Diabetes Mellitus - Hyperosmolar Hyperglycaemic State (HSS) - Full Clinical guideline

Reference No.: CG-T/2023/053

Does my patient have confirmed HHS?

HHS carries significant morbidity and overall higher mortality than DKA. It needs to be diagnosed promptly and managed intensively.

A precise definition of HHS does not exist. However, the following would be reasonable:

1. High osmolality, often 320 mosmol/kg OR MORE
2. High capillary blood glucose (CBG), usually 30mmol/l OR MORE
3. Severely dehydrated and unwell

Confirm that patient does NOT have DKA

For patients with the following, follow the DKA guideline:

- Venous pH < 7.3 **or**
- Venous HCO_3 < 15mmol/l **or**
- Ketones – capillary ketones > 3mmol

What are the immediate actions required?

- ABC assessment including all routine observations including GCS
- Capillary blood glucose check and ketone check
- Obtain urgent IV access and commence fluids (As per box A, action 2)
- Venous bloods obtained for U&E, bicarbonate , FBC and venous blood gas and blood cultures
- Urinalysis for ketones (if capillary ketones not available), MSU, βHCG (*if applicable*)
- VTE prophylaxis - unless contraindicated
- **Calculate osmolality (2 X Na + glucose + urea)**

What are the areas of prescribing/management that need consideration?

Assess the patient and using this HHS full guideline or the HHS summary guideline, formulate a plan for the following:

1. Prescribe IV fluids as appropriate
2. Assess K+ level and add K+ to fluids if appropriate
3. Commence Fixed rate insulin infusion (FRII) at 0.05units/kg/hr **IF APPROPRIATE**
4. Ensure that the medical team and nursing staff know what monitoring is required
5. Be clear about what resolution of HHS looks like (the exit strategy). Unlike DKA, the complete correction of electrolyte and osmolality abnormalities will likely take greater than 24 hours.

What are the KEY clinical considerations for safe management of patients'?

1. Underlying precipitant of HHS must be identified and treated if appropriate.
2. Fluid losses can be between 100-200ml/kg (10-22 litres in a person weighing 100kg)
3. When rehydrating patients, caution is required, especially in the elderly as too rapid rehydration may be **harmful** as it may precipitate heart failure. Insufficient rehydration may fail to reverse acute kidney injury.
4. Intravenous 0.9% sodium chloride solution should be used as the principle fluid to restore circulating volume and reverse dehydration. <u>The sodium may initially rise and is not an indication for hyotonic fluids.</u>
5. Osmolality (2 X Na + glucose + urea) should be calculated frequently to monitor response to treatment.
6. IV fluid replacement should aim to achieve a positive balance of 3-6 litres by 12 hours.
7. Assessment for complications should be undertaken every 1-2 hours. Eg. Fluid overload, cerebral oedema or central pontine myelinolysis.
8. The fall in blood glucose should be no more than 5mmol/l/hr. Low dose insulin infusion (0.05units/kg/hr) should ONLY be started if the blood glucose is no longer falling with IV fluids alone **OR** if there is significant blood ketone (ketones > 1
9. Prophylactic anticoagulation should be considered in all patients. Consider contraindications. Early mobilisation is essential.
10. All patients should be assumed to be at high risk of foot ulceration. Appropriate foot offloading and regular review should be arranged.

When should a patient's care be escalated?

If patient does not respond to treatment as expected, **call for senior advice**. Severe HHS needs discussion with HDU/ITU.

- Osmolality greater than 350mosmol/kg
- Sodium above 160mmol/l
- Venous/arterial pH below 7.1
- Hypokalaemia (<3.5mmol/l) or hyperkalaemia (>6mmol/l)
- GCS < 12 or abnormal AVPU
- Shocked pulse > 100 or SBP < 90
- SpO_2 < 92%
- Urine output < 0.5ml/kg/hr
- Serum creatinine > 200μmol/l
- Hypothermia
- Macrovascular event such as MI or stroke
- Other serious co-morbidities

IV INSULIN INFUSION CAN BE STOPPED ONCE THE PATIENT IS EATING AND DRINKING BUT IV FLUIDS MAY NEED TO BE CONTINUED FOR LONGER.

What do we ultimately want to achieve?

