

FASTING AND SURGERY- TYPE 1 DIABETES MELLITUS (T1DM)- CHW

PRACTICE GUIDELINE [®]

DOCUMENT SUMMARY/KEY POINTS

- This practice guideline is intended primarily for use in the tertiary Paediatric environment of The Children's Hospital at Westmead. However, it can be applied for minor procedures and surgery in other settings according to the judgement and supervision of the treating medical team (anaesthetist, surgeon, and others). Except in emergencies, major surgery should be performed in a tertiary paediatric surgery whenever possible.
- The Diabetes team (via the on-call service) is available to assist with advice to treating medical staff related to this protocol, however they do not have the authority to directly manage patients outside of The Children's Hospital at Westmead.
- Pre-surgical assessment should be done by anaesthetists as standard practice in the days/weeks leading up to elective surgery. This is to allow for an assessment of glycaemic control, electrolyte status, ketones (urine or blood) and to plan the insulin and fluid regimen for surgery and liaison with the endocrine team if necessary.
- Schedule operations early in the morning if possible. If not possible, schedule first on the afternoon list. This allows postoperative stabilisation during the day.
- Some insulin is needed, even when fasting, to avoid ketoacidosis.
- Specific adjustment of insulin doses and schedule is required depending on the type of surgery (major or minor) and the time of the surgical procedure.
- The optimal method of maintaining metabolic control during major surgery (surgical procedure lasting ≥ 2 hours) or prolonged fasting is by an insulin infusion. See [Appendix 1: Preparing, starting and adjusting an insulin infusion using Insulin Adjustment Algorithm](#)
- Blood glucose monitoring is generally required hourly once fasting commences (i.e. the time of the first missed meal), and during and immediately after the surgical procedure. Aim for blood glucose levels between **5–10mmol/L**.
- If hypoglycaemia (blood glucose $< 4\text{mmol/L}$) occurs while fasting AND it is more than 1 hour before surgery, the hypoglycaemia may be treated orally with carbohydrate

This document reflects what is currently regarded as safe practice. However, as in any clinical situation, there may be factors which cannot be covered by a single set of guidelines. This document does not replace the need for the application of clinical judgement to each individual presentation.

Approved by:	SCHN Policy and Procedure Committee	
Date Effective:	1 st March 2021	Review Period: 3 years
Team Leader:	Staff Specialist	Area/Dept: Endocrinology CHW

containing clear fluids (e.g. fruit juices (no-pulp) or carbohydrate rich drinks (CarbPlus)), as per [Hypoglycaemia Management Paediatric Diabetes Practice Guideline](#).

- A patient on a basal/bolus insulin regimen (insulin glargine or insulin detemir as the basal insulin) or continuous subcutaneous insulin infusion (pump therapy) may initially receive an IV fluid infusion without glucose for minor surgery or procedures lasting less than 2 hours.
- A continuous IV Glucose infusion is required for major surgery or procedures lasting ≥ 2 hours or if patient is treated with intermediate acting insulin which peaks 4-12 hours after administration, insulins such as Protophane, Humulin NPH.

CHANGE SUMMARY

- Due for mandatory review – no major changes in practice.

READ ACKNOWLEDGEMENT

- Clinicians (medical and nursing) caring for patients who have Type 1 diabetes and who require surgery should read and acknowledge they understand the contents of this document.

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1 Insulin delivery in type 1 diabetes

Typically, insulin is delivered in one of three ways in patients with Type 1 diabetes (T1DM).

1.1 Insulin pumps (CSII)

Continuous subcutaneous insulin infusion (CSII) pumps deliver rapid acting insulin continuously at pre-programmed basal rates (expressed in units of insulin per hour). Boluses of insulin are delivered before meals and to correct hyperglycaemia.

