MANAGING HYPERGLYCEMIA AND SICK DAYS TO AVOID DKA

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Objectives

• Review diagnosis and causes of diabetic ketoacidosis (DKA)

• Discuss progression and events leading to DKA

• Review pathophysiology of DKA, along with treatment and outcomes

• Review cases and understand how to assess for DKA, including recognizing risk factors and signs and symptoms. Understand how to start treatment to prevent DKA
Glucose Management in Diabetes

- Management of glucose levels in Type 1, and often Type 2, diabetes involves a balance between giving appropriate insulin doses to keep glucose in a target range while avoiding hypoglycemia.
- Involves frequent blood glucose monitoring and intensive insulin regimen (basal insulin plus bolus dosing).
- Chronically poor control may lead to long-term complications and morbidity.
- Acute complications include hypoglycemia, hyperglycemia, dehydration, and in severe cases, diabetic ketoacidosis (DKA).
Diabetic Ketoacidosis

• DKA is a diabetes emergency and may be life-threatening
• Occurs mainly in Type 1 diabetes, but is also seen in Type 2 diabetes
• Frequent pediatric diagnosis
  o Occurs in 25% of patients with new onset diabetes
  o Exact incidence unknown, estimated to be 4-8 per 1000 children with diabetes
Causes of DKA

• DKA is a complex metabolic state involving high blood sugars, elevated ketones, or ketosis, and elevated blood acidity, or acidosis

• It results from lack of insulin and is exacerbated by dehydration and rising blood acidity

• Lack of insulin:
  o New onset diabetes
  o Missed basal or multiple bolus doses; lack of adherence to insulin regimen
  o Pump malfunction or disruption of infusion site
  o Concurrent illness or physical stress and increased insulin resistance
The Triad

Hyper-glycemia

Acidosis

DKA

Ketosis

Abbas E. Kitabchi et al. Dia Care 2001;24:131-153
Hyperglycemia

- Elevated blood glucose
- Cause for concern, but not alarm
- Onset:
  - Usually gradual
  - May be more rapid with illness/infection or insulin pump malfunction
- Often secondary to insufficient insulin
- Chronic and acute
- In acute and severe settings, can lead to osmotic diuresis and loss of free water and electrolytes
Signs of Hyperglycemia

• Acute signs include:
  o Polydipsia, polyuria, polyphagia
  o Dehydration
  o Blurred vision
  o Decreased energy
  o Decreased ability to concentrate
  o Mood changes

• In addition, chronic signs include:
  o Weight loss
  o Poor growth, failure to thrive
  o Declining grades
  o Frequent infections
**Ketosis**

- Due to insulin deficiency, glucagon levels rise and lead to lipolysis and proteolysis, which leads to production of ketone bodies.

- Ketones are an alternate fuel source in the absence of intracellular glucose.
Signs of Ketosis

• Fatigue
• Confusion or difficulty concentrating
• Abdominal pain, nausea
• Fruity, or acetone, breath
• Measurable:
  o Urine strips or blood ketone meter
  o Levels:
    • Small or <0.6 mmol/L
    • Medium or 0.6 to <1.5 mmol/L
    • Large or 1.5 mmol/L or greater
Acidosis

• Secondary to:
  o Production of ketoacids
  o Hypovolemia due to dehydration and production of lactic acid

• Signs include:
  o Mental status changes
  o Vomiting, nausea
  o Rapid breathing

• Lab testing generally shows blood pH < 7.30
Signs of DKA on Exam

• Lethargy, fatigue
• Vomiting
• Tachycardia
• Dry mucous membranes
• Normal or low blood pressure
• Poor perfusion
• Fruity breath
• Altered mental status
• Prolonged capillary refill, reduced skin turgor
• Sunken eyes
• Kussmaul breathing
Lab Findings in DKA

- Glucose levels > 200-300 mg/dL
- Positive ketones ("Large" in urine or >1.5 mmol/L in blood)
- pH < 7.30
- Low bicarbonate (<18)
- Pseudo-hyponatremia
- Hemoconcentration (elevated blood counts, including white blood cells)
Initial Treatment in DKA

- IV fluid resuscitation
  - Normal saline 10-20ml/kg given as bolus
- Initiation of IV insulin
  - Regular insulin, 0.05-0.1 unit/kg/hr

- Neurologic assessment
  - In severe cases, concern for cerebral edema (and thus increased risk for herniation) may lead to CT scan, treatment with hypertonic solution (i.e. hypertonic saline/3% saline)
Inpatient Management of DKA

- **FLUIDS, INSULIN, TIME**
- Fluids:
  - Continuous IVF fluids
  - Electrolyte replacement: potassium and phosphorus
- Insulin:
  - Continuous IV insulin 0.1 unit/hr/hr
- Serial neurologic and cardiovascular assessments
- Typically managed in intensive care unit
Resolution of DKA

