# 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)

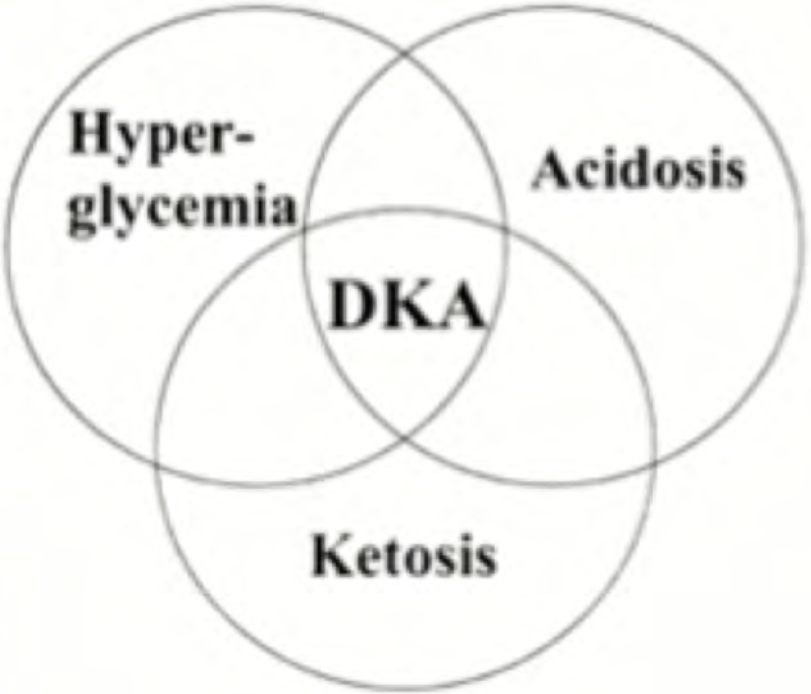
# Diabetic Ketoacidosis

- 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
  - Occurs in 25% of patients with new onset diabetes
  - 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:
  - New onset diabetes
  - Missed basal or multiple bolus doses; lack of adherence to insulin regimen
  - Pump malfunction or disruption of infusion site
  - Concurrent illness or physical stress and increased insulin resistance

