increase in the secretion of catabolic hormones in the presence of a relative insulin deficiency. Even non-diabetic patients will become hyperglycaemic peri-operatively due to a combination of decreased insulin secretion and tissue insulin resistance. In patients with diabetes, the aims of peri-operative metabolic management should be to:

- avoid hypoglycaemia;
- avoid excessive hyperglycaemia;
- avoid loss of electrolytes (potassium, magnesium and phosphate);
- prevent lipolysis and proteolysis.

A high blood glucose concentration (12–14 mmol.l⁻¹) is associated with major complications that include impaired healing of both wounds and surgical anastomoses, an increased risk of infection, exacerbation of ischaemic damage to the brain and myocardium as well as dehydration and electrolyte loss. It is for such reasons that a blood glucose ≤ 10 mmol.l⁻¹ is aimed for peri-operatively. However, there is no evidence that lowering the blood glucose further is associated with increased benefits in patients with diabetes undergoing routine surgery. Indeed, there is very little evidence to guide the peri-operative management of type 1 diabetes and much has been extrapolated from data collected in type 2 diabetic populations.

Recommendations for ‘tight’ peri-operative glycaemic control have been extrapolated from a seminal study of 1548 intensive care unit (ICU) patients, mostly postcardiac surgery [10]. In this study, the patients were randomly allocated to receive tight glycaemic control (blood glucose maintained in the range 4.4–6.1 mmol.l⁻¹) or normal glycaemic control (blood glucose ≤12 mmol.l⁻¹) using insulin therapy. Tight glycaemic control in these patients was associated with a decrease in mortality from 8.0% to 4.6%, with the main effect on mortality seen in patients who remained in ICU for > 5 days. In particular, intensive insulin therapy in this study was associated with a decrease in the incidence of death from multi-organ failure and with decreases in the incidence of bloodstream infections, acute renal failure and polyneuropathy. It is tempting to extrapolate the conclusions of this large study to routine surgical practice but the generalisability of the data has not yet been established.

The following factors influence blood glucose values in the peri-operative period:

- the diabetes itself;
- starvation (both pre-operative and postoperative);
- hormonal and metabolic response to surgery;
- anaesthetic drugs;
- immobilisation.
Pre-operative management of diabetes patients

Diabetic patients present a challenge to the anaesthetist and so the pre-operative anaesthetic evaluation should pay particular attention to:

- diabetes – type of disease, method of home monitoring and usual metabolic control;
- drugs – antidiabetic medication, medication for associated diseases;
- cardiovascular disease – including an assessment of exercise tolerance;
- renal disease;
- neuropathy – peripheral and autonomic, in particular gastric paresis;
- musculoskeletal – diabetics with stiff joint syndrome (due to glycosylation) often have limited mobility of the upper cervical spine and are more likely to have a poor view on direct laryngoscopy and they may therefore present difficulties with tracheal intubation.

In practice, the essential pre-operative investigations in these patients are:

- blood glucose – fasting and if possible postprandial;
- urinalysis for ketones and albumin;
- blood urea, creatinine and electrolytes;
- haemoglobin;
- ECG.

Intra-operative management of diabetes patients

During the peri-operative period, diabetics usually have increased insulin requirements. Throughout the period of peri-operative starvation it is essential to administer parenterally a carbohydrate source such as an intravenous glucose solution and to avoid excessive catabolism and inadvertent hypoglycaemia. Concurrently running separate infusions of insulin and glucose, or an infusion of glucose mixed with insulin (with or without added potassium) can provide a safe and stable method of glycaemic control in these patients provided adequate blood glucose monitoring is carried out. Combined glucose-insulin-potassium solutions (the GIK system, or ‘Alberti regimen’) have the advantage of inherent safety, as such methods provide both insulin and glucose in the same solution. Fifty per cent glucose solutions with insulin 0.25 or 0.5 units.ml⁻¹ can deliver amounts of insulin and glucose equivalent to more conventional regimens and avoid the administration of large volumes of free water. The disadvantage of such infusions is that the hypertonic 50% glucose solution needs to be given into a central vein, which is not always practical or appropriate.

