11 year-old female with altered mental status in the setting of diabetic ketoacidosis

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University of Chicago
Thursday, January 23rd, 2014
Chief Complaint

- 11 yr and 10-mo female with history of Type 1 DM from out of state
- Presented with nausea and elevated blood sugars x 1 day
- Visiting father in Chicago over winter vacation
History of Present Illness

• Day prior to admission:
  ▫ Felt “sick” in the evening, did not sleep well
  ▫ Several episodes non-bloody, non-bilious emesis
  ▫ Generalized abdominal pain
  ▫ Loose stool x3-4
  ▫ Diminished appetite
  ▫ Dehydrated 2º polydipsia -> rehydrated with OJ
  ▫ Polyuria x 1 day, no dysuria
• Blood sugar “high”; + ketonuria → urgent care (no sick day rules attempted)
Diabetes History

- Diagnosis: 9 yo when admitted with DKA
- Hospitalizations for DM: once (at onset)
- Follows Endocrine physician group out of state
  - Last visit: 2 wks PTA
  - Last HgbA1c: 11%
- Insulin pump 2012-13
  - d/c’d 2 wks PTA for non-compliance
Home Diabetes Management

- Home insulin regimen:
  - Lantus 15 units qhs
  - Humalog mealtime 1:15g with BF, L; 1:20g with D
  - Humalog hyperglycemia correction = 1u:75 >100
- Insulin injection sites: abdomen, arms
- BG monitoring: Reported 5x/day
## Glucometer Interrogation

<table>
<thead>
<tr>
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<th>BF</th>
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<th>Bed</th>
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More History...

- **Past Medical History:**
  - Type 1 DM

- **Surgical History:**
  - None

- **Allergies:**
  - NKDA

- **Medications:**
  - Insulin (as previously described)

- **Social History:**
  - “Good Student”
  - Lives in mother
  - Visiting father in Chicago over holidays

- **Family History:**
  - No diabetes, thyroid disease or other autoimmune disease
Review of Systems (Page 1 of 2)

- **General:**
  - +fatigue, +anorexia, +weight loss (4lb), +polydipsia.
  - No fever or chills.
- **HEENT:**
  - +dry lips/mouth.
  - Negative for congestion, rhinorrhea, dysphagia, sore throat.
- **Cardiac:**
  - +chest pain with deep breath and ”heart racing.”
  - No lower extremity edema.
- **Pulm:**
  - +shortness of breath x 1 day.
  - No cough.
Review of Systems (Page 2 of 2)

• Abdomen:
  ▫ +generalized abdominal pain. +nausea, +vomiting, +loose stool.
• GU:
  ▫ +polyuria
  ▫ No dysuria.
• Skin:
  ▫ +dry skin.
  ▫ No rash.
• MSK:
  ▫ +generalized muscle pain/arthralgias x 1 day.
• Neuro:
  ▫ +confused, +headache 6/10.
  ▫ No seizures.
Urgent Care Course (OSH)

• Serum Chemistry:

<table>
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<tr>
<th>138</th>
<th>97</th>
<th>26</th>
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<td>6.7</td>
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<td>1.7</td>
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  819

• Anion Gap: **36**
• Urine ketones: **>160 mg/dL**
• **Treatment:**
  - **20cc/kg bolus NS** and transfer to Comer Children’s PICU
Physical Exam upon arrival to PICU

- Vitals: T 99.7°F, P 147, BP 111/57, R 28, 100% on room air, Wt 35.9kg
- General: appears uncomfortable
- HEET:
  - conjunctiva normal, oropharynx clear.
  - +dry mucous membranes.
- Neck:
  - supple.
  - +thyroid mildly enlarged, symmetric.
- Chest: tanner IV breast.
- CV:
  - +tachycardia
  - no murmur.
• Pulmonary:
  ▫ Deep, labored breathing
  ▫ clear to auscultation
• Abdominal:
  ▫ normal bowel sounds, soft, non-distended
  ▫ +tender diffusely, no guarding or rebound
• Genitourinary: Tanner 4 pubic hair
• MSK:
  ▫ tender diffusely
• Neuro:
  ▫ +decreased muscle tone.
  ▫ waxing and waning mental status
• Skin:
  ▫ warm, cap refill < 3 sec.
  ▫ +diaphoretic. +pallor. +lipohypertrophy on back of the arms.
Laboratory Studies on Admission (22:00)

- VBG: pH 7.061, POC2 15, Base excess -24
- Beta-OHB: 10.14 mmol/L
- Lactate 4.67 mmol/L
- Serum osmolality: 358 (275-295 mOsm/kg)
- Urinalysis: 1.027, 1+ protein, 3+ glu, 3+ketones, (-) LE, (-) WBC
- HgbA1c: 10.6%
Next Step in Management