# The Triad

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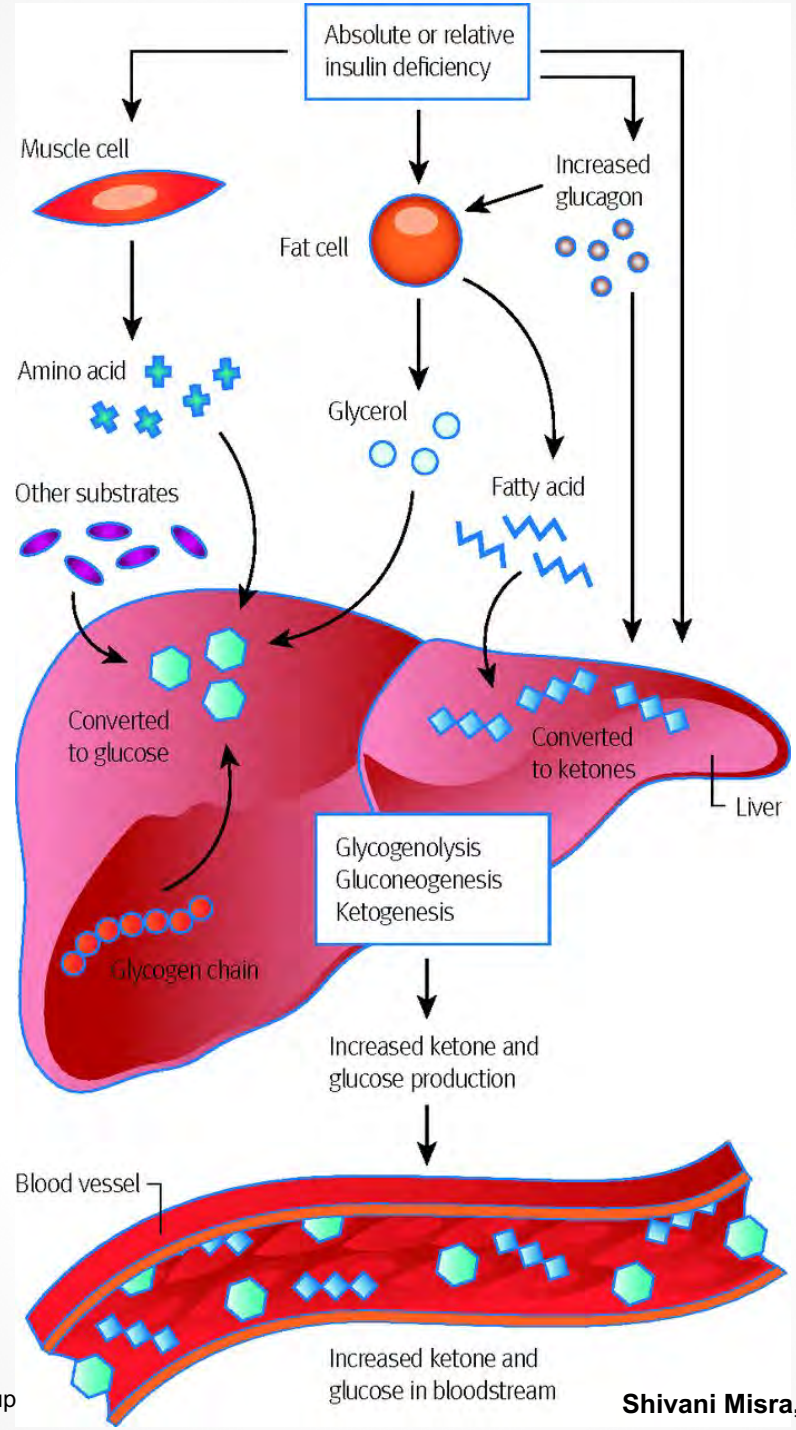