Separate infusions of glucose and insulin may provide better glycaemic control and have been found to be more acceptable to nursing staff. Medical and nursing staff need to be vigilant when using separate infusions as one may be stopped inadvertently whilst the other continued, with potentially disastrous consequences.

The metabolic management of diabetics is determined by the type of diabetes. In type 1 diabetics a GIK regimen should be used in the peri-operative period to maintain good glycaemic control and to avoid acidosis. In type 2 diabetics, glycaemic control can be achieved for minor surgical procedures by simply omitting oral hypoglycaemic agents. However, in type 2 diabetics undergoing moderate or major surgery
a GIK regimen should be used. Patients who require GIK regimens should have these infusions started before surgery on the ward, ideally the night before surgery.

In all diabetic patients frequent blood glucose estimations are essential (minimum 2-h interval) and appropriate action should be taken to maintain blood glucose at <10 mmol.l\(^{-1}\). In addition, plasma potassium should be measured at least every 4 h, and more frequently in the presence of cardiovascular instability or high insulin requirements. Plasma potassium levels should be maintained in the range 4.0–4.5 mmol.l\(^{-1}\) to decrease the incidence of cardiac arrhythmias due to hypokalaemia. There are arguments in favour of peri-operative arterial blood gas, urinary ketone (acetoacetate) and blood hydroxybutyrate analysis to help achieve optimal metabolic control in diabetic patients. However, this is not practical in most circumstances.

There is no evidence that anaesthetic technique affects mortality and morbidity in diabetic patients. Regional anaesthesia has the advantages that the patient is awake, the surgical stress response is obtunded, tracheal intubation is avoided and such techniques are associated with decreased blood loss and a decreased risk of thrombo-embolism. However, the disadvantages of neuraxial blockade in patients with diabetes are an increase in cardiovascular instability, an increased risk of infection and the possible exacerbation of a peripheral neuropathy. Peripheral nerve blockade avoids some of these complications.

There is much debate about the optimal intravenous fluid for patients with diabetes. Lactate-containing solutions, such as Hartmann’s solution, may be used safely in diabetes patients. Postoperative hyponatraemia is common if only glucose solutions are administered. Glucose and lactate are present in red cell concentrates and these metabolites may influence glycaemic control when patients with diabetes require blood transfusion.

**Postoperative management of diabetes patients**

After surgery in diabetics, intravenous insulin (if used) should be continued for at least 2 h after the first meal. Nausea and vomiting should be prevented if possible and should be treated vigorously to re-establish normal dietary intake as soon as possible after surgery. Good analgesia is important, as adequate pain relief decreases catabolic hormone secretion. Non-steroidal anti-inflammatory drugs can be used for analgesia but they should be used with caution as many diabetics have pre-existing renal dysfunction.

**Special situations**

It is not practical to admit diabetic patients several days before surgery to stabilise their antihyperglycaemic medication. Even for major procedures, admission on the day of surgery is common and, fortunately, seems safe. More operations are now done on a day-case basis and there is no evidence to support blanket exclusion of diabetic patients from day surgery. Diabetics attending day surgical centres for minor procedures should have oral intake and absorption re-established before discharge, normal medication resumed as soon as possible and adequate glycaemic monitoring available on discharge.
In summary, due to the rising prevalence of diabetes, the provision of safe anaesthesia for these patients will become increasingly important. Type 1 diabetes always requires the administration of insulin and type 2 patients undergoing moderate or major surgery will require conversion to an insulin regimen during the peri-operative period. Good glycaemic control is associated with a decreased risk of infection and therefore blood glucose is usually maintained at <10 mmol.l⁻¹. However, the ideal range of blood glucose in the peri-operative period has only been established in cardiac surgical patients. Continuous insulin infusions have been shown to provide better glycaemic control than intermittent regimens and combined glucose-insulin-potassium regimens have the advantage of inherent safety. Blood glucose must be monitored frequently and controlled carefully, and this is the key to successful peri-operative management.

References