

PEDIATRIC DIABETIC EMERGENCIES

Kristin Kim, MD, PhD

ETOS Grand Junction

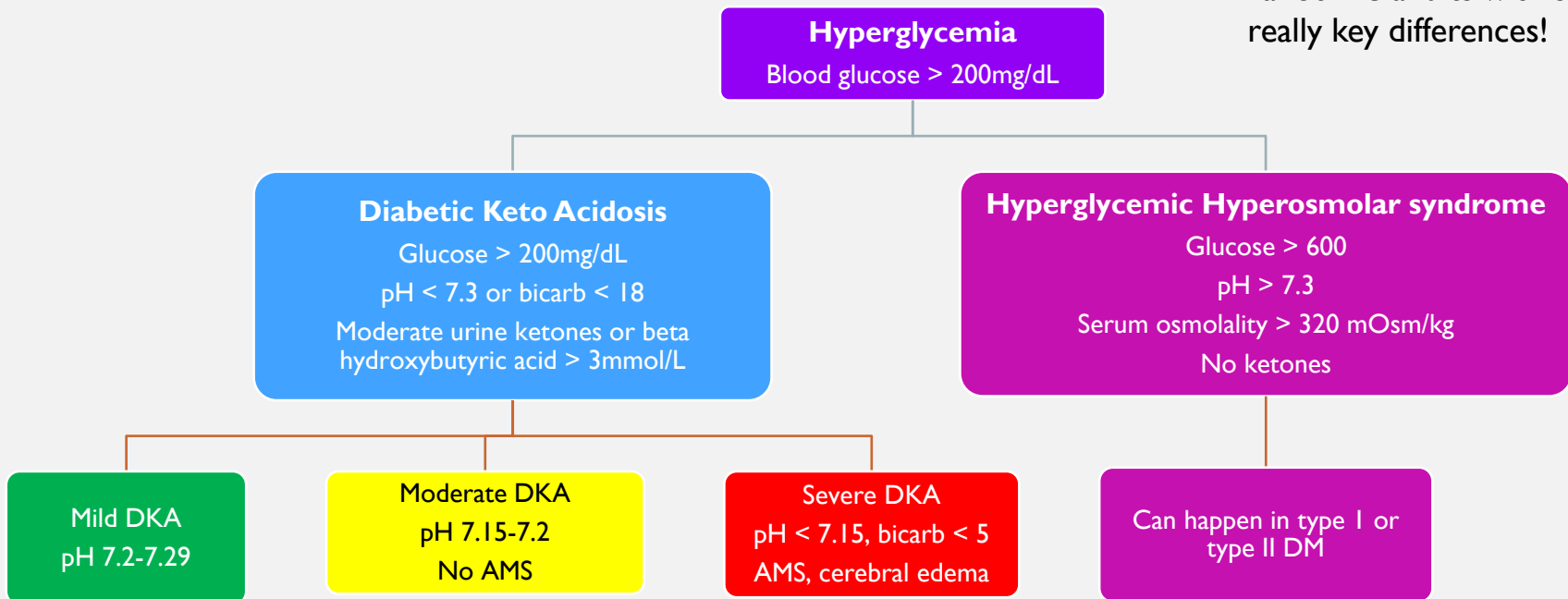
June 12, 2024

CASE 1 – “DIFFICULTY BREATHING”

- 16 yo boy presents to the ED with concern for fatigue, vomiting and respiratory difficulty.
- He is ill appearing and gaunt although his mother is also quite thin.
- He reports his symptoms started 2 days ago and have worsened, however the fatigue began about a week ago. You ask about weight loss and he tells you that he's lost about 15 pounds in the past month despite eating constantly. When you ask – he states that he's been very thirsty and almost wet the bed last night as he had to run to empty his bladder.
- On exam – he has dry lips and mouth, HR 120, RR 20, BP 106/60, sat 100% on RA. Lungs CTA but breathing hard and a bit fast. Abdomen very mildly uncomfortable with palpation. Cachectic appearing.

