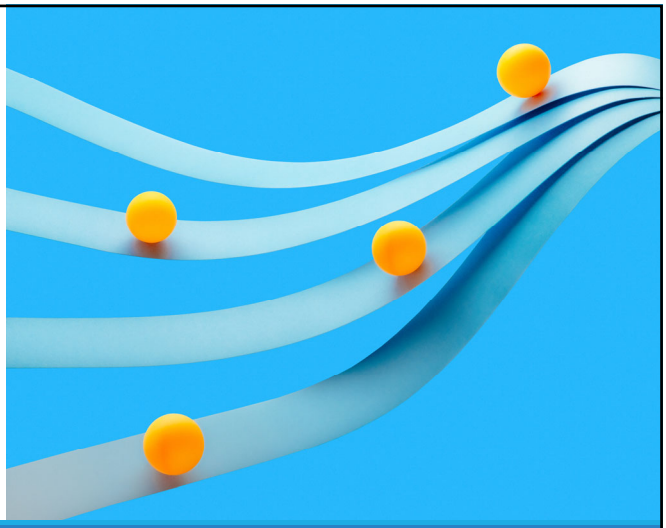
Managing Diabetic Ketoacidosis (DKA)



FAITH POLLOCK, APRN, CNS, CDCES, BC-ADM
ZACH TAYLOR, APRN, CNS
ALLINA HEALTH DIABETES/ENDOCRINOLOGY CARE | APRIL 2024

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Disclosures

- No disclosures

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Objectives

Upon completion of this lecture, participants should be able to:

- Describe nursing assessment of diabetic ketoacidosis
- Describe the four management goals for diabetic ketoacidosis

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Diabetic Ketoacidosis (DKA)

Life-threatening, **preventable** condition resulting from cascading effects of:

- Insulin deficiency
- Lipolysis
- Gluconeogenesis
- Ketogenesis
- Acidosis

Epidemiology:

- Most frequently associated with T1DM (due to absolute insulin deficiency)
- Incidence rate for primary diagnosis DKA increasing 2003-2017 (0.32% to 0.62% of all U.S. hospital admissions)
- Mean age 38.4 years
- Mean total charges $30,836/hospitalization
- Mean LOS 3.22 days
- Mortality rate 0.38%

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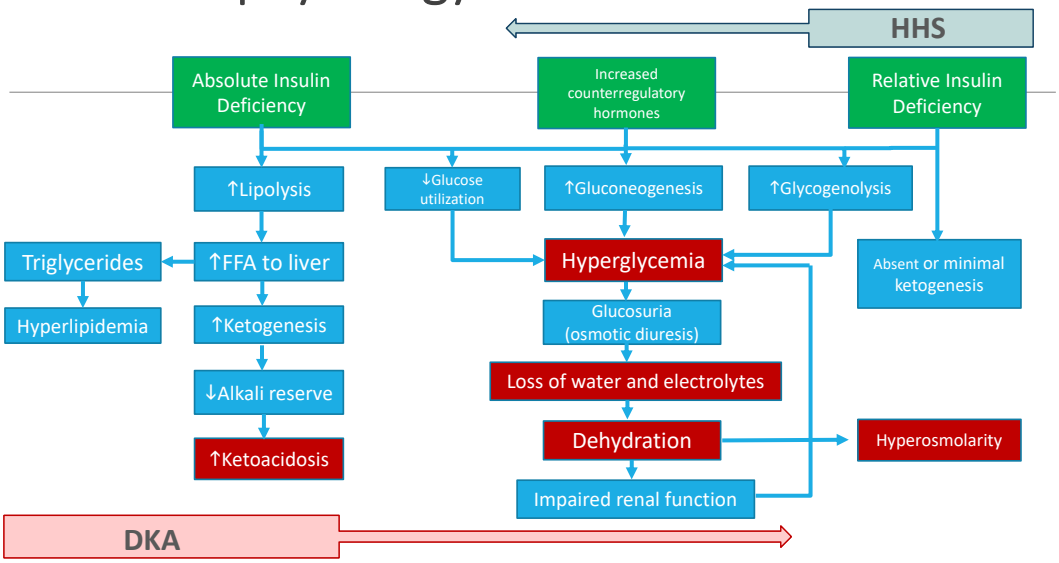
DKA Pathophysiology



Adapted from Kitabchi, A. E. et. al. (2009). Hyperglycemic crises in adult patients with diabetes. Diabetes Care, July 2009, vol. 32, no. 7: 1335-1343.

