DIABETIC KETOACIDOSIS

Erin Stutz, PA-C

University of Rochester Medical Center

AAPA Boot Camp 2020

DISCLOSURES

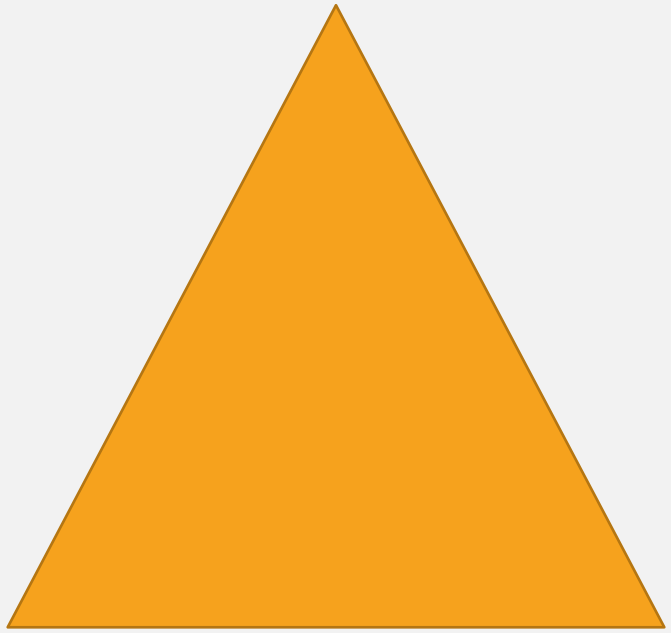
- No relevant commercial relationships to disclose.

OBJECTIVES

- Compare and contrast diabetic ketoacidosis and hyperosmolar hyperglycemic state
- Review the most common inciting events and provoking factors that contribute to the development of DKA
- Discuss treatment guidelines while implementing concepts with patient case
- Identify disease and treatment related complications that arise during management

MAKING THE DIAGNOSIS

"Anion gap metabolic acidosis"



"Ketones"

"Hyperglycemia"

EXCEPTIONS…

- Anion gap can be normal (normal 10-12mEq/L)
  - AG = Na - (Cl- +HCO3-)
- Blood glucose may be mildly elevated (euglycemic DKA)
  - Pregnancy
  - Treatment with insulin prior to arrival
  - Poor oral intake
  - SGLT2 inhibitors (ex: canagliflozin, dapaglifozin, empagliflozin)

