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PEDIATRIC DKA UPDATE





DKA in Children

CHEO ED Outreach



Conflict Disclosure Slide

- I have no financial or personal relationships to disclose.



Learning Objectives

- Participants will be able to:
 - Describe the differences between adult and pediatric DKA
 - Treat pediatric DKA using an algorithm



Type 1 Diabetes Mellitus

- Pancreatic beta cell destruction
- Diagnosis:
 - Fasting PG > 7.0 mmol/L
 - Random PG > 11.1 mmol/L + symptoms of diabetes
 - 2-hour PG in a 75-g OGTT > 11.1 mmol/L
- Prone to ketoacidosis



Diabetic Ketoacidosis

- Common complication
- Leading cause of morbidity/ mortality due to Type I DM



Diabetic Ketoacidosis

- Acidosis (pH<7.3 and/ or $\text{HCO}_3 < 15$)
- Ketones
- Diabetes (either new onset or existing)



Diabetic Ketoacidosis

| Mild DKA | Moderate DKA | Severe DKA |
|-----------------------|-----------------------|----------------------|
| pH < 7.3 | pH < 7.2 | pH < 7.1 |
| HCO ₃ < 15 | HCO ₃ < 10 | HCO ₃ < 5 |



Diabetic Ketoacidosis

- Dehydration
- Tachycardia
- Tachypnea, Kussmaul respirations
- Ketotic breath
- Nausea, vomiting
- Abdominal pain
- Confusion, drowsiness, decreased LOC



Cerebral Edema

- <1% of episodes of DKA complicated with cerebral edema
 - 95% of episodes in < 20 year olds
 - 1/3 in < 5 year olds
 - 2/3 in children with new onset DM in DKA



Signs of Cerebral Edema

- Headache, vomiting
- Confusion, GCS < 15
- Irritability in young children



Risk Factors for Cerebral Edema


- Younger age (< 5 years)
- Greater acidosis (lower pCO₂, lower pH)
- New onset diabetes
- Longer duration of symptoms
- Sick appearance
- More severe evidence of dehydration
- ↑ hematocrit, urea, potassium



Bottom Line...

- Early recognition
- Good management of new onset disease
- Compliance and management in known DM





DIABETIC KETOACIDOSIS GUIDELINES for CHAMPLAIN LHIN USE



1. Initial Investigations:

- Consult CHEO Diabetes Doctor on call.
- Blood glucose, pH, pCO₂, HCO₃, Na, K, Cl, urea, creatinine, urine ketones
- If new onset diabetes, include TSH, thyroid antibodies and HbA1c (Note: these will be drawn at CHEO)
- Calculate:
 - Anion gap [Na - (Cl + HCO₃)] [normal range 12-16]
 - Serum osmolality (2 x Na + glucose) [normal 275-295 mosm/L]
 - Corrected Na: a 3.5 mmol/L increase in serum glucose depresses serum sodium by 1 mmol/L. Note: initial corrected serum Na >145 mmol/L has been associated with increased risk of cerebral edema.
- Admission to PICU is recommended for all patients in DKA with pH < 7.1, age < 2 years, hypotension or suspected cerebral edema (see item 6). **Contact CritiCall (1-800-668-4357) if considering PICU admission**

2. Monitoring

- Cardiorespiratory monitor and O₂ saturation monitor.
- Hourly monitoring of vital signs (HR, RR, BP), neurovitals and presence of headache is essential. (Refer to section 6 on cerebral edema). Accurate intake and output q1h in PICU and q2-4hr on ward.
- Bedside glucose q1h until dextrose added to iv, then q2h (and 1 hour after any changes in insulin dose).
- Blood gas, glucose, Na, K, Cl, urea, urine ketones, serum osmolality q4h while on insulin infusion, or more frequently as clinically indicated.
- Notify most responsible physician/Diabetologist if measured serum sodium fails to rise as the glucose decreases
- NPO in severe acidosis until nausea subsides - may then have ice chips.
- Initial fluids:** Normal saline 0.9%
- ii) If hypotensive:** 10 cc/kg minibolus over 20-30 minutes, then reassess and repeat if still hypotensive. Never leave the iv open and unattended.
- iii) If normotensive:**

