Academic Half Day: Diabetes
Facilitator Guide

1:00-1:05 Theory Burst
1:05-2:25 Case
2:25-2:30 Questions for the expert

Case: **Hospital Day 1**
Mr. Shugar is a 56 y/o M who presents to the ED with spreading redness and pain of his left leg for the past 3 days after scraping his ankle accidentally while working on his car. Two days ago, he went to urgent care and received antibiotics. Since then, the redness has worsened despite taking the medication as directed. Yesterday, he developed a fever to 101F, so he decided to come to the ED.

PMHx: reports hx of HTN, COPD, but hasn't been to doctor in long time
Meds: Cephalexin 500 mg TID
SocHx: smokes 1ppd, no EtOH, works as mechanic.

Physical Exam:
Vitals: T 101.4 HR 90 BP 128/76 RR 14 Pulse ox 97% Room Air Wt: 220lb (100kg)
General: Overall well appearing, no acute distress, obese
Cardiac: Normal S1, S2 with regular rate and rhythm. No murmurs
Pulm: Lungs clear to auscultation b/l
Extremities: Erythema and warmth of the L lateral lower extremity streaking towards knee. No fluctuance. Tender to palpation only in the area of erythema/warmth. No edema.

Labs from the ED:
Na 135, K 4.2, CL 102, CO2 22, BUN 14, Cr 1.1, glucose 240
WBC 11.2, Hgb 13.2, Hct 39.2, Platelets 354
CRP 4.6, ESR 32

Imaging:
Doppler US: Negative for DVT
X-ray Left Tib/Fib: Negative for fracture, soft tissue swelling noted

1. **You notice the patient is hyperglycemic on his renal panel. What other questions would you like to ask him? What factors may contribute to hyperglycemia in this patient?**
    - Need to inquire about:
        - Prior hx (has he ever been told he was hyperglycemic , pre-diabetic, or diabetic), and any symptoms of hyperglycemia (polyuria, polydipsia, acanthosis, weight gain)
        - Family hx: strongly correlated in T2DM
        - Most recent meal (is this fasting or post-prandial hyperglycemia?), diet 2
        - Any recent medications that may contribute (think steroids for recent COPD exacerbation?)
        - Obesity, weight gain → long standing issue? May reflect insulin resistance
    - Factors contributing to stress hyperglycemia:
        - Increased glucagon, cortisol, and epi → increased gluconeogenesis and lipolysis

- Increased cytokines → insulin resistance and increased glucagon
- Diet, nutritional status, iatrogenic: steroids

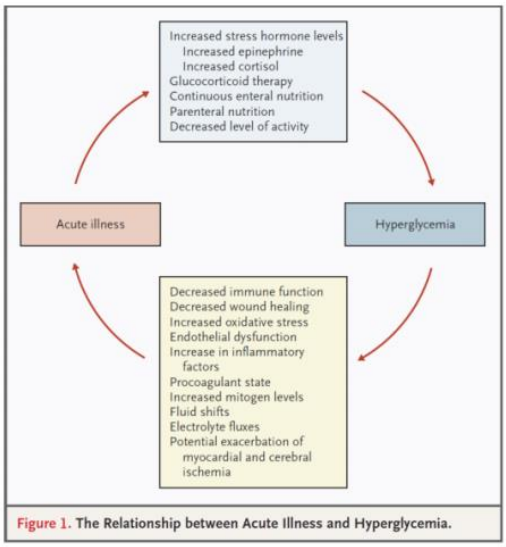
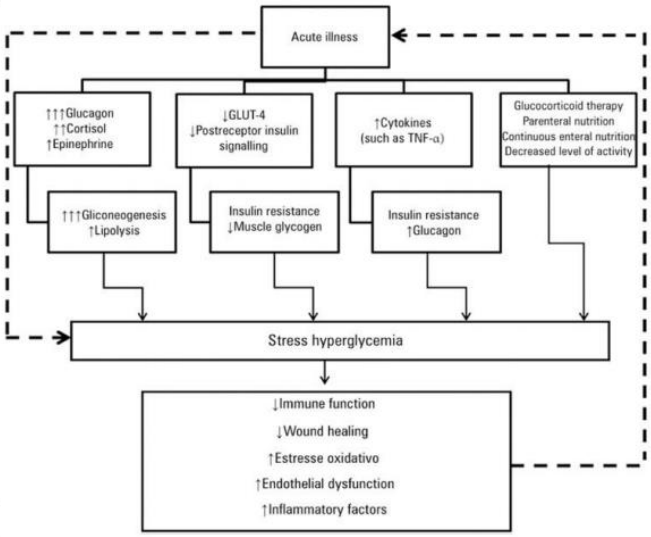


Figure 1. The Relationship between Acute Illness and Hyperglycemia.