• Resolution of hyperglycemia ≠ end of DKA
• DKA resolves once acidosis is resolved and ketosis is resolving
• May take hours to days depending on underlying cause, age of patient, new vs. known diagnosis of diabetes, and severity of presentation
• Dehydration may persist
• Increased risk for relapse of DKA during this time
DKA Outcomes

• Typically excellent prognosis
• In severe cases:
  o Cerebral edema and neurological damage
    • Higher risk in young patients
  o Death
    • Overall mortality rate is 0.2-2%
    • Cerebral edema is most frequent cause in children and adolescents
    • Comorbid condition is also frequent cause, i.e. infection

DKA Complications

- Electrolyte deficiencies
  - Potassium and phosphorus; require oral replacement
- Acute kidney injury
- Loss of work for parents, caregivers
- School absence
- Life disruption
- In recurrent cases, involvement of CPS
- Cost
  - Varies considerably by hospital
  - *Pediatrics*, 2013: $4,125-11,916 per admission; length of stay 1.5-4 days
Long-term Complications?

• Potential neurological and cognitive effects
  o Cameron FJ, et al. Diabetes Care, 2014:
    • Persistent evidence of white matter changes and changes in attention and memory at 6 months following DKA

• Effect from recurrent admissions?
  o Renal
  o Mental health
  o Cognitive
DKA is a preventable outcome of diabetes. What can we do to prevent it?
Recognizing Those at Risk

- Children and adolescents with poorly controlled diabetes
- Use of insulin pump, especially if there are signs of infrequent blood glucose monitoring
- During periods of illness, e.g., acute gastroenteritis or influenza
Early Intervention to Avoid DKA

- Hyperglycemia should be treated
- Persistent hyperglycemia should be cause to monitor more carefully, and consider further evaluation
  - Check ketones (especially if glucose >240 mg/dL x 2)
  - Encourage water intake
- Monitor glucose and ketones in children with other signs of illness (vomiting, diarrhea, fever, cold symptoms)
- With early treatment with increased oral fluids and insulin corrections, DKA may be avoided
Hyperglycemia and Sick Day Management

• With signs of illness or blood glucose >240 mg/dl on two consecutive checks (2-3 hours apart):
  o Check ketones
  o Give water
  o CONTINUE INSULIN
Zero, Trace or Small Ketones (or <0.6 mmol/L)

- Give insulin correction for glucose (if approximately 2-3 hours from last correction) and carbohydrates as needed
- Encourage water intake
- Repeat glucose check again in 3-4 hours and if needed, repeat ketone check
- Alert parent/caregiver, but if child is otherwise well, keep in school!
Medium to Large Ketones

- Start sick day management
- Contact family, and do not hesitate to contact diabetes clinic, especially for large ketones, or >1.5 mmol/L
Sick Day Management

• Guidelines vary, but general treatment includes:
  o If a pump is in use, change pump site
    • DO NOT suspend or stop pump if a new site is not available, continue insulin through pump
    • Give corrections through injection
  o Give short acting insulin correction based off sliding scale every 2-4 hours
  o Encourage fluid intake:
    • Goal of 16 oz/hour or at least 1 oz/year of age/hour
    • Use water if glucose is >200 mg/dl
    • If glucose drops <200 mg/dL and corrections are still needed, add juice or other caffeine-free drink with sugar
  o Recheck blood glucose and ketones every 2-4 hours
  o Call diabetes provider office- the sooner, the better!!
    • Especially with large ketones (or 1.5 mmol/L or greater)
  o If child is not responding to treatment, or condition worsens, we generally advise evaluation, usually in emergency department
Vanderbilt Sick Day Guidelines

- Online and provided on yellow card at office visits
- Sick Day Guidelines
Urgent Signs and Symptoms

- Vomiting, unable to take oral fluids
- Confusion, lethargic
- Fruity smell to breath
- Rapid breathing
- Dry lips, oral mucosa
- Rapid heart rate
- Cool extremities

- Alert parent/caregiver ASAP, call 911/Emergency services as needed. Proceed with checking glucose and ketones as able and giving bolus correction as able

- Encourage parent/caregiver to call on-call endocrine provider (615-322-SUGA or 615-322-7842)
Be an Advocate

• Remind family to provide ketone strips for school and to have them available at home
• Encourage them to check ketone levels when child is sick (calls in sick from school or goes home sick)
• Model:
  o Checking ketones during persistent hyperglycemia
  o Encouraging water intake
  o Ask about/check/help with pump site change
  o Give correction for hyperglycemia
  o Encourage family to contact their endocrine provider if ketones are elevated – ketosis and hyperglycemia can be managed at home successfully, and DKA and hospital admission avoided if caught and treated early enough!
Hyperglycemia Cases
Case #1: Anna
Case #1

- Anna is a 15 year old female. She has had Type 1 diabetes for 7 years. She recently started wearing a pump 8 months ago.

