

ISPAD Clinical Practice Consensus Guidelines 2009 Compendium

Management of children and adolescents with diabetes requiring surgery

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This article is a chapter in the *ISPAD Clinical Practice Consensus Guidelines 2009 Compendium*. The complete set of guidelines can be found at www.ispad.org. The evidence grading system used in the ISPAD Guidelines is the same as that used by the American Diabetes Association. See page 2 (the Introduction in *Pediatric Diabetes* 2009; 10 (Suppl. 12): 1–2).

When children with diabetes require surgery or other procedures requiring sedation or anaesthesia, optimal management should maintain adequate hydration and near to normal glycemia, while minimising the risk of hypoglycemia. The stress of surgery may cause acute hyperglycemia, which increases the risk of postoperative infection (1, 2) [B].

Evidence-based controlled studies of perioperative care in children have not been conducted, but a review of management has recently been published in the anaesthesiology literature (3); our current guidelines are consistent with the recommendations in that reference. A review of perioperative management of type 1 diabetes in adults was published in 2003 (4).

The current, revised guidelines are based on those in the 2000 edition ISPAD Consensus Guidelines with additions and amendments from the Australasian Clinical Practice Guidelines: Type 1 Diabetes in Children and Adolescents (5), and the Canadian Diabetes Association: Clinical Practice Guidelines for the Prevention and Management of Diabetes in Canada (6). As there are few relevant scientific papers on management during surgery, the recommendations are mostly based on expert consensus.

Glycemic targets for surgery

In the past, adults with diabetes have had an approximately 10-fold increased risk of postoperative wound

infections (in a study of 23,000 patients in 1973) (7) [C]. However, when blood glucose (BG) is maintained between 6.8 and 9.3 mmol/l (122–168 mg/dl) after major vascular surgery, there is no difference in the risk of postoperative wound infections (8) [B]. Maintaining BG levels below 11 mmol/L (200 mg/dl) for the first two postoperative days decreased the risk of sternal wound infections after heart surgery from 2.4% to 1.5% (9) [C]. Improved postoperative glycemic control (plasma glucose levels of 4.5–6.0 mmol/l [\sim 80–110 mg/dl]) using continuous intravenous (IV) insulin infusion significantly decreased mortality and morbidity in patients who required postoperative intensive care and mechanical ventilation after major surgery (10) [A]. With this degree of tight glycemic control, 5.2% of subjects experienced hypoglycemic episodes compared to 0.8% in the control group; however, none of the episodes was severe (11) [A].

The safe implementation of such intensive glycemic control with a continuous IV insulin infusion requires a written protocol and staff training to ensure effectiveness and to minimise the risk of hypoglycemia.

To achieve optimal glycemic control, insulin dosage may need to be increased on the day of major surgery and for approximately 2 days after surgery. This is best achieved by continuous IV insulin infusion even after the resumption of oral feeding (12) [C].

Appropriate perioperative glycemic targets for brief and minor surgical procedures are less clear. To date, no intervention studies have assessed the impact of different BG levels on morbidity or mortality in these circumstances. However, a few studies in adults that compared different methods of achieving glycemic control during minor and moderate surgery did not demonstrate any adverse effects of maintaining perioperative glycemic levels between 5–11 mmol/l (\sim 90–200 mg/dl) (13, 14) [A] (15) [B].

Because the data in adults show adverse effects of hyperglycemia, and support tight perioperative control of glucose in patients undergoing major surgery, it seems reasonable to aim for BG levels between 5–10 mmol/l (90–180 mg/dl) during surgical procedures in children [E].

The benefits of tight glycemic control must be weighed against the risk of perioperative hypoglycemia, which may not be recognized during anaesthesia; however, this risk can be mitigated by frequent capillary BG monitoring.

Children with Type 1 diabetes or Type 2 treated with insulin requiring a major surgical procedure

- ◇ must be admitted to hospital for general anaesthesia
- ◇ need insulin, even if fasting, to avoid ketoacidosis

- ◇ should receive a glucose infusion when fasting for more than 2 hours before an anaesthetic to prevent hypoglycemia.
- ◇ should be carefully monitored via capillary blood glucose measurement for hypo- and hyperglycemia, stress caused by surgery may cause hyperglycaemia and increased insulin requirements.
- ◇ Anaesthesia may cause vasodilatation and drop the blood pressure (BP). If there is an unexpected acute event (drop in BP), normal saline 0.9% (NS) or Ringer's lactate must be infused rapidly. In this case, potassium-containing fluids must not be infused rapidly.