The patient tells you that he's never been told he has high blood sugars, but diabetes is prevalent in his family. And now that you mention it, he does urinate pretty frequently. He drinks a few liters of soda each day to mitigate his thirst...

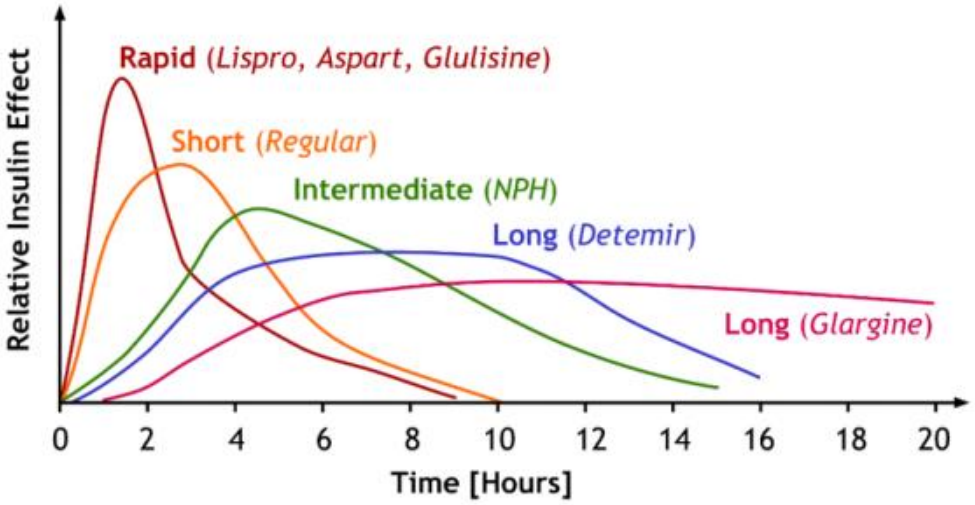
2. **What is the next step in the evaluation of his hyperglycemia? What do you include in your inpatient admission orders?**
   - ADA Diabetes Care 2019 recommends the following:
     - Perform an A1C on all patients with diabetes of hyperglycemia (blood glucose > 140 mg/dL) admitted to the hospital if not performed in the prior 3 months
       - Encouraged to document prior history of diabetes (Type 1 or Type 2) or no previous history of diabetes
       - Limitations to A1C testing:
         - A1C > 6.5 identifies fewer cases of undiagnosed diabetes; it is a less sensitive test
         - A1C may be falsely low in certain conditions (hemoglobinopathies, hemodialysis, iron deficiency anemia, and after blood transfusions)
     - Glucose monitoring with Point-of-Care meters:
       - In the Pt who is eating meals, glucose should be performed before meals (may also consider before bedtime)
       - In the Pt who is NPO, glucose monitoring is advised every 4-6 hour 3
   - Could consider a carbohydrate consistent diet (AKA Diabetic Diet)

You finish your admission orders and H&P, starting the patient on Vancomycin for a concerning cellulitis that did not improve with Keflex. But you forgot to put in your sign out to night float to follow up on his sugars.

Hospital Day 2:
The next morning as you pre-chart on Mr. Shuger, you notice the following in his labs:

HbA1c 8.6 POC gluc 5pm 242 POC gluc 9pm 274 Serum gluc 6am 210

3. **You decide it's time to improve his glycemic control. How do you initiate treatment for this insulin-naïve patient? What medications do you choose and why**?
    - Review types of insulin while having them complete the following chart (See below)
    - Identify which meds are appropriate for use as basal vs bolus insulin.
        - Basal: Detemir and Glargine; NPH with twice daily dosing (cheap)
            - Glargine is most commonly used inpatient
            - NPH is often used as a bridge when transitioning from a insulin drip in the morning hours until night time dose of glargine.