| Weight | Fluid rate (equivalent to maintenance + 10% deficit given evenly over 48 hours) |
|----------|---|
| 3-9 kg | 6 cc/kg/hr |
| 10-19 kg | 3 cc/kg/hr |
| >20 kg | 4 cc/kg/hr (to a maximum of 250 cc/hr) |
- Ongoing iv fluid therapy:** 0.9% saline with 40 meq/L KCl until dextrose is added (see below).
- Do not insert central venous lines unless all other options have been exhausted.
- Do not add KCl while anuric or K > 5.0 mmol/L.
- Once acidosis is corrected (HCO₃ > 18), can then D/C iv fluids and complete rehydration orally.
- Glucose:** should be added to the iv when BG < 15 mmol/L (when adding glucose change to D5/45NS or D10/45 NS as required to maintain glucose 10-15 mmol/L). Alternatively, D5NS or D10NS may be used. The goal is to decrease the glucose by not more than 5mmol/L/hour. If BG decreases > 5 mmol/L/hour, increase the concentration of dextrose in the iv solution. If D5NS or D10NS are used, monitor for hyperchloremic metabolic acidosis.
- Follow serum osmolality with goal of no greater than 2-3mmol/L/hr decrease.

Fluids in Pediatric DKA

- Only bolus fluid if patient hypotensive, poorly perfused
- Treat deficit and maintenance over 48 hours
- Start insulin infusion (0.1 units/kg/hr) 1-2 hours after IVF started



RECALL: Hypotension in children

- Decompensated shock
- Late and often sudden finding

| Age | 5%ile SBP |
|---------------------|----------------------------|
| Neonate (0-28 days) | 60 mmHg |
| Infant (1-12 mos) | 70 mmHg |
| Child (1-10 years) | 70 + 2 (age in years) mmHg |
| Child (> 10 years) | 90 mmHg |



Case 1

- A 14-year old boy presents with a one-month history of feeling unwell with a 10 pound weight loss
- 3 day history of significant fatigue
- Polyuria and polydipsia for a couple of weeks
- Nocturia 2-3 x/night recently
- Denies headache



Case 1 - Examination

- HR 110, BP 120/80, RR 26, Sats 100% RA
- Weight 50 Kg
- Bedside glucose – critical high at triage



Case 1 - Examination

- Tired but alert and oriented, GCS 15
- Tachypneic, deep respirations, no indrawing
- Clear chest
- Cap refill 2-3 sec, dry MM, pale, normal HS
- Abdo benign
- Normal neuro exam



What are your orders?
Initial investigations?
Management?



Case 1 - Results

- Serum glucose 38
- Na 130, K 4.8
 - Corrected Na = 139
- Cl 103, Cr 75, urea 8
- VBG = 7.25/35/40/10
- Urine ketones 3+, glucose 3+



Diagnosis

New onset Type 1 Diabetes with Diabetic Ketoacidosis



Case 2

- A 2 year old girl presents with lethargy for the past 24 hours
- No infectious signs/ symptoms or contacts
- Concerned triage nurse brings her directly to your resuscitation area



Case 2 - Examination

- HR 150, BP 80/50, RR 44, Sats 100% RA
- Weight 18 Kg
- Bedside glucose – critical high at triage



Case 2 - Examination

- A: Airway patent
- B: Breathing rapid and deep, mild indrawing, equal AE bilaterally, no adventitious sounds
- C: Dry MM, cap refill 3-4 s, cool extremities, pulses present
- D: GCS 10 – eyes open to pain (2), cries to pain (3), localizes to pain (5)
- Can't see fundi, no other focal findings



What are your orders?
Initial investigations?
Management?

What are you worried about?



