

Blood Glucose Management in Adult Critical Care

This guideline describes the glycaemic control of patients in Adult Critical Care. It includes guidance on insulin management, how often to measure blood glucose levels, and management of diabetic ketoacidosis (DKA) and hyperosmolar hyperglycaemic state (HHS)

Key Points:

- **Standard insulin preparation is 50units insulin Actrapid® to 50mL sodium chloride 0.9%**
- **Target blood glucose (BG) levels (arterial) between 4.5mmol/L- 10 mmol/L**
- **Type 1 diabetics must be given regular insulin (either by a continuous infusion or prescribed regular subcutaneous [SC] injections) with additional intravenous glucose given if BG is below the target range**
- **For hyperglycaemia during critical illness, insulin should be prescribed to maintain target BG if level is above 10 mmol/L for TWO consecutive readings within two hours**

See algorithm on insulin administration during critical care admission

- **Be mindful of the transition phase to a SC regimen when a patient still requires continuous enteral or parenteral feeding**

See conversion table to SC therapy

- **Ensure handover of glucose management to the ward is provided in writing and verbally.**

Disclaimer: Every effort has been made to ensure the content of these guidelines are correct. The information contained in these guidelines is not exhaustive. If in doubt, contact a senior colleague or expert.

Contents

	page
• Introduction	3
• Background	3
• Blood glucose management	3
• Frequency of glucose measurements	4
• Treatment of high glucose measurements	4
• Stopping feeds	5
• Transition from surgery and to ward care	5
• Converting to subcutaneous insulin therapy	5
• Hypoglycaemia	5
• Diabetic ketoacidosis	6
• Hyperosmolar hyperglycaemic state	6
• References	6
• Table 1	7
• Flowchart 1	8

Introduction

The monitoring and control of blood glucose concentrations is vital for all critical care patients. Patients will fall into one of five categories (although there may be some 'cross-over' in these):

1. Known type 1 diabetics with intercurrent illness
2. Known type 2 diabetics with intercurrent illness
3. Patients with ketoacidosis (DKA)
4. Patients with in a hyperosmolar hyperglycaemic state (HHS)
5. Non-diabetic patients with glycaemic control compromised by acute illness

Background

It is increasingly recognised that the glycaemic management strategy should depend on which of these groups a patient is in. In addition to this, three principles should be considered:

1. Type 1 diabetics always require some insulin. Insulin infusions or long-acting insulin administered sub-cutaneously should not be interrupted. If a patient is hypoglycaemic, glucose should be administered and the intravenous infusion rate or sub-cutaneous dose of insulin reduced or reviewed but not discontinued.
2. Patients in HHS require controlled rehydration before insulin therapy is considered.
3. Regular and frequent blood glucose monitoring is essential and should be at an intensity dictated by the stability of the patient's glycaemic control.

Blood glucose measurement

Blood glucose (BG) measurements may be completed using a glucose meter or using a blood gas analyzer. Staff should ensure they have received appropriate training with the relevant equipment beforehand.

Both glucose meters and blood gas machines may be needed for the measurement of patients managed on the ICUs. Blood gas analysis machines are recognized as being more accurate, and where possible should be used in preference to blood glucose meters.

Blood samples used for blood glucose measurements may be taken from arterial blood or venous blood. For venous samples, ensure the catheter is not being used to deliver a glucose-containing infusion.

When an alternative is not available samples may also be taken using a finger-prick technique. Finger-prick samples are less accurate in hypotensive patients or those on large doses of vasopressors and in patients with HHS and should be avoided in the ICU wherever possible.

Blood samples aspirated from venous or arterial lines are simple to use and cause patients less trauma than repeatedly taking finger prick samples. A drawback of these samples is that they may occasionally be contaminated by infusion fluids used for arterial or venous catheter flush lines. This risk is greatest if the infusion fluid contains glucose.

- **On admission to the ICU, all patients must have a BG measured**
- **BG levels MUST be checked in the event of sudden loss of consciousness, or unexplained sweating, tachycardia or hypotension**
- **Any abnormal BG level (>18mmol/L or <4mmol/L) MUST be confirmed by taking a second sample (in high results check no glucose containing product potentially contaminating the sample)**
- **A venous blood sample must be sent to the laboratory for BG measurement if blood gas or glucose meter measurement reads <2.2mmol/L**

Frequency of blood glucose measurement

As a guide check glucose measurements:

- On admission
- At first hour after admission
- At second hour after admission
- At fourth hour after admission
- Every 4 hours thereafter

If a variable rate insulin infusion is started, check BG **every hour** for the first 2 hours. If changes are made to the insulin rate, new glucose infusion or feeding rate, re-check after 15mins.

