Diabetes Ketoacidosis

Abdulmoein Eid Al-Agha, MBBS, DCH, CABP, FRCPCH
Professor of Pediatric Endocrinology,
King Abdulaziz University Hospital
Website: http://aagha.kau.edu.sa

Goals & Objectives

- What is DKA?
- Understand the Pathophysiology of DKA.
- Criteria of diagnosis.
- Clinical and laboratory features.
- Discuss the management approach to the patient with DKA.
- Appreciate the complications that occur during treatment.

Diabetes Ketoacidosis

- Diabetic ketoacidosis (DKA) is the leading cause of morbidity & mortality in children with type 1 diabetes mellitus.
- DKA is the major acute complication of type 1 DM.
- DKA can also occur in children with type 2 diabetes (particularly obese African American adolescents), although at lower rates than those observed in type 1 diabetes.
- In new-onset diabetes, DKA can be prevented through earlier recognition and initiation of insulin therapy.
- Caution is necessary in management of paediatric DKA due to increased risk of cerebral edema, which carries high rates of morbidity & mortality.

Pathophysiology

- Hyperglycemia as a result of impaired glucose uptake secondary to insulin deficiency & excess glucagon secretion.
- Ketone bodies provide alternative usable energy sources in the absence of intracellular glucose.
- Ketoacids (acetoacetate, β-hydroxybutyrate, acetone) are products of lipolysis.
- Hyperglycemia causes osmotic diuresis which leads to excessive loss of free water & electrolytes with secondary hypovolemia , decreased tissue perfusion & lactic acidosis.

Criteria of diagnosis

- Hyperglycemia > 200 mg/dl.
- Dehydration (variable, mild, moderate or severe).
- Ketonemia & Ketonuria.
- MetabolicAcidosis:
  - PH < 7.30.
  - Bicarbonate < 15 mmol/l.

Degree of severity in DKA

	Mild DKA	Moderate DKA	Severe DKA
Plasma glucose (mg/dL)	> 200	> 200	> 200
Arterial pH	7.2-7.30	7.00-7.2	< 7.00
Sodium Bicarbonate (mEq/L)	<15	<10	< 5
Urine Ketones	Positive	Positive	Positive
Serum Ketones	Positive	Positive	Positive
Serum Osmolality (mOsm/kg)	Variable	Variable	Variable
Anion Gap	> 10	> 12	> 12
Mental Status	Alert	Alert/Drowsy	Stupor/Coma

Clinical Manifestations

- Ketoacidosis might be, the initial presentation in 25 – 75 % of children with newly diagnosed diabetes.
- Clinical manifestations, in addition to polyuria, polydipsia & weight loss include:
  - Nausea & vomiting.
  - Dehydration.
  - Kussmaul pattern of breathing.
  - Acetone odor on the breath.
  - Abdominal pain or rigidity (mimic acute abdomen).
  - Cerebral confusion & coma.

Signs of DKA

- Dehydration.
- Tachycardia.
- Dry mucous membrane.
- Delayed capillary refill.
- Poor skin turgor.
- Hypotension.
- Kussmaul breathing.
- Decreased sensorial mental status, varies from sleepiness, drowsiness, confusion, semi coma & coma.

Clinical Assessment

- Measure vital signs & assess signs of shock caused by volume depletion (e.g., decreased blood pressure, reduced peripheral pulses, tachycardia, & significant postural changes in blood pressure).
- Measure weight for use in calculating fluid replacement and insulin infusion rates.
- Estimate the degree of dehydration.
- Assess the neurologic state using the Glasgow Coma Scale (GCS) or similar assessment initially, then repeated hourly until the patient is recovered from ketoacidosis and mental status has returned to normal.

Laboratory

- Serum glucose.
- Urinary/plasma ketones.
- Serum electrolytes.
- BUN/Creatinine.
- Serum Osmolality (measured/calculated).
- CBC, blood culture (if infection is suspected).
- Venous blood gas.
- Anion gap : The anion gap can be used as an index of the severity of the metabolic acidosis

Management

Correction of the following:

- Dehydration.
- Hyperglycemia.
- Electrolytes deficits.
- Metabolic acidosis.
- Underlying precipitating factors (Infection, omission of insulin, stress, ….etc.)

Fluid management

- Volume depletion is caused by urinary losses from osmotic diuresis, as well as gastrointestinal losses from vomiting & insensible losses from hyperventilation.
- Average water losses in children with DKA are approximately 70 ml/Kg (range 30 - 100 ml/Kg).
- Fluid calculations usually should be based upon degree of dehydration.
- Children with DKA have a fluid deficit in the range of 5-10%
  - Mild DKA 3-5%.
  - Moderate DKA 5-7%.
  - Severe DKA 10% dehydration.
  - Shock is rare in pediatric DKA.

