

Care of children and young people with diabetes who require surgery

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Article points

1. Caring for children with diabetes requiring surgery needs close collaboration between surgeons, anaesthetists and the paediatric diabetes team.
2. It is important that guidelines are followed in order to reduce errors in management and ensure a consistent approach to care. The Association of Children's Diabetes Clinicians guidelines for children with diabetes who require surgery are invaluable.
3. Good glycaemic control both in the pre-operative and peri-operative period helps reduce risk of complications following surgery.

Key words

- Glycaemic control
- Guidelines
- Peri-operative procedure
- Surgery

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Surgery can carry extra risks for people with diabetes but these risks can be reduced by following clear guidelines. Surgery and general anaesthesia cause a complex neuroendocrine stress response that can lead to hyperglycaemia and contribute to increased morbidity in patients with diabetes. To reduce the risk of such adverse outcomes, children and young people undergoing surgery need to have their fluid and insulin therapy carefully managed, ensuring there is optimal hydration while avoiding hyperglycaemia or hypoglycaemia. Written guidelines with algorithms and a systematic approach to glycaemic management will help reduce errors in management and ensure a consistent approach to care. Guidelines have been produced by the Association of Children's Diabetes Clinicians to help guide healthcare professionals when caring for a young person with diabetes who needs surgery, and this article presents some of its main points.

Children with diabetes are at risk of blood glucose alterations when undergoing surgery. This risk arises from a change in routine, change in or lack of peri-operative insulin, and physical and emotional stress related to the surgical procedure, surroundings, anxiety and pain. There are increases in the levels of counter-regulatory hormones such as epinephrine, glucagon, cortisol and growth hormone during surgery and general anaesthesia, and these hormonal changes lead to relative insulin resistance, excessive glycogenolysis, gluconeogenesis, increased lipolysis and protein catabolism, which can lead to hyperglycaemia and even ketosis (Hirsch and McGill, 1990). Other adverse events that can occur in the peri-operative period include hypoglycaemia, iatrogenic hyponatraemia and medication errors when converting from the intravenous insulin infusion to usual medication.

For these reasons, it is very important that

every unit looking after children with diabetes who require surgery has written guidelines to follow.

There are currently no evidence-based controlled studies of peri-operative management of children with diabetes. The Association of Children's Diabetes Clinicians (ACDC), whose aims include improving services for children with diabetes and sharing good practice, has recently published consensus guidelines for medical and nursing staff on the care of children requiring surgery (ACDC, 2014). This article will present the key aspects of the guidelines relating to the management of children and young people requiring surgery.

The peri-operative management of children who are on insulin treatment depends on their insulin regimen, rather than on their type of diabetes. It also depends on the type of surgery planned, which, in the ACDC guidelines, are divided into the following two categories:

- Minor surgery which refers to short procedures (usually less than 30 minutes) with or without sedation or anaesthesia, where rapid recovery is anticipated and the child is expected to be able to eat by the next meal. Examples include endoscopic biopsies, myringotomy, incision and drainage.
- Major surgery which includes all surgery requiring more prolonged general anaesthesia lasting more than 30 minutes or a procedure that is likely to cause post-operative nausea, vomiting or the inability to feed adequately.

The guidelines also offer advice on emergency surgery for young people with diabetes.

When to postpone elective surgery

There have been no studies in children to establish whether there is a pre-operative HbA_{1c} level above which elective surgery should be postponed. However, the ACDC guidelines and guidelines from the Australian Diabetes Society (ADS) recommend that elective surgery be postponed, if possible, if glycaemic control is poor (HbA_{1c} >75 mmol/mol [9.0%]) (ADS, 2012; ACDC, 2014). Studies in adults have shown that those with poor diabetes control experience significantly more adverse outcomes, including the increased risk of post-operative wound complications, and increased morbidity and mortality (Dronge et al, 2006; O'Sullivan et al, 2006; Halkos et al, 2008; Han and Kang, 2013). Dronge et al (2006) suggested that this might be because the overall general health and metabolic status are better in people with well-controlled diabetes and post-operative glucose control may be easier for these people.

Hyperglycaemia has deleterious effects on the phagocytic activity of leucocytes and impairs the ability to fight infections. In addition, it adversely affects wound healing by interfering with collagen production, thereby leading to reduction in the tensile strength of wounds. Published guidelines from Boston Children's Hospital recommend that surgery should be delayed if possible when metabolic control is unsatisfactory (Rhodes et al, 2005). If the child has poor diabetes control, the benefits of proceeding with surgery should be balanced against the potential risks of surgical complications, such as delayed wound healing and wound infection.

