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REVIEW

Diabetes: a major risk factor in trauma and orthopaedic surgery

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Abstract

Diabetes mellitus is a growing epidemic and places a great burden on healthcare services in the UK. Trauma and orthopaedic surgeons find themselves dealing with patients with diabetes on an increasingly regular basis. Any level of surgical trauma can lead to a physiological stress response involving the hypothalamic–pituitary–adrenal axis. The resultant hormone releases can have negative effects on glucose homeostasis. General risks of operating on patients with diabetes include endothelial dysfunction, postoperative sepsis, impaired wound healing and cerebral ischaemia. Polytrauma patients with diabetes have a significantly greater risk of mortality than patients who do not have diabetes. Non-union of fractures is more common in patients with diabetes, as are deep-seated postoperative infections. National guidelines from the Joint British Diabetes Societies for Inpatient Care advise how to manage patients with diabetes in the perioperative period. Trauma and orthopaedic surgeons must be aware of these increased risks of operating and ensure that patients are involved in surgical decision making.

Key words: Diabetes; Fracture; Guidelines; Orthopaedics; Surgery; Trauma

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Introduction

Diabetes mellitus is a growing epidemic, with over 3.9 million people in the UK known to have the condition (Diabetes UK, 2019); up from 3.3 million just 5 years previously (Diabetes UK, 2014). The financial implications of this are vast, with the UK spending over £13 billion per year on diabetes care alone (Kanavos et al, 2012). With this increasing prevalence, orthopaedic surgeons are seeing patients with diabetes on a more frequent basis. Poor management of the condition can pose a risk to the intended outcome of surgery and to the patient's overall health.

This article reviews diabetes mellitus as a major risk factor for both trauma and elective orthopaedic surgery, and highlights strategies and guidelines to manage these patients in the perioperative period.

General risks

All operations carry risks in addition to their intended benefits, but the risks of operating on a patient with diabetes mellitus are elevated, sometimes to the point where those risks may outweigh the benefits of the proposed procedure. Insulin is involved in blood glucose regulation and a lack of insulin secretion or resistance to insulin results in impairment of this regulation. Add to this a period of starvation and absence of a patient's regular anti-hyperglycaemic medication, and this results in a large insult to the patient's already poor blood glucose regulation.

Surgery itself leads to a stress response stemming from activation of the hypothalamic–pituitary–adrenal axis and the sympathetic nervous system (Desborough, 2000). Hypothalamic secretion of growth hormone-releasing hormone and corticotropin-releasing hormone triggered by surgery results in increased secretion of growth hormone and adrenocorticotropic hormone from the anterior pituitary (Finnerty et al, 2013). Although the main action of growth hormone is on growth regulation during childhood, it has many effects on metabolism. It promotes protein anabolism, fat catabolism, inhibits glucose absorption by cells and stimulates glycogenolysis in the liver, leading to increased blood sugar levels (Desborough, 2000). Adrenocorticotropic hormone acts upon the adrenal

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cortex, stimulating the secretion of cortisol. Cortisol levels are easily measured and increase rapidly in response to surgery, with peak values seen 4–6 hours after surgery, which may be sustained for up to 72 hours. Concentrations of >1500 nmol/litre may be seen following major surgery (Nicholson et al, 1998). Cortisol promotes protein and fat catabolism, gluconeogenesis and reduced glucose absorption by cells, resulting in elevated blood sugar concentrations. Activation of the sympathetic nervous system by the hypothalamus causes increased release of catecholamines from the adrenal medulla. The resulting elevated levels of circulating catecholamines and direct sympathetic nervous system activity can lead to inhibition of pancreatic β-cell activity and stimulation of pancreatic α-cell activity. The combination of reduced insulin secretion from β-cells and increased glucagon secretions from α-cells further raises blood sugar concentrations (Desborough, 2000).

The transient period of hyperglycaemia brought about by this stress response, combined with the already impaired glucose regulation and period of starvation, is responsible for a number of general perioperative risks. These include endothelial dysfunction, postoperative sepsis, impaired wound healing and cerebral ischaemia (Dagogo-Jack and Alberti, 2002). In severe cases, patients may develop diabetic ketoacidosis or hyperosmolar hyperglycaemic state. Hyperosmolar hyperglycaemic state is associated with a significant risk to life, with a mortality of 15–20% (Scott et al, 2015), although this may be up to 42% following some surgical procedures (Dagogo-Jack and Alberti, 2002).