Drug	Onset	Peak	Duration
Aspart (Novolog) Lispro (Humalog) Glulisine (Apidra)	3-15 min	0.5-1.5 h	2-4 h
Regular -Novolin/Humulin R	30 min	2-4 h	5-8 h
NPH -Novolin/Humulin N	120 min	4-12 h	12 h
Glargine (Lantus)	120 min	No peak	20-24 h
Detemir	120 min	3-9 h	6-24 h
Degludec	120 min	No peak	>40 h
Regular U-500 -Humulin R U-500	30-45 min	2-4 h	6-10 h

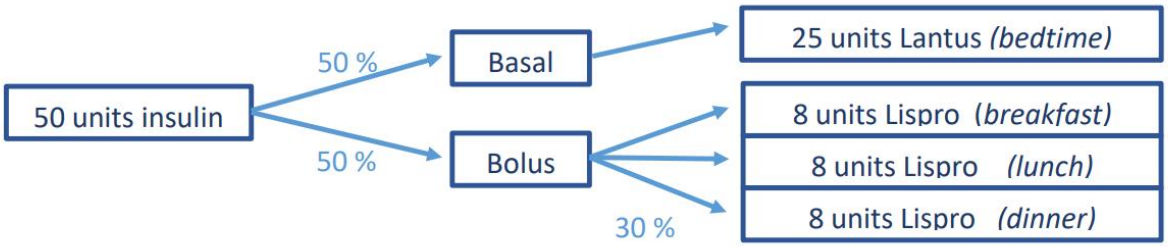
        - Discuss initiation of insulin therapy for insulin-naïve patient using weight-based total daily dosing.
            - Some review articles recommend starting a total daily dose of 0.4-0.5 U/kg/day

- ½ basal and ½ bolus (divided into three doses intended to be with meals) 4

- Discuss basal bolus dosing:
  - Basal insulin prevents fasting hyperglycemia and limits hepatic gluconeogenesis
  - Bolus insulin prevents post prandial hyperglycemia, limit post-prandial glucose rise

Table 1. Determining a TDD for Insulin-Naive Patients

TDD Estimation	Patient Characteristics
0.3 units/kg body weight	• Underweight • Older age • Hemodialysis
0.4 units/kg body weight	• Normal weight
0.5 units/kg body weight	• Overweight
≥ 0.6 units/kg body weight	• Obese • Insulin resistant • Glucocorticoids



4. **Could you use sliding scale insulin as main treatment? What about oral agents since he is insulin-naïve?**
   - **<u>RABBIT-2 Trial</u>**
     - Brief overview: prospective, multicenter RCT designed to compare the efficacy and safety of a basal-bolus insulin regimen with that of sliding-scale regular insulin (SSI) in patients with type 2 diabetes. They enrolled 130 T2DM insulin-naïve pts admitted to general med services (non-ICU) and randomized them to receive basal bolus therapy (glargine once daily and glulisine before meals at starting TDD 0.4 units/kg) vs SSI regimens (QID dosing). <u>Pt treated with basal bolus had greater improvement in glycemic control as compared to SSI without increased risk of hypoglycemia.</u>
     - Sliding scale has been ABANDONED as sole therapy for hyperglycemia in inpatient setting. It is a reactive, not proactive strategy that leads to playing catch up.
     - Only suitable for adjustment based on degree of hyperglycemia, but does not take into account basal insulin needs, diet, patient factors.
   - Oral agents are usually not started or continued during hospitalization
     - Lack of evidence to suggest their efficacy for inpatient glycemic control
     - Generally, less reliable/predictable in achieving goal blood glucose
     - Could share that there is a risk for metformin and lactic acidosis in the setting of renal impairment

5. **How would your regimen change if Mr. Shuger was a known diabetic on insulin therapy at home?**
    - Many factors come into play when choosing appropriate therapy for known diabetic patients, including prior degree of glycemic control, nutritional status, comorbidities, etc.
    - If Pt is on insulin (basal-bolus) regimen at home, generally can decrease home regimen 10-25% to limit possible hypoglycemia
        - Keep in mind that hospital food is not like the food they eat at home, so carbohydrate restriction will also change glycemic control while inpatient