Planning for surgery

As soon as the decision is made to undertake surgery, the surgeon should inform both the hospital paediatric diabetes team and the anaesthetist about the date and timing of a planned procedure. Ideally, children with diabetes should be put first on the morning list. It is important to ensure that the patient has clear written instructions regarding their glycaemic management both before and after surgery, including any medication adjustments prior to surgery. If the surgery is planned to take place in another hospital, then the local diabetes team must inform the hospital's diabetes team and share basic information about the child, including recent weight, current diabetes treatment or insulin regimen and most recent recorded doses, any comorbidities, most recent HbA_{1c}, hypoglycaemia awareness and any current issues with severe hypoglycaemia.

Ideal blood glucose level during the peri-operative period

It is very important to monitor blood glucose closely in the peri-operative period. Patients with hyperglycaemia can tip into diabetic ketoacidosis (DKA) following surgical stress.

Several studies in adults suggest that peri-operative hyperglycaemia is an independent risk factor for post-operative mortality and morbidity (Doenst et al, 2005; Gandhi et al, 2005; Ata et al, 2010). The incidence of deep wound infection was significantly reduced in adults with diabetes undergoing coronary artery bypass by maintaining the blood glucose level after surgery at <11.1 mmol/L (Zerr et al, 1997). Van den Berghe et al (2001) demonstrated that maintaining blood glucose between 4.4 mmol/L and 6.2 mmol/L by intensive insulin therapy led to significant reductions in morbidity and mortality in adult surgical patients.

However, a Cochrane meta-analysis of available literature showed that implementation of intensive glycaemic control in adults during the peri-operative period was associated with higher numbers of patients experiencing hypoglycaemia (Buchleitner et al, 2012). Hypoglycaemia can be fatal if undetected during general anaesthesia. The risks of hypoglycaemia, especially severe hypoglycaemia, can offset the benefits of tight

Page points

1. Guidelines from the Association of Children's Diabetes Clinicians and the Australian Diabetes Society recommend that elective surgery for children be postponed, if possible, if glycaemic control is poor.
2. Hyperglycaemia impairs the ability to fight infections and adversely affects wound healing. For a child with poor diabetes control, the benefits of proceeding with elective surgery should be balanced against the potential risks of complications for a child with poor diabetes control.
3. When the decision is made to undertake surgery on a child with diabetes, the surgeon should quickly inform the hospital paediatric team and the anaesthetist. The surgery should be scheduled first on the morning list.

“If the patient uses an insulin pump, it is possible to continue with the usual management until the time of surgery.”

blood glucose control. In view of this, it seems prudent to aim for target blood glucose between 5 and 11.1 mmol/L.

Management of a child with diabetes during the peri-operative period for major surgery

The child should be admitted the day before surgery. Weight, blood glucose, ketones, urea, electrolytes, creatinine levels and full blood count should be measured. In addition, the pre-meal and pre-bedtime capillary blood glucose levels should be measured. The usual insulin dose should be given in the evening and night before surgery, and any correction doses required to maintain target levels should be administered.

On the day of surgery, the usual morning dose of rapid-acting insulin should be omitted, but if basal insulin is normally taken in the morning, then this should be given. The child should have nothing to eat for 6 hours before the operation, but clear fluids can be taken until 2 hours before surgery. An intravenous infusion of maintenance fluids as well as an intravenous infusion of insulin should be started (*Box 1*). Capillary blood glucose should be monitored hourly before and after surgery (but half-hourly during surgery). After surgery, intravenous fluids and insulin should be continued until the patient starts eating.

If the patient uses an insulin pump, it is possible to continue with the usual management until the time of surgery, when the pump should be stopped and an intravenous infusion started as above.

Management of a child with diabetes during the peri-operative period for minor elective surgery

Parents should be briefed by the diabetes team about any insulin adjustments required before admission on the day of surgery. Basal insulin should be taken the night before if that is in the patient's regimen. If they usually have basal insulin in the morning, this should be given in the usual way. Rapid-acting insulin should be omitted in the morning as the patient will not be eating. The child will not need intravenous infusion of fluids or insulin, but a cannula should be inserted and the capillary blood glucose level should be monitored hourly. Once the child is

able to eat following surgery, they should be given short-acting insulin with the late breakfast.