Case 2 - Results

- Serum glucose 44
- Na 126, K 4.8
 - Corrected Na = 137
- Cl 103, Cr 75, urea 12
- VBG = 7.03/30/40/4
- Urine ketones 3+, glucose 3+



Diagnosis

New onset Type 1 Diabetes
with Diabetic Ketoacidosis
and Cerebral Edema



Case 2 – High Risk for Cerebral Edema

- Clinical factors:
 - New onset diabetes
 - Age <5 years
 - Severe dehydration
- Laboratory results:
 - Initial pH<7.1
 - High urea



Pediatric Diabetic KetoAcidosis (DKA) Algorithm

Recognition of DKA:

DKA can occur in existing or new onset type 1 or type 2 diabetes

Clinical features:

Polyuria, polydipsia, weight loss, dehydration, headache, Kussmaul breathing, decreased level of consciousness, abdominal pain, vomiting

Alert Pediatric Referral Centre



Make diagnosis of DKA

Diagnostic criteria:

1. Diabetes (random blood glucose \geq 11.1 mmol / L)

+ Ketonuria

+ Acidosis

| | Mild | Moderate | Severe |
|-------------------------------|------------|------------|--------|
| pH | 7.2 – 7.29 | 7.1 – 7.19 | < 7.1 |
| HCO ₃ ⁻ | 10 – 14 | 5 – 9 | < 5 |



Initial Management:

- Assess ABCs, cardiorespiratory and BP monitoring
- Rapid bedside glucose
- O₂ 10-15 L non-rebreather mask (if signs of shock)

- IV Access x2 lines (consider intraosseous if unsuccessful)
- Serum glucose, electrolytes, venous blood gas, urea, creatinine, serum osmolality
- Urinalysis for glucose, ketones; bladder catheterization if needed

• Consider other investigations:

- Obtain cultures (e.g. blood, urine, throat) if clinical evidence of infection
- ECG for baseline assessment of K⁺ status (if serum K⁺ is delayed)



HYPEROSMOLAR HYPERGLYCEMIC STATE (HHS)

Consider if:

- Glucose ≥ 33 mmol/L
- Osmolality ≥ 330 mOsm/L
- Minimal acidosis/ketosis
- $\text{HCO}_3^- > 15$
- Negative or trace urine ketones