- Over the past year, she has been checking glucose levels less frequently, especially in the mornings if she does not eat breakfast.

- One day, she presented to her school nurse at 10am, complaining of nausea and abdominal pain. Her blood glucose was checked and was read as “HI”

- What is the best next step?
Case #1, cont’d

• Check for ketones!
• Anna has signs of illness with hyperglycemia. She is also at higher risk for DKA due to pump use and infrequent glucose monitoring
Case #1, cont’d

• Anna’s ketones were medium.

• She was given a correction with humalog through a syringe injection, based off her sliding scale. She was given a glass of water and her family was called.

• What was the likely cause of her hyperglycemia and what are next best steps?
Case #1, cont'd

• She did not have pump supplies at school. Her mother brought them to school, and her pump site was changed and restarted. Her old site was kinked.
• It likely kinked overnight or in the morning, but she was not aware as she missed her morning glucose check.
• After an hour, her blood glucose level was down to 280 mg/dL. Her symptoms improved. After another hour, her ketones had decreased to small. By that evening, they were gone.
• Her family and school nurse discussed monitoring for blood glucose checks in the mornings.
Case #2: Luke
Case #2

- 13 year old male with diabetes since age 3 years. He uses insulin pens.
- Frequently misses school due to diabetes-related illnesses and is very poorly controlled, with A1c 12.4%
- At lunch, he went to his school nurse for a glucose check, which was 423 mg/dL.
- He complained of thirst and fatigue. His father was called due to the hyperglycemia. Ketone strips were not included with his supplies.
- He was given a correction at school, and a glass of water. His father was asked to pick him up.
- **What advice would you give Luke’s family?**
Case #2, cont’d

- Luke’s father picked him up. They went home and Lucas went to sleep. In the evening, when he woke up, his glucose was rechecked and read “HI.” He was given a correction but then began vomiting.

- His family tried giving him water, but he continued to vomit. He was brought to an outside ED, where he had a pH 7.05 and was transferred to Vanderbilt Children’s Hospital in DKA and was admitted to the PICU.

- Could his DKA have been prevented? What steps would have changed his outcome?
Case #2, cont’d

• Remind family to include ketone strips with supplies
• Check ketones at school
• Advocate!
  o Ask family to check ketones at home
  o Remind them to check glucose level again 2-3 hours after initial correction
  o Encourage them to call diabetes clinic right away with elevated ketones or signs of illness such as vomiting
Case #3: Emma
Case #3

- Emma is a 7 year old female. She was diagnosed with diabetes last year.
- She presented to school with cough and runny nose. She did not want to eat lunch. Her blood glucose was 270 mg/dL. Her mother was called and advised giving a correction.
- Two hours later, her glucose was checked again and was 260 mg/dL. She was also noted to be flushed and temperature was measured and was 100.9°

What are next best steps?
Case #3, cont’d

- Emma has a low grade fever and likely viral URI, with hyperglycemia
- Check ketones!
- Emma’s ketones were small
- Her mother was called, and she agreed to a correction for Emma’s glucose based off her sliding scale, while she came to pick Emma up due to the fever
- Emma’s nurse encouraged her to take sips of water
- When Emma’s mother arrived, she and Emma’s nurse discussed pushing fluids at home and rechecking ketones later that day
Case #3, cont’d

- Emma’s mother listened to this advice, and Emma drank Pedialyte and water.
- Repeat ketones in the evening remained small, and Emma’s mother called the Diabetes clinic. She was encouraged to continue oral fluids, and to give a correction based on blood glucose every 4-6 hours as needed.
- By the next day, Emma still had a low grade fever and small ketones. Her mother continued to push fluids, closely monitor glucose levels, give corrections and check ketones.
- By the following day, Emma was feeling better, and her ketones were gone. She returned to school.
Case #3, success!

- Ketones can develop with illness.
- With close monitoring and care, mainly fluids and corrections as needed, DKA can almost always be avoided!
Recap

- DKA is a severe but preventable outcome of Type 1 and, to a lesser extent, Type 2 diabetes.
- It is due to absolute vs. relative insulin deficiency and involves a triad of hyperglycemia, ketosis and acidosis.
- Treatment involves inpatient hospital admission, frequently in PICU. It can be life-threatening.
- DKA can be avoided with careful attention to increased risk factors and appropriate evaluation of persistent hyperglycemia and/or illness, monitoring of ketones, and followed by appropriate treatment.
- If there are signs of DKA, children should be brought to ED immediately.
- When in doubt, call the diabetes clinic! 615-322-SUGA.
Thank you for all that you do for our patients!

• Questions or comments?
References


