Case Conference

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DKA：Definition

- hyperglycemia (>200 mg/dL), anion gap metabolic acidosis (pH<7.3 , HCO3<15 meq/L), and ketonemia.

	DKA		
	Mild	Moderate	Severe
Plasma glucose (mg/dL)	>250	>250	>250
Arterial pH	7.25-7.30	7.00-7.24	<7.00
Serum bicarbonate (mEq/L)	15-18	10 to <15	<10
Urine ketones*	Positive	Positive	Positive
Serum ketones*	Positive	Positive	Positive
Effective serum osmolality (mOsm/kg)*	Variable	Variable	Variable
Anion gapΔ	>10	>12	>12
Alteration in sensoria or mental obtundation	Alert	Alert/drowsy	Stupor/coma

	Mild	Moderate	Severe
Defining features			
Venous pH	7.2-7.3	7.1-7.2	<7.1
Serum bicarbonate	10-15	5-10	<5

~ESPE/LWPES consensus statement on diabetic ketoacidosis in children and adolescents.

Recurrent DKA

- Risk factors：
  - Higher A1C levels and higher reported insulin requirements
  - Female adolescents, with the highest risk in female adolescents over 13 years of age
  - Children over 13 years of age, who are underinsured and/or have a history of psychiatric disorders
  - Longer duration of DM

~Predictors of acute complications in children with type 1 diabetes. JAMA 2002 May 15;287(19):2511-8.

DKA：Clinical Manifestation1

- earliest symptoms are related to hyperglycemia.
- polyuria (due to the glucose-induced osmotic diuresis), polydipsia (due to the increased urinary losses), and fatigue, weight loss.
- abdominal pain (unusual in HHS)：associated with the severity of the metabolic acidosis

DKA：Clinical Manifestation2

- Hyperventilation and deep (Kussmaul) respirations：the respiratory compensation for metabolic acidosis.
- Neurologic findings： from drowsiness, lethargy, and obtundation to coma, are related to the severity of hyperosmolality and/or to the degree of acidosis.

DKA management

- Assess severity：
  - Neurologic status：potential risk for cerebral edema
  - Acid-base status： venous pH 、serum bicarbonate concentration、 respiratory rate
  - The anion gap：A high anion gap may also reflect decreased renal perfusion, which limits ketoacid excretion.
  - Assessment of volume depletion status.
  - Duration of symptoms：long duration of symptoms, as well as depressed level of consciousness or compromised circulation, is evidence of severe DKA

DKA management：Fluid repletion1

- Assess degree of dehydration in children with DKA is DIFFICULT →less likely to show the classic signs of hypovolemia (ex：dry oral mucous membranes or decreased skin turgor)
- To reduce risk of cerebral edema →accomplishing the volume expansion gradually and with isotonic fluids
- Initial fluid management ：assumption of a 5 to 7 percent deficit for moderate DKA, and 10 percent dehydration for severe DKA

DKA management：Fluid repletion2

- moderate to severe DKA：usually begun with an infusion of 10 to 20 mL/kg over one hour.
- If hemodynamic is stable→ slowly administration of isotonic saline for 4 to 6 hours →then switch to one-half isotonic saline (may add Potassium)
- Based upon body surface area, the volume should be no greater than 2500 mL/m2 for 24 hours (may increase risk of cerebral edema).

DKA management：insulin1

- suppress glucose and ketone production, and stimulate peripheral glucose and ketone metabolism.
- After the initial fluid bolus → insulin infusion is begun at a rate of 0.1 unit/kg per hour.
- IV bolus of insulin is NOT recommended in the first hour before initiation of fluid therapy.

~The UK case-control study of cerebral oedema complicating diabetic ketoacidosis in children. Diabetologia. *2006 Sep;49(9):2002-9. Epub 2006 Jul 18.*

DKA management：insulin2

- F/S：250 to 300 mg/dL→ shift saline to 5 % dextrose in isotonic saline or lactated Ringer's solution (continued administration of insulin→ correct ketoacidosis)
- Ideal goal→ gradual decrease glucose about 50 to 100 mg/dL
  - For younger children→ keep serum glucose around 150 to 200 mg/dL or
  - For older children→keep 100 to 150 mg/dL

→ Then switch to subcutaneous insulin

DKA management：Sodium

- Usually low measured serum sodium→ osmotic effect of hyperglycemia.
- Reversing the hyperglycemia with insulin → lower the plasma osmolality, cause water to move from the extracellular fluid into the cells→ Na ↑
- If Na →or ↓ ：may predict risk of cerebral edema

Bedside evaluation of neurological state of children with DKA

Major criteria
Altered mentation/fluctuating level of consciousness
Sustained heart rate deceleration (decline more than 20 bpm) not attributable to improved intravascular volume or sleep state
Age-inappropriate incontinence
Minor criteria
Vomiting
Headache
Lethargy or being not easily aroused from sleep
Diastolic blood pressure >90 mmHg
Age <5 years
Diagnostic criteria
Abnormal motor or verbal response to pain
Decorticate or decerebrate posture
Cranial nerve palsy (especially III, IV, and VI)
Abnormal neurogenic respiratory pattern (eg, grunting, tachypnea, Cheyne-Stokes respiration, apneusis)

Cerebral edema is diagnosed if any of the diagnostic criteria is present.
And it is also likely if two major criteria **OR** one major and two minor criteria are present.

~Cerebral edema in childhood diabetic ketoacidosis: natural history, radiographic findings, and early identification. Diabetes Care 2004; 27:1541.

DKA management：Potassium

- most DKA patients ：K→or ↑
- After initial IV expansion：K ↓ (to normal range)
  - If K→ ： potassium replacement should be given with the start of insulin therapy
  - If K ↓ ： potassium replacement should be started immediately,
  - If K ↑ ： potassium replacement should be initiated when the serum potassium falls to normal

DKA management：Metabolic Acidosis

- Insulin： promotes the metabolism of ketoacid anions, resulting in the generation of bicarbonate, and stops the ongoing production of new ketoacids.
- sodium bicarbonate ：NO clinical benefit from the routine administration.
  - Maybe a risk factor for cerebral edema
- patients with severe acidemia (arterial pH <6.90) or severe hyperkalemia → may use sodium bicarbonate

~ESPE/LWPES consensus statement on diabetic ketoacidosis in children and adolescents.

DKA management：Discontinuing the insulin infusion

- Serum anion gap reduced to normal (12 ± 2 meq/L)
- Venous pH is >7.30 or serum HCO3 is >15 meq/L
- Plasma glucose <200 mg/dL
- Tolerating oral intake

- a persistent normal anion gap acidosis is NOT a contraindication for switching the patient to subcutaneous insulin

Thanks for your attention !