PEDIATRIC HYPERGLYCEMIC HYPEROSMOLAR STATE (HHS)

Pediatric HHS patients should be managed in conjunction with a pediatric diabetes specialist

DEFINITION

- Plasma glucose >33.3 mmol/L
- Venous pH >7.25
- HCO_3 >15 mmol/L
- Absent to mild ketonemia (β-hydroxy-butyrate (BOHB) <1.5 mmol/L or ketonuria neg to small)
- Effective serum osmolality >320 mOsm/kg (2 × Na + glucose)

INITIAL MANAGEMENT

- Continuous cardiorespiratory monitor
- Assess ABCDs, vital signs (including BP), neurovitals (GCS, pupils)
- O_2 10–15 Lpm non-rebreather mask (if signs of shock)
- IV access × 2 lines (large bore, consider intraosseous if unsuccessful)
- Immediate fluid resuscitation
- Serum glucose, electrolytes, venous gas, BOHB, urea, creatinine, serum osmolality, Ca, Phos, Mg, CK
- Urinalysis for glucose, ketones (bladder catheterization if needed)
- ECG for baseline assessment of K status (if delay in getting serum K level)

FLUID MANAGEMENT

FLUID RESUSCITATION:

- Administer NS (0.9% NaCl) or RL 20 mL/kg (MAX 1 L) IV bolus over 20 minutes (rapid push over 5–10 min if patient is hypotensive)
- Repeat NS or RL 20 mL/kg (MAX 1 L) IV bolus if ongoing hypoperfusion (cap refill >3 sec centrally, cool extremities)

ONGOING FLUID MANAGEMENT

- After initial bolus fluids, change to 0.45 to 0.75%* NaCl (+ potassium as below)
- Change to 0.9% NaCl if there is evidence of hypoperfusion, compromised hemodynamic status or cerebral injury
- Rate = **Maintenance + Deficit** [12–15% over 24–48 hours] **+ urine output (UO)**

HHS REHYDRATION TABLE (replacing 12% dehydration over 36 hours)
Baseline rate includes maintenance + deficit. Add UO q 2–4 hours

Weight	First 12 hours (mL/kg/h)	Next 24 hours (mL/kg/h)
5 to <10 kg	8 + UO	6 + UO
10 to <20 kg	7.5 + UO	5.5 + UO
20 to <40 kg	6.5 + UO	4.5 + UO
≥40 kg	5.5 + UO *(Max 500 + UO)*	4 + UO

**0.675% NaCl can be achieved by running ½ fluids as 0.9%NaCl and ½ as 0.45%NaCl*
0.75% NaCl can be achieved by running 2/3 fluids as 0.9%NaCl and 1/3 as 0.45%NaCl

GLUCOSE

- Rapid decline typical in the first several hours with rehydration alone
- If decreasing by more than 5.5 mmol/L/hr after the first few hours, add dextrose 2.5% to 5% to rehydration fluid
- If decreasing by less than 3 mmol/L, start insulin

ELECTROLYTES

- If K <5.5 mmol/L, add 40 mmol/L KCl into IV fluid.
- Risk of severe ↓ PO_4 leading to rhabdomyolysis. Treat if PO_4 is <0.5 mmol/L or symptomatic. Consider 20 mmol/L KCl plus 20 mmol/L KPhos
- Replacement of Mg should be considered in any patient with symptoms

INSULIN

- IV regular insulin 0.025–0.05 U/kg/h when BG no longer decreases with fluids alone
- Titrate insulin to decrease BG by 3–4 mmol/L/h

GOALS OF TREATMENT

- Decline of corrected serum Na 0.5 mmol/L/h. Higher mortality associated with failure of corrected Na to decline with treatment
- Ideal decline of serum glucose by 3–4 mmol/L/h (up to 5.5 mmol/L is acceptable)

ONGOING MONITORING

- Contact Peds Referral Centre/Transport Service/PICU
- Admit to PICU
- Cardiac monitor
- Q1h neurovitals, HR, BP, fluid ins-and-outs, POC glucose
- Q1–2h: Na, K, Cl , osm, venous gas
- Q2–4h: urea, creatinine, Ca, Phos, Mg, CK, (BOHB). Consider including lactate if concern for hypoperfusion

CAUTION

- Patients with HHS tend to have ***profound dehydration*** and electrolyte abnormalities at presentation. Do not rely on clinical or laboratory evidence to calculate % dehydration for rehydration fluids. Hypertonicity can result in an underestimate of the degree of dehydration.
- Osmotic diuresis may persist for several hours so ***aggressive fluid replacement is required*** to avoid vascular collapse and acute kidney injury.

MIXED HHS AND DKA

- Management must account for complications of both conditions, including cerebral injury. See DKA guidelines
- Use higher fluid rates than typical DKA, lower insulin rate (0.05 U/kg/h), and defer insulin until perfusion normalized

COMPLICATIONS

- Venous thrombosis with use of central venous catheters
- Rhabdomyolysis resulting in acute kidney injury, severe ↑ K, ↓ Ca, and compartment syndrome
- Malignant hyperthermia-like state (monitor for fever and ↑ CK)
- Altered mental status, but cerebral injury is uncommon. If present, refer to DKA guidelines

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