1.2 Basal-bolus insulin regimen with insulin glargine or insulin detemir

- Basal insulin is long-acting insulin (insulin glargine or insulin detemir) and is given subcutaneously in the evening or morning.
- Boluses of short (insulin rys) or rapid-acting insulin (insulin aspart) are given before each meal.

1.3 Other regimens with intermediate/isophane/NPH or premixed/biphasic insulin

- This method of insulin delivery is not routinely used in current practice. Please consult the on-call endocrine team well in advance to discuss the insulin adjustment prior to surgery.
- Examples of intermediate or biphasic insulin include: Humulin NPH[®], Protaphane[®] Hypurin Isophane[®], Humulin 30/70[®], Mixtard 30/70[®] or Mixtard 50/50[®], NovoMix 30, Humalog Mix25, Humalog Mix50.

2 Patients wearing a Continuous Glucose Monitoring system (CGM)

A continuous glucose monitoring system (CGM) is a small, self-inserted sensing device worn on the body. CGM transmits interstitial glucose levels to an insulin pump screen or receiver device (e.g. smartphone) about current sensor glucose status. Graphs and trend arrows show the direction of glucose values and rate of change, providing users with additional information to help their diabetes management. It is important to note that the sensor measures the interstitial glucose level and not the blood glucose level.

The guidelines for hospitalised patients are:

1. Sensor glucose values via CGM cannot be used for clinical decisions while an inpatient (e.g. insulin administration, dose adjustment and hypoglycaemia management). In these instances, a blood glucose level is required (finger stick) using a standard hospital glucometer. Exceptions to this need to be approved by the endocrinology team.

2. Remove the sensor and transmitter from the patient before Magnetic Resonance Imaging (MRI), Computed Tomography (CT) scan, or high-frequency electrical heat (diathermy) treatment.
3. Remove the sensor and transmitter from the patient prior to surgery. Medical and nursing staff are required to continue blood glucose monitoring (by finger stick) using a standard hospital glucometer during surgery to guide clinical decisions.
4. CGM has not been evaluated or approved in persons on dialysis or in critically ill patients. It is not known how different medical conditions or medications commonly used in the critically ill population may affect performance of CGM. Sensor glucose levels may be inaccurate in critically ill patients. Medications containing paracetamol/acetaminophen can give a false high reading and there is limited data about the effect of other medications on CGM accuracy.
5. In some circumstances, following team discussion and with the approval of the treating endocrinologist, CGM may be used in the hospital setting to provide information in addition to finger prick blood glucose levels. In these situations, the frequency of finger stick blood glucose monitoring should be stated by the treating endocrinologist and the decision to use CGM should be reviewed at least daily and also at the addition of any new medications or change in clinical situation.

3 Pre-operative assessment of children with diabetes

Pre-operative assessment should be performed by an anaesthetist as a standard process in a Pre-operative Clinic prior to elective surgery. This assessment should include assessment of recent BGL control, recent HbA1c result and review of the child's total daily insulin requirements, insulin regimen/doses or insulin pump data.

If control is uncertain or poor, liaise with the diabetes team and consider admission 1–3 days beforehand for assessment and stabilisation. Consider postponing elective surgery if HbA1c is >10%, Elective surgery should only be performed if diabetes is under good control.

For patients who are known to the CHW diabetes team, the pre-operative assessment clinic staff should make contact with the CHW diabetes team **well in advance** in order to allow the Diabetes Educator to review the diabetes management and provide pre-operative advice. Suggest: email SCHN-CHW-DiabetesClinic@health.nsw.gov.au or phone the diabetes centre on 9845 3169 during office hours and ask to speak to the Diabetes Educator team leader.

For patients who receive their diabetes care external to CHW, the pre-operative clinic team should make contact with the patient's diabetes care team to develop a pre-operative management plan. In general, the CHW diabetes team do not provide pre-operative management advice for patients treated at other diabetes centres unless specifically requested by the patient's treating diabetes team.