21:00

- Started continuous infusion insulin 0.1 units/kg/hr
- Started NS at 110 cc/hr (= MIV rate)
- Attempt A-line for more frequent lab monitoring
# Overnight Course

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<th>pH</th>
<th>Na</th>
<th>*Na</th>
<th>HCO3</th>
<th>AG</th>
<th>BHB</th>
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*Na = corrected Na
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<th>Time</th>
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Case Summary

- Pubertal female w/ T1DM under the care of a parent unfamiliar with DM sick-day management
- Presented with severe dehydration, DKA and hyperosmolarity in setting of insulin resistance +/- insulin omission
- Had steep drop in BG soon after initiation of treatment for DKA
- Developed mental status changes and treated with 3% HS with significant improvement
Cerebral Edema in DKA

- Life-threatening consequence of DKA
- Occurs in 0.5-1% of children with DKA
- Mortality is 21-24%
- Young children > adolescents > young adults
- Pathophysiology not well-understood
  - 1) Cytotoxic edema
  - 2) Vasogenic edema

Bohn, Desmond. Pediatric Critical Care Medicine 2010.
Clinical Questions

1. What are the most sensitive and specific signs/symptoms of cerebral edema in children?

2. Which osmotic agent is more effective in treating cerebral edema: hypertonic saline or mannitol?
Cerebral Edema in Childhood Diabetic Ketoacidosis

Natural history, radiographic findings, and early identification

Table 1—Bedside evaluation of neurological state of children with DKA

<table>
<thead>
<tr>
<th>Diagnostic criteria</th>
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<tr>
<td>Abnormal motor or verbal response to pain</td>
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<tr>
<td>Decorticate or decerebrate posture</td>
</tr>
<tr>
<td>Cranial nerve palsy (especially III, IV, and VI)</td>
</tr>
<tr>
<td>Abnormal neurogenic respiratory pattern (e.g., grunting, tachypnea, Cheyne-Stokes respiration, apneusis)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Major criteria</th>
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</thead>
<tbody>
<tr>
<td>Altered mentation/fluctuating level of consciousness</td>
</tr>
<tr>
<td>Sustained heart rate deceleration (decline more than 20 bpm) not attributable to improved intravascular volume or sleep state</td>
</tr>
<tr>
<td>Age-inappropriate incontinence</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Minor criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vomiting</td>
</tr>
<tr>
<td>Headache</td>
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<tr>
<td>Lethargy or being not easily aroused from sleep</td>
</tr>
<tr>
<td>Diastolic blood pressure &gt;90 mmHg</td>
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<tr>
<td>Age &lt;5 years</td>
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Signs that occur before treatment should not be considered in the diagnosis of cerebral edema.

Cerebral Edema Diagnostic Criteria

- Abnormal motor or verbal response to pain
- Decorticate or decerebrate posture
- Cranial nerve palsy (esp III, IV, VI)
- Abnormal neurogenic respiratory pattern

Early Indicators of Cerebral Edema

• Major Criteria
  ▫ AMS
  ▫ Sustained HR deceleration not attributable to improved intravascular volume
  ▫ Age-inappropriate incontinence

• Minor Criteria
  ▫ Vomiting
  ▫ Headache
  ▫ Lethargy/Not easily aroused
  ▫ Diastolic BP >90mmHg
  ▫ Age <5

Clinical Question

- Which osmotic agent is more effective in treating cerebral edema: hypertonic saline or mannitol?
Mannitol vs. Hypertonic Saline for Treatment of Cerebral Edema

Decoursey et al. Pediatric Critical Care Medicine 2013.
**TABLE 3. Adjusted Odds Ratio of Mortality in Patients Treated for Cerebral Edema in Diabetic Ketoacidosis**

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>OR (95% CI)</th>
<th>Adjusted OR (95% CI)*</th>
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</thead>
<tbody>
<tr>
<td>Treatment with hypertonic saline alone</td>
<td>2.03 (0.94–4.39)</td>
<td>2.71 (1.01–7.26)</td>
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<tr>
<td>Male gender</td>
<td>3.45 (1.79–6.65)</td>
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<td>Mechanical ventilation</td>
<td>22.8 (10.7–48.9)</td>
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<tr>
<td>Brain imaging with CT</td>
<td>2.14 (1.00–4.57)</td>
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<td><em>International Classification of Diseases, 9th Revision code</em></td>
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<td>250.2</td>
<td>3.84 (1.29–11.4)</td>
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<td>250.3</td>
<td>3.31 (1.46–7.47)</td>
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*OR = odds ratio.*
Learning Points

- Cerebral edema is a devastating complication of DKA.
- Mechanism of cerebral edema in DKA is still unknown, but is likely multi-factorial.
- Cerebral edema is a clinical diagnosis and should be identified early with the bedside examination.
- Hypertonic saline may be associated with higher mortality than mannitol for the treatment of DKA but there are no definitive prospective trials comparing the two treatments.
Works Cited