HYPERGLYCEMIC EMERGENCIES IN KIDS*

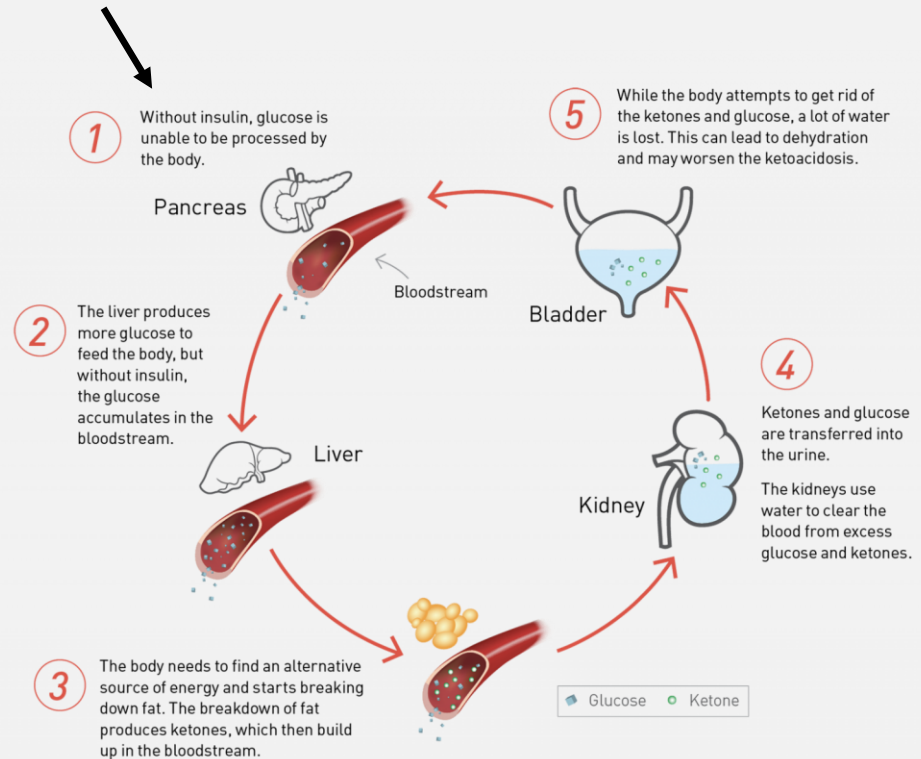
*a lot like adults with some really key differences!



PEDIATRIC DKA

- Hyperglycemia
 - Insulin deficiency → Cells can't use glucose, excess in the extracellular space
- Ketosis
 - Cells use fat (& protein) for metabolism → beta-hydroxybutyrate is made (ketones)
- Acidosis
 - Acidosis – due to both ketosis and poor perfusion
- A leading cause of death in children with type 1 diabetes
- Can be the initial presentation of new-onset type 1 diabetes

Insulin deficiency



DKA IN NEW ONSET DKA - HISTORY

- Symptoms can be vague and non-specific (particularly in younger children)
- Fatigue
- Abdominal pain and / or vomiting (if vomiting without diarrhea – consider DKA)
- Weight loss – can be profound and rapid
- Dehydration (may not have decreased urination)
- The “polys”
 - Polyuria (osmotic diuresis) – in younger children can be new onset of bedwetting or daytime enuresis
 - Polydipsia (in direct response to the polyuria)
 - Polyphagia (due to metabolic inadequacy)
- May have a preceding illness



DKA IN NEW ONSET DKA – EXAM FINDINGS

- Respiratory distress with clear lungs – Kussmaul breathing (deep, a bit fast, irregular)
- Acetone /fruity smell to breath (30% of people can't smell acetone)
- Dehydration – can be profound however the extracellular glucose may fool you into underestimating the dehydration extent
- Tachycardia and occasionally hypotension
- Abdominal tenderness – usually diffuse but can be severe pain
- Altered mental status – this is ominous

INITIAL EVALUATION

- Suspect DKA but don't anchor the diagnosis yet – other causes can precipitate the insulin deficiency or hyperglycemia
- Initial labs –
 - VBG, glucose – bedside if at all possible
 - Comprehensive metabolic profile, Phos, beta-hydroxybutyrate, HgbA1C, Urinalysis
 - Look for other things: thyroid studies, CBC, blood cultures if febrile, Ucx, consider lactate
- Continuous cardiorespiratory monitoring (consider an ECG if ill appearing)
- IV placement – 1 if well appearing, 2 if ill appearing or DKA is confirmed
- Initial fluid administration – 0.9% NS (avoid K until known level)
 - First bolus 10-20 cc/kg 0.9% NS (over 1 hour if not shock)
 - Treat shock with 10-20 cc/kg boluses until perfusion improves
- Consider other causes – sepsis, cardiac, respiratory infection