4 Peri-operative fasting: general approach

4.1 Safe Fasting Times

Refer to [Fasting Guideline for Children Having General Anaesthesia](#) for safe fasting times.

- Patients on insulin should be scheduled as the first case on the morning list when possible. If not possible, schedule first on the afternoon list. This minimises fasting times and allows postoperative stabilisation during the day.
- BGL monitoring should commence from the time of fasting (i.e. the time of the first missed meal). Blood glucose monitoring is generally required hourly. Aim to maintain blood glucose levels of 5–10mmol/L.

4.2 Managing inadvertent hypoglycaemia

If hypoglycaemia (blood glucose < 4mmol/L) occurs while fasting AND it is **more than 1 hour** before the start of anaesthesia, it may be treated orally with clear apple juice (3mL/kg to a maximum of 150mL)

Pre-operatively (≥1 hour before anaesthesia)

- **3-12mths (not for neonates)**
 - Give 3mL/kg of clear apple juice orally.
 - Consider giving infant a breastfeed or bottle depending on the fasting time (refer to [Fasting Guideline for Children Having General Anaesthesia](#))
 - Retest BGL in 15 -20 minutes. If child remains hypoglycaemic, repeat treatment and call Endocrine team as IV fluids containing Glucose will need to be commenced, usually 0.9% sodium chloride + 5% glucose.
- **1yr and older**
 - Give 3mL/kg of clear apple juice orally.
 - Retest the BGL in 15 – 20minutes. If child remains hypoglycaemic repeat treatment and call Endocrine team as IV fluids containing Glucose will need to be commenced, usually 0.9% sodium chloride + 5% glucose.

Pre-operatively (< 1 hour before anaesthesia)

- If hypoglycaemia (blood glucose < 4mmol/L) occurs within 1 hour of starting general anaesthesia, notify the anaesthetic team immediately.
- Place an IVC and administer 2mL/kg IV bolus of 10% glucose as a bolus followed by maintenance IV fluids containing 5% glucose.
- Surgery may need to be postponed until later on the list if no IVC is in situ and if hypoglycaemia needs to be treated orally to prevent delay in treatment of hypoglycaemia.

Intra-operatively

- Measure BGL at least hourly.
- For those on intravenous insulin infusion use the algorithm for hourly insulin adjustment taking into account ambient BGL and change over the last hour (in response to previous change in infusion rate). See [Appendix 1: Preparing, starting and adjusting an insulin infusion using Insulin Adjustment Algorithm](#)
- If patient is not on an intravenous insulin infusion i.e. on subcutaneous insulin injections or an insulin pump follow below:
 - If BGL less than < 5 mmol/L, commence 5% glucose, or if already on 5% glucose then increase the rate or glucose concentration of the infusion in increments of 2.5% glucose.
 - If the BGL is < 4 mmol/L administer an initial 2mL/kg IV bolus of 10% glucose.
 - Measure the BGL after 15 minutes and adjust glucose infusion to 7.5% or 10% as necessary to maintain the BGL >5 mmol/L.

5 Peri-operative care for children with diabetes on insulin

5.1 Minor surgery (i.e. procedure which lasts less than 2 hours)

- Schedule procedure for 8am. Check 6am BGL and then monitor blood glucose level hourly.
- If BGL is <4mmol/L and it is **more than 1 hour** before the start of anaesthesia, this may be treated orally with clear apple juice (3ml/kg to a maximum of 150mls)
- If BGL is <4mmol/L and it is <1hour before the start of anaesthesia, place an IVC and administer 2mL/kg IV bolus of 10% glucose as a bolus followed by maintenance IV fluids containing 5% glucose for example 0.9% sodium chloride + 5% glucose.
- If there is any delay in the operating theatre or in establishing oral intake following the procedure, consider starting IV 5% glucose +/- an insulin infusion and contact the endocrine team if further advice is required.
- Specific adjustment of the insulin schedule will depend upon the type of surgery (minor or major), the time of the procedure (morning or afternoon) and the patient's usual insulin regimen, the three most common regimens being:
 - Patients on continuous subcutaneous insulin infusion (pump therapy).
 - Patients on basal-bolus regimen with insulin glargine or insulin detemir
 - Patients on regimens containing intermediate/isophane/NPH or premixed insulin.