Emergency surgery

Children requiring emergency surgery should be assessed with a full history and a thorough examination including weight, blood glucose levels, venous blood gases, blood ketones, electrolytes, urea and creatinine. If they have DKA this should be managed according to national guidelines (British Society for Paediatric Endocrinology and Diabetes, 2013). Surgery should be delayed until the child is rehydrated, blood pressure is stable, blood gas is normal and sodium and potassium levels are in the normal range. This may not be possible for some life-saving operations. If the child does not have DKA, then the guidelines on major elective surgery should be followed and fluid maintenance and intravenous insulin should be started as in *Box 1* (International Diabetes Federation/International Society for Pediatric and Adolescent Diabetes, 2011; ACDC, 2014). If intravenous fluids and insulin are required for longer than 12 hours, it is important to ensure that the usual long-acting subcutaneous insulin is written up and given each day at the usual time. This will allow subcutaneous insulin to be restarted more quickly when the child is again able to eat.

Children on oral diabetes drugs

The main concern regarding metformin therapy during surgery relates to the rare complication of lactic acidosis. However, more recent evidence suggests that the risk of lactic acidosis is only increased in patients with other comorbidities and may not be significantly different from other oral diabetes medications (Salpeter et al, 2010; Sirvinskas et al, 2010). Metformin has a long biological half-life (17–31 hours), so it should be stopped at least 24 hours before any planned surgery. If emergency surgery is required and when metformin is stopped for less than 24 hours before surgery, it is important to ensure optimal hydration to prevent the rare risk of lactic acidosis. If a young person is taking other oral medications, such as sulphonylureas or thiazolidinediones, then they should be stopped on the day of surgery.

Box 1. Maintaining fluids during surgery for children with diabetes (Association of Children's Diabetes Clinicians [ACDC], 2014)

Fluid of choice: 0.45% saline, 5% glucose

Glucose

Use 5% glucose.

- However, if there is concern about hypoglycaemia, then use 10% glucose.
- If blood glucose is high (>12 mmol/L), then increase insulin supply.

Sodium

Use 0.45% saline. Change to 0.9% saline if sodium levels are falling.

Potassium

Monitor electrolytes, but always include 20 mmol/L potassium chloride (KCl) in intravenous fluid.

Maintenance fluid calculation:

Body weight in kg	Fluid requirements in 24 hours
For each kg between 3–9	100 mL/kg
For each kg between 10–20	Add an additional 50 mL/kg
For each kg over 20	Add an additional 20 mL/kg

Insulin infusion guide

Dilute 50 units short-acting soluble insulin in 50 mL normal saline; 1 unit per mL.

Start infusion at:

- 0.025 mL/kg/h (i.e. 0.025 units/kg/h) if blood glucose is between 6–8 mmol/L
- 0.05 mL/kg/h if blood glucose is between 8–12 mmol/L
- 0.075 mL/kg/h if blood glucose is between 12–15 mmol/L
- 0.1 mL/kg/h if blood glucose is between >15 mmol/L.

Monitor blood glucose hourly before surgery and every 30 minutes during the operation and until the child recovers from anaesthesia. Adjust intravenous (IV) insulin accordingly.

If blood glucose <5 mmol/L, stop the IV insulin infusion, but only for 10–15 minutes. Give bolus of IV 10% glucose 2 mL/kg; re-check blood glucose 15 minutes later.

How to restart subcutaneous insulin after being on intravenous insulin

If the child is ready to eat following surgery, give the following insulin:

- For those patients on insulin regimens using long-acting basal insulin analogues, give rapid-acting insulin with meal. Check that long-acting insulin has been carried on throughout stay. If they have missed a dose, delay re-starting subcutaneous insulin until they have had the long-acting insulin.
- For those patients on insulin pump, the parents can re-start the insulin pump at the usual basal rate once the child is feeling better and blood glucose levels are stable with no ketones. Parents should be allowed to manage according to their usual practice.

For more details, see the ACDC guidelines at <http://bit.ly/1ufGG1M>

“The Association of Children's Diabetes Clinicians guidelines are an invaluable resource for healthcare professionals caring for children with diabetes who require surgery.”

Conclusion

Caring for a child or young person with diabetes requiring surgery needs close collaboration between surgeons, anaesthetists and the paediatric diabetes team. Written guidelines with algorithms and a systematic approach to glycaemic management will help reduce errors in management and ensure a consistent approach to care. Children with diabetes should not have to spend longer in hospital because their diabetes management has been unduly complicated because of poor management during surgery. The ACDC guidelines are an invaluable resource for healthcare professionals caring for children with diabetes who require surgery, and should be consulted and followed by the multidisciplinary team. ■

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