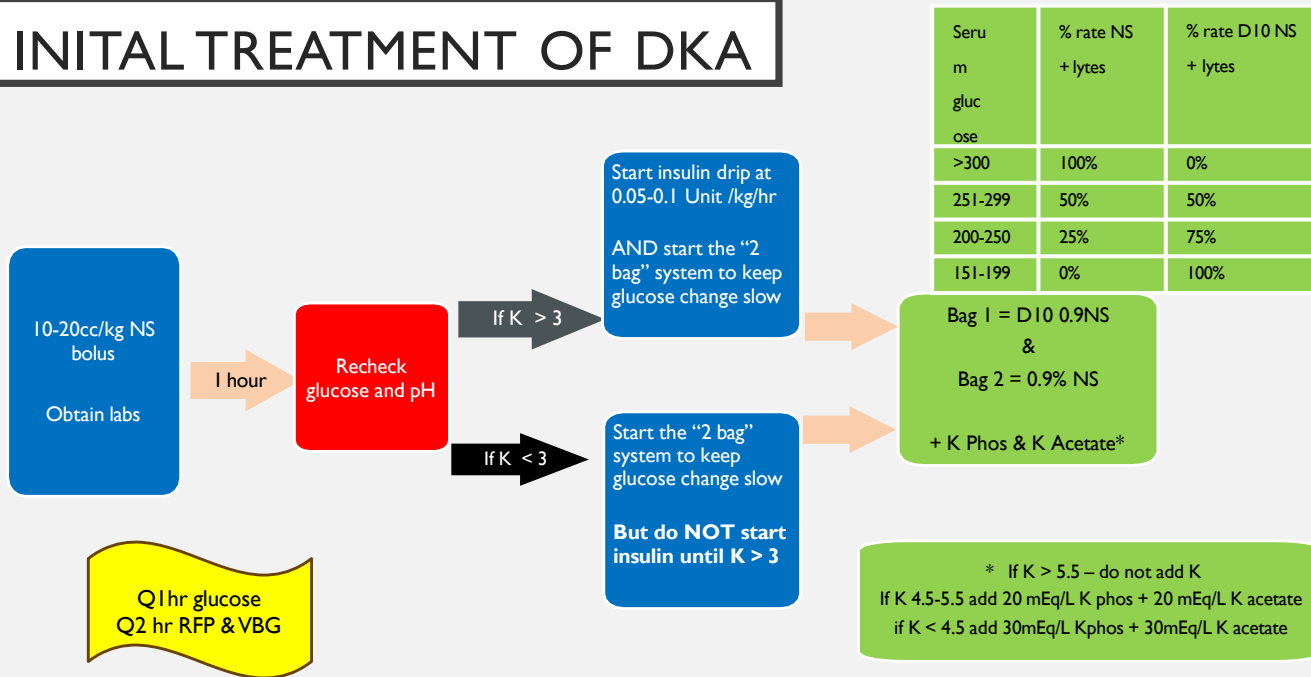
DKA IN PATIENTS WITH KNOWN DIABETES

- DKA can occur in patients with Type I or Type II diabetes
- Often precipitated by illness or injury
- May be due to failure to deliver insulin
 - Insulin pump failure / complication
 - Missed doses of SQ insulin
 - Misunderstanding of patient or family
- Treat the DKA but also look for the other underlying or precipitating event
- Initial evaluation labs are similar to new onset DM with DKA
 - Bedside – glucose, VBG
 - Laboratory – Renal function panel, HgbA1C, Urinalysis, Beta hydroxybutyrate
- Consider other causes including sepsis!

