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Harrogate District Hospital
Critical Care Unit

Guidelines for Glycaemic Control in Critical Care

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CONTENTS

INTRODUCTION

Hyperglycaemia is commonly seen in patients who are critically ill and represents the body's impaired ability to regulate glucose levels during periods of stress such as acute illness, surgery or trauma. This phenomenon is described as Stress Induced Hyperglycaemia (SIH).[1] It is thought to be the result of several different metabolic processes that include gluconeogenesis, catecholamine and cortisol release mediated by the hypothalamic-pituitary-adrenal (HPA) axis and the sympatho-adrenal system.[1]

Glucose control in the critically ill has become a topic of increased interest and importance over recent years following a landmark study by Van Den Berghe et al in 2001. This study reported an absolute reduction in mortality of 4% in patients who's glucose levels were kept between 80 and 110mg/dL (4.4-6.2mmol/L), compared to a cohort where treatment was initiated when levels were greater than 200mg/dL (11.1mmol/L).[2] In addition to increasing mortality, hyperglycaemia has been shown to impair wound healing, increase the risk of infection and increase length of stay.[3]

Hypoglycaemia however is a complication which may occur as a result of treatment for SIH and can cause significant complications such as seizures, coma and death if untreated.[4,5,6,7] The implementation of "tight glycaemic control" (BG 4.4-6.2 mmol/L) was shown in later trials to increase rates of hypoglycaemia, which was associated with an increase in mortality.[8,9]

The literature suggests therefore that uncontrolled blood glucose levels are unacceptable, and that tight control may increase the risk to patients.[2,10-13] We can conclude that dysglycaemia should be avoided in the critically ill but it remains unclear as to what value constitutes normoglycemia in such patients.

To address this, a number of national and international groups have suggested parameters for Blood Glucose (BG) levels, recommending that ideal blood glucose should be kept in the range of 6-10mmol/L and that 4-12mmol/L is acceptable.[14-18]

As such, we conducted an audit of current glycaemic control practice in Harrogate District Hospital Critical Care using the values of 4-10mmol/L as the target range. The results showed that more than half of our patients (both ventilated and non-ventilated) spent considerable time out of the set glycaemic range. Whilst not statistically tested, the patients who spent time out of range had a longer duration of stay in critical care compared to those that did stay in range in the first 48 hours.

This guidance has been produced in response to the need identified to standardize our care of dysglycaemia on our critical care unit. A number of other Critical Care protocols were reviewed for guidance, notably Nottingham University Hospitals NHS Trust[19], Alfred Health[20], Yale New Haven Hospital[21], Sheffield Teaching Hospitals NHS trust, and Joint British Diabetes Societies for inpatient care[22].

Exclusions

This guideline is only for use on the critical care unit. It is not intended to be applied to the following patient groups:

- Patients who are not on critical care
- Patients with diabetic ketoacidosis or hyperosmolar hyperglycaemic state
- Adults receiving end of life care
- Children

Associated documentation available on HDFT trust website: (add links….)

- Hypoglycaemia
- Diabetic Keto-acidosis
- Hyperglycaemic Hyperosmolar State

Variable Rate Intravenous Insulin Infusion (VRIII)

Insulin is prescribed as a Variable Rate Intravenous Insulin Infusion (VRIII). It is important that it is made up correctly and given according to the protocol. At HDFT, the VRIII are pre-made and available from pharmacy. However should you need to set up a VRIII please see the below.

How to set up a VRIII (Joint British Diabetes Society):

Two registered nurses must check and prepare the VRIII and every time the rate of infusion is changed.

- INSULIN MUST BE DRAWN UP USING AN INSULIN SYRINGE. NO OTHER SYRINGE TO BE USED
- Draw up 50 units of prescribed Human Actrapid insulin* and add to 49.5 ml of 0.9% sodium chloride in a 50 ml luer lock syringe. Mix thoroughly
- This will provide a concentration of 1 unit/1ml
- Complete the drug additive label in full; signed by 2 registered nurses and placed on the syringe barrel; not obscuring the numerical scale
- Prime through an appropriate giving set with a non-return valve
- Set up an intravenous insulin syringe-driver pump
- Discard any unused insulin solution after 24 hours

- Intravenous fluid must be administered using a volumetric infusion pump
- Delivery of the substrate solution and the VRIII must be via a single cannula or two lumens of a central line with appropriate one-way and anti-siphon valves
- Set the concurrent fluid replacement rate to deliver the hourly fluid requirements of the individual patient as prescribed which must take into account their individual circumstances. (See section 3.7 of main guideline). The rate must not be altered thereafter without senior advice
- Insulin should not be administered without substrate unless done in a critical care setting and upon senior advice
- Insulin must be infused at a variable rate aiming for a glucose of 6-10 mmol/L (acceptable range 4-12 mmol/L)
- Continue the substrate solution and VRIII until the patient is eating and drinking and back on their usual glucose lowering medications

Monitoring

Testing Methods

Capillary Blood Glucose (Finger Prick) sampling can result in erroneous results in patients with hypotension or those receiving high dose vasopressors. We therefore recommend aspirating samples from arterial or venous lines, and to use the blood gas analysis machine.