Decrease frequency to every 2 hours if BG remains stable.

Treatment of high blood glucose levels

Any BG >10mmol/L should be checked one hour later. Start insulin if BG is >10mmol/L on two consecutive readings.

Target BG is 4.5-10mmol/L.

Insulin infusion is made up using human actrapid insulin 50 units to 50ml sodium chloride 0.9% (1 unit/mL).

Insulin infusions must be accompanied with supportive parenteral glucose supplementation or enteral feeding.

Inform medical staff if BG level is:

- < 4mmol/L
- >20mmol/L
- >10mmol/L after 6 hours of insulin

Factors which may increase insulin requirements:

- Rises in temperature
- Diabetic patients, or patients with a high body mass index (BMI)
- Steroid therapy
- Post seizures

Stopping feed

If feeding is stopped, check the most appropriate strategy for the insulin infusion. Options are:

- Stop insulin – but not in type 1 diabetics.
- Start a glucose infusion if insulin infusion continues

Re-commence hourly blood glucose measurements until BG levels are stable

Transition from surgery and to ward care:

From theatres:

- All surgical patients will not be given enteral nutrition typically for the first 12- 24 hours after surgery.
- Type 1 diabetics - glucose and insulin infusions are always initiated in theatres and continued on the ICU. Insulin dosing is managed as per Flowchart 1 (see end of document) strategy.
- Type 2 diabetics – insulin is initiated as per Flowchart 1 strategy. Glucose must be initiated if the BG is < 10mmol/L and patient is unlikely to be extubated within 4 hours after surgery
- Insulin and glucose therapy is continued until the patient is extubated and enteral nutrition is established i.e. patient can eat and drink or the insertion of a nasogastric feeding tube.

NOTE: cardiac surgical patients require glucose 50% as the dilution of choice

To wards:

- Parenteral glucose may be required – senior to review.
- The diabetes team should be involved if new or undiagnosed diabetic.
- Ensure patients who have insulin infusion ceased prior to discharge, handover to ward to check BG within 4 hours.
- All patients discharged must have a handover strategy written in the discharge summary as well as a verbal handover.

Converting to subcutaneous insulin therapy

1. Insulin-Naïve Patients - When patient is able to eat and drink:

Total daily dose (TDD) : patient's actual weight (kg) x 0.3units. If obese (BMI>30), use 0.5units/kg.

Basal-bolus regimen	Lantus® – 50% total dose at 10pm Novorapid®– remaining dose divided equally between pre-breakfast, pre-lunch and pre-evening.	The first dose should be the long acting insulin. Discontinue IV insulin 1hour after SC dose of Lantus.
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2. Re-Commencing Pre-Admission Insulin Therapy in Type 1 Diabetic Patients Who Can Eat and Drink

Check most recent HbA_{1c}
<58mmol/mol (7.5%), restart as above for basal-bolus regimen
>58mmol/mol (7.5%), discuss with the diabetes team

Hypoglycaemia

Typically happens when:

- Too much insulin is given inadvertently
- Insulin is given in the absence of feeding or glucose supplementation
- Occasionally in severely septic patients
- Occasionally in patients with severe liver failure or adrenal failure

Symptoms can be difficult to spot in sedated patients but include:

- Loss of consciousness, include seizure activity
- Sudden sweating
- Sudden tachycardia
- Sudden hypotension or resistance to inotropes

Management of severe hypoglycaemia (<2.2mmol/L):

- Stop insulin infusion
- Immediately re-check BG to confirm severe hypoglycaemia
- If confirmed send laboratory BG sample
- IV Bolus 50mL glucose 10% or 25mL glucose 20% or 10-20mL 50%
- Re-check BG in 15mins then hourly thereafter

Diabetic ketoacidosis (DKA)

- Fixed dose insulin infusion of 6 units/hour
- Rehydration
 - 0.9% NaCl solution and other electrolytes, as required
 - For monitoring parameters, refer to the **Grey Book** guidelines on DKA

Intranet access:

[http://stginet/Publications/Clinical%20Publications/Grey%20book/Diabetic%20Ketoacidosis%20\(DKA\).pdf](http://stginet/Publications/Clinical%20Publications/Grey%20book/Diabetic%20Ketoacidosis%20(DKA).pdf)

Hyperosmolar hyperglycaemic state (HHS)

HHS is frequently precipitated by intercurrent illness, in particular sepsis. Associated mortality is much greater than that for DKA and patients are frequently best managed in a high dependency unit (HDU) setting.