Postoperative nausea and vomiting is a common side effect of surgery, affecting 30% of all patients (Pierre and Whelan, 2013). The combination of a reduced circulating volume as a result of vomiting with the increased osmotic diuresis caused by hyperglycaemia may increase the risk of ischaemic events and acute renal failure. The electrolyte disturbances associated with this effect on plasma volume may also precipitate cardiac arrythmias (Dagogo-Jack and Alberti, 2002).

Trauma surgery

The term ‘trauma surgery’ covers the surgical management of a wide spectrum of orthopaedic injuries, from minor cases such as wound closure under local anaesthetic to major, multiple-specialty procedures on polytrauma patients following life- and limb-threatening injuries. Any level of trauma itself leads to a physiological stress response as described above, with greater stress response to greater levels of trauma. For this reason, diabetic trauma patients are at increased risk of developing complications even before surgery occurs. A UK study of data from the Trauma Audit and Research Network found that there was significantly higher mortality among polytrauma patients with diabetes mellitus vs those with no comorbidities (32.4% vs 12.9%, $P<0.05$) (Tebby et al, 2014).

Bony trauma often requires surgical fixation, which may present with specific risks in the general population, but these risks are often elevated in patients with diabetes. Healing of fractures in patients with diabetes is prolonged by 87% (Jiao et al, 2015). In pilon ankle fractures, the rate of delayed or non-union in the general population is 16%, but in patients with diabetes this rises to 43% ($P=0.02$) (Kline et al, 2009). It is believed that diabetes mellitus reduces osteoblast differentiation, increases osteoclast activity and alters the apoptosis of chondrocytes and osteoblasts, resulting in delayed fracture healing (Jiao et al, 2015). Postoperative infections are also more common in trauma patients who have diabetes. The same study of complications in pilon ankle fractures found an infection rate of 71% for patients with diabetes, compared to 19% for patients who do not have diabetes. When comparing deep-seated infections, this study showed a 43% risk in patients with diabetes compared to just 9% in the control group ($P<0.001$) (Kline et al, 2009).

A large proportion of trauma patients require a period of immobilisation of their injured limb following surgery, whether this is to allow for bone healing or to rest the soft tissues, but one of the most serious risks associated with this is venous thromboembolism. The incidence of patients with lower limb immobilisation developing venous thromboembolism is 11% (Smith and Wood, 2012), but the risk of venous thromboembolism in patients with diabetes has been shown to be 2-fold more than that of patients who do not have diabetes (Petrauskiene et al, 2005). Therefore venous thromboembolism is a significant risk to patients with diabetes who require lower limb immobilisation.

Elective orthopaedic surgery

One of the mainstays of elective orthopaedic surgery is arthroplasty surgery, with Learmonth famously calling the total hip replacement 'the operation of the century' (Learmonth et al, 2007). Despite its clear benefits to patients with severe joint pain and loss of function, arthroplasty surgery does have its risks including, but not limited to, dislocation, venous thromboembolism, wound problems, bleeding, nerve injury, loosening, peri-prosthetic fracture and prosthetic joint infection. A study of 7181 primary hip and knee replacements found that the risk of prosthetic joint infection in patients with diabetes was more than double that of patients who do not have diabetes (Jämsen et al, 2012). Another large study of over 13 000 patients with primary total joint arthroplasty showed that preoperative hyperglycaemia was associated with an increased incidence of prosthetic joint infection (hazard ratio 1.4, $P<0.01$). The same study also demonstrated an increased risk of mortality in patients with a perioperative glycated haemoglobin (HbA_{1c}) ≥7% (hazard ratio 1.3, $P=0.01$) (Chrastil et al, 2015).

As is well documented, patients with diabetes are at high risk of developing foot and ankle pathology. Ankle and hindfoot fusions are commonly performed in patients with diabetes for various reasons (arthritis, deformities such as Charcot foot, post-traumatic). A retrospective comparative study showed that the postoperative infection rate in patients with diabetes having ankle and hindfoot fusion surgery is 17-fold higher than that of patients who do not have diabetes ($P<0.01$). Poorly-controlled patients with diabetes, which they defined as those with HbA_{1c} ≥7%, were five times more likely to develop postoperative infections than well-controlled patients with diabetes with HbA_{1c} <7% ($P<0.05$) (Myers et al, 2012). Delays in presentation as a result of diabetic peripheral neuropathy can further compound the issue of postoperative infection, leading to greater risk to health.