TREATMENT OF DKA

- Fluid administration
 - Treat any shock with fluids, then switch to a controlled “2 Bag” system of fluids to allow quick change of dextrose infusion to prevent rapid changes in blood glucose
 - Use 1.5 x maintenance fluid rate after initial fluid boluses –
 - Add K⁺ and phosphorus as indicated by the initial labs – remember insulin will push K⁺ intracellular
- **Insulin administration – 0.5 -1 Units/kg/hour** (with dextrose as needed to slowly lower glucose and avoid hypoglycemia)
 - This stops the ketosis and the acid production
 - Fast isn't better....
 - **Do NOT give a bolus or loading dose of insulin**
 - **Do NOT give insulin if K⁺ < 3. this can cause life threatening cardiac dysrhythmia**
- Close monitoring of electrolytes and glucose - Q1hr glucose, Q2hr lytes, VBG
- **Do not give sodium bicarbonate** to correct acidosis unless cardiac arrest - NaCO₃ can increase mortality

INITIAL TREATMENT OF DKA



Serum glucose	% rate NS + lytes	% rate D10 NS + lytes
>300	100%	0%
251-299	50%	50%
200-250	25%	75%
151-199	0%	100%

CASE I CONTINUES

- You immediately suspect DKA as a possible cause and obtain laboratory evaluation:
 - Bedside glucometer – BG 600
 - VBG – pH 7.02, pCO₂ 15, pO₂ 55, HCO₃ 5, lactate 1.8
- You obtain the rest of the labs for new onset DM as well as a few more given the vague presentation....
- While labs are returning you start a 20cc/kg bolus of 0.9% NS (max of 1 L)
- After the NS bolus – you recheck the glucose which is now 480.
- His K⁺ is 5 and glucose > 300 so you start his insulin at 0.1 unit/kg/hour and start the 2-bag system at 1.5 x M rate with 100% of the rate using NS + 20meqKPhos + 20meq K acetate

- Unfortunately, his mental status starts to worsen and he complains of a severe headache....

COMPLICATIONS OF DKA – CEREBRAL EDEMA

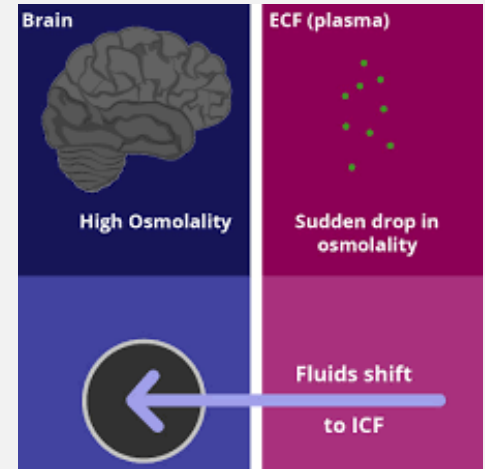
More common in children than adults

- **Highest risk:**
 - Children < 5 years old
 - New onset diabetes with DKA
 - BUN > 20mg/dL (likely AKI, severe dehydration)
 - Severe DKA with $pCO_2 < 21$ mmHg on ABG
- **Symptoms usually start within 12 hours of onset but can develop after treatment**
 - Severe headache
 - Persistent vomiting
 - Altered mental status
 - Hypertension
 - Ominous symptoms – drop in HR, agitation, slurred speech, urinary incontinence

Do not wait for CT to begin treatment

CEREBRAL EDEMA - TREATMENT

- Early recognition and treatment is key
- Give either:
 - 3% NS (3-5ml/kg) over 15 minutes
 - Mannitol 0.5-1g/kg over 15 minutes
- Slow IV fluids to $I \times M$ – be sure isotonic fluids are running
- Slow the insulin rate to 0.5 Units / kg / hr
- Elevate head of bed
- Do NOT give steroids or sodium bicarb
- Do NOT wait for imaging to start treatment
- Call for help! Pediatric endocrinology, Pediatric Critical Care and / or Pediatric Emergency Medicine colleagues can help



CASE I CONTINUES...