Indications for admission to an area of higher level care:

Osmolality > 350 mosmol/kg	Sodium > 160 mmol/L*	Venous/arterial pH < 7.1
Hypokalaemia (< 3.5 mmol/L) or hyperkalaemia (> 6 mmol/L)	Macrovascular event such as myocardial infarction or stroke	Oxygen saturation < 92% on air
Systolic blood pressure < 90 mmHg	Pulse > 100 or < 60 bpm	Urine output < than 0.5 mL/kg/hr
Serum creatinine > 200 µmol/L	Hypothermia	GCS < 12
Other serious co-morbidity		

***Caution: patients presenting with a mixed DKA and HHS profile may feature with normo- or hyponatraemic state. Seek senior review to exclude this diagnosis**

- Fluid resuscitation first
 - 0.9% NaCl solution and other electrolytes, as required with close monitoring
- Serum osmolality should be calculated from the formula [(2 x Na) + urea + glucose] (as a surrogate for serum osmolality) using the most recently available values.
 - Initial calculations are made hourly from newly measured values by blood gas analysis
 - Calculated serum osmolality should fall by no more than 2 mosmol per litre per hour
- Insulin is only given if there is mixed DKA & HHS i.e. ketonuria 2+
- **See Table 1 for management of HHS**
- Avoid metformin
 - until renal function has improved
 - if IV radio-contrast is anticipated

REFERENCES

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2. Kramer AH, Roberts DJ, Zygun DA. Optimal glycaemic control in neurocritical care patients: a systematic review and meta-analysis. *Crit Care* 2012; DOI: 10.1186/cc11812
3. Joint British Diabetes Societies Inpatient Care Group . The management of the hyperosmolar hyperglycaemic state (HHS) in adults with diabetes. 2012 <http://www.diabetes.org.uk/Documents/Position%20statements/JBDS-IP-HHS-Adults.pdf> [Accessed April 2014]
4. McCartney MM, Gilbert FJ, Murchison LE, Pearson D, McHardy K, Murray AD. Metformin and contrast media - a dangerous combination? *Clin Radiol*. 1999; 54: 29-33.

Table 1. Management strategy for HHS

Tasks/Monitoring - Action in first 24 hours of ICU admission			
Caution in elderly -heart failure (rapid rehydration), acute kidney injury (insufficient rehydration)			
Assess:	Recent changes in medical/drug history	Degree of dehydration	
	Sepsis? Vascular event?	GCS	
	Foot risk score		
Measure:	Capillary BG	Venous BG	U&E
	Blood ketones	Lactate	Venous blood gas
	FBC	Blood cultures	ECG
	CXR	Urinalysis & culture	CRP
	Calculated osmolality (2Na + glucose + urea)		
Record hourly:	Osmolality	Glucose	Na
	Continuous pulse oximetry		Urine output
	Fluid balance		
	Continuous cardiac monitoring		
Prescribe:	NaCl 0.9% IV 500mL/hour - target 5-9L positive in first 12 hours		
	Prophylactic LMWH		
	IV antibiotics if sepsis identified/suspected		
Potassium:	>5.5mmol/L	⇒	No action
	3.5-5.5mmol/L	⇒	supplement 40mmol/L (over 4 hours)
	<3.5mmol/L	⇒	Supplement 40mmol over 2-4 hours and repeat if required
Monitor changes in serum Na and BG:			
Na*	Osmolality	FluidBalance	Action
↑	↓	-	NaCl rate unchanged
↑	↑	Check balance	change rate ⇕ depending on target
-	↑	√	Start NaCl 0.45% at same rate
-	↓>8mosmol/kg/hr	-	↓rate of fluids and insulin (if started)
If significant ketonuria (2+ or more) – mixed DKA &HHS (Target BG 10-15mmol/L – if <14mmol/L start glucose 5% or 10% at 125mL/hour)			
Start insulin if: BG is no longer decreasing with rehydration OR There is significant ketoacidosis Initial dose: fixed rate 0.05 units/kg/hour Check fluid balance and increase NaCl rate If positive balance, increase insulin (if already running) to 0.1unit/kg/hour			
Monitor:	CNS injury e.g. cerebral oedema		sepsis
	daily U&Es		LMWH
	Foot checks		
* In the early phase, serum sodium may rise but osmolality continues to fall during NaCl rehydration. This is expected and not an indication to use fluids to lower sodium at this stage.			

FLOWCHART 1. INSULIN INTRAVENOUS INFUSION GUIDELINE

Notes:

- 10% (peripheral) and 20% (central) glucose is the preferred dilution.
- *50% (central) glucose is the preferred dilution in diabetic patients only after cardiac surgery
- **DO NOT USE THIS FLOWCHART FOR THE INITIAL MANAGEMENT OF DIABETIC KETOACIDOSIS (DKA) OR HYPERGLYCAEMIC HYPEROSMOLAR STATE(HHS)**