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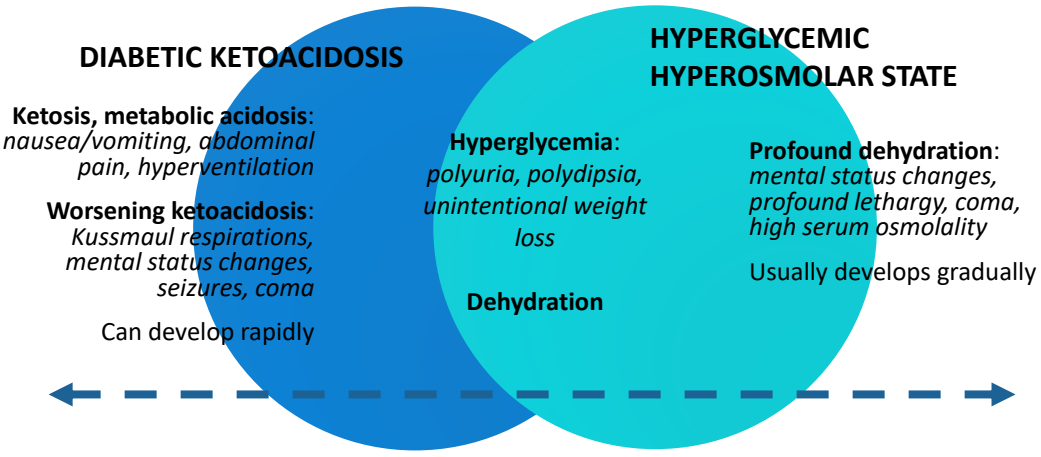
Clinical Features



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Diagnostic Criteria

Lab Evaluation	DKA	HHS
Arterial pH. Ref 7.38-7.42	Less than 7.3	Greater than 7.3
Serum bicarbonate (mEq/L). Ref 22-29	**Less than 18**	Greater than 18
Beta hydroxybutyrate (primary ketone). Ref < 0.6 mmol/L	**Positive**	None to slightly elevated
Anion gap. Ref 5-18	**Greater than 10**	Variable
Glucose (mg/dL)	Usually greater than 250 Less than 250 = **"euglycemic DKA"**	**Usually greater than 600**
Serum osmolality (mOsm/kg)		**Greater than 320**

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DKA Precipitating Factors

Certain conditions can "trigger" DKA by:

- Decreasing insulin secretion/availability
- Increasing insulin resistance
- Creating a ketosis-prone state

Insufficient insulin to maintain normal metabolism

- New onset/new diagnosis of diabetes
- Inappropriate adjustment or omission of insulin

Physiologic stress of acute illness

- Infections (20-25%)
- MI, CVA, pancreatitis

Pharmacologic effects

- Second-generation antipsychotics (olanzapine, quetiapine, etc.)
- Cocaine
- Cannabis (cyclical vomiting syndrome)
- SGLT2 inhibitors (empagliflozin, dapagliflozin, etc.)
  - Euglycemic DKA

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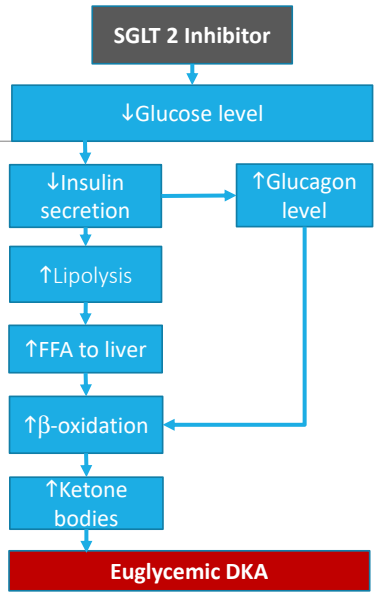
SGLT2 Inhibitors and DKA

SGLT2I Mechanism of Action

- prevent glucose reabsorption from the proximal renal tubules, resulting in increased glucosuria and decreasing plasma glucose

Euglycemic DKA

- Glucose normal to less than 250 mg/dL



Model adapted from Ogawa & Sakaguchi (2016)