It is helpful in the management of children with diabetes undergoing surgery to divide procedures into two categories:

- (a) **Minor Surgery or Procedures** that require a brief general anaesthetic (GA) [or heavy sedation], usually of less than one hour duration, and which should not have a major impact on glycemic control. Examples include: Endoscopies, jejunal biopsy, adenotonsillectomy, grommet insertion, or repeated short procedures such as in oncology or burns wards.
The child will usually be discharged from hospital on the day of procedure.
- (b) **Major Surgery** that requires more prolonged general anaesthesia (GA), is associated with greater risks of metabolic decompensation, and the child is unlikely to be discharged from hospital on the day of procedure.

Although the majority of surgical procedures are elective, both types of procedure may occur as emergencies.

Elective surgery

This should be performed when the diabetes is under the best possible control.

- If glycemic control is uncertain or poor, consider admission to hospital prior to surgery for assessment and stabilisation of glycemic control.
- If control remains problematic, surgery should be cancelled and re-scheduled.

Scheduling of surgery

- Procedures are preferably scheduled first on surgical lists, ideally in the morning
- Admit to hospital in the afternoon prior to surgery for **major** operations, but in appropriate circumstances, it is possible to admit early on the day of surgery for both **minor** and **major** operations [E]

Table 1. Infusion guide for surgical procedures

1. Maintenance fluid guide

• Glucose

5 % glucose; 10 % if there is concern about hypoglycemia. If BG is high (>14 mmol/l, 250 mg/dl), use 1/2 normal saline or NS without glucose and increase insulin supply but add 5% dextrose when BG falls below 14 mmol/l (250 mg/dl).

• Sodium

Saline 0.18–0.25% (~20–40 mmol Na/litre) with glucose is widely used. There is evidence that the risk of acute hyponatremia may be increased when using hypotonic maintenance solutions (i.e. <0.9% NaCl) in hospitalised children (17). Many centres, therefore, use saline 0.45–0.9% (77–154 mmol Na/litre). A compromise would be to give 0.45% saline with 5% glucose, carefully monitor electrolytes, and change to 0.9% saline if plasma Na concentration is falling.

• Potassium

Monitor electrolytes. After surgery, add potassium chloride 20 mmol to each litre of intravenous fluid. Some centres add potassium routinely only if infusion is required for more than 12 h

Example of calculation of maintenance requirements ([E], tables for this vary between centres, use one that is locally agreed and established):

	Body Weight	Fluid Requirement/24h
for each kg between	3–9 kg	100 ml/kg
for each kg between	10–20 kg	add an additional 50 ml/kg
for each kg over	20 kg	add an additional 20 ml/kg
(max 2000 ml female, 2500 ml male)		

2. Insulin infusion

- Add soluble insulin 50 units to 50 ml normal saline 0.9%, making a solution of 1 unit insulin/ml; attach to syringe pump and label clearly
- Start infusion at 0.025 ml/kg/h (i.e., 0.025 U/kg/hour) if blood glucose is <6–7 mmol/l, 0.05 ml/kg/h if 8–12 mmol/l, 0.075 ml/kg/h between 12–15 mmol/l and 0.1 U/kg/h if > 15 mmol/l.
- Aim to maintain BG between 5–10 mmol/l, depending of the type of surgery, by adjusting insulin infusion hourly
- BG must be measured at least hourly when the patient is on IV insulin
- **Do not stop the insulin infusion** if BG <5–6 mmol/l (90 mg/dl) as this will cause rebound hyperglycemia. Reduce the rate of infusion.
- The insulin infusion may be stopped temporarily if BG <4 mmol/l (55 mg/dl) but only for 10–15 min

Evening prior to surgery

- Frequent BG monitoring is important especially before meals and snacks and at bedtime (measure blood β -hydroxybutyrate and/or urinary ketone concentration if BG is >15–20 mmol/l) [E]
- Give the usual evening or bedtime insulin(s) and bedtime snack
- Ketosis or severe hyperglycemia will necessitate correction, preferably by overnight IV insulin infusion, and might delay surgery.

Major elective surgery

(that requires, at a minimum, overnight hospital stay postoperatively)

- Procedures preferably should be first on the list, ideally, in the morning.
- No solid food for at least 6 hours prior to surgery
- Clear fluids (including breast milk) may be allowed up to 4 hours before surgery (check with anaesthetist)
- Omit the usual morning insulin dose
- At least 2 hours before surgery start an IV insulin infusion (dilute 50 units regular [soluble] insulin in 50 mL normal saline, 1 unit = 1 mL) and glucose 5% (10% if there is concern about hypoglycemia) (see Table 1) (4) [E]. If blood glucose is high

(>14 mmol/l, 250 mg/dl), use 1/2 normal saline or NS without glucose and increase rate of insulin infusion, but add 5% dextrose when BG falls below 14 mmol/l (250 mg/dl).