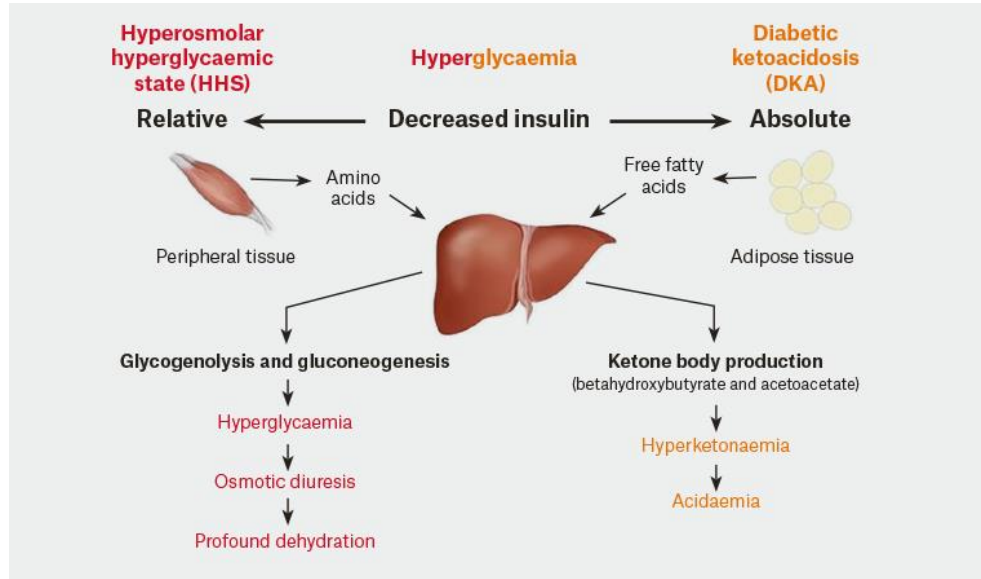
- You immediately suspect cerebral edema and begin treatment:
- You give 3cc/kg of 3% NS over 15 minutes
- Slow his insulin rate to 0.5 Units/kg/hour
- Slow the IVF rate to 1 x Maintenance
- Call for transport to the closest appropriate tertiary children's hospital

- After you get off the transport call – your patient is looking a bit better, he is now alert, answering questions appropriately and his headache has lessened a bit.

CASE 2

- 16 yo girl arrives to the ED with concern for severe sleepiness and confusion. No recent fevers, vomiting, no abdominal pain. No known ingestions and family has been with her for the past 72 hours. No known trauma. Pupils are normal and reactive. You notice a dark discoloration of her neck.
- Wt = 90kg
- As part of your initial evaluation – you give Narcan (no response) and start an IV.
- You check a bedside glucose and a quick bedside VBG:
 - Glucose >700
 - VBG - pH 7.35 / pCO₂ 50 / pO₂ 60
- She gives you a quick U/A dipstick
 - negative for LE, nitrates, blood.
 - + glucose and no ketones.
 - Spec grav > 1.30
- What are you thinking now?

HYPERGLYCEMIC HYPEROSMOLAR SYNDROME



- Just enough insulin to avoid ketosis but not enough to prevent severe hyperglycemia
- Severe hyperglycemia → osmotic diuresis
- Dehydration is severe to profound (assume 12 – 15% dehydration)
- Can occur in both type 1 and type 2 DM and can be a presentation of new diagnosis of Type 2 DM
- Can be a mixed DKA /HHS presentation
- Complications include AKI and rhabdomyolysis
- Thrombosis, stroke and DIC are possible in HHS
- High mortality

HHS TREATMENT

- Initial fluid resuscitation
 - Normotensive: Initial 20cc/kg NS bolus over 1 hour , may need repeat to improve perfusion – monitor electrolytes, osmolality and urine output hourly
 - Hypotensive – give 20cc/kg NS bolus initially fast then 10cc/kg boluses with frequent re-evaluation to support BP
- Calculate fluid losses (12-15% of total body water) and give over next 24-48 hours
- Monitor electrolytes, glucose and Osm hourly
- Keep electrolyte and glucose changes slow:
 - Glucose 70-100mg/dL/hour
 - Na < 0.5 mmol/L/hour
 - K⁺ changes can be severe – initially can be hyperkalemic but may drop rapidly and require supplementation (if below 5.5 – start K supplementation at 40mEq/L – 1/2 should be Kphos to prevent hypophosphatemia)
- Replace urinary losses with 1:1 1/2NS – once profound dehydration is improved there may be a rapid osmotic diuresis
- Mental status should be improving with fluid rehydration – if not – consider stroke cerebral venous thrombosis, cerebral edema & obtain CT