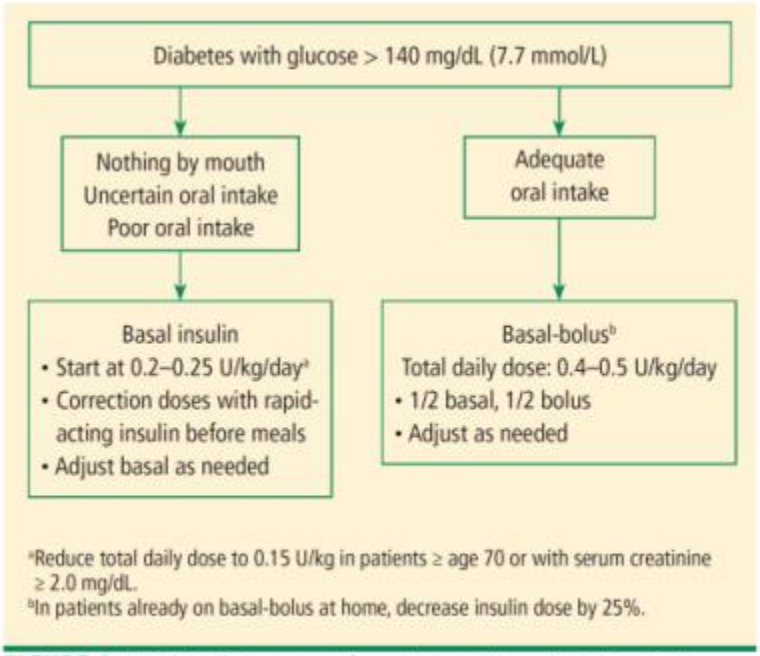


FIGURE 1. Initial insulin treatment for patients with type 2 diabetes in the non-intensive care setting.

6. **What are the goals for glycemic control? Why is this important?**
    - Review target glucose levels in inpatient units:
        - Of note, this was more controversial in 2017 when the different national organizations did not agree on goals. Now, there is a more consistent goal.

Organization	ICU	Non-ICU
American Diabetes Association/ American Association of Endocrinologists	• Initiate insulin if glucose persistently > 180 • **Goal: 140-180 mg/dL**	• Initiate insulin if glucose persistently > 180 • ***Goal: 140-180 mg/dL** • 110-140 may be appropriate for selected patients
American College of Physicians	• Recommend against IIT • **Goal: 140-180 mg/dL**	• Recommend against intensive insulin therapy • **Goal: 140-180 mg/dL**
Society of Critical Care Medicine	• Initiate insulin if glucose persistently > 150 • **Goal: < 150 mg/dL**	• None provided
Endocrine Society	• None provided	• **Premeal glucose < 140 mg/dL** • **Random glucose < 180 mg/dL**

*The 2017 ADA Standards of Medical Care in Diabetes rated this level C evidence (suggested pre-meal <140 and random < 180). However, in 2018 this became level A evidence.

- Importance: poor glycemic control associated with bad outcomes, including length of hospital stay, increased rates of infection, healthcare costs.
    - Dr. Falciglia studied this in VA-ICU patients. Her retrospective cohort study demonstrated increased odds/risk of mortality with hyperglycemia. This is even more dramatic in hyperglycemic patients without diagnosis of diabetes (poor prognostic indicator).
    - Why not drive glucoses <140? NICE-SUGAR trial in ICU patients reported increased mortality in patients allocated to intensive glucose control (gluc 81-108) vs conventional target (gluc <180).

You initiate insulin treatment with Lantus 25units qHS , Lispro 8units with meals and a low dose sliding scale with meals. Unfortunately, Ms. Shuger is reporting worsening pain and swelling of his leg, and you notice progression of the erythema of his leg, with increased induration and concern for fluctuance. You consult general surgery to evaluate the patient for likely abscess formation. Their note is not in by the time you leave, so you sign this out to cross-cover to follow up surgery recommendations.

Hospital Day 3:
You are pre-rounding the next morning when night float tells you that surgery left their recommendations late last night to make the patient NPO for OR the next morning. You quickly review Mr. Shuger's labs:

Yesterday:		**Today:**
Serum glucose 6am	**210**	**Renal panel: Na 140 K 4.0 Cl 105 HCO3 23 BUN 25 Cr 1.4 Glu 60**
POC glucose 9am	**245**	
POC glucose 12pm	**194**	**CBC: WBC 13.4 Hgb 13.1 Hct 39 PLT 345**
POC glucose 5pm	**175**	
POC glucose 9pm	**153**	

7. **Calculate how much insulin the patient received yesterday based on your orders (assume no changes were made to the regimen you ordered because this was not in your sign out).**

