Diabetic Ketoacidosis: When Sugar Isn’t Sweet!!!

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Introduction

• Diabetes remains one of the most common chronic diseases in the pediatric population.
• Diabetic ketoacidosis (DKA) is a major complication of diabetes and results in significant cost, morbidity and potential mortality.
• Diabetic ketoacidosis (DKA) is a complex metabolic state resulting in significant dehydration and electrolyte imbalances.

Introduction

• Metabolically, DKA is:
  – Hyperglycemia
  – Anion gap metabolic acidosis
  – Ketonemia
• DKA is a direct result of:
  – Absolute or relative insulin deficiency
  – Excess counter hormonal regulation
• DKA leads to significant dehydration and complex electrolyte disturbances.
Introduction

• The mainstays of the treatment of DKA are rehydration, insulin therapy and a return of electrolyte homeostasis.
• Early recognition and treatment of DKA are associated with an excellent prognosis.
• Prolonged DKA and/or multiple incidences of DKA are associated with cerebral edema, which is the most devastating complication of DKA and the leading cause of mortality.

Epidemiology

• Diabetes a prevalent and growing problem in the pediatric population.
• DKA at the time of diagnosis of diabetes is approximately 1/3 or 12-80% depending on geographic location.
• DKA can be a result of Type 1 or Type 2 diabetes.
• Increasing rates of obesity are leading to marked increases in Type 2 diabetes, both adult and pediatric.

Epidemiology

• Risk factors for DKA:
  – Young children-5 years and younger
  – Teenagers with recurrent episodes
  – Females
  – Lack of relatives with diabetes
  – Socioeconomic factors
  – Missed diagnosis at presentation, delayed treatment
  – Infection
  – Large insulin dosing schedule, missed insulin administration
Pathophysiology

• Insulin deficiency—absolute or relative:
  – Pancreatic failure, insulin omission, insulin resistance, infection, stress
• Counter regulatory hormone increase:
  – Glucose homeostasis
• DKA:
  – Hyperglycemia—blood glucose > 200
  – Metabolic acidosis—pH < 7.3 or HCO₃ < 15
  – Ketonemia

Pathophysiology

• Dehydration:
  – Hyperglycemia leads to fluid and electrolyte shifts
  – Ketone induced nausea and vomiting
  – Kussmaul respirations
• Electrolyte abnormalities:
  – Sodium, potassium, chloride, phosphorus, calcium and magnesium all affected
  – Most significant and life threatening is hypokalemia

Prehospital Treatment

• Initial focus must be on diagnosis and management of life-threatening complications
• ABCDEs
• If DKA suspected, rapid glucose determination
• IV access
• Cardiac monitoring
• Oxygenation
• Fluid therapy/resuscitation
• Reevaluation after treatment measures
Emergency Department: Presentation

• Acute or insidious onset
• Classic triad—polyuria, polydipsia and weight loss with or without polyphagia
• Abdominal pain, nausea, vomiting
• Muscle pain, cramps, “fruity” breath
• Mental status changes, Kussmaul respirations, headache, focal neurologic changes

Emergency Department: History

• Is the patient a known diabetic?
• If not, history of classic symptoms?
  – Young children a challenge
• Persistent candidal infection
• New onset enuresis
• Medications

Emergency Department: Physical

• ABCDEs
• Vital signs
• Weight
• Thorough exam to establish a baseline
• Assessment of dehydration
• Mental status baseline
• Sources of infection
Emergency Department: Labs

- Rapid glucose determination
- Blood gas
- Serum chemistry panel
- Serum ketones
- Complete blood count
- Urinalysis
- Hemoglobin A1C
- EKG

Emergency Department: Labs

- Blood gas
- Chemistry calculations:
  - Corrected Sodium
    - Serum Na + 1.6 x [(serum glucose mg/dL - 100)/100]
  - Anion gap
    - Serum Na – (serum chloride – serum bicarbonate)
- Ketone testing
  - Quantitative serum beta hydroxybutyrate test is the best measure
- Hemoglobin A1C

Emergency Department: Management

- Management goals:
  - Fluid resuscitation/rehydration
  - Correction of hyperglycemia
  - Correction of ketosis
  - Correction of electrolyte imbalances
  - Avoidance of complications
  - Education and prevention
Emergency Department: Management Fluid Therapy

- Resuscitation:
  - Hypovolemic shock - bolus 10cc/kg
  - Timing?
- Rehydration:
  - Rehydration over 24 to 48 hours
  - Include fluids PTA
  - Maintenance plus replacement
- Decreased blood glucose level

Emergency Department: Management Fluid Therapy

- Assessment of dehydration:
  - Usual indicators of dehydration may not be reliable in the setting of DKA.
- Degree of dehydration important in determining treatment parameters
- Estimates of dehydration for fluid replacement:
  - 10% - Historical
  - 5-8% - Cerebral edema concerns
  - Moderate DKA - 5-7%
  - Severe DKA - 7-10%
  - 6%?