DKA VS HHS

DKA	HHS
Glucose > 200	Glucose > 600
Acidosis – pH < 7.3, bicarb < 18	No acidosis, pH >7.3
Ketone production - + urine ketones	No ketone production
Usually awake unless severe DKA	Altered mental status, LOC, stupor and coma
Serum osmolality can vary	Serum osmolality > 330
Treat with insulin to stop ketone production	Do NOT start insulin initially (slow lowering of glucose with fluids)
Treat with judicious fluids and careful management of electrolytes	Treat with fluids – initially 20 cc/kg then add Dextrose to fluids to have slow decrease in glucose (75-100 mg/dL/hr)

CASE 2 - CONTINUED

- You quickly consider if this is a new onset diabetes with HHS as the presenting symptoms.
- You obtain all the “new onset DM” labs as well as considering other causes.
- You start a 20cc/kg bolus of NS and obtain a head CT quickly
- Her labs come back as:
 - Na 148, K 5, glucose 850mg/dL , BUN 21 mg/dL
- You calculate the serum osm = $2 [Na + K] + [glucose]/18 + [BUN]/2.8$
 - Osm = 253
- You recognize that this is HHS and start careful treatment with labs, monitoring, fluids and urine replacement
- You call to have her transferred to the closest tertiary children’s hospital for care
- She starts to improve and is waking up and more alert before she leaves your facility

COMPLICATIONS OF DKA

- Hypoglycemia
 - Add dextrose to fluids to prevent rapid change in glucose and prevent hypoglycemia
 - (In kids with DM – avoid hypoglycemia – treat if glucose < 70)
- Thrombosis
 - Hyperglycemic and dehydrated states increased risk of thrombosis
 - Avoid central lines
- Cerebral edema
 - In DKA – assume mental status changes are due to cerebral edema and treat quickly
 - Consider head CT but do not delay giving mannitol or 3% NS
 - HHS may present with mental status changes – also consider SVT and stroke
 - Fluid administration is still a bit controversial but doesn't really appear to make cerebral edema happen
- Electrolyte abnormalities

ELECTROLYTES AND DKA

- Potassium
 - Total body potassium deficit due to the vomiting and urinary losses
 - Initial serum can be high, low or normal but is likely to decrease with treatment
 - Add potassium when K is below 5.5 mEq/L – use K Ph + K acetate to prevent hypophosphatemia and hyperchloremia
 - Hold insulin until K is above 3-3.5 mEq/L
- Calcium and Magnesium
 - Both Ca and Mg can become deficient with K phos treatment – monitor carefully and supplement if symptomatic or very low
 - ECG can help determine need for supplementation
- Sodium Bicarbonate – DO NOT GIVE in either DKA or HHS unless the patient is in cardiac arrest and has severe acidosis

CASE 3

- 8 yo boy with a known history of type 1 DM presents with fever, vomiting and cough. Symptoms began 2 days ago with coughing, fever and malaise. He started vomiting last night and now has abdominal pain. Parents report that he does use an insulin pump and a continuous glucose monitor (CGM). CGM current reading is 550, he hasn't yet peed this morning so no ketone check at home.
- On first glance – he is mildly ill appearing with tachypnea. HR 140, BP 95/65, RR 25, Sat 95% on RA. Cap refill 3 seconds. Lungs – few crackles at bases but good air entry, CV S1, S2, no murmurs or gallops. Abdomen – mild diffuse tenderness to palpation. MM are slightly dry.
- Wt = 30kg
- What would you like to do next?

CASE 3

- Turn off insulin pump
- Place onto continuous monitors
- Place IV and draw labs
 - Bedside glucose is 560
 - VBG pH 7.1 / pCO₂ 27 / pO₂ 65 / HCO₃ 8
- Start 20cc/kg bolus of NS over 1 hour and wait for the renal function panel
- RFP comes back with:
 - K 4.5, Na 140, BUN 18, Cr 0.7, glucose 545,
- You start the insulin at 0.1 Unit/kg/hr (3 units / hr) and order the 2 fluid bags:
 - D10 NS + 20mEq/L Kphos + 20 mEq/L Kacetate – hold this bag in reserve for when the glucose drops
 - NS + 20mEq/L Kphos + 20 mEq/L Kacetate – start this at 1.5 x M = 140 cc/hour
- Recheck glucose every hour, repeat VBG and RFP every 2 hours
- Admit to the PICU or transfer to the nearest tertiary children's hospital