Steroid injections are often used for a range of orthopaedic conditions including osteoarthritis, inflammatory arthritis, frozen shoulder, carpal tunnel syndrome and lumbar radiculopathy. Steroid injections have a negative impact on blood sugar levels. A study of patients receiving hand and wrist injections found a significant increase in average blood sugar levels on days 1, 5 and 6 post-injection (Catalano et al, 2012). Another study of spinal patients showed a transient rise in blood sugar levels by almost 80% following epidural injection (Even et al, 2012).

Perioperative management

There are national guidelines advising how to manage patients with diabetes mellitus in the perioperative period, and many trusts will also have their own local guidelines. The appropriate management depends on the scenario, with elective surgery allowing for weeks of planning, but emergency and/or trauma surgery only allowing for hours of planning. The Joint British Diabetes Societies for Inpatient Care (2016) guidelines 'Management of adults with diabetes undergoing surgery and elective procedures: Improving standards, 2nd edition' were released in March 2016 and focus on the management of patients with diabetes undergoing elective surgery from primary care referral to discharge from surgical care. The take-home recommendations for the immediate perioperative period focus on list planning, oral intake, intravenous insulin use and monitoring of blood glucose levels.

It is advised that patients with diabetes mellitus are listed first on planned theatre lists to minimise the period of starvation. If first on a morning list, then they are likely to be recovered in time for lunch at normal time and will have only missed a single meal. It is also advised that appropriate emergency medications for perioperative hypoglycaemia and hyperglycaemia should be prescribed well in advance of surgery, such as during a preoperative assessment. For patients requiring prolonged starvation (more than one missed meal) or those with HbA_{1c} >8.5%, a variable rate intravenous insulin infusion is recommended. This involves running an insulin infusion, adjusted by the nursing staff according to capillary blood glucose, alongside a continuous infusion of fluids. The fluids used vary by trust, but the Joint British Diabetes Societies for Inpatient Care guidelines recommend 5% dextrose in 0.45% sodium chloride with either 0.15% or 0.3% potassium chloride. Although short- and intermediate-acting subcutaneous insulins should be stopped, it is recommended that the patient should continue their long-acting insulin at 80% of their

Key points

- Diabetes is a growing epidemic, with orthopaedic surgeons treating patients with diabetes more frequently.
- The physiological stress response to trauma or surgery can lead to hyperglycaemia.
- General risks of surgery include endothelial dysfunction, postoperative sepsis, impaired wound healing and cerebral ischaemia.
- Polytrauma patients with diabetes are at greater risk of mortality than patients who do not have diabetes.
- Risk of prosthetic joint infection and other post-surgical deep-seated infections is increased in patients with diabetes.
- Joint British Diabetes Societies for Inpatient Care guidelines focus on the perioperative care of patients with diabetes, including list planning, oral intake, intravenous insulin use and monitoring of blood glucose.

usual dose to reduce the risk of going into rebound hyperglycaemia on withdrawal of the insulin infusion postoperatively. Intraoperatively, the patient's capillary blood glucose should be checked before induction of anaesthesia and then at least hourly, targeting 6–10 mmol/litre. Postoperatively, patients should be encouraged to return to normal eating and drinking as soon as possible, so that the insulin infusion can be withdrawn and the normal patient-led antihyperglycaemic regimen can be restarted. For emergency and/or trauma surgery, it may not be possible to follow these guidelines precisely, but certain points such as the use of a variable rate intravenous insulin infusion can certainly be incorporated into practice.

Conclusions

Diabetes mellitus can pose a great threat to the outcomes of trauma and orthopaedic surgery. As a result, the decision to operate should never been taken lightly. Patients should always be involved in the decision-making process and appropriate consent obtained given the elevated risks to life and limb. When surgical options are pursued, patients must be managed appropriately following national and/or local guidelines in order to minimise risk to their health. In cases of poorly controlled diabetes, it may be prudent to liaise with diabetes specialists before procedures and even consider delaying surgery where possible, until blood sugars are under better control.

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Conflicts of interest

The authors declare no conflicts of interest.

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