Hyperglycemic Emergencies

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Case #1

- Previously well 26 y.o. male
- 4 wks of polyuria/polydipsia, then 36 hours of N/V, then 8 hours of stupor
- Hypotensive, volume depleted, Kussmaul’s respiration
- Plasma glucose - 640, AG - 26, serum HCO3 - 9, pH - 7.15, PCO2 - 16

Case #2

- 80 year old male with dementia lives in NH
- Brought to ER because of gradual progression to coma over 3 days
- Pulse - 120, BP - 80/40
- Plasma glucose - 900, Creatinine - 3.0, serum osm - 365
- NI AG, serum HCO3 - 10, pH - 7.38

Goals and Objectives

- Significance to you
- Pathophysiology
- Clinical Presentation
- Diagnostic Criteria
- Clinical Evaluation
- Management (6 components)

Significance to you

- Diabetic Ketoacidosis (DKA)
  - 2-8% of all diabetic hospital admissions
  - 2-10% mortality rate
- Hyperglycemic Hyperosmolar Nonketotic Syndrome (HHNS)
  - 1/1000 admissions to the hospital
  - 12-46% mortality
**Type I Diabetes**

- **Initiating event**: Decreased glucose uptake
- **Insulin deficiency**: Hyperglycemia
- **Hyperosmolarity**: Dehydration
- **Electrolyte depletion**: Acidosis

**Characteristics of insulin deficiency**

- **Decreased glucose uptake**
- **Hyperglycemia**
- **Hyperosmolarity**: Dehydration
- **Electrolyte depletion**: Acidosis

**Clinical Presentation**

- **DKA**: Relatively short duration of sx (hours - 2 days)
- **HHNS**: Usually insidious (several days)

**DKA/HHNS diagnostic criteria**

<table>
<thead>
<tr>
<th>Mild</th>
<th>Moderate</th>
<th>Severe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glucose (&gt;250)</td>
<td>(&gt;250)</td>
<td>(&gt;600)</td>
</tr>
<tr>
<td>Art pH (7.25 - 7.30)</td>
<td>(7.00 - 7.24)</td>
<td>(&lt; 7.00)</td>
</tr>
<tr>
<td>Serum HCO₃ (15 - 18)</td>
<td>(10 - &lt;15)</td>
<td>(&lt;10)</td>
</tr>
<tr>
<td>Urine ketones (pos)</td>
<td>pos</td>
<td>pos</td>
</tr>
<tr>
<td>Serum ketones (pos)</td>
<td>pos</td>
<td>pos</td>
</tr>
<tr>
<td>Serum osm var</td>
<td>var</td>
<td>&gt;320</td>
</tr>
<tr>
<td>Anion gap (&gt;10)</td>
<td>&gt;12</td>
<td>&gt;12</td>
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**Hot Seat Question:**

- What are characteristics of insulin deficiency?

**Type II Diabetes**

- **Initiating event**: Hyperglycemia/Hyperosmolality
- **Insulin deficiency**: Dehydration, ketosis
- **Dehydration**: Prerenal azotemia
- **Dehydration**: Decreased thirst

**Clinical Presentation**

- **DKA**: Relatively short duration of sx (hours - 2 days)
- **HHNS**: Usually insidious (several days)

**Hot Seat Question:**

- What if a patient has hyperglycemia, pH < 7.3, elevated AG, serum osm > 320?
Initial Clinical Evaluation

- **Focused H&P**
  - Volume status, precipitants
- **Labs**
  - Full lytes, ABG, ketones (serum and urine), serum osm
  - Calculate AG, osm, corrected Na+
- **Screen for precipitants**

Helpful Formulae

- **Corrected Na+**
  - Subtract 1.6 from measured Na+ for every 100 BS is above 200
- **Calculated serum osm**
  - $2(Na+) + \text{BUN}/2.8 + \text{glucose}/18$

Free water deficit

- **TBW = 0.6 x wt (kg) (0.5 for female, .45 for elderly)**
- **Free water deficit = TBW x (Na+/140 - 1)**
  - $= 2/3 \times 70 \times [\text{Na+} - 140/140]$
  - $= \text{Delta Na+/3}$

Precipitants

- **DM - New onset, poorly controlled, cessation of treatment, pump failure**
- **Acute Illness - infection, MI, pancreatitis, intraabdominal catastrophe, CVA, severe burns, PE, GI bleed**
- **Meds - thiazides, glucocorticoids, chemo, hyperalimentation, BB, CCB**
- **Substance abuse - EtOH, cocaine**

Management

- Replacement of fluid losses
- Correction of hyperglycemia/acidosis
- Replacement of electrolyte losses
- Detection and rx of precipitants and complications of rx
- Conversion to a durable regimen
- Prevention of recurrence
You are the MICU intern

- AD calls you, pt admitted for DKA
- BS 220, pt feeling well... “Can we move him out and stop the insulin drip?”
- Hurry up!
Assess need for bicarbonate:

- pH < 6.9
  - Dilute NaHCO₃ (100 mmol) in 400 cc H₂O. Infuse at 200 cc/hr
- pH 6.9 – 7.0
  - Dilute NaHCO₃ (50 mmol) in 200 cc H₂O. Infuse at 200 cc/hr
- pH > 7.0
  - No HCO₃ unless hemodyn. unstable

Repeat HCO₃ administration every 2 hrs until pH > 7.0. Monitor serum K⁺.

