Metabolic complications of diabetes in adults

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Diabetic acidoketosis

• Definition
  Serious complication in type I diabetes:
  Hyperglycemia
  Metabolic acidosis
  Acidic ketone bodies

• Epidemiology
  0.4-0.8% of type I diabetes
  100,000 admissions USA for DKA
  1 billion dollars
  30% of type I diabetes discovered after DKA
  40 admissions/year SAT, 10% death associated with underlying disease
St Antoine hospital

- 20 DKA/792 admissions in 2003
- AGE : 44,4 years
- SAPS II : 34,4
- Length of stay : 5 days
- MV : 5 (20%)
- ICU mortality 5% (13,5% of general mortality)
Causes

- Stress
- Physical or emotional trauma
- Infection
- Surgery
- Heart attack, stroke
- Alcohol or drug abuse
- Error in insulin therapy
Pathophysiology

I. release of fatty acids from adipose tissue

II. liver conversion into ketone bodies

III. osmotic diuresis

IV. potassium loss
Acidose métabolique à trou anionique augmenté

Hyperventilation + déshydratation + odeur acétonique de l’haleine

POUMON

H_{2}O + CO_{2}

H^{+} + HCO_{3}^{-} \rightarrow H_{2}CO_{3}

POUMON

glucose

Hyperglycéémie

muscle

Glycosurie, cétonurie

Polyurie \rightarrow déshydratation

foie

acétylCoA

corps cétoniques

βOH butyrate, acétoacétate

acétone

T. ADIPEUX

glycogène

alanine

glucose
Signs & Symptoms

- Pronounced thirst
- Nausea and vomiting
- Abdominal pain
- Frequent urination
- Loss of weight
- Polypnea (Kussmoll !!!)
- Shortness of breath
- Fruity-scented breath
- Dehydration
And the neurological signs

- Normally absent in DKA
- Asthenia only
- If patients present confusion, stupor or coma

Search for complications

SNC infection
Stroke
Dysnatremia
Biological diagnosis

• Hyperglycemic state > 2,5gr/l
• Metabolic acidosis <7,30
• Bicarbonate decreased < 20 mmol/l
• Increased anion gap >12
• Blood and urine ketonic bodies
Usefull biological parameters

- Osmolality
  \[2(\text{Na}+\text{K})+\text{glucose (mmol/l)} + \text{urea (mmol/l)}\]

- Anion gap
  \[\text{Na} - (\text{Cl} + \text{HCO}_3^-)\]
Treatment

• Fluid replacement
  – Emergency
  – 6-8 lt of water loss
  – 2 l of saline 0,9% in the first 2h
  – Then 1l of saline 0,9% / 4h if glucose > 3gr/l
  – Or isotonic glucose 5% if glucose < 3gr/l
  – Free acess to water
Treatment

• Insulin therapy
  – IV insuline
  – First bolus 10 IU
  – Then 0,1 IU /kg h
  – Maintain constant insulin perfusion as long as ketone production persists
  – If necessary increase glucose infusion
  – When ketone =0 stop constant perfusion and switch for Insulin protocol
Treatment

• Potassium
  – Total body K is depleted
  – Insulin and pH correction decrease K
  – 40 mmol/h if K< 3mmol/l
  – 30 mmol/h if K< 4mmol/l
  – 20 mmol/h if K< 5mmol/l

• Phosphore if Ph is low

• Treatment of the cause

• Monitoring
Is alcalinisation usefull?

And cardiac output?

<table>
<thead>
<tr>
<th>VARIABLE</th>
<th>AT BASE LINE</th>
<th>AFTER CORRECTION OF KETOACIDOSIS</th>
<th>P VALUE*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arterial blood pH</td>
<td>7.07±0.2</td>
<td>7.42±0.05</td>
<td>0.005</td>
</tr>
<tr>
<td>Plasma bicarbonate (mmol/liter)</td>
<td>6.9±4.9</td>
<td>22.8±2.6</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Heart rate (beats/min)</td>
<td>104±20</td>
<td>98±23</td>
<td>0.33</td>
</tr>
<tr>
<td>Left ventricular fractional shortening (%)†</td>
<td>37.8±3.9</td>
<td>36.6±2.6</td>
<td>0.26</td>
</tr>
</tbody>
</table>

*P values were calculated with the Wilcoxon test.
†The mean normal value is 36±6 percent.

