

# KETONES – SIGNIFICANCE AND CARE

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# OBJECTIVES

- Recall the physiology of ketone production
- Explain implications of ketones particularly in patients with diabetes
- Outline management of ketones in patients with diabetes
- Discuss!

# WHAT IS A KETONE?

- **Alternative fuel**
  - In low glucose situations, ketones allow sparing of glucose utilization and protein breakdown
  - Fasting/low carb state → fatty acid breakdown → acetoacetate
    - Encouraged by starvation, low insulin, or high fat diet
  - Promotes insulin resistance → so glucose doesn't decrease further

# WHAT IS A KETONE?

- **A weak acid**
  - Acetoacetate →
    - Reduction in mitochondria → beta-hydroxybutyrate + H<sup>+</sup> (acid)
      - Beta-hydroxybutyrate ~ acetoacetate in normal circumstances
    - Spontaneous decarboxylation → acetone – what you smell

# WHAT IS A KETONE?

- **A natural consequence**
  - Fasting
  - Exercise
  - Dehydration – fat broken down for water content

# NORMAL KETONE CONTROL

- Anti-ketone
  - Insulin
- Pro-ketone
  - Epinephrine and glucagon
- Insulin and glucagon inhibit each other



## WHAT DOES IT MEAN FOR PATIENTS WITH DIABETES?

- No endogenous insulin → less control
- Higher insulin resistance → lowered efficacy of exogenous insulin
- Less insulin effect → less inhibition of ketone production
- Higher beta-hydroxybutyrate levels → higher H<sup>+</sup> production
  - DKA overwhelms body's buffering capacity

## SYMPTOMS

- Abdominal pain
- Nausea
- Vomiting
- Heavy breathing
- Also consider – low appetite, irritability, perceived shortness of breath, **or few/no symptoms**



## WHO IS AT RISK FOR KETONES?

- (All patients with diabetes INCLUDING type 2, but especially):
  - Insulin deficiency (unknown diagnosis, missed insulin doses)
  - Insulin resistant states (acute illness, existing ketones, obesity)
  - Toddlers (lower hepatic glycogen stores)
  - Pregnancy (insulin resistance)
  - Prolonged exercise
  - Ketogenic diet

## WHAT TO DO?

- Stop ketone production
  - **Insulin**
  - Encourage modest intake of carbohydrates to allow insulin boluses
- Encourage ketone elimination
  - Exhalation of acetone – no control
  - Oxidation – no control
  - **Urination – encourage hydration**
- Keep track of care and symptoms – handoffs are for parents too!

## WHAT NOT TO DO (AUTOMATICALLY)?

- Exercise
- Send home routinely
  - Many times ketones can be handled successfully outpatient
  - Consider your availability for care
  - Consider disruption of quality of life created by repeated missed school
  - Consider disruption of care created by waiting for parent, travel time, possibility of less supervision at home
- Anti-nausea medications
  - Take away symptoms → take away a window into their clinical status

# HOW MUCH INSULIN?

- More...just more
  - Higher ketones – higher insulin resistance – expect higher needs at first
- Be aware of different clinical practices. **Every 2-3 hours:**
  - **Standard correction**
  - 110% of correction
  - 120% of correction
  - 10% TDD
  - Correction + 10% TDD
  - Round up to the next half unit
  - Round up to the next whole unit

## WHAT TO MONITOR?

- Ketones – every void/every 2-3 hours
  - Urine = filtrate of blood; urine ketones run behind what is actually happening, therefore:
- **Clinical improvement**
  - Decreasing nausea
  - Decreasing abdominal pain

## WHEN TO CALL OR ESCALATE CARE

- Ketones and hypoglycemia
- Intractable vomiting inhibiting PO
- **Labored breathing → THINK DKA**

THANK YOU!

## LET'S DISCUSS!

- What clinical factors are relevant?
- What non-clinical factors (social, etc.) are relevant?
- What conclusions can you confidently draw right now?
- What are unknowns?
- What scares you and why?
  - What information can you get to reassure yourself or inform your next step?
  - When do you think it is appropriate to escalate care?



## CASE

- A 9 year old boy with type I diabetes comes for his pre-lunch bolus looking tired. The stomach flu is floating around at school and he says he doesn't feel like eating lunch. His ketones are moderate and his glucose is 89 mg/dL. He is irritable and impatient to get back to his friends at recess. He has gym at the end of the day.

## CASE

- A 17 year old with type 2 diabetes comes to school for the first time in a week. Parents are separated; he typically stays with his mom but had a fight and stayed at a friend's house for several days before agreeing to stay with his father for the time being instead. His glucose is 293 and he is drinking a 20 oz regular soda. 'ate like crap' while he was staying at his friend's house last week. You offer him his metformin and he says 'oh I stopped taking that.' You ask him if he has taken his long or short acting insulin and he shrugs and says 'I didn't bring it with me.'

## CASE

- You are returning to school after summer vacation and a 14 year old straight A student with type I diabetes and mild intermittent asthma comes in with difficulty breathing. She waves off a ketone check: 'I feel fine.' You notice that she is a bit thinner than the end of the school year last year and she brightens, stating that she has been working hard to lose weight this past summer. Her glucose is 367 mg/dL.