5.1.1 Patients on continuous subcutaneous insulin infusion (pump therapy)

- Continuous subcutaneous insulin infusion should be continued during the surgical procedure when possible.
- Family should be advised to change and secure the subcutaneous insulin infusion cannula away from the surgical site the night before the surgery.
- Continue the basal insulin infusion rate via the insulin pump as usual.
- Check BGL hourly once the patient is nil by mouth, during the procedure and post operatively until oral intake resumes.
- Insert IV cannula and consider starting IV fluids depending upon fasting time etc. Patients with a blood glucose level >4mmol/L may initially have IV fluids without glucose.
- If BGL is <4mmol/L and it is **more than 1 hour** before the start of anaesthesia, this may be treated orally with clear apple juice (3ml/kg to a maximum of 150mls) if the patient suitable for 1hr clear fluid fasting as per the CHW Fasting Guideline
- If BGL is <4mmol/L and it is <1hour before the start of anaesthesia, place an IVC and administer 2mL/kg IV bolus of 10% glucose as a bolus followed by maintenance IV fluids containing 5% glucose for example 0.9% sodium chloride + 5% glucose. Basal insulin can be temporarily suspended, if necessary for no more than 30 minutes to assist correction of hypoglycaemia but does not replace need for glucose administration if hypoglycaemic.
- Consider setting a temporary basal rate (e.g. 80% of usual basal rate) if surgery is delayed or food is not tolerated post operatively or BGLs are below 5mmol/L.
- Postoperatively, stop IV fluids once oral intake resumes. Family/patient/nursing staff to give bolus doses of insulin via the insulin pump when the patient starts eating after the procedure (by entering amount of carbohydrates and BGL for correction).

5.1.2 Patients on basal-bolus insulin with insulin glargine or insulin detemir

Procedure first on morning list

- Consider the need for reduction (20–30%) of evening basal (long acting) insulin if there is a pattern of low blood glucose levels (BGL) in the mornings.
- If basal (long acting) insulin is usually given in the morning, give the usual dose.
- Omit the morning dose of short or rapid-acting insulin.
- Check BGL hourly once the patient is nil by mouth, during the procedure and post operatively until oral intake resumes.
- If BGL is <4mmol/L and it is **more than 1 hour** before the start of anaesthesia, this may be treated orally with clear apple juice (3ml/kg to a maximum of 150mls) if the patient suitable for 1hr clear fluid fasting as per the CHW Fasting Guideline
- If BGL is <4mmol/L and it is <1hour before the start of anaesthesia, place an IVC and administer 2mL/kg IV bolus of 10% glucose as a bolus followed by maintenance IV fluids containing 5% glucose for example 0.9% sodium chloride + 5% glucose.
- Insert IV cannula and consider starting IV fluids depending upon fasting time etc. Patients with a blood glucose level >4mmol/L may initially receive IV fluids without glucose.
- Postoperatively, give additional rapid-acting insulin, usually 5-10% of total daily dose as needed 2-4-hourly if BGL>10mmol/L. Alternatively, if the patient has a known and documented Insulin Sensitivity Factor (ISF), the correction dose of insulin can be calculated using this. The ISF is the expected reduction in blood glucose (mmol/L) that 1 unit of rapid-acting insulin will cause.
- Usually can resume normal food and insulin from lunchtime.