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DKA Assessment

Clinical evaluation

History	• Diabetes diagnosis • Diabetes self-management knowledge and resources • Potential triggers • Duration of illness
Physical	• Vital signs • Airway, breathing, circulation • Nausea and vomiting • Fluid volume status • Mental status
Labs/Imaging	• Serum glucose • Serum electrolytes, anion gap, BUN, creatinine • CBC – leukocytosis common due to ketosis • Ketones – Betahydroxybutyrate • pH, venous or arterial blood gases • Hemoglobin A1C • Possibly: Cultures, chest x ray, lipase (pancreatitis)

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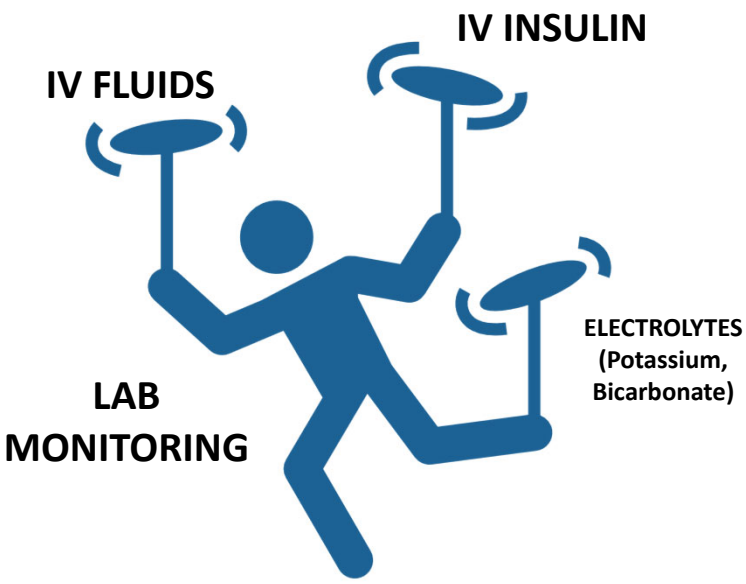
Treatment

Simultaneous management of four goals



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The DKA order set involves multiple **simultaneous** actions. Notice that IV fluid resuscitation, IV insulin, monitoring, and bicarbonate (if indicated) are initiated at the same time. The below chart illustrates the **general sequencing** of interventions for effective DKA treatment.

HOUR	1	2	3	4	5	6	7	8	9
IV FLUIDS +/- POTASSIUM: Treats Dehydration, Electrolyte Imbalance									
Fluid Boluses									
Maintenance Fluids for DKA				Usually NS or LR. Switch to fluids with dextrose when BG < 200-250 mg/dL (per institution). May need to add potassium.					
Maintenance Fluids for Euglycemic DKA	Start with dextrose fluids since initial BG already < 250 mg/dL. May need to add potassium.								
IV INSULIN: Treats Acidosis									
IV Insulin	Treat with IV insulin until anion gap (AG) < 14 or per organization. Ensure potassium is greater than 3.3 before starting IV insulin.								
DIET, GLUCOSE AND ELECTROLYTE MONITORING									
Diet Recommendation	NPO or Clear Liquid recommended to until acidosis cleared. Advance as tolerated once AG < 14								
Bicarbonate (if applicable)	For pH < 7								
POC BG Checks	Q1-2 hours per IV insulin infusion policy/protocol								
Serum Potassium	Q2 hours until discontinued								
Serum Electrolyte Panel	Q4 hours until discontinued								

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Treatment: IV Fluids

- Treats dehydration, restores fluid volume losses
- Treats hyperglycemia by dilution of glycemic concentration
- Starts with fluid boluses for resuscitation, then maintenance fluid
- **Switch to IV fluid with dextrose once BG < 200-250. Why?**
  - IV insulin is the key treatment for the acidosis

Normal Saline
Lactated Ringers

Dextrose-containing solution

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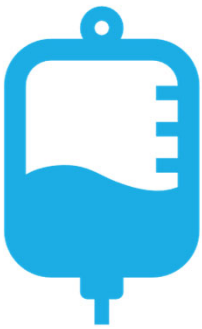
Treatment: IV Insulin

- **Reduces ketoacidosis by restoring normal metabolic functioning**
  - Suppresses lipolysis and ketogenesis
- **Reduces blood glucose**
- **Risk for hypokalemia – must ensure potassium is greater than 3.3 mEq/L BEFORE starting infusion.**



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Treatment: Electrolyte Management