It is the responsibility of the staff member taking the sample to ensure that a blood sample is taken from a line not primed with a glucose solution. It is protocol at HDFT to use 0.9% Sodium Chloride for arterial lines. If a venous line is used such as central venous catheter, please ensure that no glucose containing infusions are running concurrently.

Frequency

Blood glucose should be measured **on admission** to the unit and then **every hour** until **three** consecutive readings of 4-10mmol/L are recorded. If the BG level does not fall below 11 mmol/L over these 3 readings, start a VRIII (see Hyperglycaemia section).

Any patient on a VRIII should have their BG checked **every hour** for the first **3 hours**, and then every **2 hours**. If at any point the rate is changed, then check the BG **hourly** for the following 2 hours, and if it remains in range then revert checking to every 2 hours.

The following patients should have their BG checked every **4 hours**:

- All diabetic patients
- Those receiving iv glucose, TPN, or continuous enteral feed
- Patients who are nil by mouth
- Those with acute liver failure or acute pancreatitis
- Patients receiving steroids

Non diabetic patients who are eating and drinking normally or on long term enteral feed, and are NOT critically ill should have their BG checked **once daily**.

Blood Ketones

If BG >14 mmol/L, blood ketones (BK) should be checked.

- BK <0.6
  - Normal
- BK 0.6 – 1.4 mmol/L
  - Check BK in 2 hours
- BK 1.5 – 2.9 mmol/L
  - Increase VRIII to next regime up, and repeat BK every 2 hours
  - Increase regimes until BK <1.5 mmol/L
- BK >3 mmol/L
  - Check urine ketones, pH, HCO3 and osmolality
  - May need to convert to DKA or HHS protocol

Fluid and feeding requirements

Insulin is a hormone that controls blood sugar levels. It stimulates uptake of glucose and potassium into cells for use in metabolic pathways. A VRIII infusion must therefore be accompanied by a form of carbohydrate substrate to prevent inducing hypoglycaemia in patients following the administration of insulin. Potassium may also need to be replaced to maintain normal levels.

The standard fluid prescription for critical care patients is:

- 50mL/hour 10% Glucose + 20mmol KCL

This should run alongside the VRIII into the same port of access.

In different situations, the need for a glucose solution may change:

BG <14mmol/L

The VRIII must be accompanied by a carbohydrate source (glucose/food source) to prevent hypoglycaemia. The options are as follows:

- Glucose infusion (50mL/hour of 10% Glucose + 20mmol KCL)
- Oral diet
- Total Parenteral Nutrition (TPN)
- Feeding via nasogastric, nasojejunal, jejunosotomy or percutaneous gastrostomy tubes
    - 40 mL of absorbed standard enteral feed is equivalent to 50mL of 10% Glucose

BG >14mmol/L

If the blood glucose is above 14 mmol/L in a patient receiving a VRIII, they **do not require** an additional glucose infusion. The glucose infusion should be recommence as soon as the BG drops below 14mmol/L. If a patient is receiving a form of feed however, this should continue.

If feeding is commenced or ceased, **hourly** blood glucose monitoring should recommence, and the need for insulin reviewed. Should insulin still be required, and the BG is <14mmol/L, start 10% Glucose infusion at 50mL/hr until feed can be recommenced.

Potassium

- Aim to keep the potassium between 4.0-5.0 mmol/L
- If potassium > 5.5, no additional potassium is needed
- If potassium <3.5, additional potassium may be required

Management of Hyperglycaemia

None-Diabetic Patients

If a patient has 3 (on admission, at hour 1, then at hour 2) consecutive BG >10 mmol/L, a VRIII should be commenced:

- BG 10-18 mmol/L
  - Start regime 1
  - Repeat BG in 1 hour
  - Adjust VRIII according to result

- BG >10mmol/L for more than 6 hours despite being on VRIII:
  - Increase VRIII – regime 2

- BG >18mmol/L
  - Nursing staff to inform the medical staff

A reading of over 18mmol/L should lead to the consideration of a bolus dose of short acting insulin such as Novorapid or Humalog. We would advise giving **1 unit of Novorapid** or **Humalog** to aim to drop the BG by 3mmol/L. The dose may need to be repeated, and therefore hourly BG readings should be taken. If after 2 hours, the BG remains uncontrolled a second dose of Novorapid or Humalog may need to be given, taking into account the response from the first bolus (may need a higher dose for the second bolus).