Procedure first on afternoon list

- Give the usual dose of morning or evening basal (long acting) insulin.
- The patient is usually allowed breakfast.
- At approximately 7am give the usual dose of rapid-acting insulin with breakfast. If the patient has short acting insulin with breakfast, give 60% of the usual short acting insulin with breakfast.
- Check BGL hourly once the patient is nil by mouth, during the procedure and post operatively until oral intake resumes.
- If BGL is <4mmol/L and it is **more than 1 hour** before the start of anaesthesia, this may be treated orally with clear apple juice (3mL/kg to a maximum of 150mL) if the patient suitable for 1hr clear fluid fasting as per the [CHW Fasting Guideline](#)
- If BGL is <4mmol/L and it is <1hour before the start of anaesthesia, place an IVC and administer 2mL/kg IV bolus of 10% glucose as a bolus followed by maintenance IV

fluids containing 5% glucose for example 0.9% sodium chloride + 5% glucose. Increase glucose to 7.5% or 10% if required.

- Depending upon clinical situation, consider starting IV fluids 0.9% sodium chloride + 5% glucose at maintenance fluid rates, 1-2 hours before surgery. Increase glucose concentration to 7.5% or 10% if required.
- Postoperatively, give additional rapid-acting insulin, usually 5-10% of total daily dose as needed 2-4-hourly if BGL>10mmol/L. Alternatively, if the patient has a known and documented Insulin Sensitivity Factor (ISF), the correction dose of insulin can be calculated using this. The ISF is the expected reduction in blood glucose (mmol/L) that 1 unit of rapid-acting insulin will cause.
- Usually can resume normal food and insulin at dinner or supper time.

5.1.3 Patients on regimens containing intermediate/isophane/NPH or premixed insulin

- Contact the endocrine team well in advance to discuss insulin adjustment for the day of surgery.
- Admission the day before surgery may be required.
- Options for insulin adjustment include:
 - Changing to basal-bolus regimen for the peri operative period.
 - If first on the morning list, give 50% of the usual morning intermediate acting insulin and withhold the usual morning short/rapid acting insulin until after the procedure.
 - If first on the afternoon list, give 50% of the usual morning intermediate acting insulin. Given rapid acting insulin to cover for breakfast if breakfast is permitted
- Depending on the insulin adjustment regimen chosen, consider starting IV fluids 0.9% sodium chloride + 5% glucose at maintenance fluid rates, 1-2 hours before surgery. Increase glucose concentration to 7.5% or 10% if required.
- Check BGL hourly once the patient is nil by mouth, during the procedure and post operatively until oral intake resumes.
- If BGL is <4mmol/L and it is **more than 1 hour** before the start of anaesthesia, this may be treated orally with clear apple juice (3mL/kg to a maximum of 150mL) if the patient suitable for 1hr clear fluid fasting as per the [CHW Fasting Guideline](#)
- If BGL is <4mmol/L and it is <1hour before the start of anaesthesia, place an IVC and administer 2mL/kg IV bolus of 10% glucose as a bolus followed by maintenance IV fluids containing 5% glucose for example 0.9% sodium chloride + 5% glucose.
- Postoperatively, stop IV fluids once oral intake resumes.
- Postoperatively, give additional rapid-acting insulin, usually 5-10% of total daily dose as needed 2-4-hourly if BGL>10mmol/L.
- The usual dose of evening insulin can be given if the patient has recovered and is eating normally, otherwise a reduced dose will be needed.

5.2 Major surgery (i.e. procedure which lasts more than 2 hours)

The optimal method of maintaining metabolic control during major surgery or prolonged fasting is by an intravenous insulin infusion with hourly blood glucose levels.

Optimally the insulin infusion should start at least 2 hours prior to surgery to establish the rate of insulin infusion required to stabilise the blood glucose levels.

See [Appendix 1: Preparing, starting and adjusting an insulin infusion using Insulin Adjustment Algorithm](#)

5.3 Emergency Surgery

Although most surgical procedures are elective, both minor and major procedures may occur as emergencies. It is important to remember that acute illness can precipitate DKA and that DKA can present as an acute abdomen.