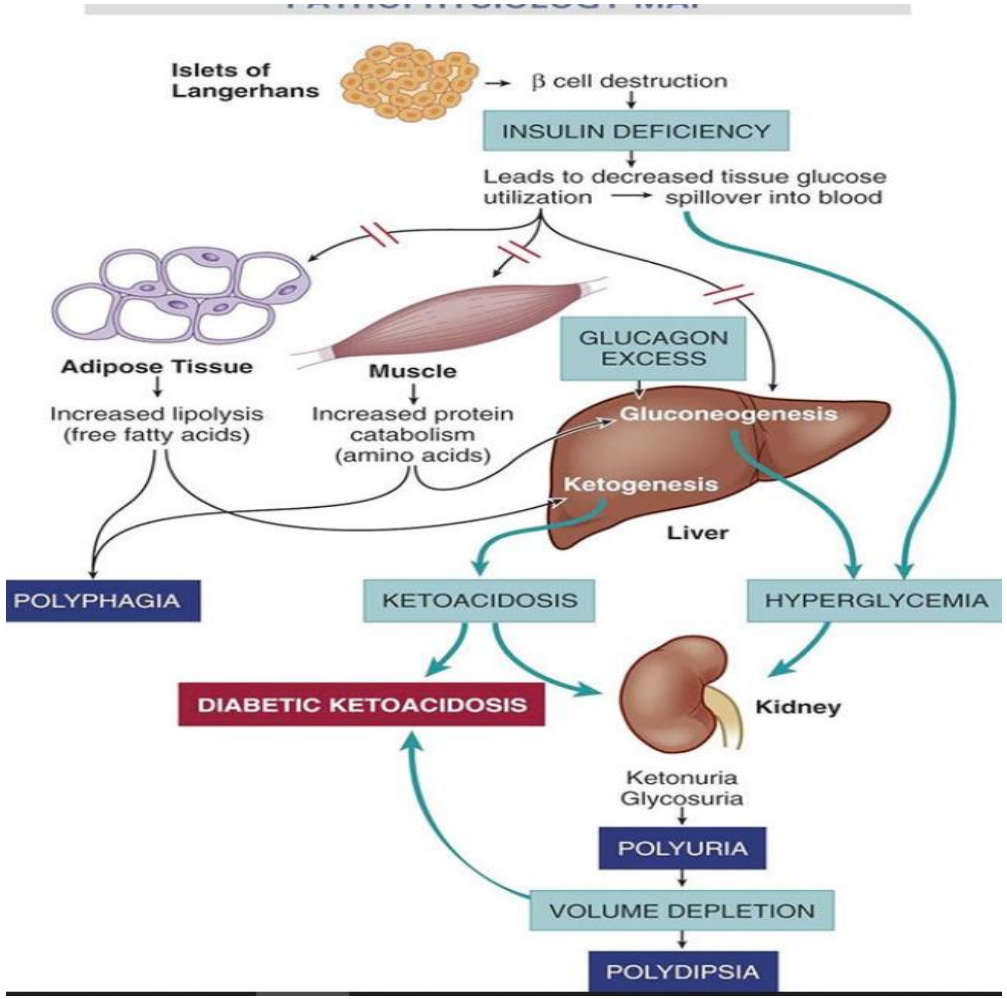
HYPERGLYCEMIC STATES

DKA

- Younger patient
- Hx DM1, occ DM2 or no hx DM
- Evolves < 24hrs
- + Ketones
- pH < 7.3
- Unless severe DKA, alert or drowsy
- BG < 250
- Moderate hypovolemia

HHS

- Older patient, think SNF resident
- Hx DM2
- Develops over days - weeks
- - Ketones
- pH > 7.3
- Comatose
- BG > “600”
- Severe hypovolemia



https://www.bing.com/images/search?view=detailV2&ccid=k5hwqQNM&id=A63800CBF1DC89A22E39E9ED869D48711B1399E7&thid=OIP.k5hwqQNMsYfsgTP8W8BjEgHaKg&mediaurl=https%3a%2f%2fi.pinimg.com%2foriginals%2f76%2f36%2f9d%2f76369d6213a6e5e63f870b85eed421b8.jpg&exph=914&expw=644&q=dka+pathophysiology+diagram&simid=608048677675403414&ck=C5903BCB63BE9573A0C99D66F0A909C8&selectedIndex=18&ajaxhist=0