Emergency Department: Management Fluid Therapy

- Monitoring:
  - Continuous cardiac monitoring
  - Pulse oximetry
  - Hourly:
    - Vitals
    - Neurologic status
    - Blood glucose, +/- pH
    - Accurate fluid intake and output
- Fluid types
Emergency Department: Management
Insulin

- Rehydration alone can decrease blood sugar
- Insulin required to reverse lipolysis and ketogenesis
- Start insulin after resuscitation/rehydration initiated and chemistries known
- Insulin bolus not necessary
- Low-dose regular insulin drip 0.1 units/kg/hr
- IM or SQ insulin can be used if drip unavailable

Emergency Department: Management
Insulin

- Resolution of hyperglycemia:
  - Target blood glucose 200 mg/dL
  - Addition of glucose to fluids
- Must continue insulin until acidosis resolves
- Transition from IV to Subcu insulin
- Complications/Considerations:
  - Hypoglycemia
  - Hypokalemia
  - Cerebral edema

Emergency Department: Management
Two-Bag System

- DKA and its management lead to rapid and wild fluctuations in fluid, electrolyte and glucose levels and requirements.
- The two-bag system was developed in the 1990s to facilitate frequent and rapid adjustments in DKA therapy.
- The “two-bags” contain identical electrolyte solutions with differing glucose concentrations.
- The rate of delivery of the “bags” is then dialed in dependent on the individual patient’s levels and response to management.
- Allows for “customization” of treatment for each patient.
Emergency Department: Management
Two-Bag System

• Advantages:
  – Rapid response to changes in clinical status
  – Flexible
  – Timely
  – Cost effective

• Disadvantages:
  – Comfort level of providers
  – “New technology”

• ED Pharmacists

Emergency Department: Management
Electrolytes

• Sodium:
  – The corrected sodium level should be monitored and should increase with treatment.
  – Cerebral edema is associated with a failure to increase or a decreasing sodium level

• Potassium:
  – DKA results in potassium depletion but levels might be normal or increased
  – Insulin therapy causes a decrease in potassium
  – Must follow levels to prevent severe hypokalemia
  – EKG an adjunct if cannot measure potassium
Emergency Department: Management Electrolytes

- Bicarbonate:
  - Not recommended or indicated in the treatment of DKA
  - Acidosis will correct with fluids and insulin

Complications: Cerebral Edema

- Most life-threatening complication of DKA
- Exclusive to pediatric patients
- Research has revealed no single causative mechanism.
- Usually occurs within 4 to 12 hours of initiation of treatment but can be delayed up to 24 or 48 hours.

Complications: Cerebral Edema

- Risk Factors for Cerebral Edema:
  - DKA at diagnosis of diabetes
  - Younger age
  - Longer duration of DKA
  - Degree of acidosis at presentation
  - Increased initial fluid resuscitation rate
  - Insulin during the first hour of treatment
  - Bicarbonate treatment
  - Slow rise in serum sodium
Complications: Cerebral Edema

- Monitoring:
  - Neuro checks
  - Vitals
  - Symptoms
- Low threshold for diagnosis and treatment
- Treatment:
  - Raise head of bed
  - Decrease IVF rate
  - CT scan
  - Mannitol, 3% saline
  - Intubation

Emergency Department: Disposition

- New diabetes diagnosis-hospital admission
- Mild DKA, known diabetic:
  - Discharge if alert, taking po and have supplies and supervision at home.
  - Admission if requiring continued fluids, or unable to continue.
- Severe DKA:
  - ICU admission for close monitoring of clinical and laboratory status.

Summary

- The incidence of pediatric DKA is increasing along with a rise in pediatric diabetes.
- DKA is a complex entity hallmarked by dehydration and metabolic changes.
- Management of DKA is composed of fluid resuscitation/rehydration, insulin therapy and vigilant monitoring of glucose, electrolytes and the patient’s clinical status.
- Prompt recognition and management leads to an excellent prognosis in pediatric DKA patients.