- Review SSI dosing and how to calculate total daily dose

Blood glucose	Low dose SSI (<40units insulin/day)		Medium dose SSI (40-80units insulin/day)		High dose SSI (>80units insulin/day)	
	AC	HS	AC	HS	AC	HS
100-149	0	0	0	0	0	0
150-199	1	0	1	0	2	0
200-249	2	1	3	2	4	2
250-299	3	2	5	3	7	5
300- 349	4	3	7	5	10	7
>350	5	4	8	7	12	10

Lispro 8units + 2units SSI (b/c glucose was 245)	= 10 units with breakfast
Lispro 8units + 1unit SSI (b/c glucose was 194)	= 9 units with lunch
Lispro 8units + 1unit SSI (b/c glucose was 175)	= 9 units with dinner
Lantus	= 25 units at bedtime
Total	= 53 units insulin

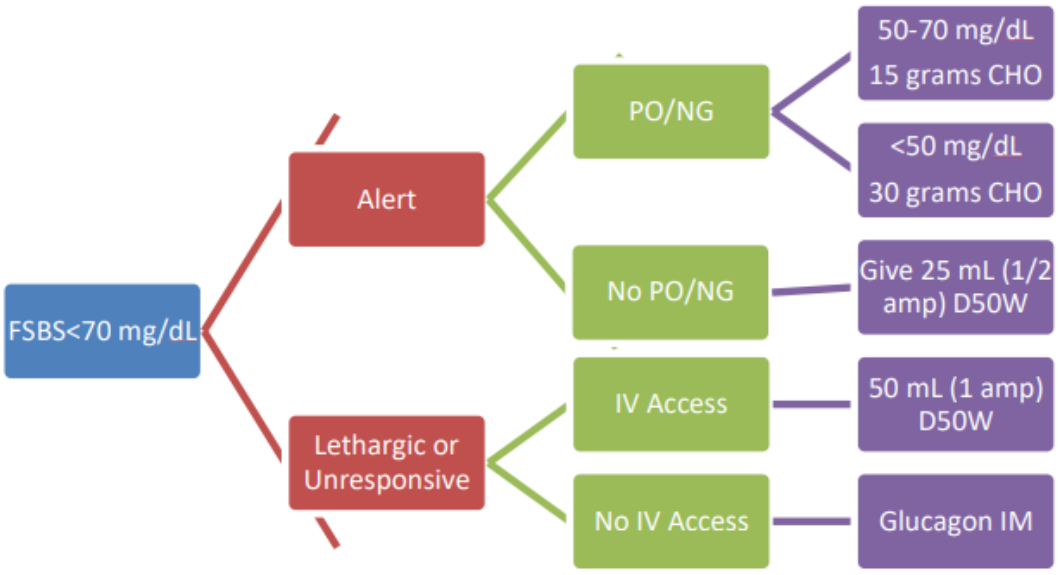
You quickly go to see Mr. Shuger. He is sitting on the edge of the bed, and does not look well. He says he is feeling dizzy and sweaty, which he thinks he may be nerves due to his upcoming procedure. He says he didn't eat dinner last night because the surgeons told him not to.

8. You check a POC glucose and it reads 60. What are risk factors for hypoglycemia in the hospital setting? How do you manage this?
   - What is hypoglycemia: Hypoglycemia: Blood glucose < 70 mg/dL or if patient has neuroglycopenic symptoms (dizziness, confusion, nausea, shakiness, etc)
   - Risk Factors: prior episodes, older age, CKD, CHF, liver disease, malnutrition, nutritional interruption, cancer, insulin regimen, altered mental status
   - Review Rule of 15 for management of hypoglycemia:
     - Treat with 15 grams of carbohydrate
     - Check blood glucose in 15 minutes
     - If your blood glucose is still < 70mg/dL, eat another 15 grams of carbohydrate and re-check blood glucose in 15 minutes. Repeat as needed until blood glucose is in goal range.

     Things with 15 grams of carbohydrates:

     - 3 squares of glucose tablets
     - 8 ounces of milk
     - ½ c fruit juice
     - 1 tablespoon of sugar/honey/syrup
     - 8 lifesavers
     - 1 small tube of cake decorator frosting
     - 4 oz. Soda
     - 15 jelly beans

9. **What if Mr. Shuger was unresponsive when you found him? What if he lacked IV access?**
   - Review various methods of correcting hypoglycemia in the hospital setting, including D50 and glucagon
     - Remind residents not to try to give oral glucose if patient is altered/lethargic
   - Inpatient hypoglycemia should be a NEVER event.



