

# Diabetes Mellitus and Anaesthesia

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ABSTRACT

Diabetes mellitus is a non-communicable disease that affects all age groups. A patient with diabetes scheduled for surgery requires special care as diabetes has effects on anaesthesia and surgery; anaesthetic agents and techniques also has effects on diabetes. Close monitoring of the blood glucose is done pre, intra and postoperatively. This is a review article on anaesthesia and diabetes mellitus.

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## INTRODUCTION

In recent times, non-communicable diseases such as diabetes mellitus, cardiovascular diseases, ischemic heart diseases, hypertension, stroke, cancer, chronic kidney and respiratory diseases are leading causes of mortality worldwide (Okafor & Ofoegbu, 2011). Diabetes mellitus is the most common endocrine disorder globally (Falase, 2009). It is a metabolic disorder characterised by chronic hyperglycaemia resulting from defects in insulin secretion, insulin action or a combination of both with disturbances in the metabolism of carbohydrate, fat, and protein (Puppets et al, 2003; Chadwick & Wilkinson, 2004; Bartholomeusz, 2006; Morgan et al, 2006; Yentis et al, 2009; Falase, 2009; Kasiam et al, 2009; Black & McEwen, 2010; Tobi, 2011). This result in lipolysis, gluconeogenesis, and glycogenolysis with hepatic conversion of fatty acids to ketones bodies and hyperglycaemia (Gordon, 1994; Yentis et al., 2009). The resultant glycosuria causes an osmotic diuresis, with polyuria, polydipsia, and excessive sodium and potassium ion loss (Yentis et al., 2009). Deficiency of insulin

action is due to inadequate insulin production or peripheral resistance to insulin (Falase, 2009). Diabetes mellitus is a disease that affects several organs in the body with complications occurring in the affected organs (Tobi, 2011). It is a chronic disease with one of the highest social and healthcare costs, it is associated with a three to four-fold increment in cardiovascular morbidity and mortality (Simo & Hermaindez, 2002) and it is one of the most common medical conditions that complicate pregnancy (Braveman, 2006). The diagnosis is based on an elevated fasting plasma glucose (>140 mg/dl) or blood glucose (126mg/dl) (Morgan et al., 2006).

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Diabetes is classified as type 1 and 2 diabetes (WHO, 2019). In type 1 diabetes mellitus insulin is deficient, hyperosmolar ketoacidosis will progress to hypokalaemia, dehydration, coma and even death if it is not treated (Mason, 2001). Insulin enhances glucose

uptake, glycogen storage, protein synthesis, amino acid transport, and fat formation. Basal insulin secretion is essential even in the fasting state to maintain glucose homeostasis (Slover & Slover, 2009).

Diabetes mellitus affects patients of all ages and due to its increased prevalence, all physicians will be confronted with patients with diabetes requiring anaesthesia and surgery (Giquel et al., 2017; Vaughan & Robinson, 2010). Patients with diabetes have a significant risk of mortality and an increased risk of microvascular and cardiovascular complications and often appear ill than most patients with diabetes and therefore place a larger burden on anaesthetic services (Giquel et al., 2017). People with diabetes have a two to four fold increase in the risk of dying from the complications of cardiovascular disease (Kolawole et al., 2004).

Gestational diabetes may be defined as carbohydrate intolerance of variable severity with onset and diabetes may present for the first time in pregnancy. Some of these women may have had undiagnosed diabetes for some time and are at a high risk of foetal and maternal complications as gestational diabetes gives rise to both maternal and foetal complications (Ilyburn, 2008). Poorly controlled diabetes increases the risk of perioperative infection (Dodds et al., 2007). Maternal complications of diabetes mellitus include pregnancy induced hypertension, pre-eclampsia, polyhydramnios, increased risk of gestational diabetes in subsequent pregnancy and increased risk of Type II diabetes later in life while the foetal complications macrosomia, shoulder dystocia, hypoglycaemia, hypocalcaemia, polycythaemia and hyperbilirunaemia (Ezike, 2009).

The goals of treatment of diabetes are to prevent or delay complications, maintain good glycaemic control, decrease mortality and mortality; avoid hyperglycaemia, ketoacidosis, and hypoglycaemia, and maintain a good quality of life (Simo & Hermaindez, 2002). Good control of glycaemia makes it possible to reduce the incidence of microvascular complications such as retinopathy, nephropathy and neuropathy (Simo & Hermaindez, 2002).