Also – look for causes of fever – consider a CXR, fluid PCR, U/A. Treat fever with ibuprofen/Tylenol

Consider an ECG if slow lab turn around or if K too high or too low

CASE 4

- 2 year old girl presents with 5 days of vomiting and increased "lethargy" per parents. She had a fever at the onset of symptoms which resolved 3 days ago. Initially had 1-2 episodes of diarrhea but that improved after the 1st day. She continues to vomit and looks much more ill and is sleepier than usual. No cough but parents also report that she is breathing a bit funny.
- HR 160, RR 41, BP 83/50, sat 96% on RA
- Difficult to arouse and ill appearing, tachypneic, dry mucus membranes. Lungs are CTA, abdomen is soft, ND but diffusely tender. Skin feels doughy. TM clear, no LAD.
- What next?

CASE 4

- Broad differential – sepsis, intracranial mass, pyelonephritis, malignancy, DKA, malrotation / volvulus, appendicitis
- Place pt on CR monitors
- Obtain IV access, give initial 20cc/kg NS bolus and check bedside labs
 - Lactate 2.5
 - Glucose 580
 - VBG pH 6.9 / pCO₂ 15 / pO₂ 60/ HCO₃ < 5
- You give a dose of ceftriaxone (for sepsis) but tell the team you are most worried about DKA and possibly cerebral edema so order the labs and start a bolus of 5cc/kg of 3% NS to be run over 15 minutes.
- Your team asks - “Should we intubate – she’s difficult to arouse and has an irregular breathing pattern”

CASE 4 – AVOID INTUBATION

- **Avoid intubation if at all possible in DKA**
 - Patient is compensating for metabolic acidosis with hyperventilation
 - This is very, very difficult to match with mechanical ventilation
 - If you can adequately oxygenate and ventilate without intubation – **DO NOT** intubate
- Almost all children with DKA or HHS do not require intubation – even if cerebral edema or altered mental status
- If you must intubate – **prepare for cardiac arrest** that may be refractory to epinephrine

PITFALLS AND PEARLS - DKA

PITFALLS

- Do not give insulin bolus
- Avoid intubation if at all possible
- Consider DKA early – bedside VBG and glucose
- Do not start insulin if $K < 3$
- Do not use hypotonic fluids
- Do not wait for imaging if you suspect cerebral edema – treat immediately

PEARLS

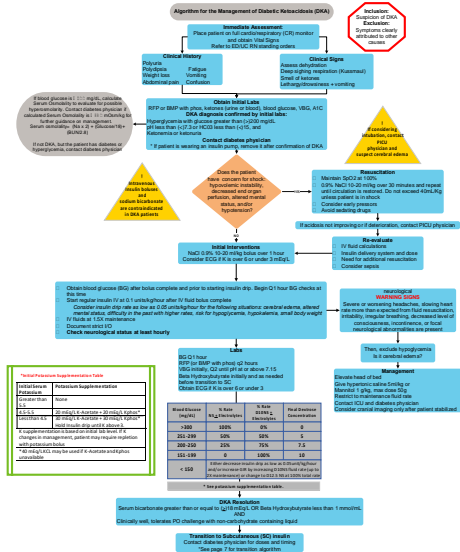
- Consider DKA early – bedside VBG and glucose
- Slow correction of electrolyte abnormalities
- Use the “2 Bag” system to quickly address rapid glucose and avoid hypoglycemia
- Add Potassium to fluids if $K < 5.5$
- Worry about the acidosis – not the hyperglycemia

TAKE HOME POINTS

- DKA is treated a bit differently in children – less aggressive fluids, slow insulin administration
- DKA can be the presentation of new onset of diabetes mellitus
- Severe hyperglycemia without acidosis – consider HHS
- Suspect cerebral edema if mental status changes or headache – treat before confirming with CT
- DKA protocols decrease mortality in a high risk situation!

CLINICAL PATHWAY

Diabetic Ketoacidosis (DKA) Treatment ALGORITHM



THANK YOU

Kristin.kim@childrenscolorado.org

- EMSC Colorado / COPPER website:
 - <https://www.emscolorado.com>
 - lots of resources
- CHCO DKA pathway
- <https://www.childrenscolorado.org/globalassets/healthcare-professionals/clinical-pathways/diabetic-ketoacidosis.pdf>