Association of Children's Diabetes Clinicians

Clinical Guideline

Care of children under 18 years with Diabetes Mellitus undergoing Surgery or MRI under GA

SETTING *Insert hospital name*

FOR STAFF Medical and nursing staff

PATIENTS This guideline is intended for use in managing all children and young people up to the age of 18 years with diabetes mellitus who require surgery or MRI under general anaesthesia (GA).

Guidance

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1. Introduction

Children with diabetes mellitus are at risk of blood glucose (BG) alterations when undergoing surgery. This risk results from a change in routine, change in or lack of perioperative insulin, physical and emotional stress related to the surgical procedure, surroundings, parental anxiety, and surgical pain. Adverse events which can occur include:

- Hypoglycaemia
- Hyperglycaemia

These can result from -

- Inappropriate use of intravenous insulin infusion
- Medication errors when converting from the intravenous insulin infusion to usual medication

For the above reasons, it is very important that every unit looking after diabetic children requiring surgery has written guidelines. There should be close liaison between the surgeon, the anaesthetist and the paediatric diabetes team. Children with diabetes should not have to spend longer in hospital because their diabetes management has been unduly complicated

2. Definitions

The peri-operative management of children who are on insulin treatment depends on their insulin regimen rather than on whether they have type 1 or type 2 diabetes mellitus.

Minor surgery: short procedures (always less than 2 hours, and usually less than 30 minutes) with or without sedation or anaesthesia where rapid recovery is anticipated and child is expected to be able to eat by the next meal. Examples include endoscopic biopsies, myringotomy, incision and drainage.

Major surgery: includes all surgery requiring more prolonged general anaesthesia lasting >30 minutes or a procedure which is likely to cause post-operative nausea, vomiting or inability to feed adequately. If you are unsure about the length of anaesthetic or risk of slow post-operative recovery from anaesthesia please discuss with anaesthetist

Multiple daily injections (MDI/Basal bolus): A long acting background insulin is given once or twice a day (e.g. glargine) , with boluses of rapid insulin (e.g. Novorapid/ Humalog/ Apidra) with meals.

Twice or three times daily: A fixed mixture of rapid and intermediate acting insulin (e.g. Novomix 30) is given in both the morning and evening (**twice daily**) or given in the morning, with a rapid insulin (e.g Novorapid /Humalog/ Apidra) given at evening meal and a long -acting insulin (e.g. Glargine) is given at bed time

Continuous glucose Monitoring (CGM): A device that continuously provides a reading of interstitial glucose. As there will be a difference between blood glucose and interstitial glucose it is **not** currently recommended to use the CGM readings for monitoring during surgery

Flash glucose monitoring (Flash GM): A device that provides monitoring of interstitial glucose and will provide a glucose reading each time the sensor is scanned, as well as the readings for the preceding 8 hours. As there will be a difference between blood glucose and interstitial glucose it is **no**t currently recommended to use the CGM readings for monitoring during surgery.

Insulin Pump with Artificial Pancreas System (APS): Some children will have an insulin pump and continuous glucose monitoring (CGM) device that communicate with an algorithm that allows automatic adjustment of basal rate to keep blood glucose in the normal range, thus functioning as an artificial pancreas system. There are NHS provided devices with built in APS algorithms which should not be continued intraoperatively. At the time of writing NHS approved APS include Medtronic Minimed 670G,

Medtronic Minimed 780G, CamAPX FX, t:slim X2™ insulin pump with Control-IQ®. Interstitial glucose monitoring is not a substitute for blood glucose monitoring peri-operatively and Capillary BG must also be monitored concurrently

NB. A minority of children have open-source APS devices (also known as DIY looping) which are not regulated or NHS approved. These should not be used in the hospital inpatient setting peri or intra operatively.

3. Glycaemic Targets Prior to Elective Surgery:

Elective surgery should be postponed if possible if glycaemic control is very poor (HBA1c >75mmol/mol [9.0%]) *Consider admission to hospital prior to elective surgery for assessment and stabilisation if glycaemic control is poor. If control remains problematic, surgery should be cancelled and re-scheduled.*

- There are currently no published data in children on the impact of pre-operative glycaemic control on post-operative outcomes. However Dronge et al found that in adults, an HbA1c ≥ 7% (53 mmol/mol) more than doubles the risk of post-operative wound infection [1])

4. Pre-operative Assessment for Elective Surgery

Role of surgeon carrying out surgery/procedure:

As soon as the decision is made to undertake surgery, the surgeon needs to inform both the hospital paediatric diabetes team and the anaesthetic service coordinator/ pre-operative care service about:

a. Date and timing of planned procedure. (if possible please put child first on the morning list)
b. Type of procedure and whether it is judged to be major or minor surgery as defined above

Role of the paediatric diabetes team:

- Try to optimise glycaemic control prior to planned surgery
- Ensure patients have clear written instructions regarding the management of the child's diabetes (including any medication adjustments) prior to surgery
- Where the surgery is taking place in another hospital, then the local diabetes team must inform the diabetes team in the other hospital in advance of the surgery.
- Basic information to be passed on includes:
  - Recent weight
  - Current diabetes treatment or insulin regimen and most recent recorded doses
  - Most recent HbA1c (and date)
  - Hypoglycaemia awareness and any current issues with severe hypoglycaemia
  - Any co-morbidities (thyroid disorders/ Addison's disease/ Coeliac Disease)

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5. Pre-operative Fasting Guidelines[2,3.]

- No solid food should be consumed for 6 hours before elective surgery in children.
- In infants, breast milk is safe up to 4 hours, and other milks up to 6 hours. Thereafter, clear fluids should be given as in older children.
- Children should be encouraged to drink clear fluids (including. water, low-sugar squash) up to 1 hour before elective surgery. Where this is not possible, then an intravenous fluid (IV) should be started.

6. Peri-operative Blood Glucose Targets

- BG should be kept between 5-11.1mmol/l during the peri-operative period
- BG should be checked at least hourly before during and after surgery using capillary blood glucose testing.
    - There are no Paediatric studies on the ideal BG targets to aim for peri-operatively. In adults, the implementation of intensive glycaemic control was associated with a higher number of patients experiencing hypoglycaemic episodes[4].
    - CGM, Flash GM or APS systems should not be used in place of blood glucose monitoring intra-operatively due to lack of evidence of reliability in the intraoperative setting[5,6] .

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7. Guideline for Children Who Are Insulin Treated

7a. Minor Elective Morning Surgery

Day before surgery	Advise normal insulin and diet
Morning of procedure	○ Child can be admitted on the morning of the surgery ○ Child should be first on the list ideally ○ IV Cannula to be placed on admission to the ward ○ No IV fluids or insulin infusion needed ○ Measure and record the capillary BG hourly preoperatively and half hourly during the operation **IF on multiple daily injection regimens (MDI/basal bolus)** and BG is stable between 5-11.1mmol/L ○ Omit rapid acting insulin in the morning until after procedure when they can have it with the late breakfast. ○ If basal insulin analogue is usually given in the morning continue to give it as usual **IF on insulin pumps** or **pump with NHS approved and provided APS** **Prior to surgery**: ○ Run the pump at the usual basal rate (request the parent to disable APS immediately pre surgery if used) ○ Check capillary BG hourly and ask parents to adjust basal rates to maintain BG between 5-11.1 mmol/L ○ Anaesthetist to familiarise with pump controls to be able to suspend/ restart pump if required **During surgery**: ○ Run the pump on the normal basal setting for the duration of the procedure (APS disabled). ○ Basal rate can be suspended for 30 minutes to correct any episodes of mild hypoglycaemia. If the pump is stopped for up to 1 hour, the child must be started on IV insulin and intravenous fluid (as per section 7F and 7G) as they have **NO** basal insulin in their body. **IF on premixed insulin in the morning, (Twice daily or three times daily regimen**) ○ delay the morning dose till after procedure when they can have it with a late breakfast **However, FOR ALL INSULIN REGIMENS** - If ○ BG <5 mmol/l – give bolus of IV 10% Glucose 2ml/kg; recheck BG 15 minutes later ○ BG >12 mmol/l – start IV insulin infusion and IV fluids as per sliding scale in section 7F and 7G. ○ If for some reason procedure is delayed for a further 2 hours or child is has had repeated low BGs, start on maintenance IV fluids (section 7F)
After procedure	**Multiple daily injections (MDI/Basal bolus)** ○ Once eating, give usual dose rapid acting insulin generally taken with that meal ○ If needing IV fluids & insulin infusion Go to section 7H for guide on how to change back to subcutaneous insulin **Insulin pump regimen (with or without APS)** ○ Allow parents to re-start the pump at the usual basal rate once the child has recovered. ○ Home when eating and drinking, regardless of BG level; parent will control better at home **Premixed insulin** ○ Give morning dose with late breakfast.