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# Hyperglycemia

- 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

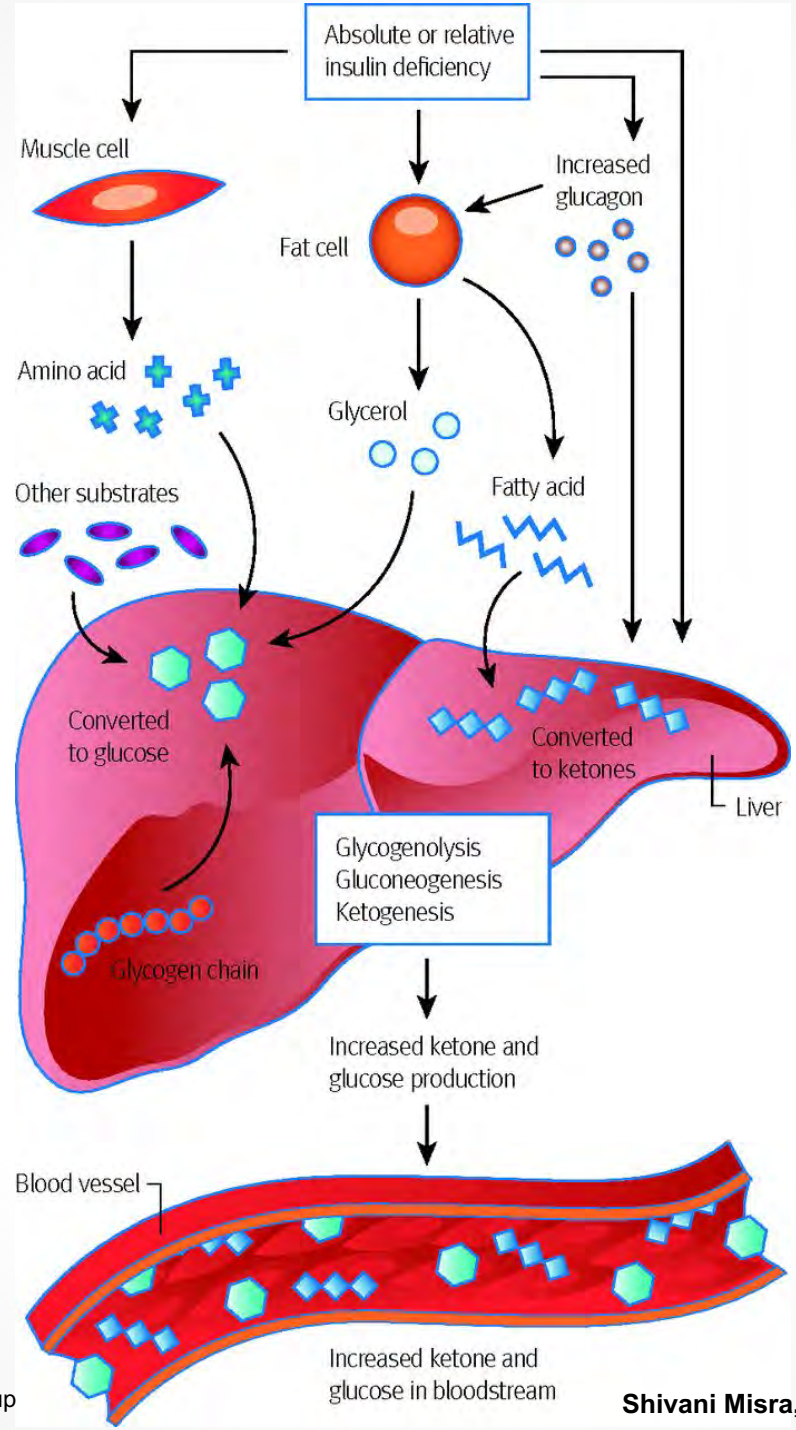
# Signs of Hyperglycemia

- Acute signs include:
  - Polydispsia, polyuria, polyphagia
  - Dehydration
  - Blurred vision
  - Decreased energy
  - Decreased ability to concentrate
  - Mood changes
- In addition, chronic signs include:
  - Weight loss
  - Poor growth, failure to thrive
  - Declining grades
  - 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