Fluid management

- Rapid fluid replacement has been associated with cerebral edema.
- Initially fluid bolus of 7-10 ml/kg over 60 minutes (only in severe DKA, otherwise start fluid rehydration without bolus by maintainace & deficit replacements
- Fluid deficit should gradually be corrected over 48 hrs.
- Start with NS, then to switch to dextrose 5% with ½ NS, when glucose drop to 250 mg/dl

Hyperglycemia Management

- Insulin should be given through intravenous route & continued till acidosis & dehydration resolved.
- Insulin drips 0.075- 0.1 U/kg/hr (NO BOLUS).
- Gradual correction by reducing serum glucose by 50-100 mg/dl/hr. (No hurry!).
- Serum glucose often falls after fluid bolus due to increase in glomerular filtration with increased renal perfusion.
- When acidosis resolved, insulin to be shifted to subcutaneous route.
- Dextrose should be added to IVF whenever, serum glucose is less than 250 mg/dl.
- Not lower insulin infusion unless, acidosis has been resolved.

Do not reduce or discontinue the insulin infusion based solely upon the blood glucose

The insulin infusion should be continued until Ph >7.30 and/or the HCO_3 >15 mmol/l

Electrolyte replacements

- Serum sodium & chloride will be corrected gradually by giving normal saline or 0.45 NS over 48 hours.
- Serum potassium level, is the most important electrolyte disturbance in patients with diabetic ketoacidosis.
- A patient with a low serum potassium level should be assumed to have a potentially life-threatening total body potassium level.
- As a result of the potential for hypokalemia-induced dysrhythmias, not to give insulin until potassium replenishment is underway.

Electrolyte replacements

Potassium:

- Initially, might be false normal or high values because of metabolic acidosis.
- Should be added to fluids as soon as insulin has been started unless potassium is more than 5.5 mmol/l.
- Be sure of passing urine, prior of giving potassium.
- Total body depletion will become more prominent with correction of acidosis
- Continuous EKG monitoring is essential.
- Dose of 30-40 mmol/l in either KCl or K phos.

Electrolyte replacements

Phosphate:

- Total body depletion will become more prominent with correction of acidosis.
- Theoretically, to be corrected but practically not necessarily needed.
- Hypophosphatemia may cause rhabdomyolysis, hemolysis, impaired oxygen delivery to the tissues.
- Calcium should be monitored during replacement as acute hypocalcaemia may develop due to intravenous phosphate infusion.

Metabolic Acidosis

- Ketosis & lactic acidosis produce a metabolic acidosis; however, supplemental bicarbonate is not recommended.
- Acidosis usually resolves with isotonic fluid volume replenishment and insulin therapy.
- Remember that intravenous insulin & hydration is the treatment of metabolic acidosis in DKA patients.
- Only indicated in severe metabolic acidosis (pH < 7.0) or patient is in chock with DKA.
- Studies confirmed that bicarbonate therapy may cause paradoxical intracellular acidosis, worsening tissue perfusion, hypokalemia & cerebral edema.

Metabolic Acidosis

- Bicarbonate is almost never administered.
  - Bicarbonate administration leads to increased cerebral acidosis.
  - Bicarbonate passes the Blood Brain Barrier slowly.
  - CO_2 diffuses freely exacerbating cerebral acidosis & depression.
- Indications for bicarbonate use: only in severe acidosis leading to cardio-respiratory compromise or if PH < 7.

Management of underlying cause

- In each case, we need to look for precipitating factors.
- Infections especially viral is the most common factor.
- Using antibiotics should not be routine in children as most infections are viral.
- Presence of leukocytosis initially in DKA is due to dehydration & stress (not usually indicates infection).
- We need to improve education “sick-day managements” in order to reduce number of DKA episodes.

DKA Complications

Cerebral edema

- Occurs in less than 1% of Pediatric DKA episodes.
- Accounts for 60% to 90% of all DKA deaths.
- 10% to 25% of survivors have permanent neurological injury.
- Typically develops within the first 12- 24 hr of treatment.
- Etiology is still unclear.
- Signs & symptoms include:
  - Headache.
  - Confusion.
  - Slurred speech.
  - Bradycardia.
  - Hypertension.

Risk factors for Cerebral edema

- Younger age (< 5 years).
- Severe metabolic acidosis.
- New-onset diabetes.
- Severe dehydration.
- Rapid administration of hypotonic fluids.
- IV bolus of insulin with rapid drop of glucose.
- Usage of bicarbonate.
- Idiopathic (could happen even prior to treatment).

Cerebral Edema: Treatment

- Reduce rate of intravenous fluids.
- Elevate head of bed to at least a 30°angle.
- Mannitol 0.25 -1 gram/kg IV over 30 minutes.
- May repeat if no initial response in 30 minutes to 2 hours.
- Intubation for impending respiratory failure but avoid aggressive hyperventilation.

DKA complications

- Cerebral Edema.
- Pulmonary Edema.
- CNS Hemorrhage
- Thrombosis.
- Cardiac Arrhythmias.
- Renal Failure.


Wishing you
Best Success