12-Year-Old Girl with Ketotic Hyperglycemia Hyperosmolar Syndrome

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Endorama

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HPI

• 12-4/12 yo girl with history of obesity and OSA presents to LaRabida with N/V and AMS
• Developed fatigue, N/V, abdominal pain and diarrhea 4 days prior to admission → improved then resumed 1 day later
• On the day prior to admission had decreased appetite and increasing fatigue → confusion
• Initial serum glucose > 700, venous pH 7.01
• Transferred to Comer PICU
ROS

- Constitutional: Unspecified weight loss over past 6 months, thought due to improved diet; + fatigue x 1 week, - fevers
- HEENT: no URI sx, h/o OSA
- Resp: + SOB x 1 day
- CV: - chest pain, leg swelling
- GU: polyuria/polydipsia “for weeks;” Menarche age 10-11, monthly periods
- Msk: + back pain, weakness x 1 day
- Neuro: + confusion, - seizures
- Psych: - behavioral problems, depression, anxiety
History

PMH
• Obesity
• OSA

PSH
• T & A age 10 y

Meds
• None

All
• None

FH
• Graves’-Mother
• Diabetes-MGGM
• Thyroid disease-MGM, MGGM

SH
• Lives with mother, brother (behavioral problems), 2 sisters
• 6th grade
Physical Exam

Vitals: T 96.4, HR 102, RR 30, BP 92/75, O2 Sat 100% room air
wt 88 kg (99th%) Ht 162.5 cm (60th%) BMI 33 (> 99th%)
 Constitutional: She appears lethargic. No distress. Obese
HENT: Mouth/Throat: Mucous membranes are dry. Dentition is normal.
Eyes: Conjunctivae are normal. Pupils are equal, round, and reactive to light.
Neck: Neck supple. No thyromegaly
Cardiovascular: Normal rate, S1 normal and S2 normal. Tachycardia. Extremities cool but with good pulses
Pulmonary/Chest: Breath sounds normal. Kussmaul respirations
Genitourinary: Tanner 5 breast development. + Foul, white vaginal discharge
Musculoskeletal: She exhibits no edema.
Neurological: She appears lethargic. Initially confused and inappropriate (thought she was in church) but responsive, but on re-exam was barely responsive to sternal rub, not following commands
Skin: Skin is cool and dry. Capillary refill takes less than 3 seconds. + acanthosis on neck and axilla
**Labs-Initial**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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<tbody>
<tr>
<td>Serum Osm</td>
<td>345</td>
</tr>
<tr>
<td>pHa</td>
<td>6.993</td>
</tr>
<tr>
<td>B-OHbutyrate</td>
<td>10.72</td>
</tr>
<tr>
<td>Lactate</td>
<td>3.3</td>
</tr>
<tr>
<td>Amylase</td>
<td>106</td>
</tr>
<tr>
<td>Lipase</td>
<td>137</td>
</tr>
<tr>
<td>C-peptide</td>
<td>&lt; 0.03</td>
</tr>
<tr>
<td>HbA1c</td>
<td>14.6%</td>
</tr>
<tr>
<td>Ca</td>
<td>10.4</td>
</tr>
<tr>
<td>Mg ip</td>
<td>2.8</td>
</tr>
<tr>
<td>&lt; 5</td>
<td>2.4</td>
</tr>
<tr>
<td>20</td>
<td>1003</td>
</tr>
<tr>
<td>6.7</td>
<td>3.9</td>
</tr>
<tr>
<td>0.4</td>
<td>23</td>
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<tr>
<td>17</td>
<td>233</td>
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<td>13.6</td>
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</tr>
<tr>
<td>25.6</td>
<td></td>
</tr>
<tr>
<td>43.6</td>
<td></td>
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<td>284</td>
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**Severe DKA + Hyperosmolar state a.k.a. Ketotic Hyperglycemic Hyperosmolar Syndrome**

**Mixed HHS & DKA**

**Hyperosmolar DKA***
First 24 hours

- Insulin 0.1 u/kg/h
  - BG decrease 35-45 mg/dL/h
- IVF: 0.9 NS @ 1800 ml/m2/h
  - Total ~ 2500 ml/m2 in first 24h
- HypoK and HypoP
  - 20 meq Kphos + 20 meq Kacetate ➔ 40 meq each
  - Multiple K & P riders
- AMS: became unresponsive
  - Improved with mannitol
  - CT head negative
- Fever to 102
- Severe abdominal pain
- Body aches, weakness
- Hypotension
Next 24 hours