Patients with diabetes undergoing surgery belong to the high-risk group of patients. Surgical procedures lead to increased stress and high counter regulatory hormonal activity

with decrease in insulin secretion (Slover & Slover, 2009). Surgery evokes the 'stress response' that is the secretion of catecholamine, cortisol, growth hormone and in some cases glucagon (McAnulty et al., 2000; Dodds et al, 2007). The consequences of the stress response are impaired breakdown of carbohydrate, lipid, and protein, reduced peripheral utilization of glucose. The 'stress response' to surgery is associated with hyperglycaemia because of increase secretion of catabolic hormones as these hormones oppose glucose homeostasis since they are anti-insulin and have hyperglycaemic effects (McAnulty et al., 2000). Therefore in patients with diabetes without adequate insulin replacement, the combination of insulin deficiency and excessive counter regulatory hormones results in severe hyperglycaemia and diabetic ketoacidosis which are associated with hyperosmolarity and increase in protein catabolism, fluid loss, lipolysis and protein breakdown (Slover & Slover, 2009; McAnulty et al., 2000). Glyconeogenesis is stimulated and peripheral glucose uptake decrease (McAnulty et al, 2000). In such patients scheduled for elective surgery, surgery should be postponed to allow time for assessment of the diabetes and possibly resuscitation (Elegbe, 2007). Some patients with diabetes may present for surgery because of complications that arise from diabetes or other illnesses. It may be because of ophthalmic or vascular disease or for drainage of an abscess. The metabolic changes produced by surgery will worsen the state of the diabetes. Surgery and stress aggravate diabetes and may be accompanied by some degree of insulin resistance (Mason, 2001). Anaesthetic consideration of diabetes mellitus is the most common endocrine disorder in patients presenting for surgery (Werret, 2017) therefore they are frequently encountered by the anaesthetists (Giquel et al, 2017).

#### **Anaesthetic Considerations**

The aim of the anaesthetic management of the patients with diabetes is to ensure adequate glucose delivery to the tissue while avoiding hypoglycaemia and hyperglycaemia occurring intraoperatively (Ezike, 2008).

**Age of Patient:** Worst outcomes occur in the extreme of ages. About 75% of patients with diabetes scheduled for surgery are over the age of 50 years (Ezike, 2008). Children with

diabetes presenting for surgery need careful preparations though this may not always be possible if the surgery is urgent (Black & McEwen, 2010).

#### **Clinical State of the Patient and Glycaemic Control:**

There is high perioperative morbidity and mortality in with diabetes than patients without diabetes (Mason, 2001). The golden rule is that no elective surgical procedure should be performed on any patient with uncontrolled diabetes (Mason, 2001; Elegbe, 2007). The surgery should be postponed to correct acidosis, any other metabolic derangement and achieve good glycaemic control (Elegbe, 2007) as better glycaemic control has been shown to improve perioperative mortality and morbidity (McAnulty et al., 2000).

**Complications from diabetes:** The presence of complications from diabetes may worsen the state and outcome of the patient. The major risk factors affecting patients with diabetes undergoing surgery include cardiovascular dysfunction, renal insufficiency, joint collagen tissue abnormalities (example cervical joint stiffness) and neuropathies (cardiovascular and gastrointestinal tract effects) all of which may affect anaesthesia therefore a major focus for the anaesthetist should be the preoperative evaluation (Giquel, 2007). The cardiovascular, renal, and peripheral nervous manifestations of diabetes cause the greatest concern to anaesthesia (Ezike, 2008). Diabetes affects the heart, the blood vessels, and kidneys, therefore these systems should be investigated especially in long-standing diabetes (Bartholomeusz, 2006). Diabetic autonomic neuropathy when present may limit the ability of the heart to compensate for intravascular volume changes predisposing the patient to cardiovascular instability (Morgan et al, 2006). The major concerns associated with autonomic neuropathy include a greater propensity to develop hypotension during both regional and general anaesthesia and an increased risk of aspiration due to gastroparesis. Gastroparesis is characterized by a delay in gastric emptying without any gastric outlet obstruction. Increased gastric contents increase the risk of aspiration and likelihood of regurgitation (Chadwick & Wilkinson, 2004). Nephropathy causes hypertension and electrolyte

disturbances particularly of potassium and creatinine, these disturbances are a reflection of renal function and give some indication of the adequacy of fluid and electrolyte homeostasis and drug excretion (Werret, 2017). The end organ disease associated with diabetes is cardiovascular disease, autonomic neuropathy, joint collagen tissue disorders, and immune deficiency (Kakoil, 2010). Long standing diabetes mellitus increases the risk of cardiovascular disease complications possibly including silent myocardial ischemia (Dodds et al., 2007).