- Before emergency surgery always check BGL and blood or urinary ketones. If ketones are elevated check EUC and blood gas.
- Monitor BGLs regularly.
- Allow clear fluids with added glucose up until 1 hour pre-operatively unless nil by mouth status assigned by the treating surgical team.
- Contact on-call endocrine team for further advice on insulin adjustment.

6 Post-Operative Management

- Measure BGL hourly until the patient is eating or drinking.
- If the patient is expected to be able to eat and drink soon after their operation, then once this occurs their usual insulin management can be recommenced.

7 Fasting unrelated to surgical procedure in patients with type 1 diabetes

- Some T1DM patients have prolonged periods of fasting unrelated to surgery. E.g. for diagnostic imaging, gut rest etc., and this protocol can be used for such patients.
- Shorter periods of fasting can be dealt with by adjustments of subcutaneous insulin or pump regimen as described above. For more prolonged fasting, an intravenous insulin infusion with hourly BGLs is a reliable method of controlling BGL.
- To set up an IV insulin infusion refer to [Appendix 1: Preparing, starting and adjusting an insulin infusion using Insulin Adjustment Algorithm](#)

8 References

1. Jefferies C, Rhodes E, Rachmiel M, et al. ISPAD Clinical Practice Consensus Guidelines 2018: Management of children and adolescents with diabetes requiring surgery *Pediatr Diabetes*. 2018;19 Suppl 27:227-236. doi:10.1111/pedi.12733
2. Craig ME, Twigg SM, Donaghue KC, Cheung NW, Cameron FJ, Conn J, Jenkins AJ, Silink M, for the Australian Type 1 Diabetes Guidelines Expert Advisory Group. National evidence-based clinical care guidelines for type 1 diabetes in children, adolescents and adults, Australian Government Department of Health and Ageing, Canberra 2011. (<http://www.nhmrc.gov.au/guidelines/publications/ext4> accessed on June 6, 2014).
3. Association of Children's Diabetes Clinicians. Care of children under 18 years with Diabetes Mellitus undergoing Surgery (http://www.a-c-d-c.org/wp-content/uploads/2012/08/ACDC_surgery_guideline2014-pdf.pdf accessed on March 25, 2014).
4. Rhodes ET, Ferrari LR, and Wolfsdorf JL. Perioperative management of pediatric surgical patients with diabetes mellitus. *Anesth Analg*. 2005;101(4):986-99.
5. Kaufman FR, Devgan S, Roe TF, and Costin G. Perioperative management with prolonged intravenous insulin infusion versus subcutaneous insulin in children with type I diabetes mellitus. *J Diabetes Complications*. 1996;10(1):6-11.
6. Dronge AS, Perkal MF, Kancir S, Concato J, Aslan M, and Rosenthal RA. Long-term glycemic control and postoperative infectious complications. *Arch Surg*. 2006;141(4):375-80.
7. Cruse PJ, and Foord R. A five-year prospective study of 23,649 surgical wounds. *Arch Surg*. 1973;107(2):206-10.
8. Kao LS, Meeks D, Moyer VA, and Lally KP. Peri-operative glycaemic control regimens for preventing surgical site infections in adults. *Cochrane Database Syst Rev*. 2009;3:CD006806.
9. Griesdale DE, de Souza RJ, van Dam RM, Heyland DK, Cook DJ, Malhotra A, et al. Intensive insulin therapy and mortality among critically ill patients: a meta-analysis including NICE-SUGAR study data. *CMAJ*. 2009;180(8):821-7.
10. Moghissi ES, Korytkowski MT, DiNardo M, Einhorn D, Hellman R, Hirsch IB, et al. American Association of Clinical Endocrinologists and American Diabetes Association consensus statement on inpatient glycemic control. *Endocr Pract*. 2009;15(4):353-69.
11. Agus MS. Tight glycemic control in children--is the target in sight? *N Engl J Med*. 2014;370(2):168-9.
12. Srinivasan V, and Agus MS. Tight glucose control in critically ill children--a systematic review and meta-analysis. *Pediatr Diabetes*. 2014;15(2):75-83.
13. Vlasselaers D, Milants I, Desmet L, Wouters PJ, Vanhorebeek I, van den Heuvel I, et al. Intensive insulin therapy for patients in paediatric intensive care: a prospective, randomised controlled study. *Lancet*. 2009;373(9663):547-56.
14. Macrae D, Grieve R, Allen E, Sadique Z, Morris K, Pappachan J, et al. and Investigators CH. A randomized trial of hyperglycemic control in pediatric intensive care. *N Engl J Med*. 2014;370(2):107-18.
15. Buchleitner AM, Martinez-Alonso M, Hernandez M, Sola I, and Mauricio D. Perioperative glycaemic control for diabetic patients undergoing surgery. *Cochrane Database Syst Rev*. 2012;9:CD007315.
16. Christiansen CL, Schurizek BA, Malling B, Knudsen L, Alberti KG, and Hermansen K. Insulin treatment of the insulin-dependent diabetic patient undergoing minor surgery. Continuous intravenous infusion compared with subcutaneous administration. *Anaesthesia*. 1988;43(7):533-7.
17. Raucoules-Aime M, Lugin D, Boussofara M, Gastaud P, Dolisi C, and Grimaud D. Intraoperative glycaemic control in non-insulin-dependent and insulin-dependent diabetes. *Br J Anaesth*. 1994;73(4):443-9.
18. Brady M, Kinn S, Ness V, O'Rourke K, Randhawa N, and Stuart P. Preoperative fasting for preventing perioperative complications in children. *Cochrane Database Syst Rev*. 2009;4:CD005285.
19. Mucha GT, Merkel S, Thomas W, and Bantle JP. Fasting and insulin glargine in individuals with type 1 diabetes. *Diabetes Care*. 2004;27(5):1209-10.
20. Al-Khawari M, Al-Ruwayeh A, Al-Doub K, and Allgrove J. Adolescents on basal-bolus insulin can fast during Ramadan. *Pediatr Diabetes*. 2010;11(2):96-100.