10. How would you have changed his insulin regimen if you knew he was going to be NPO for surgery?

- Important to maintain basal dosing to assist with glycemic control, though dose can be decreased as much as 50%. If his AM fasting glucose was still elevated, could likely maintain same dose of Lantus. Remember that basal insulin helps with fasting hyperglycemia, but should not be the main cause of hypoglycemic episodes (bolus dosing is more responsible for that)
- Need to DISCONTINUE his mealtime Lispro and SSI, start regular insulin SSI q6hrs while NPO
- Also remember to change glucose check to q6hrs! FSBS< 200 mg/dL
- Allows for continued insulin administration while avoiding hypoglycemia

Hospital Day 4:
You treated Mr. Shuger's hypoglycemia appropriately with glucose tabs and he was shortly whisked away to the OR. He underwent successful debridement of his leg abscess, the initial cultures of which are growing GPC in clusters.

The following morning, you are pre-charting on Mr. Sugar. The labs include:

Yesterday:		**Today:**
Serum glucose 6am	**59**	**Renal panel: Na 133 K 3.9 Cl 93 HCO3 18 BUN 25 Cr 1.4 Glu 455**
POC glucose 12pm	**151**	
POC glucose 6pm	**241**	**CBC: WBC 11.2 Hgb 13.7 Hct 39 PLT 345**
POC glucose 12am	**302**	**ABG: pH 7.21 pCO2 33**

You rush to see him. He reports the surgery went well, and that he was very hungry afterward so he ate a lot. But now he feels poorly, with some nausea and abdominal discomfort. You happen to notice his IV beeping with D5 NS running at 125cc/hr.

11. **Define the metabolic derangement. What are possible reasons for this?**

- Anion gap metabolic acidosis with appropriate respiratory compensation – Diabetic Ketoacidosis
  - AG: Na – (Cl + HCO3) 133 – (93 + 18) = 22
  - Winter's formula: pCO2 = 1.5 (18) + 8 +/- 2 = 33
- Possible reasons: acute illness vs extraneous glucose infusion vs inadequate insulin therapy

12. **How do you know this is DKA and not HHS?**
    - Review clinical characteristics:

DKA	HHS
• Short (< 1-2d) clinical course of fatigue, polyuria, polydipsia, and weight loss • GI complaint • Altered mental status • Dehydration • Kussmaul respirations • Fruity breath odor	• Progressive (several days) fatigue, polyuria, polydipsia, blurry vision • Gradual decline in mental status • Dehydration • Typically older patient with other acute illness who has delayed seeking care

    - Reviewed laboratory characteristics:

Table 1—*Diagnostic criteria for DKA and HHS*

	DKA			HHS
	Mild (plasma glucose >250 mg/dl)	Moderate (plasma glucose >250 mg/dl)	Severe (plasma glucose >250 mg/dl)	Plasma glucose >600 mg/dl
Arterial pH	7.25–7.30	7.00 to <7.24	<7.00	>7.30
Serum bicarbonate (mEq/l)	15–18	10 to <15	<10	>18
Urine ketone*	Positive	Positive	Positive	Small
Serum ketone*	Positive	Positive	Positive	Small
Effective serum osmolality†	Variable	Variable	Variable	>320 mOsm/kg
Anion gap‡	>10	>12	>12	Variable
Mental status	Alert	Alert/drowsy	Stupor/coma	Stupor/coma

*Nitroprusside reaction method. †Effective serum osmolality: 2[measured Na^+ (mEq/l)] + glucose (mg/dl)/18. ‡Anion gap: $(Na^+) - [(Cl^- + HCO_3^-$ (mEq/l)]. (Data adapted from ref. 13.)