**Elective or Emergency Surgery:** In emergency surgery, the urgent need to save life becomes the only support for these procedures (Ezike, 2008). Adequate resuscitation should be performed with treatment of ketoacidosis if present (Dodds et al., 2007). Surgery should be delayed in patients with poorly controlled blood glucose unless it is an emergency and lifesaving.

#### **Preoperative Assessment**

Patients should be fully assessed for fitness for surgery, anaesthesia, blood glucose control and scheduled for surgery early in the day (Yentis et al., 2009). The aim is to avoid hyperglycaemia, ketoacidosis, hypoglycaemia and electrolyte imbalance (Yentis et al., 2009) therefore a good multisystemic evaluation is important (Ilyburn, 2008). This includes history taking, clinical examination, and investigations. A comprehensive preoperative assessment, intensive intraoperative and postoperative management by a multidisciplinary team is ideal. The patient should be assessed by a diabetologist if available. In developing countries where this may not be possible, the patient should be assessed by a physician with interest in diabetes. Surgery produces a stress response that can be modified by anaesthetic agents (Giquel et al, 2017). Patients with end stage renal disease or any patient on dialysis should be dialysed within the 24 hours before elective surgery. Patients with diabetes are a challenge to the anaesthetist, therefore there is need for careful monitoring and an understanding of the relevant pathophysiological features (Famewo, 2004).

**History:** History should be detailed and comprehensive. This should include type, and duration of diabetes mellitus; level of care, patients' therapy, and level of control, present

and previous complications, drug and dosage adjustments, presence of comorbidities, history of previous exposure to anaesthesia and adverse reactions to anaesthesia. In the parturient, signs, symptoms and history of hypertension and pre-eclampsia, sepsis, renal dysfunction should be taken (Pani et al., 2010).

### **Clinical Examinations**

A thorough physical assessment of the patient with diabetes scheduled for surgery should be done. A general clinical examination checking for weight loss, pallor, dehydration, cyanosis, and jaundice is done. Pulse rate, blood pressure to eliminate hypertension, which may coexist with diabetes. The body mass index (BMI) is calculated from the weight and height. Patients with diabetes should routinely be evaluated preoperatively for adequate temporomandibular joint and cervical spine mobility to help anticipate difficult endotracheal intubation, which occurs in approximately 30% of persons with Type I diabetes (Morgan et al, 2006). The diabetic stiff joint syndrome is common in prolonged Type I diabetes. It is limited to the atlanto-occipital joint movement, may predispose to difficult endotracheal intubation looking out for the prayer sign as one screens for difficult endotracheal intubation (Ilyburn, 2008). Though the remainder of the airway examination may be normal, patients with diabetes may have decreased mobility in the atlanto-occipital joint, which can complicate oral endotracheal intubation (Slover & Slover, 2009). Stiff joint syndrome is suggested by the inability to approximate the palmar aspect of the fingers also known as the prayer sign. The patient cannot touch the palmar aspects of the fingers together when the palms are together (Slover & Slover, 2009).

### **Investigations**

Haemoglobin estimation

**Urinalysis:** Presence of protein and albumin indicates nephropathy.

**Serum Electrolytes and Creatinine:** Hypokalaemia results in the presence of uncontrolled hyperglycaemia, which results in osmotic diuresis and loss of potassium ion in urine. There is risk of arrhythmia with hypokalaemia. Glycosylated haemoglobin reflects the blood glucose control.

**Electrocardiogram:** This can reveal any silent myocardial infarction.

### **Choice of Anaesthesia**

The patients' clinical state and levels of risks usually dictate the choice of anaesthetic technique (Ezike, 2008) following the pre-anaesthetic assessment and evaluation (Bartholomeusz, 2006; Elegbe, 2007). A regional anaesthetic technique if suitable is the anaesthetic technique of choice as it has the advantages in obtunding the stress response to endotracheal intubation, decreased blood loss, the patient remaining conscious, decreased thromboembolic complications and decrease surgical stress response (Bartholomeusz, 2006; Giquel et al., 2017). Premedication is administered the night before surgery and morning of surgery as anxiety may increase blood glucose levels.

When general anaesthesia is the anaesthetic technique of choice, rapid sequence endotracheal induction is necessary because of gastric stasis. General anaesthesia can be problematic because of gastroparesis, limited atlanto-occipital joint extension, haemodynamic response to endotracheal intubation and impaired counter regulatory hormone responses to hypoglycaemia during sleep (Pani, 2010).