The goals of treatment of HHS are to treat the underlying cause and to gradually and safely:

- Normalise the osmolality
- Replace fluids and electrolyte losses
- Normalise blood glucose

Prevent

- Arterial or venous thrombosis
- Other potential complications such as cerebral oedema/central pontine myelinolysis
- Foot ulceration

Please refer all patients with confirmed HHS to the diabetes team

Box A: Immediate Management: 0 to 24 hours	
Action 1.	**URGENT INITIAL ASSESSMENT AS ABOVE** **Assess for precipitating factors:** Non-compliance, sepsis/infection, stress, cardiac event, idiopathic, others (steroids, alcohol, pregnancy) **Stop** all nephrotoxic drugs and give prophylactic anticoagulation **CONTINUE BASAL INSULIN if patient usually has insulin -** For example Insuman Basal®, Humulin I®, Glargine®, Levemir®, Degludec®, Toujeo® Semglee® , Abasaglar®**.** **If FRII is indicated (see action 3), continue SC basal acting alongside the FRII.**
Action 2.	**IV FLUIDS** - exercise extreme caution in the elderly, CCF and end stage renal failure Commence 0.9% sodium chloride via an infusion pump **Is the patient shocked?** If systolic BP < 90mmHg: • Give 1 litre of 0.9% sodium chloride over 15 minutes • If systolic BP remains < 90mmHG, repeat and call senior medical colleague for advice If systolic BP > 90mmHg: • The rate of fluid replacement depends on the age, fitness, dehydration of the patient. Plan fluid replacement and use clinical judgement. Typically, though (for guidance): **Bag 1** – 0.9% sodium chloride 1 litre +/- potassium over next 2 hours **Bag 2** – 0.9% sodium chloride 1 litre +/- potassium over next 2-4 hours **Bag 3** – 0.9% sodium chloride 1 litre +/- potassium over next 4-6 hours **Bag 4** – 0.9% sodium chloride 1 litre +/- potassium over next 6-8 hours **Bag 5** – 0.9% sodium chloride 1 litre +/- potassium over next 8-10 hours PLEASE REFER TO **ACTION 4** TO ASSESS IF POTASSIUM IS REQUIRED **Aim to reduce calculated osmolality by <u>5mosmol/kg/hr</u>.** **Aim to reduce the capillary blood glucose by <u>5mmol/l/hr</u>** **Once the glucose is no longer falling by 5mmol/hr , consider starting the fixed rate insulin infusion (FRII) – see Action 3**

Action 3.	**INSULIN** Insulin replacement prior to adequate fluid resuscitation may result in cardiovascular collapse as water moves out if the intravascular space. **Option 1.** <u>If significant ketonaemia is NOT present</u> (blood ketone <1) - do NOT start insulin If patient usually uses insulin at home, the patients usual BASAL insulin should be continued. Once blood glucose level <u>has ceased to fall by 5mmol/hr despite fluid resuscitation</u> (ensure no ketone throughout): • Reassess fluid status • If CBG NOT falling by 5mmol/hr, start fixed rate insulin infusion (FRII) at **0.05units/kg/hr** (eg. 4 units/hr in an 80kg man) • If blood glucose drops **more than 5mmol/hr** – reduce the fluid rate as per clinical picture • Aim to keep blood glucose 10-14mmol in the first 24 hours. If CBG drops below 14mmol/l, start 10% glucose at 125ml/hr **Option 2.** If blood ketones > 1 - This indicates relative hypoinsulinaemia and insulin should be started at time 0 ALONGSIDE the fluids. If patient usually uses insulin at home, the patients usual BASAL insulin should be continued alongside the FRII. • Start fixed rate insulin infusion (FRII) at **0.05units/kg/hr** (eg. 4 units/hr in an 80kg man) • Aim to keep blood glucose 10-14mmol in the first 24 hours. If CBG drops below 14mmol/l, start 10% glucose at 125ml/hr <u>Rapid changes must be avoided – a safe rate of fall of plasma glucose of between 4 and 6 mmol/hr is recommended</u> Refer to **Box C** for guidance on stopping FRII