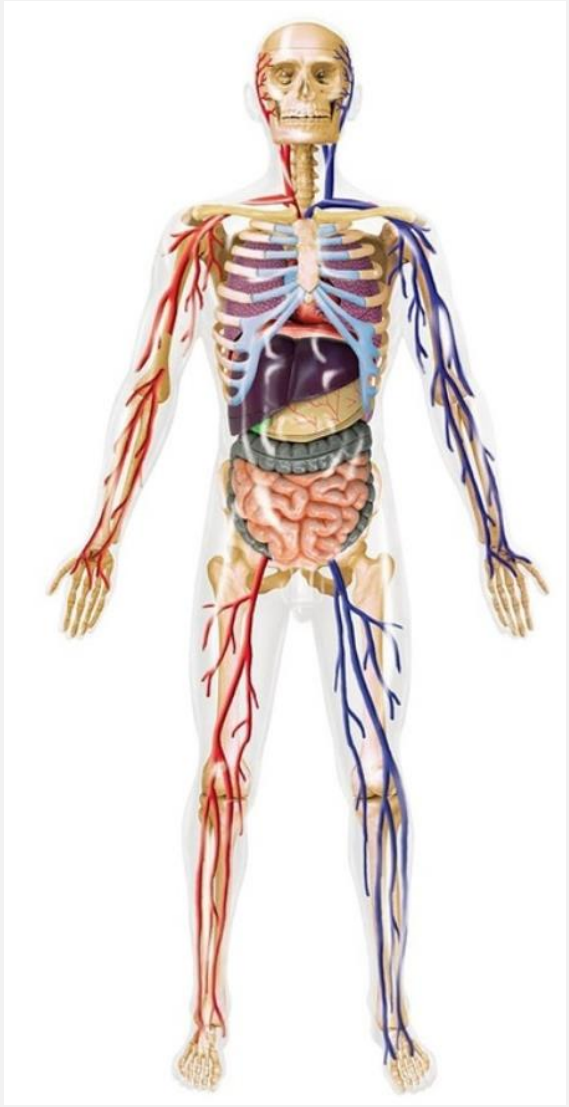
CLINICAL FEATURES OF INTEREST

Neurologic:
AMS, stupor, coma

Respiratory:
Kussmaul's

GI:
N/V, abdominal pain

GU:
Polyuria



HEENT:
Fruity odor, flat neck veins, dry mucus membranes, excessive thirst

CVS:
Arrythmias, hypotension

Skin:
Decreased turgor, dry axillae

Complications of DKA/HHS:
- Heart failure
- Cerebral edema
- ARRYTHMIAS

PRECIPITATING FACTORS

- Major events: MI, CVA, pancreatitis, sepsis
- New diagnosis
- Poor compliance
- Medications: SGLT2 inhibitors, steroids, thiazides, antipsychotics
- Gastroenteritis - patient stops eating and therefore stops insulin
- Pregnancy
- Cocaine
- Malfunction of insulin pump
- Psychosocial factors

MS TATE

The ER calls and asks you to admit Ms Tate. She is a 25F w/ PMHx significant for DM1 on insulin pump who presented w/ 3-day history of abdominal pain, N/V. She was found to have a metabolic acidosis, hyperglycemia and acute kidney injury. The ER provider had the patient disconnect her insulin pump.

Of note, weight 80kg.

Vitals: T 37, RR 30, HR 115, BP 99/40, Spo2 98 on RA

DDX

- What else can cause ketosis, acidosis, neurologic changes?
  - Alcoholic ketoacidosis
  - Starvation ketosis
  - Toxic metabolic encephalopathy
  - Anion gap acidosis
  - Metformin induced lactic acidosis

BETA HYDROXYBUTYRATE

- If elevated, strongly supports diagnosis of DKA
- In DKA, think BHB > 3mmol/L
- 1 of 3 ketone bodies
  - relative proportion in blood 78%, compared w/ acetoacetate 20%, acetone 2%

Mayo Clinical Laboratories Clinical and Interpretive Testing. Accessed 7/30/2020.
Sheikh-Ali M, Karon B, Basu A, et al. Can serum beta-hydroxybutyrate be used to diagnose diabetic ketoacidosis? *Diabetes Care*. 2008;31(4):643-64

LABS

pH 6.9 / PaCO2 30 / PaO2 70 / HCO3 16

Na 142, K 6.8, Cl 95, Bicarb 15, Cr 5.2, Glucose 580 -> dehydration universal in DKA but remember hyperglycemia has dilutional effect on sodium

WBC 17, no bands -> ketonemia produces leukocytosis, so band forms more reliable marker of infection

Lactate 4.6

Beta hydroxy 3.5

Troponin I 0.09

EMERGENCY ROOM COURSE

- 2 PIVs placed
- Given 2L NS bolus followed by NS at 100mL/hr
- Insulin IV 15 units followed by insulin gtts at 5 units/hr
- Calcium gluconate 1gm IV
- Emesis 3x s/p ondansetron 4mg IV w/ improvement
- No urinary output

DIAGNOSTIC EVALUATION

- Basic metabolic panel
- Calcium
- Magnesium
- Phosphorus
- CBC w/ differential
- Beta-hydroxybuterate or ketones (urine, serum)
- Amylase/lipase
- Serum osmolality
- Blood and urine cultures
- EKG then enzymes if warranted
- CXR
- Cardiac enzymes
- U/A
- HCG or pregnancy test
- Urine tox
- ABG/VBG