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7b. Minor Elective Afternoon Surgery

Day before procedure	○ Advise usual doses of insulin night before procedure
Morning of procedure	○ Advise the child to have a normal breakfast no later than 7.30 a.m. ○ Patient to have breakfast insulin dose dependent on regimen: **IF on Multiple daily injections (MDI/Basal bolus) regimen**, ○ Give FULL usual dose of rapid-acting insulin (e.g insulin aspart (NovoRapid), Humalog lispro (Humalog), glulisine (Apidra)) according to carbohydrate content of breakfast as well as usual correction dose depending on pre-meal BG level (BG). ○ Glargine (Lantus) or Detemir (Levemir) if given in the morning, should also be given in FULL. **IF on insulin pump (with or without APS)** ○ Run the pump on the normal basal setting, BG should be checked at least hourly and Carer/patient asked to alter infusion rate if required to maintain BG between 5-11.1 mmol/L ○ Anaesthetist to familiarise with pump controls to be able to suspend/ restart pump if required **IF on premixed insulin in the morning, (Twice daily or three times daily regimen**) ○ Give ½ of rapid-acting component of morning dose as rapid-acting insulin. Example: if usual morning dose is 10 units of Novomix 30 or Humulin M3, then the usual fast acting component is 3/10 x10=3 units of rapid acting insulin (e.g insulin aspart (NovoRapid), Humalog lispro (Humalog), glulisine (Apidra)).
Peri-operatively	○ Measure and record capillary BG on arrival ○ Insert IV cannula ○ Child should be first on the list ○ Measure and record capillary BG hourly once nil by mouth and half hourly during the operation ○ No IV fluids or insulin infusion needed routinely **However, If** ○ BG<5 mmol/l – give bolus of IV 10% glucose 2ml/kg; recheck BGL 15 minutes later ○ If for some reason procedure is delayed for a further 2 hours or child is continuing to have low BGs, start on maintenance IV fluids as in section 7F. ○ BG>12mmol/l – start IV insulin infusion and IV fluids as per sliding scale in Section 7F and 7G **Children on insulin pumps (with or without APS)** should continue their pump provided their BG remains between 5-11.1mmol/L ○ BG should be checked hourly pre-operatively and half-hourly during surgery ○ If BG <5 mmol/l suspend the pump for 30 minutes as well as giving glucose bolus (see above) ○ If the pump is stopped for up to 1 hour, the child must be started on IV insulin and intravenous fluid as per section 7F & 7G as they have **NO** basal insulin in their body.
After procedure	**Multiple daily injections (MDI/Basal bolus) or Premixed Insulin** ○ Once eating, give usual dose rapid acting insulin or premixed insulin generally taken with that meal ○ If needing IV fluids & insulin infusion go to section 7H for guide on how to change back to subcutaneous insulin **Insulin pump regimen (with or without APS)** ○ Allow parents to re-start the pump at the usual basal rate once the child has recovered. ○ Home when eating and drinking, regardless of BG level; parent will control better at home

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7c . MRI Scan under GA

Before MRI	**FOR ALL MRI scans** ○ Remove any insulin pumps, metal canulae and continuing glucose monitoring devices – eg. Dexcom/ Libre/ Libre 2, prior to entering MRI scanner ○ MRI Scan must be interrupted as necessary to enable a blood glucose sample to be obtained every 30 minutes. The blood glucose testing equipment will need to be remain outside the scan room. **IF on Multiple daily injections (MDI/Basal bolus) regimen or** **IF on premixed insulin in the morning, (Twice daily or three times daily regimen**) ***if scan expected to be < 2 hours*** ○ Follow guidelines in 7a and 7b as per minor elective surgery depending on timing of MRI ***If expected to be longer than 2 hours*** ○ Follow guidelines in 7d and 7e as per major elective surgery depending on timing of MRI **IF on insulin pump (with or without APS)** ***If scan expected to be < 1 hour*** ○ Follow guidance in 7a and 7b as per minor elective surgery depending on timing of MRI **BUT Remove insulin pump/ metal canulae AND any CGM** (if using) ○ The insulin pump can safely be removed for up to 1 hour if BG are in target 5-11.1 mmol. ○ Provision must be made to enable reinsertion of insulin pump after 1 hour. If insulin pump cannot be reinstated after 1 hour from when it was discontinued then IV fluids and Insulin should be commenced as they have **NO** basal insulin in their body. ***If scan expected to be > 1 hour*** ○ Follow guidance in 7d and 7e as per major elective surgery depending on timing of MRI **BUT Remove insulin pump/ metal canulae AND any CGM** (if using).
After MRI	○ Follow 7a, b, d, or e as per post- surgery ○ Replace insulin pump and/or continuing monitoring device (if used) post MRI. ○ For children on insulin pump **a correction bolus** may be required if blood glucose is above target on reinsertion of the insulin pump. The parent/carer can deliver this as per their usual practice. ○ If **BG is 14mmol or more** on pump re-insertion sick day rules should be followed in accordance with local guidelines

