UC DAVIS HEALTH | CHILDREN'S HOSPITAL

PEDIATRIC HYPEROSMOLAR DIABETIC KETOACIDOSIS (DKA) TREATMENT PROTOCOL

GENERAL CONCEPTS

- Calculate serum osmolality: 2[Na(+)] + Blood Glucose(mg/dL)/18 + BUN(mg/dL)/2.8
- If this patient has: Plasma glucose above 600mg/dL AND serum osmolality greater than 325mOsm/kg with ketosis/acidosis, use this protocol (Hyperosmolar DKA)
- If this patient has: Plasma glucose above 600 mg/dL , AND minimal or no acidosis, AND minimal or no ketosis, AND osmolality greater than325 mOsm/kg, do not use this protocol, use HHS PROTOCOL.
- DKA causes anion gap metabolic acidosis due to production of ketoacids (beta-hydroxybutyrate & acetoacetate), causing extracellular shift and osmotic diuresis Exam and vital signs underestimate total body fluid deficits. It is generally safe to assume 5-10% dehydration, and plan to replace this over 24-48h
- Acidosis will correct with treatment; administration of bicarbonate is not recommended unless symptomatic hyperkalemia is present or CPR/resuscitation is necessary. It may increase risk for cerebral injury, worsen intracellular acidosis and hypokalemia
- Cerebral injury is the leading cause of morbidity and mortality in DKA (see below)
- Total body stores of all electrolytes (Na, K, Phos, Mag) are low in DKA due to renal losses
    - Na corrected = Na measured + 1.6 x [(Glucose-100)/100]; should normalize with treatment
    - Serum K may be high/normal/low, but total body stores are low
    - Low Phosphorous can lead to poor oxygen delivery to tissues

- ** For patients with known diabetes that use an insulin pump: please ensure that the insulin pump and infusion site are disconnected from the patient.

ED/PICU MANAGEMENT INITIAL RESUSCITATION/REHYDRATION

- Use actual body weight for fluid calculations (not ideal body weight)
- Do not administer bicarbonate unless symptomatic hyperkalemia or CPR/resuscitation
- Initial bolus: 20 ml/kg NS over 30 minutes. (maximum of 1 liter per bolus)
- Should be repeated if persistent evidence for inadequate organ perfusion on reassessment – many patients will require a second bolus based on clinical exam.
- Assume 10 to 12% dehydration.
- After bolus, start 0.45% NaCl at 3.5 x maintenance rate to replace the deficit (see below, maximum fluid rate of 500mL/hr)
- When “2 bags” are available (see below), transition to 2 bag system at this same rate.

INSULIN

- Do not bolus insulin
- Use actual body weight for fluid calculations (not ideal body weight) (Maximum initial insulin infusion 5 units/hr; infusion rate may be adjusted as needed later during treatment)
- Start insulin at 0.05 Units/kg/hr. May need to reduce insulin administration if glucose declines more rapidly than 50-75 mg/dL/hr to 0.03 Units/kg/hr.
- Begin infusion 2 hours AFTER start of fluid resuscitation
- Goals:
    - Lower glucose 50-100 mg/dL every hour
    - Maintain blood glucose 150-250 mg/dL while on infusion
    - Continue IV insulin until HCO3 17 – 20 mEq/L

- Anticipate a more rapid decline in potassium and phosphorus levels after insulin is started – consider increasing K and/or Phos concentration in IV fluids when insulin is started if K and/or Phos levels are borderline or trending down.

IV FLUIDS – "TWO-BAG" SYSTEM

- For patients with known or suspected cerebral injury, use clinical judgment in selection and titration of fluids.
- Begin replacement fluids as soon as possible.
- Start 0.45% NaCl until the 2 bags are available
- Potassium and/or Phosphorus may need to be repleated – monitor potassium and phosphorus trends carefully. (For PIV administration, do not exceed 60mEQ/L potassium in a single site)
- Do not start the potassium-containing fluids if:
    - K greater than 5.5 on admission. If K greater than 6, obtain ECG
    - Urine output/renal function have not been ensured
- Consider using 0.9% NaCl fluids if patient is hemodynamically unstable or if corrected Na less than 140 or Na falls rapidly with treatment. Do not use hypotonic fluids if corrected Na is less than 130.
    - Na corrected = Na measured + 1.6 x [(Glucose-100)/100]; should normalize with treatment