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Appendix 1: Preparing, starting and adjusting an insulin infusion using Insulin Adjustment Algorithm

Preparing an insulin infusion in PICU

- In PICU due to the availability of syringe pump drivers with programmable smart pump technology a syringe containing an insulin concentration of **1unit/mL** may be prepared.
- To prepare 1unit/mL syringe for use in a programmable smart pump in PICU only:
 - Draw up 50 units of insulin (Actrapid or Humulin R) in an insulin syringe (calibrated in units) and add to sodium chloride 0.9% to give a final volume of 50 mL (giving a solution of 1 unit insulin in 1mL). Mix well by inverting the syringe several times.
 - Prime the connecting tubing by running some of the infusion into a kidney dish (usually 5mL is used to prime the line since insulin also adsorbs to plastic).

Preparing an insulin infusion in the Wards and Emergency Department

- Due to the unavailability of syringe pump drivers with programmable smart pump technology on most ward areas and in ED, a bag containing an insulin concentration of **0.1unit/mL** is used.
- To prepare 0.1unit/mL bag for use in wards and ED:
 - Add 100 units of insulin (Actrapid or Humulin R) to 1000mL of sodium chloride 0.9%.
 - Mix well by inverting the bag several times.
 - Prime the connecting tubing by running some of the infusion into a kidney dish.