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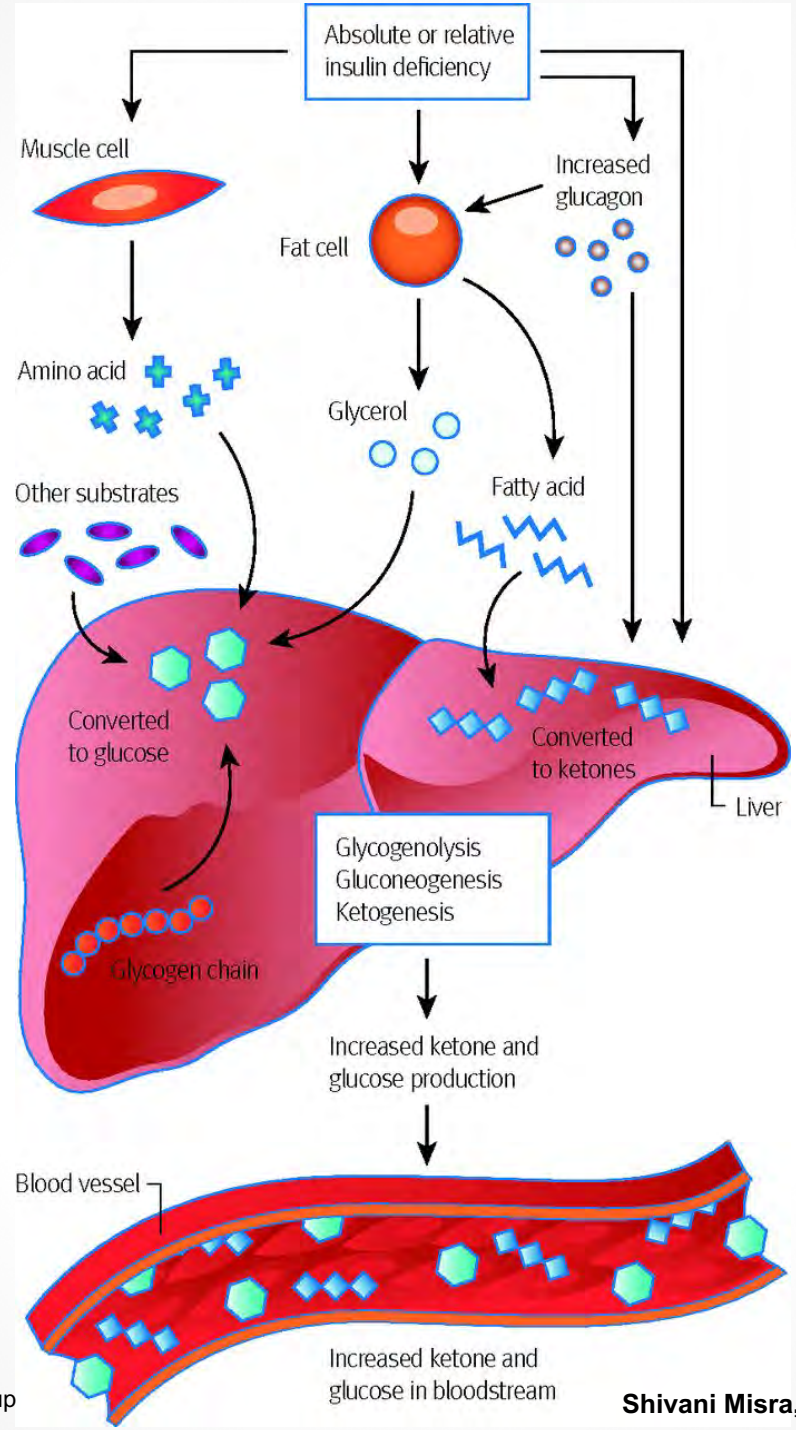
# Signs of Ketosis

- Fatigue
- Confusion or difficulty concentrating
- Abdominal pain, nausea
- Fruity, or acetone, breath
- Measurable:
  - Urine strips or blood ketone meter
  - 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:
  - Production of ketoacids
  - Hypovolemia due to dehydration and production of lactic acid
- Signs include:
  - Mental status changes
  - Vomiting, nausea
  - Rapid breathing
- Lab testing generally shows blood pH <7.30



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# 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:
  - Cerebral edema and neurological damage
    - Higher risk in young patients

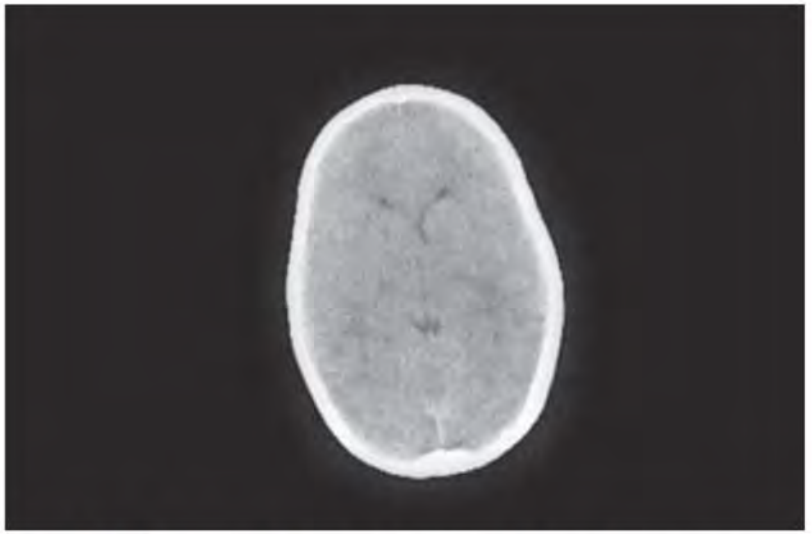


**Figure 28.5** CT scan of the brain of a child with diabetic ketoacidosis complicated by cerebral oedema. There is marked swelling of the brain substance with compression of the lateral ventricles.