- **Potassium Replacement**
  - Often need potassium replacement during IV insulin infusion to prevent hypokalemia
  - Lower threshold for replacement due to higher risk for hypokalemia
  - Potassium typically added to the maintenance fluids to avoid numerous piggyback replacements
- **Bicarbonate infusion for severe acidosis (pH < 7.0)**
- **Anion gap and serum bicarbonate must improve through duration of treatment**

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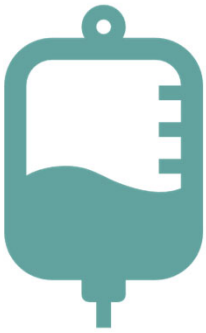
Treatment: Lab Monitoring

Important for titration of insulin rate AND to trend acid-base status, monitor serum potassium concentration

- **Blood Glucose**
  - Point of care Q1-2 hours to guide rate changes per protocol
  - BG may be labile if eating meals and snacks while on insulin infusion
- **Electrolyte Panel**
  - Sodium, Potassium, Chloride, CO2, Anion Gap



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Treatment: Transition to SQ Insulin

- **Transition to subcutaneous insulin injections appropriate when:**
  - **Acidosis is resolved (anion gap is closed)**
  - Bicarb is normal or near-normal
  - Patient able to tolerate more than CL diet
- **SQ Insulin Regimen/Dosing may be based on:**
  - Prior to admission regimen
  - Weight-based insulin dosing guidelines
  - Calculation from recent insulin infusion rates (only if BG has been stable)
  - Combination of the above

First dose of basal insulin 2 hours before discontinuing IV insulin to avoid rebound hyperglycemia

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Follow Up: Success After Discharge

- **Goals of post-discharge follow up:**
  - Prevent DKA recurrence
  - Review glycemic status, adjust care plan
  - Address diabetes self management learning needs
  - Address barriers to diabetes self-management
- **Resources for follow up:**
  - Primary Care Provider
  - Outpatient Diabetes Care & Education Specialist (1-4 we
  - Endocrinologist as needed
  - Combination of the above

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Case Studies

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Case Study 1

History and Presentation

- 18 y/o with type 1 diabetes, hyperlipidemia, hypertension
- Presents to ED with 24-hour acute nausea/vomiting associated with abdominal pain
- Coffee ground emesis
- Alert and oriented
- Uses insulin pump or SQ insulin plan for glucose management
- Previous hospital admissions for DKA
- Vital signs
  - BP 156/110
  - Pulse 134
  - Resp 14
  - Temp 98.8

History

Physical

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Case Study 1

Lab	Results	Normal Value
Na	133↓	136-145
K	5.0	3.5-5.1
Cl	87	98-107
CO2 (bicarb)	9↓	22-29
Anion Gap	37↑	5-18
Venous pH	7.24↓	7.32-7.43
Serum Glucose	623↑	70-99
Betahydroxybutyrate	5.4↑	<0.6
BUN	17	6-20
Creat	0.97↑	1.5-0.9
WBC	17.7↑	4.5-13
A1c	?	≤6.4

Labs/Imaging

CT of abdomen: Gastritis/esophagitis. Enlarged appendix.

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Case Study 1

History continued

- Lives with mother who is supportive
- Not employed, but does have health plan
- High risk for food insecurity
- History of depression and abuse. Has seen therapist in the past. Not taking antidepressant.
- Currently has multiple stressors
- Uses insulin pump, but sometimes reverts to basal/bolus insulin plan
- Has not been taking insulin regularly due to depression
- Uses cannabis regularly

History

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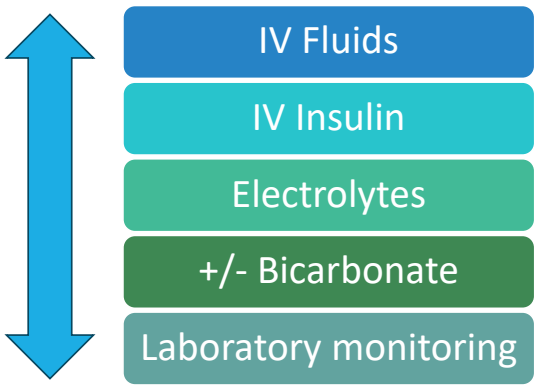

DKA Treatment Bundle

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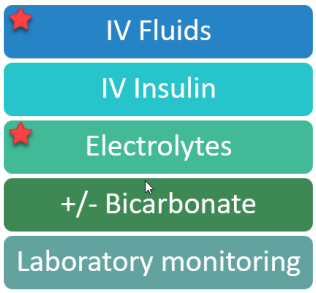
Case Study 1 Treatment:
IV Fluids and K Replacement