Starting insulin dose and adjusting the insulin infusion

- The initial insulin infusion rate is 0.02-0.03 units/kg/hr. The starting dose will be specified by the Endocrine team. The insulin infusion can be run through the same line as the IV glucose containing fluids.
- If BGL is >15mmol/L at initiation of insulin infusion consider starting at higher dose of up to 0.06units/kg/hr.
- Administer IV fluids containing 5% glucose at maintenance rate.
- Perform hourly BGLs while on an insulin infusion.
- Maintain blood glucose level (BGL) between 5 and 10mmol/L by adjusting the rate of the insulin infusion up or down by increments of 10–30%, as needed, using the “Perioperative IV Insulin Infusion Adjustment Algorithm” below.
- If the patient is hypoglycaemic (BGL between 3-4mmol/L), temporarily cease the insulin infusion for 30 minutes, then recheck BGL and resume insulin infusion at a 40% lower rate when the BGL is >5mmol/L while continuing maintenance IV maintenance fluids containing glucose (IV insulin has a half-life of only 3 to 4 minutes).

- If the patient is severely hypoglycaemic (BGL <3mmol/L or symptomatic), temporarily cease the insulin infusion and urgently give 2mL/kg IV bolus of 10% glucose or equivalent. Recheck BGL in 15 minutes and resume insulin infusion at a 40% lower rate when the BGL is >5mmol/L.
- Do not stop the insulin infusion if blood glucose 4-5mmol/L as this will cause rebound hyperglycemia. Reduce the rate of infusion instead.
- Give replacement potassium if the patient continues IV fluids and is nil by mouth for more than 12 hours.
- The intravenous insulin infusion and IV fluids containing glucose are continued until oral food intake has been established and subcutaneous insulin therapy is possible. When changing to subcutaneous insulin as per Endocrine team, continue the intravenous insulin infusion for 90 minutes after the first subcutaneous insulin injection.

Appendix 1: Peri-operative IV Insulin infusion – Adjustment Algorithm

(E.g. if a 20kg child is on a starting rate of 0.02 Units/kg/hr, this equals 0.4 Units/hr = 0.4mL per hour if using 1unit/mL solution in PICU, or 4mL per hour if using 0.1unit/mL in ED or on the wards)

The table indicates the change in insulin infusion rate from the current hourly rate according to the current BGL and rate of change of BGL in the previous hour.

Current BGL (mmol/L)	Recommended Adjustment in INSULIN infusion rate based on change in BGL in last hour and current BGL						
	No change (within +/- 0.5mmol/L of last hours BGL)	Falling slowly Fall of 0.6 – 2 mmol/L in last hour	Falling moderately Fall of 2.1-4 mmol/L in last hour	Falling quickly Fall of > 4mmol/L in last hour	Rising slowly Rise of 0.6 – 2 mmol/L in last hour	Rising moderately Rise of 2.1 – 4 mmol/L in last hour	Rising quickly Rise of > 4mmol/L in last hour
> 15mmol/L	Increase by 10%	Increase by 10%	No change	Decrease by 20%	Increase by 20%	Increase by 20%	Increase by 20%
12.1 –15mmol/L	Increase by 10%	Increase by 10%	Decrease by 10%*	Decrease by 20%*	Increase by 20%	Increase by 20%	Increase by 20%
8.1 – 12mmol/L	Increase by 10%	No change	Decrease by 20%*	Decrease by 30%*	Increase by 10%	Increase by 20%	Increase by 20%
5.1 – 8mmol/L	No change	Decrease by 10%	Decrease by 20%*	Decrease by 50%*	No change	No change	Increase by 20%
4.1 – 5mmol/L	Decrease by 10%	Decrease by 20%	Decrease by 30%*	Decrease by 50%*	No change	No change	No change
3.1 – 4mmol/L	<ul style="list-style-type: none"> Cease insulin infusion temporarily. Recheck BGL in 30 mins & when BGL >5mmol/L recommence infusion at 40% lower than the previous rate. 						
≤ 3mmol/L	<ul style="list-style-type: none"> Cease insulin infusion Give IV bolus 2mL/kg of 10% Glucose. Recheck BGL in 15 mins & when BGL >5mmol/L recommence insulin infusion at 40% lower than the previous rate 						

*Recheck BGL in 30 minutes