Any patients with a **BG of >10mmol/L** should have **hourly** samples taken, until the BG is in the range of 4-10mmol/L.

See Appendix 1 for flowchart guidance

Feeding Reminder:

- BG >14 mmol/L
  - TPN/NG/Enterally fed – continue feed (see above)
  - No current feeding regime – no requirement to start glucose iv
- BG <14mmol/L
  - Continue feed regime
  - If no feeding regime in place, commence Glucose 10% 50mL/hour

Most patients will should have their usual diabetic medication completely withheld whilst they are on a VRIII including oral and injectable hypoglycaemic drugs. The exception is long acting insulin.

Diabetic patients should **remain** on their **basal (long acting) insulin** (e.g. Levemer, Lantus, Tresiba, Insulatard, Humulin) in addition to receiving a VRIII **unless** they are receiving vasopressors (noradrenaline, metaraminol) or inotropes (adrenaline) or have uncorrected Hyperosmolar Hyperglycaemic State.

The aim should be to convert back to standard (oral or subcutaneous) medication as soon as patients are able to eat and drink, provided that the VRIII can be discontinued safely.

Avoid restarting a VRIII if a diabetic patient becomes hyperglycaemic when the VRIII is withdrawn. Please refer to the Diabetes team or Diabetes Nurse Specialist.

Discontinuation of a VRIII in a diabetic patient

Principles for a safe step down:

- Patient must have recovered from the precipitating illness/condition and be eating and drinking reliably
- Blood glucose targets must be achieved on the VRIII

For insulin treated patients

- Background insulin should have been continued. If it has not been continued or patient insulin naïve, a background insulin either within a mixed insulin or as part of a basal bolus regime MUST be given prior to stopping the VRIII
- VRIII should only be discontinued 30 minutes after subcutaneous insulin has been given. This should ideally be at a meal time, after short-acting insulin or mixed insulin has been given. Avoid stopping VRIII at bedtime where there is less observation by staff
- For insulin naïve patients the insulin dose can be calculated on a weight basis or by calculating the insulin requirement over the last few hours on the VRIII. See Appendix 2 for details
- If the blood glucose rises after VRIII is discontinued, do not restart the infusion. Contact the diabetes team for advice

For non-insulin treated patients

- Give normal treatment prior to discontinuing VRIII
- Consult the diabetes team for detailed guidance if control prior to admission was suboptimal

When ready to discontinue a VRIII and recommence short acting insulin regime, the VRIII should be stopped one hour after the first dose of short acting insulin. The patient must however be being fed, and glucose must be measured hourly for the first two hours, then two hourly for 24 hours.

Type 2 diabetics not on insulin should have their normal medications recommenced when clinically appropriate. The VRIII must be discontinued before giving the medication and the patient must be being fed. Glucose should be measured two hourly for six hours after the first tablet.

See advice from Joint British Diabetes Society on restarting insulin:

Restarting insulin for patients previously on subcutaneous insulin

Convert to subcutaneous insulin when the patient is able to eat and drink and has managed at least one meal. Ideally the transfer should take place at a mealtime, usually breakfast or lunch. Ensure that background insulin (either long acting analogue or isophane) has been given before the VRIII is withdrawn[75].

The VRIII should be continued until at least 30 minutes after the administration of a subcutaneous dose of insulin. This is to avoid rebound hyperglycaemia.

Most patients will restart their normal regime (see Table 6 for detailed advice). The pre-admission dose of insulin may need to be reduced if food intake is likely to be limited or the patient was admitted with low blood sugars.

Review diabetes treatment in all patients admitted with unstable blood glucose or HbA1c > 59 mmol/mol (7.5%), and refer to the diabetes in-patient team.

Hypoglycaemia

A separate protocol for the management of hypoglycemia already exists at Harrogate District Hospital. If a patient has a blood glucose level below 3.5 mmol/L, please refer to this protocol for management.