- Monitor BG hourly before surgery and every 30–60 minutes during the operation and until the child awakens from anaesthesia [E]
- Monitor BG hourly for 4 hours after surgery or for as long as the patient is receiving IV insulin.
- Aim to maintain BG between 5–10 mmol/l (90–180 mg/dl) and use correction rates of IV insulin during surgery [E]. With IV insulin, a suitable initial ratio of insulin to glucose for prepubertal children is typically 1 unit per 5 g of IV glucose and for adolescents 1 unit per 3 g of IV glucose (3). The dose is adjusted based on BG response.
- Once the patient is awake, it should be possible to adjust the IV insulin to maintain BG in the ideal range, 4.5–8 mmol/l (80–160 mg/dl), without excessive risk of hypoglycemia. (Table 1) [E]
- When oral intake is not possible the IV infusion should continue for as long as necessary.

Minor surgery

(where discharge home usually occurs later in the day of surgery)

- Procedures preferably should be first on a surgical list, ideally in the morning
- Aim for BG 5–10 mmol/l (90–180] mg/dl) during and after surgery [E]

Algorithms for different types of insulin regimens are suggested below. For more detail, see reference (3).

- No solid food for at least 6 hours prior to GA
- Clear fluids (including breast milk) are allowed up to 4 hours before anaesthesia (check with anaesthetist)

(a) Patients treated with twice daily (BID) insulin regimens

Morning operations scheduled 08.00h–09.00h.

- At 07.00h give 50% of the usual morning dose of intermediate-acting insulin (NPH, lente). Omit the short- or rapid-acting insulin unless needed to correct hyperglycemia. Commence IV fluids (use glucose 5–10%, as necessary, to prevent hypoglycemia)
 - After surgery, start oral intake or continue IV glucose depending on the child's condition. Give small doses of short- or rapid-acting insulin (based on the child's usual correction factor), if needed, to reduce hyperglycaemia or to balance food intake. The dinner or evening dose of insulin is given as usual.
- Alternatively, IV insulin infusion may be started at 07.00h (see below).
 - If IV insulin has been used, continue the insulin infusion until lunch and then given a small dose of short- or rapid-acting insulin to last until the dinner or evening insulin dose.
- If the child is fully recovered, it may be possible to discharge the child from hospital later in the day.

Afternoon operations scheduled for 13.00h–14.00h.

- At 07.00h, give 50% of the usual dose of intermediate-acting insulin (NPH, lente) and the usual dose of short- or rapid-acting insulin.
- Alternatively, give 30–40% of the usual morning insulin dose of short- or rapid-acting insulin (but no intermediate- or long-acting insulin) and use an IV insulin infusion beginning at least 2 hours before surgery (Table 1).
- Allow the child to eat a light breakfast. Clear fluids may be allowed up to 4 hours before anaesthesia. Start IV fluids (and IV insulin infusion, if applicable) 2 hours before surgery or no later than midday (Table 1).
- Thereafter, proceed as for morning operations (above).

(b) Patients on basal-bolus insulin regimens (16)

Morning operations scheduled for 08.00h–09.00h.

- Children on basal-bolus regimens benefit from not discontinuing their basal insulin before minor surgical procedures. This is particularly relevant for children requiring repeated procedures.
- If there is a pattern of low BG values in the morning, consider reducing by 20–30% the dose of long-acting insulin given in the preceding evening.
- If the duration of general anaesthesia is short (<1 hour), give 50% of the usual morning dose of intermediate-acting insulin dose (NPH, lente) or 75–100% of the dose if the patient takes long-acting insulin (glargine, detemir, ultratard) at 07.00h and commence IV fluids containing glucose 5% (10% if high risk of hypoglycaemia). Do not give short- or rapid-acting insulin in the morning unless necessary to correct hyperglycemia.
- Alternatively, IV regular insulin infusion may be started at breakfast time (omitting all types of morning SC insulin).
- Perform BG measurements before, during and immediately after GA (at least hourly) and, if necessary, increase glucose concentration of IV fluids to 10% to prevent hypoglycemia. Adjust glucose infusion and insulin (by SC injection of rapid-acting insulin or IV infusion) to maintain perioperative BG in the range 5–10 mmol/l [E]
- In the postoperative period, supplemental mid-morning short-/rapid-acting insulin may be given if required (10–25% of total daily dose) and, when tolerated, a light meal.
- Later in the day, the aim is to resume normal meals and pre-meal insulin doses as soon as the child is able to tolerate oral feeds.

Afternoon operations scheduled for 13.00h–14.00h.