  - 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

Image courtesy of: http://www.diabetesincontrol.com/handbook-of-diabetes-4th-ed-excerpt-27-diabetes-in-childhood-and-adolescence/2/

# 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
  - 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?
  - Renal
  - Mental health
  - 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

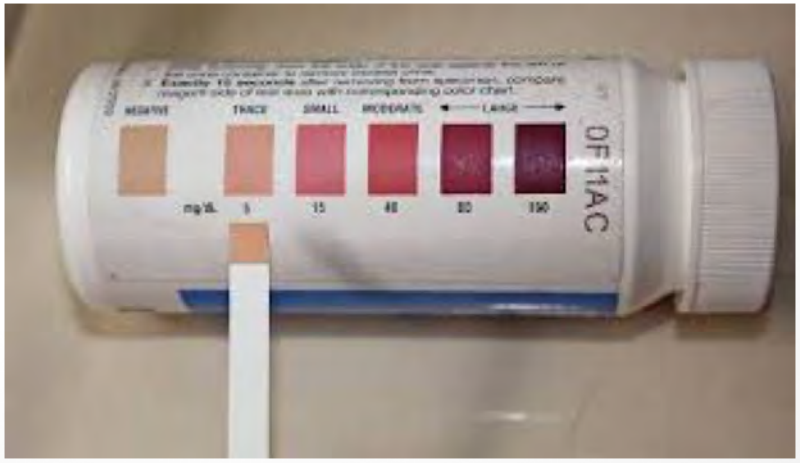
- Hyperglycemia should be treated
- Persistent hyperglycemia should be cause to monitor more carefully, and consider further evaluation
  - Check ketones (especially if glucose >240 mg/dL x 2)
  - Encourage water intake
- Monitor glucose and ketones in children with other signs of illness (vomiting, 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):
  - Check ketones
  - Give water
  - 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