Discharge From Critical Care

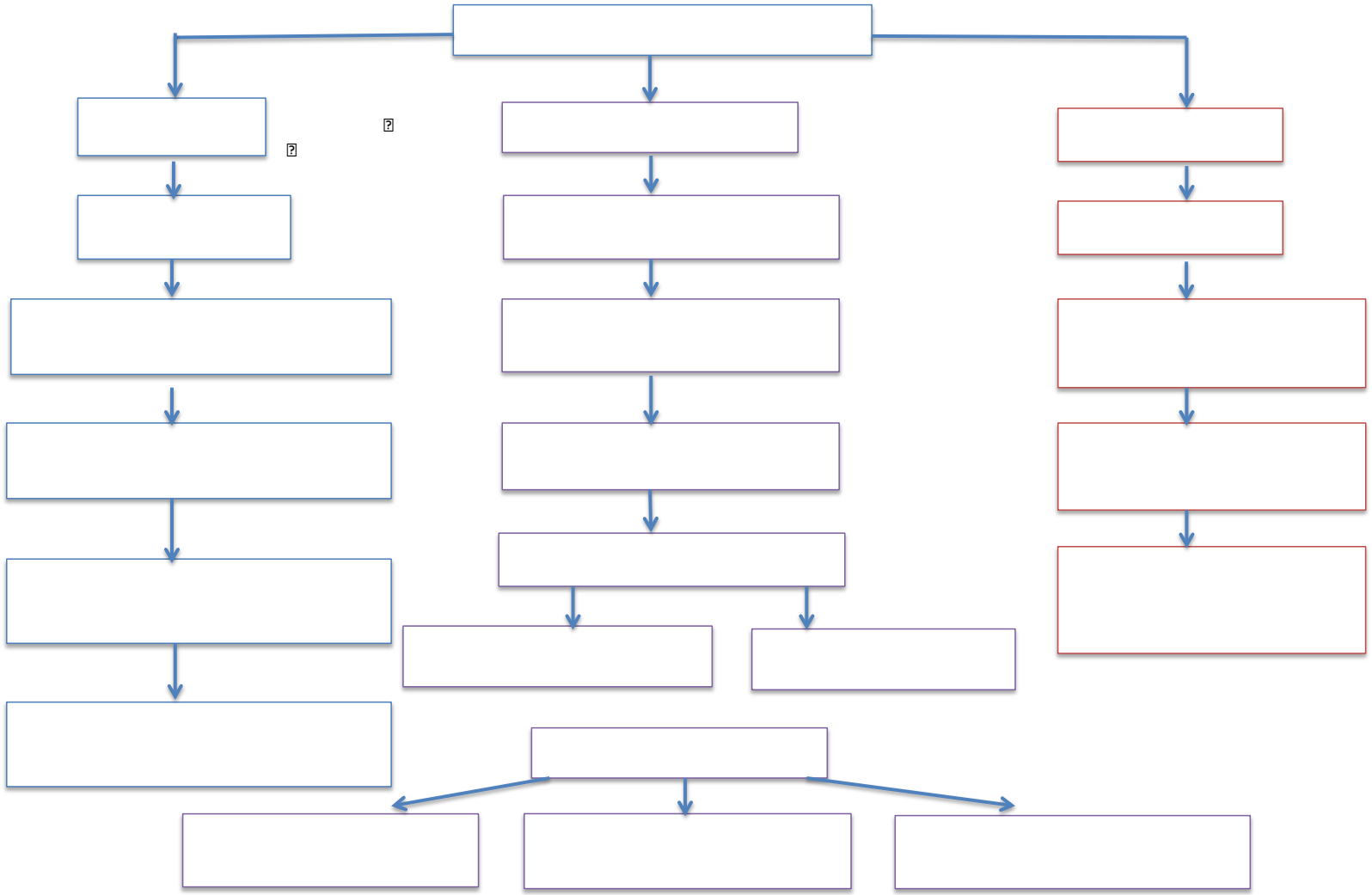
- None diabetic patients requiring <2 units/hour of insulin can be discharged without insulin, with a request for blood glucose check in 4 hours.

- None diabetic patients requiring >2 units/hour can be discharged with an ongoing VRIII. The VRIII prescription should be altered to reflect the regime used on the wards. The receiving team must be informed, and the patient referred the to the Diabetes Nurse Specialist/Endocrine team for ongoing assessment.

- For diabetic patients receiving insulin, basal and short acting insulin regimes should be recommenced when possible. Please discuss with the Diabetes Nurse Specialist.

- For Type 2 diabetic patients not usually receiving insulin, oral hypoglycaemics should be recommenced once the patient is eating and drinking. The dose of drug may need to be altered in view of the level of oral intake and previous insulin requirements. Please discuss with the Diabetic Nurse Specialist

Appendix 1 – Management of Hyperglycaemia



Appendix 2 – VRIII regimes

Blood Glucose mmol/L	Regime 1	Regime 2	Regime 3
0 – 3.9	0	0	0
4.0 – 6.9	1	1	1.5
7.0 – 8.9	2	2	3
9.0 – 10.9	3	4	5
11.0 – 13.9	4	6	8
14.0 – 19.9	6	8	10
>20.0	9	12	14

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