ICU ADMISSION

- Admitted to the ICU
- IVF continued, insulin gtts increased
- PICC placed for frequent labs, IV access
- DVT ppx – DKA patients at higher risk for VTE
- 2 hours later, BG 550
- 4 hours later…
  - Na 146, K 4.5, Cl 98, Bicarb 18

Keenan C, Murin S, White R. High risk for venous thromboembolism in diabetics with hyperosmolar state: comparison with other acute medical illnesses. *J Thromb Haemost.* 2007;5(6):1185-1190

THERAPY TARGETS

OSMOTIC DIURESIS/DEHYDRATION: IVF

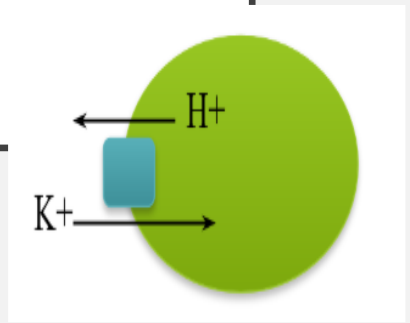
- Stop osmotic diuresis = use insulin!
- Electrolyte panel at least q4hrs, Ca, Mg and Phos q6hrs
- Trend UOP, foley if needed for accurate I&Os
- Average volume deficit 50-100mL/kg
- Set IVF infusion rate at ~15mL/kg/hr until BP within normal range, then decrease infusion to ~5mL/kg/hr
- Ms Tate was continued on NS at 800mL/hr. Once she had reached total of 6L IVF, NS was decreased to 400mL/hr.
- When BG falls to 250mg/dL, change the IVF to 1/2NS with D5 and decrease infusion rate to 150mL – 250mL/hr.

HYPERGLYCEMIA: INSULIN

- Ms Tate's weight 80kg. Given Insulin 15 units IV in ER (BG 580) then started on insulin gtts at 5 units/hr
- RECOMMENDATION: Initial bolus dosing 0.15units/kg body weight then continuous infusion 0.1units/kg/hr, trend BG hourly
- Once admitted to ICU, BG was rechecked and was 550; insulin gtts rate increased to 8units/hr
- GOAL: BG decreases by 50-75mg/dL *per hour* with insulin infusion adjusted to meet this goal (Westerberg).
- When BG falls < 250mg/dL, decrease rate to 0.1-0.5units/kg/hr and maintain BG 150-200 (add dextrose to IVF to maintain this)

American Diabetes Assoc. Hyperglycemic crisis in DM. Diabetes Care 2004; 27(suppl):S94-S102..
Westerberg DP. Diabetic ketoacidosis: evaluation and treatment. Am Fam Phys 2013; 87:337-346

POTASSIUM



- In 74% patients, initial K+ is elevated (Charfen).
- Transcellular shifts occur and K+ can drop dramatically, so recommendation is to check q 1 hr for the first 4-6 hours (Marino).
- If K is < 3.3, **hold insulin infusion** and give 40mEq K per hour until K > 3.3
- **If initial serum K is 3.3-4.9, give 20-30mEq/L IVF to keep serum K 4-5**
- If K is >5, do not give K and check q 2 hours
- Average deficit is 3-5mEq/kg so Ms. Tate has an estimated deficit between 240-400mEq K

Charfen, MA. DKA. Emer Med Clin N Am 2005; 23:609-628.

Marino, PL. Marino's The ICU Book. 2014. pp 612-613

METABOLIC ACIDOSIS

- Hyperchloremic metabolic acidosis can occur with NS, so not accurate to follow HCO3
- IV sodium bicarbonate recommended for pH < 6.9, hemodynamic instability or severe hyperkalemia
- How does insulin & IVF treatment resolve the acidosis?
  - Insulin stops hepatic production of ketoacids and release of FFA from fat
  - Hydration improves renal perfusion to promote ketone excretion
  - Insulin helps metabolism of ketoacids that generate bicarbonate

SODIUM

- Can present w/ hypo or hypernatremia
- Majority will present w/ hyponatremia from osmotic effect
- Follow q 2-4 hrs to ensure appropriate correction rate – watch out for failure to rise as glucose improves (cerebral edema)
- Benchmark ~1.6mEq/L for every 100mg/dL drop in glucose
- Ms Tate's sodium was 142 then 4 hours later was 146