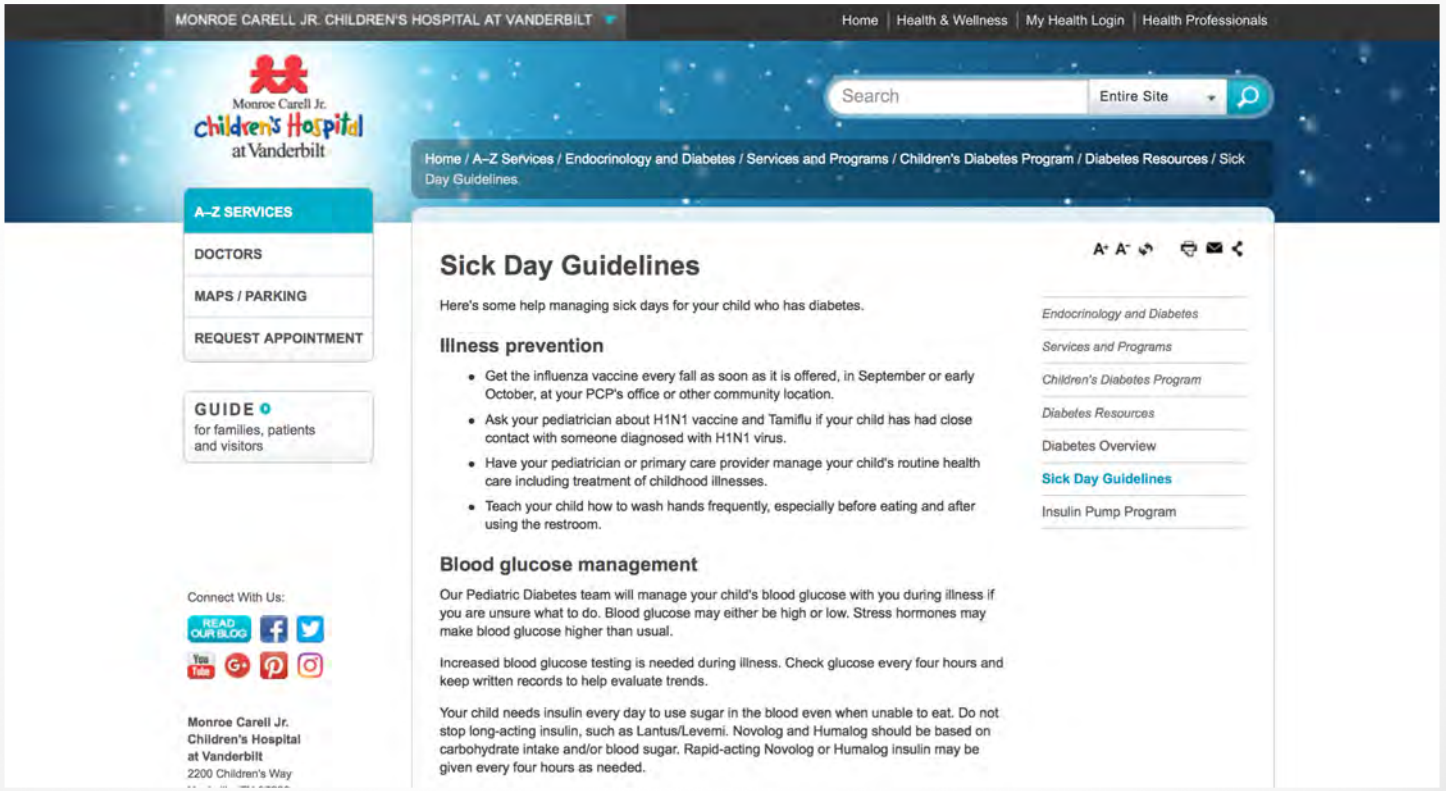
- Start sick day management
- Contact family, and do not hesitate to contact diabetes clinic, especially for large ketones, or >1.5 mmol/L

# Sick Day Management

- Guidelines vary, but general treatment includes:
  - 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
  - Give short acting insulin correction based off sliding scale every 2-4 hours
  - Encourage fluid intake:
    - Goal of 16 oz/hour or at least 1oz/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
  - Recheck blood glucose and ketones every 2-4 hours
  - Call diabetes provider office- the sooner, the better!!
    - Especially with large ketones (or 1.5 mmol/L or greater)
  - 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