7d. Major Elective Morning Surgery

Day Before surgery	○ Admit day before surgery ○ Weight, U&E, FBC, true BG, urine or blood for ketones ○ Pre-meal and pre-bedtime capillary BG on the ward ○ Usual insulin the evening and night before surgery ○ For those on insulin pumps (with or without CGM/ approved APS) continue pump as usual with parental management until the time of surgery
Morning of surgery ***First on list***	○ Nothing to eat 6 hours before operation. For morning lists patients should be starved from 03.00, but can drink clear fluids until 1 hour before surgery ○ **Omit rapid-acting insulin** in the morning ○ Glargine (Lantus) or Detemir (Levemir) if given in the morning, should be given in FULL. ○ Start intravenous maintenance fluids at maintenance rate and intravenous insulin according to sliding scale at 06.30h, to maintain BG level between 5 and 11.1mmol/l. (see section 7F & 7G) ○ Measure capillary BG pre-theatre and half-hourly during surgery **NB**: if on an **insulin pump**, parents may be able to continue with their usual management only until the time of surgery, when the pump should be stopped and the IV fluids and insulin infusions started
After surgery:	○ Capillary BG and Ketones hourly. ○ Continue IV fluids and IV insulin infusion until ready to start eating ○ Go to section 7H for guide on how to change back to subcutaneous insulin ○ **Always give basal insulin analogue (subcutaneous insulin Glargine or Levemir) at usual time even if still on IV fluids and sliding scale of insulin**

7e. Major Elective Afternoon Surgery

Day before surgery	○ Admit ○ Weight, U&E, FBC, true BG, urine or blood for ketones ○ Pre-meal and pre-bedtime capillary BG on the ward ○ Usual insulin the evening and night before surgery ○ For those on **insulin pumps** continue pump as usual with parental management until the time of surgery
Morning of surgery ****First on afternoon list****.	○ Light breakfast at 0700 on the morning of procedure, and then starve, but check with anaesthetic service coordinator/ pre-operative care service for exact timing. **IF on Multiple daily injections (MDI/Basal bolus)** ○ rapid-acting insulin (should be taken at the FULL usual dose according to carbohydrate content as well as usual correction dose depending on pre-meal BG level (BGL). Basal insulin analogue (e.g. glargine or levemir) if given in the morning, should also be given in FULL **IF on insulin pump (with or without APS)** ○ continue pump as usual with parental management until the time of surgery **IF on premixed insulin in the morning, (Twice daily or three times daily regimen**) ○ give **half** the morning insulin dose ○ Intravenous fluid infusions from 12 noon and intravenous insulin infusion (see section 7F & 7G). ○ Measure capillary BG pre-theatre and half-hourly during surgery
After surgery	○ Capillary BG and Ketones hourly including theatre. ○ Continue IV fluids and IV insulin infusion until ready to start eating ○ Go to section 7H for guide on how to change back to subcutaneous insulin ○ See section 7C above for importance of continuing basal insulin

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7f. Emergency Surgery

Before surgery	On arrival, weigh patient, measure capillary and plasma BG, venous blood gases, blood ketones, electrolytes, urea and creatinine. ○ Inform diabetes Team on admission **If ketoacidotic** ○ Follow guidelines on Diabetes Ketoacidosis (DKA)7 ○ Operate when rehydrated, blood pressure is stable, blood gas is normal, sodium and potassium in normal range. ○ Blood glucose levels should also be stable ideally between 5 and 11.1 mmo/l ○ This may not be possible for some life-saving operations. **If not ketoacidotic** ○ Follow guideline on major elective surgery and start fluid maintenance and intravenous insulin (section F & G) ○ For those on insulin pumps (with or without APS), the pump should be stopped once the IV infusion is started. **Always give basal insulin analogue (subcutaneous insulin Glargine or Levemir) at usual time even if still on IV fluids and sliding scale of insulin**
After surgery	○ Measure capillary BG hourly and check for blood ketones on every sample (including theatre) ○ Continue IV fluids and insulin infusion until ready to eat ○ Go to section 7H for guide on how to change back to subcutaneous insulin

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7g. Maintenance Fluid Guide [8,9,10,11,12,]

Fluid of choice – 0.9% saline/5% glucose

Glucose:
Use 5 % glucose,

- However, if there is concern about hypoglycaemia, then use 10 %
- If BG is high (>12mmol/l) increase insulin supply. See Section 7G.