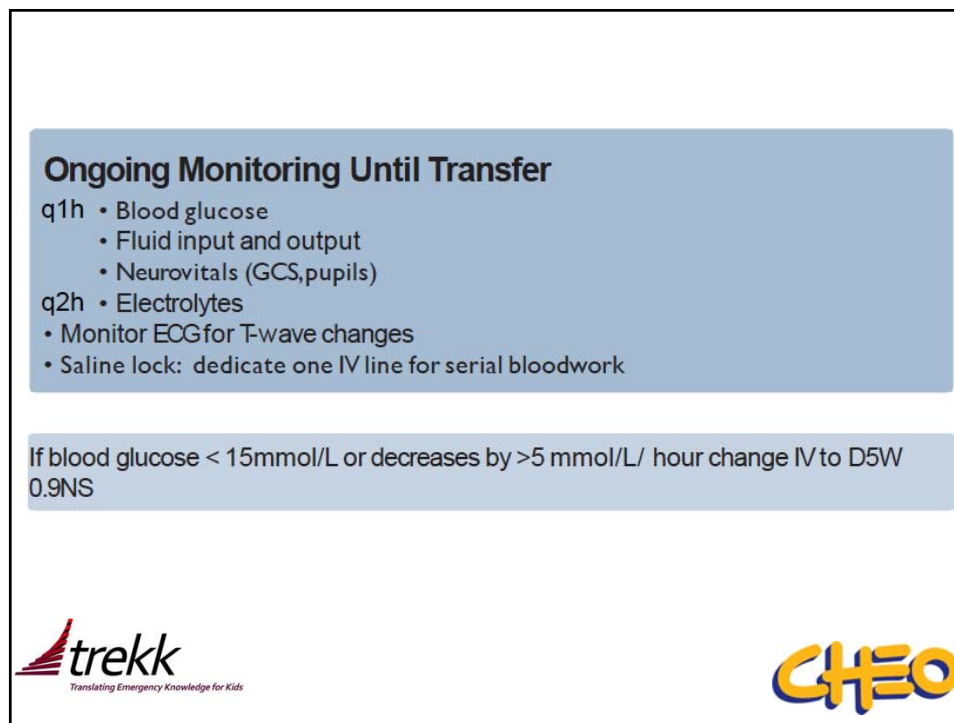
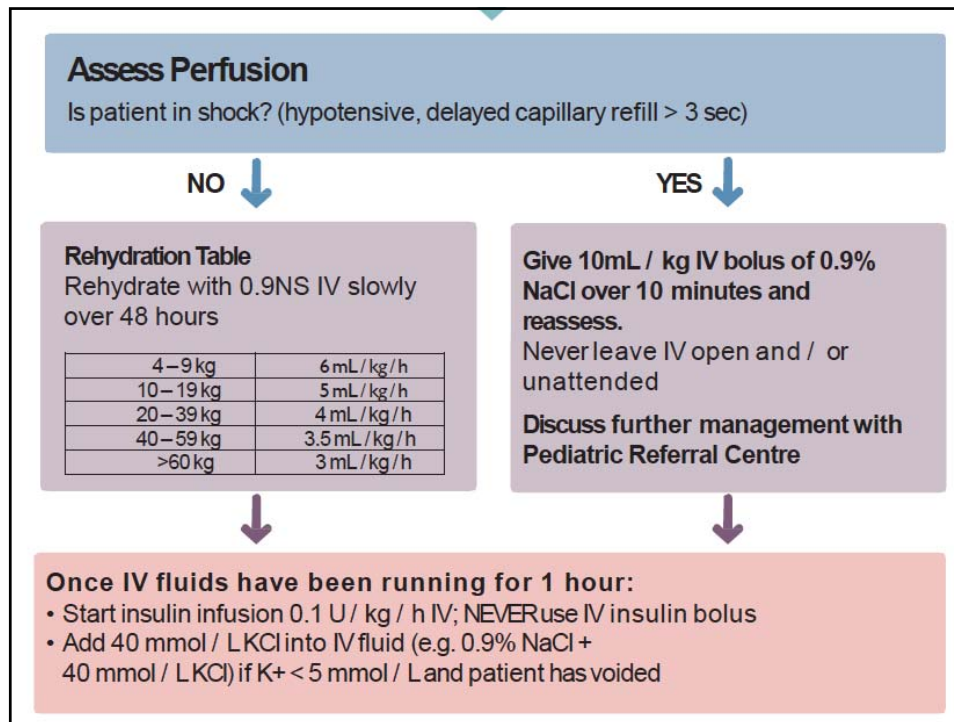
Discuss with Pediatric Referral Centre



Assess for CEREBRAL EDEMA

- ▶ If signs of neurological deterioration:
(headache, vomiting, confusion, GCS < 15 ,
and/or irritability in younger children)
- Call Pediatric Referral Centre
 - Assess and manage ABCs
 - Bed rest, elevate head of bed to 30°
 - Decrease IV fluid to 60% of rate outlined in Rehydration Table
 - **3% NaCl (5 mL/kg IV over 30 min) OR Mannitol (0.5–1 g / kg IV over 20 min)**
 - Head CT not required prior to transport





CAUTION!

Intubation and ventilation are high-risk procedures for DKA patients and should only be done in consultation with your pediatric referral centre or transport team.

Discussion with Pediatric Referral Centre:**CONSIDERATION OF:**

- Difficult vascular access
- Additional treatment of cerebral edema
- Airway management



Conclusion

- Know your resources
- Pediatric DKA is different than in adults
- Beware cerebral edema in children with T1DM