Even if pH<7.10 there is no use of alkali therapy
Hyperglycemic Hyperosmolar state

• Definition
  Acute complication of type II diabetes with:
  Hyperglycemia, dehydration, osmolarity > 320,
  neurological signs and absence of ketosis

• Epidemiology
  Less frequent than DKA (0.1/1000)
  Age > 70 years
  Sexe F>M
  Mortality 10-20%
Figure 3. Pathogenesis of DKA and HHS
Stress, Infection and/or Insufficient Insulin

Adapted from ref 1.
Hyperglycemic

- Hypernatremia blunted because of dilution caused by induced shift of water into extracellular fluid
- « Corrected value » of natremia
- When glucose increase, natremia decrease
  glucose $\uparrow$ 5.5 mmol/L  natremia $\downarrow$ 1.35 to 2.4 mmol/L

- Osmotic diuresis, extracellular volume depletion
Causes

- Stress
- Physical or emotional trauma
- Infection
- Surgery
- Heart attack, stroke
- Alcohol or drug abuse
- Error in insulin therapy

With limited access to water
Signs & symptoms

• Dehydration
• Polydipsia, polyuria, weight loss, weakness
• Neurological signs
  – Drowsiness and lethargy
  – Delirium
  – Coma
  – Focal or generalized seizures
  – Visual changes or disturbances
  – Hemiparesis
  – Sensory deficits
• Fever < 38.5°C
Biology

- Hyperosmolarity $>320 \text{ mOsm/l}$
- Hyperglycemia often $>6\text{ gr/l}$
- Dysnatremia
- Absence of ketonemia/ketonuria
- Renal failure
- pH $>7.3$ in absence of shock
Magnitude of free water deficit

\[ 0.6 \times \text{Normal body weight} \times \left[ 1 - \frac{140}{\text{Current serum}[Na]} \right] \]

Several wrong assumptions

- Immediate prehydration weight usually unknown
- Body water is always 60% of body weight
- Water lost uniformly throughout all body cells
- No solute loss
Hypernatremia

- Marker for severe underlying illness
- High mortality
  - Patients usually die with hypernatremia not because of it
  - State of consciousness cause or consequence

State of consciousness: relation to the peak serum sodium

Snyder K Ann int Med 1987
In our hospital 2008

• ICU (admission) n = 849 blood electrolytes
  - $\text{Na} \leq 130 \text{ mmol/L} : 11,3\%$
  - $\text{Na} \geq 150 \text{ mmol/L} : 1,53\% (14)$
  - $\text{Na} \leq 120 \text{ mmol/L} : 0,82\%$
  - $\text{Na} \geq 160 \text{ mmol/L} : 0,12\% (1)$

• Emergency room n = 13610 blood electrolytes
  - $\text{Na} \leq 130 \text{ mmol/L} : 3,6\%$
  - $\text{Na} \geq 150 \text{ mmol/L} : 0,31\%$
  - $\text{Na} \leq 120 \text{ mmol/L} : 2,2\%$
  - $\text{Na} \geq 160 \text{ mmol/L} : (9)$
Treatment

• **Rehydration**

  Treat patients and not numbers!!!!
  
  – Appreciate tolerance
  – Protocol example

  • 1lt of saline 0,9% in 30min
  • 1lt of saline 0,9% in 60min
  • 1lt of saline 0,9% in 120min
  • 1lt of saline 0,9% /4h for the first 12 h

• **Water intake orally when possible**
Treatment

Monitoring of neurological signs, and Na

- Risk of cerebral oedema if osmolarity correction is too fast

Slow rate is safe. Rapid correction of hypernatremia can induce cerebral edema, seizure, permanent neurologic damage and death.

0.5-1 mmol/hour, 12 mmol/day
Treatment

- **Insuline**
  - Less urgent than in DKA
  - IV bolus of 10 UI
  - Continuous infusion 0,1 UI/kg.h
  - If Glucose < 2,5 gr/l glucose 5% infusion

- **Potassium**
  - Adapted to blood levels
  - Vein thrombosis prevention
  - Treatment of the Cause
Conclusions

- Diabetes acute metabolic complications are:
  - Often
  - Severe
  - Urgent treatment
  - Rehydration
  - Insulin therapy
  - Ionic correction
  - Treatment of the cause
  - Patients education
Glycemic control in ICU

Glucose Control in Critically Ill Patients


- No mortality effect
- Hypoglycemia
- Lower operative site infections

Control glycemia < 2gr/l seems safe and reasonable