- DKA resolved
- Hypernatremia worsened
- IVF: D10 0.9NS 40 meq K acetate → D20 0.75NS @ 1800 ml/m2/d
  - 48 hr total fluid:
- Overnight worsening mental status, AKI → Intubated
- (we noted the INR 1.5)
- CK 687 → 1242
- CVVH was begun
- Hypotension → Hypotension, Epi, Norepi
- Septic work-up negative
  - Tmax 104.1
Hyperglycemic Hyperosmolar Syndrome

Absolute deficiency

Ketotic HHS

More pronounced than in DKA

Ketotic HHS

Features of HHS and DKA

<table>
<thead>
<tr>
<th></th>
<th>HHS</th>
<th>DKA</th>
</tr>
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<tbody>
<tr>
<td>Hyperglycemia</td>
<td>+++</td>
<td>+ to +++</td>
</tr>
<tr>
<td>Ketosis/Acidosis</td>
<td>+/-</td>
<td>++ to +++</td>
</tr>
<tr>
<td>Dehydration</td>
<td>+++</td>
<td>+ to +++</td>
</tr>
<tr>
<td>Osmolality</td>
<td>+++</td>
<td>+ to +++</td>
</tr>
<tr>
<td>Electrolyte Deficits</td>
<td>+++</td>
<td>+ to +++</td>
</tr>
</tbody>
</table>

- BG > 600
- CO2 > 15
- Ketones trace or neg
- Serum Osm > 320-330

- Rare, though incidence is rising, ~4% of all new onset T2DM patients (2006)
- Combination of DKA and HHS = Ketotic HHS or mixed DKA-HHS
- Insidious often unrecognized PU/PD
- Obesity complicates dehydration assessment
- Replacement of fluid deficits (often 2 x greater in HHS) vs risk for cerebral edema
- No clear guidelines for k-HHS treatment

Cochran et al. J Peds EM. 2006
High Morbidity & Mortality in Ped HHS

- 30-50% mortality various reports
- Altered mental status
  - CT usually neg for cerebral edema
- Renal failure
- VTE
  - assoc with central line use
- Rhabdomyolysis
- Malignant hyperthermia

Characteristics/Risk Factors

- Delayed care/diagnosis
- Teens (age 12-19 y)
- Males
- BMI > 95th%
- T2DM & FH of T2DM
- African-American
- Low SES
- Cognitive impairments

Rosenbloom. J Pediatr 2010
Cochran et al. J Peds EM 2006
Treatment Challenges

• Rare $\rightarrow$ treatment delay
• No evidence-based guidelines for k-HHS treatment
• Replacement of fluid deficits (often 2 x greater in HHS) vs risk for cerebral edema
• Obesity complicates dehydration assessment
**Treatment Guidelines**

**Fluid**
- Isotonic for resuscitation then 0.45-0.75 NS to goal Na decline 0.5/L/h and glucose 75-100/h

**Electrolytes**
- Aggressive replacement, esp K and P*; Mg controversial

**Insulin**
- Early tx unnecessary unless mixed/ketotic

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**Figure 3. Treatment of HHS in pediatric patients.**
Hospital course

• Glycemic control
  – Resistance and sensitivity (? 2/2 catecholamines or adrenal injury)
• HD # 4: Cortisol 91.4 & DHEAS 124
• ECMO declined by mother → patient made DNR on HD 5
  • Cortisol 26.3 on HD 5. Began Hydrocortisone 100 mg IV q8h on HD 6
• Pressors were weaned off HD 8
• IUF stopped and tracheostomy HD 1 month
• D/c to Schwab rehab 2 months after admission
Admission:
- Obesity
- OSA
- New onset type 2 diabetes
- DKA
- Hyperglycemic Hyperosmolar Syndrome
- Severe dehydration

Hospitalization:
- Obesity
- OSA
- Trach-dependence
- Type 2 diabetes
- Hyperglycemic Hyperosmolar Syndrome
- SIRS
- ARDS
- DIC
- ARF
- Rhabdomyolysis
- Persistent hypophosphatemia
- Central line thrombosis
- Ischemic gangrene bilateral forefoot
- Sacral pressure ulcer
- Relative adrenal insufficiency
- E. coli UTI
- NG-tube dependence
- Adjustment disorder
- Depression

Current:
- Obesity
- OSA
- Type 2 diabetes
  - Lantus 24
  - Humalog
- Transmetatarsal amputation
- Anxiety
- BMI 35.96
- HbA1c 5.6-6.4%
References


• Cochran JB, Walters S, Losek JD. Pediatric hyperglycemia hyperosmolar syndrome: diagnostic difficulties and high mortality rate. J Peds EM 2006; 24: 297-301