IV FLUID RATE CALCULATIONS

- For simplicity, use 3.5 x maintenance IVF rate
- Assume 10-12% dehydration and aim to replace deficit over 24h
    - Deficit (10%) = weight (kg) x 100 (b) _____ ml
    - Remaining deficit = (b) – volume of resuscitation (c) _____ ml

- Replacement rate = (c) / 24hr (d) _____ ml/hr
- FINAL CALCULATED IVF rate = (a) + (d)

- Urinary replacement is usually necessary in Hyperosmolar DKA until glucose level is less than 300 mg/dL
- Every 4h, replace each 1mL of urine with 0.5mL of 0.45% NS and give over 4 hours. Re-evaluate fluid status q4h to achieve progressively positive fluid balance.

MONITORING

Admission	Q1h	Q2h	Q4h
VBG or ABG with lytes BMP, Mg, Phos Infectious w/u as indicated Hemoglobin A1c Diabetes antibodies (new onset only) (CBC, inflammatory markers, cultures, urine studies)	POC glucose	BMP, Phos	VBG or ABG BMP, Mg, Phos

CEREBRAL INJURY

- Typically occurs 4-12 hours after treatment is initiated (but can occur prior to and up to 24-48 hours after)
- Risk factors
  - Age less than 3 years
  - pH less than 7.0
  - Failure of measured serum Na to rise during treatment

- Administration of bicarbonate therapy unless symptomatic hyperkalemia or CPR/resuscitation
- Elevated BUN (27 ± 14 mg/dL) at presentation
- Low PaCO2 levels (11.3 ± 6.5 mm Hg) at presentation

- Diagnosing Clinically Significant Cerebral Injury (Muir, et al)
  - Presence of either of the following has a sensitivity of 92% for detecting cerebral injury in the setting of DKA
    - 1 Diagnostic Criteria - or –
    - 2 Major Criteria - or -
    - 1 Major Criteria and 2 Minor Criteria Diagnostic Criteria

Diagnostic Criteria	Abnormal motor or verbal response to pain Decorticate or decerebrate posture Cranial nerve palsy (especially III, IV, and VI) Abnormal neurogenic respiratory pattern (e.g., grunting, tachypnea, Cheyne-Stokes respiration, apneusis)
Major Criteria	Altered mentation/fluctuating level of consciousness (GCS less than or equal to 13) Sustained heart rate deceleration (decline greater than 20 bpm) not attributable to improved intravascular volume or sleep state Age-inappropriate incontinence
Minor Criteria	Vomiting Headache Lethargy or not easily arousable from sleep Diastolic blood pressure greater than 90 mmHg Age less than 5 years

If cerebral injury is suspected, treat immediately with Mannitol or 3% NaCl before any neuroimaging

TRANSITION TO SUBCUTANEOUS INSULIN

- Criteria;
    - Mental status normal
    - Able to tolerate sips of clears
    - HCO3 17-20 mEq/L
- Process:
    - Administer the first subcutaneous insulin dose (Lantus and/or NovoLog) If possible, give just prior to breakfast or dinner; however, depending on clinical scenario can be given at any time
    - Stop the insulin infusion ONE HOUR after administering subcutaneous basal (Lantus) insulin.
        - **If SQ basal insulin was administered concurrently with insulin infusion, discontinue insulin infusion without one hour overlap
        - **If patient uses an insulin pump, restart insulin pump 1-2 hours prior to discontinuing insulin infusion.
    - Allow the patient to start eating; if transition does not align with meal time, give a sugar free or low carb snack (less than5g carbohydrates)
    - Discontinue IVF when the insulin infusion is discontinued and the patient is able to maintain adequate oral hydration Dextrose should be removed from IVF when insulin infusion is discontinued
    - Transition to new lab frequency: POC glucose before meals, nightly, at 2-3am (qAC, nightly and PRN), PRN UA for ketones if BG greater than 350 and/or N/V

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