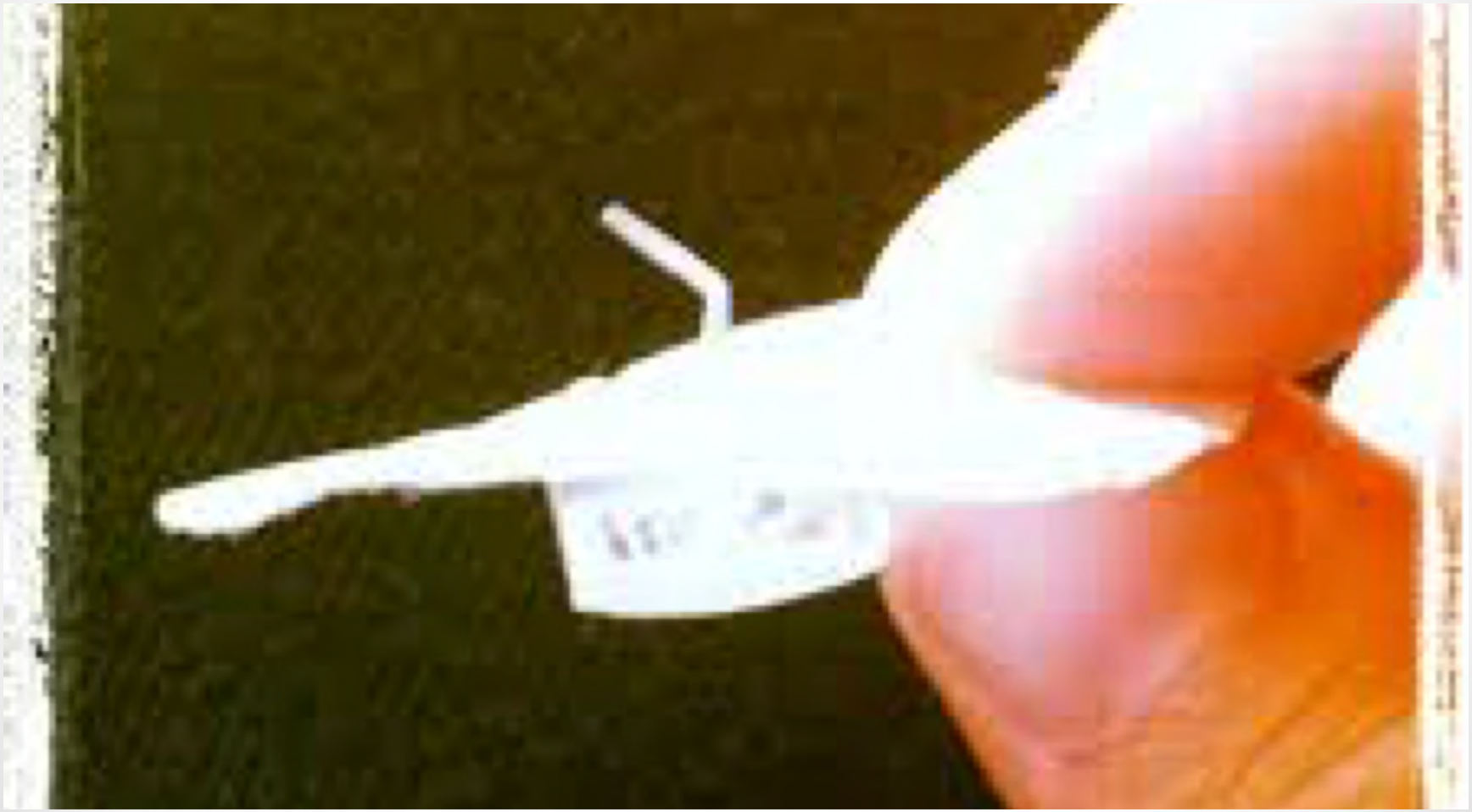
- Encourage parent/caregiver to call on-call endocrine provider (615-322-SUGA or 615-322-7842)

# 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:
  - Checking ketones during persistent hyperglycemia
  - Encouraging water intake
  - Ask about/check/help with pump site change
  - Give correction for hyperglycemia
  - 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!
  - Ask family to check ketones at home
  - Remind them to check glucose level again 2-3 hours after initial correction
  - 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


- Laffel LM, Limbert C, Phelan H, Virmani A, Wood J. Sick day management in children and adolescents with diabetes. Pediatric Diabetes. 2018 Aug 6. (Epub ahead of print) PMID: 30079506
- Usher-Smith JA, Thompson MJ, Sharp SJ, Walter FM. Factors associated with the presence of diabetic ketoacidosis at diagnosis of diabetes in children and young adults: a systematic review. BMJ. 2011 Jul 7. 343:d4092.
- Weber C, Kocher S, Neeser K, et al. Prevention of diabetic ketoacidosis and self-monitoring of ketone bodies: an overview. Curr Med Res Opin. 2009 May. 25(5):1197-207.
- Jessup AB, Grimley MB, Meyer E, et al. Effects of Diabetic Ketoacidosis on Visual and Verbal Neurocognitive Function in Young Patients Presenting with New-Onset Type 1 Diabetes. J Clin Res Pediatr Endocrinol. 2015 Sep. 7 (3):203-10.