### **Anaesthetic Management**

The key to the anaesthetic management of patients with diabetes depends largely on the preoperative preparation (Vaughan & Robinson, 2010), if the blood glucose is controlled or uncontrolled, if it is surgery is major or minor, and if it is elective or emergency surgery (Bartholomeusz, 2007). Hypotension and myocardial depression is avoided in the course of anaesthesia. The patient is placed first on the operation list. This is to prevent and avoid hyperglycaemia, ketoacidosis, and hypoglycaemia. Long acting insulin is discontinued. Intravenous insulin infusion and potassium may be necessary as the case may be. Surgery should be carried out when there is biochemical improvement. Some surgical conditions need to be treated immediately before good glycaemic control can be achieved such as amputation of a gangrenous diabetic foot. A good anaesthetic management of patients with diabetes is achieving a good glycaemic control before surgery. This is to avoid hypoglycaemia, hyperglycaemia, minimise electrolyte dysfunction and prevent lipolysis and proteolysis. Profound hypotension may occur

with deleterious consequences in a patient with coexisting coronary artery, cardiovascular or renovascular disease (McAnulty et al, 2000). Diabetes is at increased risk of perioperative complications (Famewo, 2004). There is an interaction between the surgical insult and the diabetes that needs to be properly managed to maintain stability and avoid further complications of both the diabetes and the surgery (Werret, 2017).

### **Pre-operative Preparation**

Adequate control of the blood glucose must be established preoperatively and maintained until oral feeding is resumed post-operatively. The risks of infection and vascular damage may be increased with the use of regional techniques in patients with diabetes; epidural abscesses occur more commonly following spinal and epidural anaesthesia or diabetic peripheral neuropathy presenting after epidural anaesthesia may be confused with an anaesthetic complication of regional blockade (McAnulty, 2000). Any pre-existing nerve damage should be recorded before any block (Elegbe et al., 2007). Preoperative fasting is done as in other patients (Slover & Slover, 2009). Glucose, potassium insulin infusion is set up on the morning of surgery; it is administered in an intravenous access dedicated for that purpose.

### **Intraoperative Management**

The blood glucose is monitored closely (Dodds et al., 2007). The goal of the anaesthetic management therefore is to ensure normal intraoperative blood glucose levels, adequate hydration of patients and stable cardiovascular status. The main concern for the anaesthetist in the perioperative management of the patient with diabetes is the avoidance of hypoglycaemia since its clinical signs may be undetectable in the anaesthetized patient especially general anaesthesia is administered (Mason, 2001; McAnulty et al, 2000; Giquel et al, 2017).

The immediate perioperative problems facing the patient with diabetes are surgical induction of the stress response with catabolic hormone secretion, interruption of food intake which may be prolonged following gastrointestinal tract procedures, circulatory disturbances associated with anaesthesia and surgery may alter the absorption of subcutaneous insulin (McAnulty et al., 2000). Strict aseptic technique should be followed

during administration of central neuraxial blockade, as these patients are prone to infections (Ilyburn et al., 2008). Careful monitoring of the blood glucose concentrations regardless of the anaesthetic technique used during the perioperative period (Jacobson, 2009) and half-hourly blood glucose monitoring for patients undergoing general anaesthesia is recommended (Vaughan & Robinson, 2009). Strict glycaemic control is beneficial and therefore should be achieved for patients with diabetes in the perioperative period (Jacobson, 2009).

### **Postoperative Management**

Postoperative respiratory arrest is common in patients with diabetes (McAnulty, 2000). After surgery, the insulin requirements decrease as the stress response subsides (Gordon, 2004). Close monitoring of the blood glucose must continue postoperatively. One reason for this is the individual variation in onset and duration of action of insulin preparations and the progression of stress hyperglycaemia in the recovery period (Morgan et al, 2006).

### **Prognosis**

Prognosis is good in patients with good glycaemic control. Morbidity and mortality is high in emergency procedures with hyperglycaemia or hypoglycaemia because there is not enough time available for preparation and resuscitation. Prognosis is poor in patients with autonomic neuropathy. Prolonged diabetes mellitus increases morbidity and mortality.

### **CONCLUSION**

The surgical patient with diabetes is managed by a multidisciplinary team made up of the diabetologist, anaesthetist, surgeon, physiotherapist, laboratory scientist and dietician. The preoperative assessment is geared towards good glycaemic control, metabolic control, and electrolyte balance. The aim of the anaesthetic management of the surgical patient with diabetes is to have a good glycaemic control before, during and after surgery; and also to avoid hypoglycaemia that may cause serious insult to the brain.

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### Conflict of interest

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