Action 4.	**Potassium (KCl):** Life-threatening hypokalaemia can occur with insulin infusion **Venous potassium level** — **Potassium Chloride(KCL) replacement** >5.3mmol/L — NONE 3.5-5.3mmol/L — 10mmol/hr (Eg. 20mmol over 2 hrs) <3.5 — Senior advice required **If KCl rate of infusion >10mmol/hr cardiac monitoring is recommended.** Senior input should be sought if cardiac monitoring is unavailable.
Action 5.	**Monitoring requirements** CBG → Hourly VBG → 4, 8, 12, 24, 36, 48 hours Fluid balance → Hourly NEWS → Hourly U&Es → 4, 8, 12, 24, 36, 48 hours **Osmolality** → Calculate at 4, 8, 12, 24, 24, 36 and 48 hours to monitor improvement
Action 6.	**Reassess patient:** **Poor urine output for > 2 hours** → Bladder scan/Catheterise **Persistent vomiting AND reduced GCS** → Consider NGT **SpO_2 <94% on air** → ABG/CXR **Persistent acidosis** → Consider other causes **GCS <13** → Consider CT Head **Seek senior review if patient not responding to treatment or is deteriorating**

Box B: Summary of clinical considerations	
Biochemistry	• Fall in glucose < 5mmol/L/hr • Fall in calculated osmolality of 3-8 mosmol/kg/hr • Sodium falls **must** be <10mmol/L in 24 hours • Aim for CBG target 10-14mmol/L. When CBG falls <14mmol/L, **ADD 10% glucose at 125ml/hr**. Adjust the 0.9% sodium chloride if concerned about overload. • For every 5.5mmol/l reduction in CBG, the sodium may rise by 2.4mmol/l • Complete normalisation of the biochemistry and volume status may take 72 hours. • Other electrolyte imbalances can occur – hypophosphataemia and hypomagnesemia - It these electrolytes abnormalities persist beyond the acute phase of treatment of HHS, oral or IV replacement (*as appropriate*) should be considered. -
Clinical	**Acute impairment in cognitive function is associated with dehydration.** Alterations in mental status are common with osmolalities more than 330 mosmol/kg. • Sunken eyes • Longitudinal furrows on the tongue • Extremity weakness Severe hypovolaemia may manifest as tachycardia and/or hypotension. Patients can be identified as high risk using the NEWS system. Caution advised in elderly, CCF, ERF, adolescence and pregnancy due to risk of **fluid overload**
VTE	These patients are at increased risk of thromboembolic events. In the absence of contraindications, ensure appropriate VTE prophylaxis prescribed and administered.
Foot protection	These patients are at high risk of pressure ulceration. An initial foot assessment should be undertaken and appropriate offloading provided. **Re-examine the feet daily.**

Box C: Summary of how to exit from fixed rate insulin infusion (FRII)

Aim for CBG target 10-14mmol/L. When CBG falls <14mmol/L, **ADD 10% glucose at 125ml/hr**. Adjust the 0.9% sodium chloride if concerned about overload.

Patient eating and drinking	Switch to patients subcutaneous insulin regimen. Stop FRII 60 minutes after administration of SC insulin (with meal)
Patient NOT eating and drinking or other indication for insulin infusion	Stop the FRII and **switch** to variable rate insulin infusion (VRII)

Refer to the diabetes specialist nurses early

Consider starting long-acting insulin such as Insulin Glargine (Semglee, Lantus) in new patients at 0.25 units/kg

Box D: Summary of typical fluid + electrolyte losses

Hyperglycaemia results in an osmotic diuresis and renal losses of water in excess of sodium and potassium. Thus in managing HHS there is a requirement to correctly identify and address both
dehydration and extracellular volume depletion. The deficits on presentation of HHS due to fluid losses are estimated as below:

		For 60kg patient	**For 100kg patient**
Water	100-200ml/kg	6-13 litres	10-22 litres
Na^+	5-13 mmol/kg	300-780 mmol	500-1300 mmol
Cl^-	5-15 mmol/kg	300-900 mmol	500-1500 mmol
K^+	4-6 mmol/kg	240-360 mmol	400-600 mmol

Development of Guideline:	Diabetes safety group
Consultation with:	Diabetes specialist nurses Diabetes consultants
Approved by:	Diabetes Safety Group – December 2020 Reviewed no change – DSG – Dec 2023 Medicine Division -
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