Sodium:
Use 0.9% saline.

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	3-9kg	100ml/kg
For each kg between	10-20kg	Add an additional 50ml/kg
For each kg over	Over 20kg	Add an additional 20ml/kg

7h. Insulin Infusion Guide [13,14]

- Dilute 50 units soluble insulin (Actrapid) in 50 ml normal saline; 1 unit per ml.
- Start infusion at
  - 0.025 ml/kg/h (i.e., 0.025 U/kg/hour) if BG is between 6–8mmol/l,
  - 0.05 ml/kg/h if 8–12 mmol/l,
  - 0.075 ml/kg/h between 12–15 mmol/l
  - 0.1 U/kg/h if > 15 mmol/l.
- Monitor BG hourly before surgery and every 30 minutes during the operation and until the child recovers from anaesthesia. Adjust IV insulin accordingly.
- If BG <5mmol/l, stop the IV insulin infusion but only for 10–15 min. Give bolus of IV 10% glucose 2ml/kg; recheck BG 15 minutes later.

7i. How to Restart Subcutaneous Insulin After Being On Intravenous Insulin

If ready to eat at **Lunch** give the following insulin:

-
- **For those patients on insulin regimens using long acting basal insulin analogues** e.g. Glargine: give rapid acting insulin with lunch. 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 twice or three times a day injection** regimen **NOT** using long acting basal insulin analogue e.g. Glargine, allow to eat but continue IV insulin sliding scale until evening meal (then see below)

- **For those patients on insulin pump (with or without CGM/ APS)** – the parents can re-start the insulin pump at the usual basal rate once the child is feeling better and BG levels are stable with no ketones. Parents should be allowed to manage according to their usual practice

If ready to eat by **Evening meal** give the following insulin:

- **For those patients on twice** or **three** times a day injection regimen **NOT** using long-acting basal insulin analogue e.g. Glargine give usual dose of insulin with evening meal.

- **For those patients on multiple injection regimen with** long acting basal insulin analogue e.g. Glargine**,** give rapid acting insulin with evening meal and long-acting insulin analogue at usual time.

- Always give dose of long-acting basal insulin analogue e.g. Glargine at usual time even if still on intravenous fluids and intravenous insulin overnight to prevent rebound hyperglycaemia:

- Stop IV insulin 60 minutes after subcutaneous insulin has started if the child is first given a pre mixed insulin or long acting basal insulin analogue dose.

- Stop IV insulin 10 minutes after sc insulin has started if the child is given a rapid acting insulin dose

- **For those patients on insulin pump (with or without APS)** – the parents can re-start the insulin pump at the usual basal rate once the child is feeling better and capillary BG levels are stable with no ketones. Stop IV insulin and fluids 10 minutes after sc insulin has started. Parents should be allowed to manage according to their usual practice.

8. Guideline For Children On Oral Medications

Metformin:

- Discontinue at least 24 hours before procedure for elective surgery.
- In emergency surgery and when metformin is stopped < 24 hours, ensure optimal hydration to prevent risk of lactic acidosis.
    - The main concern regarding metformin therapy during surgery relates to the rare complication of lactic acidosis. Metformin has a long biological half-life (17-31 hours) hence the need to stop it at least 24 hours prior to surgery[15,16].

Other oral medications e.g. sulphonylureas or thiazolidinediones: stop on day of surgery

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Appendix 1. Insulin Infusion Calculator

Surgery Guidelines: Insulin Sliding scale

Patient's Name : -		
Please insert patient's weight here (kg) :		
BM (mmols/L)	**Units/kg/hour**	**mls/hour**
>15	0.1	0.0
12-14.9	0.075	0.0
8-11.9	0.05	0.0
5-7.9	0.025	0.0
< 5	Give 2ml/kg 10% glucose. Stop insulin infusion for 15mins and then recheck capillary glucose. Restart insulin infusion once glucose level >6mmol/L.	