More on case #1 (DKA)

- Previously well 26 y.o. male
- 4 wks of polyuria/polydipsia, then 36 hours of N/V, then 8 hours of stupor
- Hypotensive, volume depleted, Kussmaul’s respiration
- Plasma glucose - 640, AG - 26, serum HCO₃ - 9, pH - 7.15, PCO₂ - 16
- K⁺ - 3.7

Back to Case #1 (cont.’d)

- Was treated with insulin gtt, IV HCO₃, 10mEq/L KCl
- pH increases to 7.24
- Suddenly he develops respiratory failure, cardiac arrest, and dies
- What were the therapeutic misadventures?
**Potassium**

- If serum K+ is < 3.3 mEq/L, hold insulin and give 40 mEq K+ per hour (2/3 KCl and 1/3 Kphos) until K+ > 3.3
- If serum K+ >/= 5.0 mEq/L, do not give K+ but check every two hours
- If serum K+ >/= 3.3 mEq but < 5.0 mEq/L, give 20 – 30 mEq K+ in each L of IVF (2/3 as KCl and 1/3 as Kphos) to keep serum K+ at 4-5 mEq/L

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**Hot Seat Question:**

- DKA patient, appropriately transferred to floor
- ABG is checked - pH 7.33, Chem 7 - AG - 8, BS - 280, HCO3 - 18, Cl - 116
- What is going on?

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**How can we educate this patient?**

- 22 y.o. type I DM, admitted to IMC with DKA
- felt ill 48 hours PTA with poor appetite, N, abd pain
- Limited appetite and omitted evening insulin
- FBS was 210 the next AM but because of decreased PO intake, halved AM insulin
- Fell asleep and did not recheck her blood glucose until evening and came into hospital

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**Sick day substitutions**

- 1/2 cup apple or orange juice, regular soda, regular gelatin, custard, ice cream
- 1/3 cup cranberry juice
- 1 cup Gatorade, milk
- 1 tbsp honey, jelly
- 5 lifesavers
- 6 vanilla wafers, saltines
- 8 animal crackers
- 1 slice toast
How can we educate this physician?

- 63 y.o. male, h/o DKA during MI 10 years ago, on 35 units of glargine insulin qhs
- Admitted for SBO
- Placed on bowel rest, NGT, BS - 210
- Lantus held because NPO, placed on sliding scale insulin
- BS 4 hours later was 410, was covered with 12 units regular insulin by sliding scale
- 2 hours later, BS - 510, tachypnea; DKA diagnosed

**Management of Adult Patients with DKA**

- Determine hydration status
  - Hypovolemic shock
  - Mild hypotension
  - Cardiogenic shock
  - Hemodynamic monitoring
- Evaluate corrected serum Na+
  - Serum Na+ high
  - Serum Na+ normal
  - Serum Na+ low
- Administer NS depending on state of hydration
  - 0.5 NS depending on state of hydration

**Insulin**

- Regular, 0.15 units/kg as IV bolus
- 0.1 units/kg/hr IV insulin infusion
- Check serum glucose hourly. If serum glucose does not fall by at least 50 mg/dL in first hour, then double insulin dose hourly until glucose falls at a steady hourly rate of 50 – 70 mg/dL
- When serum glucose reaches 300 mg/dL change to D51/2NS and decrease insulin to 0.05 – 0.1 units/kg/hr to maintain serum glucose between 250 – 300 mg/dL until plasma osm is ≤ 315 and patient is mentally alert.

**Potassium**

- If initial serum K+ < 3.3 mEq/L, hold insulin and give 40 mEq K+ (2/3 as KCl and 1/3 Kphos) until K+ ≥ 3.3 mEq/L
- If initial serum K+ ≥ 5.0 mEq/L, do not give K+ but check potassium every 2 hours
- If initial serum K+ ≥ 3.3 but < 5.0 mEq/L, give 20 – 30 mEq K+ in each liter of IVF (2/3 as KCl and 1/3 as Kphos) to keep serum K+ 4 – 5 mEq/L
Critical points

- Be meticulous, use a flow sheet
- Check parameters frequently
- Ensure adequate volume and electrolyte repletion
- IV insulin, moderate intensity
- Look for and treat precipitants aggressively
- Avoid complications (hypokalemia, hypoglycemia, sudden large volume shifts, inadequate volume resuscitation, premature d/c of IV insulin)
- Creation and transfer to a durable regimen
- Prevention and education

Sources

- Diabetic Ketoacidosis and Hyperglycemic Hyperosmolar Nonketotic Syndrome; *Endocrinology and Metabolism Clinics of North America*; December 2000
- Diabetic Ketoacidosis; *The Diabetic Educator*; May/June 2003
- Hyperglycemic Crises in Diabetes; *Diabetes Care*; January 2004
- Management of Diabetes and Hyperglycemia in Hospitals; *Diabetes Care*; 27: 553-591