* Treat based on sodium adjusted for hyperglycemia
  - Corrected sodium = measured sodium + 0.016 x (serum gluc – 100)

PHOSPHORUS

- Usually behaves similarly to potassium, so can add potassium phosphate to IV fluids
- Can be severely LOW in settings of hyperventilation
- Treat if < 1mg/dL, follow q6hrs
- Hypophosphatemia causes
  - rhabdomyolysis
  - paralysis/weakness
  - hemolytic anemia

CALCIUM/MAGNESIUM

- Trend q6hrs during treatment unless severe derangements
- Hypokalemia WITH hypomagnesemia >>> arrythmia
- Complications from abnormalities are rare – in DKA, usually will see hypocalcemia / hypomagnesemia

THE ANION GAP CLOSES

- Goals: glucose < 200mg/dL, pH > 7.3, HCO3 > 18
- **Ketogenesis has been shut off when AG closes**
- Start SQ insulin when patient tolerating liquids
- Do not underdose SQ insulin
- Restart home insulin regimen
- New to insulin?
  - 0.5units/kg/day in divided doses or glargine 0.25units/kg/day
- Diabetic education / SW consult to make sure patient has access to supplies

SQ INSULIN

- Do not underdose SQ insulin !!!
- Restart home insulin regimen (unless on a pump, then need to consult Endocrine)
- New to insulin?
  - Basal: 0.5-0.8units/kg/day in divided doses (glargine is q24hrs)
  - Meal: 0.08units/kg/meal
  - Follow ACHS glucose levels and titrate prn

THE ANION GAP FAILS TO CLOSE

- Inadequate IVF resuscitation
- Inappropriately dosed insulin infusion
- Malfunction of insulin infusion
- Precipitating cause has not been addressed
- CKD/ESRD

WHEN TO TRANSFER OUT OF ICU

- Hemodynamics improve after resuscitation
- Electrolytes are corrected and patient is not requiring much insulin
- Anion gap is closed (think 2 consecutive AG's are closed before transitioning to SQ insulin)
- Patient was given SQ basal insulin (NPH or glargine) and then ~>2 hours after that, insulin gtts was turned off
- Patient eating a diet

TAKE HOME POINTS

- Remember that the blood glucose level can be normal or mildly elevated in DKA, also may have normal pH
- DKA is treatable, but patients can deteriorate quickly if labs or electrolyte derangements are missed or IVFs are mismanaged
- Begin replacing K+ when the level is normal
- Mind the gap not the bicarb!

REFERENCES

- American Diabetes Assoc. Hyperglycemic crisis in DM. Diabetes Care 2004; 27(suppl):S94-S102.
- Charfen, MA. DKA. Emer Med Clin N Am 2005; 23:609-628.
- Farkas, J. Pulm Crit. Anatomy of a DKA Resuscitation. Accessed 7/31/2020.
- Hirsch, IB, Emmett M. DKA and HHS in Adults: Clinical Features, Evaluation, Diagnosis. UTD. Accessed 7/2020.
- Hirsch, IB, Emmett M. DKA and HHS in Adults: Treatment. UTD. Accessed 7/2020.
- Keenan C, Murin S, White R. High risk for venous thromboembolism in diabetics with hyperosmolar state: comparison with other acute medical illnesses. *J Thromb Haemost*. 2007;5(6):1185-1190
- Marino, PL. Marino's The ICU Book. 2014. pp 612-613.
- SCCM Fundamental Critical Care Support 5th Ed. 2012. Hyperglycemic Syndromes pp 12-16-12-20.
- Sheikh-Ali M, Karon B, Basu A, et al. Can serum beta-hydroxybutyrate be used to diagnose diabetic ketoacidosis? *Diabetes Care*. 2008;31(4):643-64
- Westerberg DP. Diabetic ketoacidosis: evaluation and treatment. Am Fam Phys 2013; 87:337-346.

QUESTIONS?

- erin_stutz@urmc.rochester.edu