- The patient is usually allowed to eat breakfast and drink clear fluids until 4 hours preoperatively
- At breakfast, give the usual dose of rapid-acting or 50–60% of the usual short-acting insulin and usual dose of basal intermediate- or long-acting insulin (if usually given at this time)
- Commence IV fluids containing glucose 5% (10% if high risk of hypoglycaemia) at a maintenance rate approximately ≥ 2 hours after breakfast
- Measure capillary BG hourly and, if necessary, adjust the glucose concentration of IV fluids to prevent hypoglycemia. Give supplemental IV insulin, if needed, to keep perioperative BG concentrations in the target range.
- After surgery, IV insulin or additional short-/rapid-acting insulin may be required until normal eating is resumed.

- Later, if tolerated, resume meals and the child's usual insulin at the appropriate times.

(c) Patients on insulin pumps (CSII)

The diabetes team should determine the approach depending on the individual patient and procedure.

- When a child on continuous subcutaneous insulin infusion (CSII) goes to the operating theatre, it is important to secure the SC infusion site to prevent dislodgement and interruption of insulin supply during the procedure.
- If the general anaesthesia is short (< ~1 hour), the pump can continue to infuse insulin at the basal rate while continuing to give an IV infusion of 5% glucose at the maintenance rate (see below). Do not give a morning/meal bolus dose unless necessary to correct hyperglycemia. Monitor BG levels hourly preoperatively and at least half hourly during GA.
- When necessary, correction doses of insulin can be given with the pump preoperatively and postoperatively. Alternatively, give extra IV insulin to keep perioperative BG within target.
- A meal bolus is given when the patient is ready to eat.
- Alternatively, CSII can be discontinued and a continuous IV insulin and glucose infusion commenced, as described above, until feeding has been satisfactorily established.

Minor procedures requiring fasting – simplified procedure

For short procedures (with or without sedation or anaesthesia) and when rapid recovery is anticipated, a simplified protocol may be formulated by personnel experienced in the anaesthesia for children with diabetes and may include the following alternatives:

- Early morning procedure (e.g. 08.00–09.00): delay insulin and food until immediately after completion of the procedure
- BID insulin: Give 50% of usual insulin dose [NPH/lente and short-/rapid-acting]) or give repeated small doses of short-/rapid-acting insulin (20–50% of morning short/rapid-acting dose)
- Basal/bolus or CSII: Give usual basal insulin/continue basal rate in the morning and, if needed, add small doses of rapid-acting insulin. Give bolus dose and food when the child can eat again.

Emergency surgery

- No fluid food or medication by mouth; in some emergency situations the stomach must be emptied by a nasogastric tube

- Secure IV access
- Check weight, measure serum electrolytes, BG, blood gases, and blood β -hydroxybutyrate or urinary ketone concentration before anaesthesia
- If ketoacidosis is present, follow protocol for DKA and delay surgery until circulating volume and electrolyte deficits are corrected
- If there is no ketoacidosis, start IV fluids and insulin infusions as for elective surgery

Type 2 diabetes

For those individuals who have type 2 diabetes and are treated with insulin, follow the insulin guidelines as for elective surgery, depending on type of insulin regimen.

Patients on oral treatment:

Metformin: discontinue 24 hours before the procedure for elective surgery, if <24 hours since the last dose for emergent surgery, it is essential to maintain hydration with IV fluids before, during and after surgery.

Sulfonylureas or thiazolidinediones: stop on the day of surgery

Monitor BG hourly and if greater than 10 mmol/l (180 mg/dl) treat with IV insulin, as for elective surgery, to normalise levels, or SC insulin if it is a minor procedure.

Recommendations

- DKA may present as an “acute abdomen”.
- Acute illness may precipitate DKA (with severe abdominal pain).
- Whenever possible, surgery on children and adolescents with diabetes should be performed in centres with appropriate personnel and facilities to care for children with diabetes.
- To ensure the highest levels of safety, careful liaison is required between surgical, anaesthetic and children's diabetes care teams before admission to hospital for elective surgery and as soon as possible after admission for emergency surgery.
- The elective surgery should be scheduled as the first case on a surgical list, preferably in the morning.
- Centres performing surgical procedures on children with diabetes should have available written protocols for post-operative management of diabetes on the wards where children are admitted.
- IV access, infusion of glucose and frequent BG monitoring is essential in all situations when general anaesthesia is given. Glucose 5% is usually sufficient; glucose 10% may be necessary when there is an increased risk of hypoglycemia.
- Elevated blood ketone (beta-hydroxybutyrate, BOHB) and BG concentrations require extra insulin and possibly intravenous fluids for correction. Such

correction also requires the consideration of delay and rescheduling of an elective surgical procedure. A bedside meter for beta-OHB levels works well in a hospital setting and may suffice for monitoring.

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