13. **What are the 4 key components in the management of DKA?**
    - Fluids – Critical first step. Patient with DKA or HHS are dehydrated with an estimated water deficit of ~100 ml/kg of body weight among patients with DKA and ~100–200 ml/kg among patients with HHS. Fluid therapy restores intravascular volume and renal perfusion and reduces the level of counterregulatory hormones which helps correct the hyperglycemia
        - 0.9 % NS bolus followed by 0.9% NS infusion at a rate of 500-1000 mL/h during the first 2– 4h, until intravascular volume is replaced.
        - Decrease rate of IVF to 200-500 mL/hr based on hydration
            - Type of IVF is determined by Na level
                - Low Na: 0.9% NS
                - Normal Na: 0.45% NS
                - High Na: 0.45% NS
            - Na correction: For each 100 mg/dL glucose add 1.6 mEq to Na value
        - Add dextrose to IVF when glucose is < 200 mg/dL

        - Allows for continued insulin administration while avoiding hypoglycemia 4. **!Continue IVF until ketosis has resolved!**
- Insulin – DKA arises due to an absolute lack of insulin. HHS arises due to a relative lack of insulin. Insulin administration restores cellular metabolism, reduces hepatic gluconeogenesis, and suppresses further lipolysis and ketogenesis
    - Bolus – regular insulin 0.1 units/kg IV
    - Continuous infusion – regular insulin 0.1 units.kg/hr IV
        - When serum glucose < 200, can slow rate of infusion to 0.02-0.05 units/kg/hr
        - Goal glucose range is 150-200 mg/dl
            - In HHS, glucose is maintained at 200-300 mg/dl
        - Remind team that when glucose is <200 D5 needs to be added to IVF
    - Continue insulin infusion until <u>anion gap is closed AND patient can reliably tolerate PO</u>
        - In HHS, insulin is continued until mental obtundation and hyperosmolar state are corrected
- Potassium – Patients with DKA and HHS have a total-body potassium deficit. Despite this deficit, the serum K+ level measured is frequently within the normal range or even elevated owing to the shift of intracellular K+ to the extracellular compartment in the setting of hypertonicity, insulin deficiency and acidosis. Must frequently check during therapy because insulin stimulates movement of K+ intracellularly.
    - Assess serum K+ level
        - If K <3.3, this is critically deficient and must be corrected BEFORE insulin can be safely administered
        - If K 3.3-5.3, include K+ supplementation in IVF (20-40mEq/L)
        - If K 5.5, no need for supplementation
    - Continue to check K+ level every 2 hours
- Bicarbonate – This is rarely required in DKA and NEVER used in HHS
    - If pH < 6.9, then you must give NaHCO3

You initiate therapy with 10units Regular insulin IV and transfer Mr. Shuger to StepDown to initiate IV insulin infusion and fluids. Over the next several hours, the anion gap slowly downtrends to normal. He also notes he starts feeling better, his abdominal pain is resolved, and he is hungry.

14. How do you transition Mr. Shuger off of the insulin infusion?

- First verify that gap is closed and that patient is willing and able to tolerate PO
- Determine dose of insulin, which can be done in one of 2 ways:
    - Calculate total daily dose with 0.5 units/kg/day and divide to basal-bolus therapy
    - Calculate total amount of insulin patient received over past 24hours, reduce this by 20%, then divide that to basal-bolus dosing
- Administer basal insulin subcutaneously AND maintain IV infusion for additional 1-2hours, allowing it to distribute and reach peak effect. Then turn off insulin infusion and IVF.

You resume basal-bolus dosing with Lispro 8units qAC and Lantus 25units qHS, then turn off the insulin infusion 2hours later. You make sure to change his POC glucose checks back to qACHS and review the plan with his nurse before leaving for the night.

Hospital Day 5: You come in to pre-round and hope that Mr. Shuger will have a good day today. Here are his labs:

Yesterday:	Today:
POC glucose 5pm 143	Renal panel: Na 141 K 3.8 Cl 101 HCO3 24 BUN 16 Cre 1.1 Glucose 195
POC glucose 9pm 175	
	CBC: WBC 9.2 Hgb 13.9 Hct 39.1 PLT 355

15. **How do you feel about Mr. Shuger's glycemic control? What would you adjust, if anything, in his regimen?**
    - Hyperglycemic this AM, with rise in glucose post-prandially last night as well
    - Discuss how you approach titration of insulin therapy to achieve goal
        - Generally can adjust insulin regimen by 10-20% each day
        - If fasting (AM) glucose level is high, suggests that basal dose is insufficient
        - If postprandial glucose levels are high, suggests that bolus/mealtime dosing is insufficient.
    - For our patient, can consider increasing his insulin regimen by ~6units → Lantus 28units qHS + Lispro 9units qAC (or adding back sliding scale)
    - Remember if using sliding scale that the total daily insulin dose needs to be calculated from the day prior and re-distributed across basal and bolus dosing.
        - Goal is to achieve glycemic control without having to use SSI!