Time	IV Fluids	K values
Admission Day		
2000	Lactated Ringers 1000 ml bolus	5.0
2200	NaCl 500 ml/hr x 1 bag (2 hours)	
2300		4.5
Day 1		
0000	NaCl with 20 mEq K at 150 ml/hr	
0230		4.0
0500	D5.45 NaCl with 40 mEq K at 125 ml/hr	
1000	Fluids discontinued	



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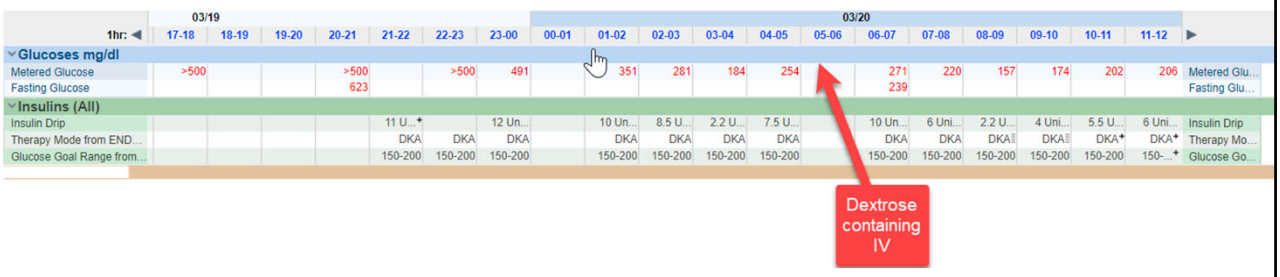
Case Study 1 Treatment:
IV Insulin

- IV Fluids
- IV Insulin
- Electrolytes
- +/- Bicarbonate
- Laboratory monitoring

Was the K in a safe range to start the insulin infusion?

Admission Day **Day 1**



Dextrose containing IV

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Case Study 1 Treatment:
Laboratory monitoring

- IV Fluids
- IV Insulin
- Electrolytes
- +/- Bicarbonate
- Laboratory monitoring

Time	CO2 (Bicarb)	Anion Gap	Venous pH
Admission Day			
2000	9↓	37↑	7.24↓
2130	10↓	35↑	
Day 1			
0130	13↓	22↑	
0630	16↓	17↑	
1630	18	12	

Bicarb 50 mEq administered

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Case Study 1 Treatment:
Acidosis cleared

- IV Fluids
- IV Insulin
- Electrolytes
- +/- Bicarbonate
- Laboratory monitoring

Moved to standard insulin infusion treatment

Day 1

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Case Study 1: DKA resolved

When patient resumed eating, discontinued IV fluids and insulin infusion

Transitioned patient to SQ insulin plan

Basal insulin degludec

Prandial insulin lispro

Correction insulin lispro

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Case Study 1: Discharge Planning

- Reinforced importance of taking insulin—basal, prandial and correction
  - Understood carb counting
- To see endocrinologist outpatient to resume insulin pump
  - Needed dose settings changed in the pump
- Verified if patient had insulin and monitoring supplies
  - Had insulin and insulin pen needles
  - Found continuous glucose monitor
- Outpatient mental health therapist

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Case Study 2

History and Presentation

- **33 y/o diagnosed with type 2 diabetes 6 months ago with A1c of 14. History of ADHD and anxiety.**
- **Started on empagliflozin, metformin and glipizide in September. A1c improved after 3 months to <6.0, so PCP stopped these meds.**
- **Presents to ED with polyuria, polydipsia, nausea, loss of appetite and fatigue over the past 2 weeks. Pt reports resuming diabetes medication 3 days prior to admission.**
- **Alert and oriented**
- **Vital signs**
  - **BP 108/80**
  - **Pulse 97**
  - **Resp 22**
  - **Temp 98.3**

History

Physical

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Case Study 2

Lab	Results	Normal Value
Na	130↓	136-145
K	4.2	3.5-5.1
Cl	103	98-107
CO2 (bicarb)	<10↓	22-29
Anion Gap	Unable to calculate	5-18
Venous pH	7.16↓	7.32-7.43
Serum Glucose	152↑	70-99
Betahydroxybutyrate	5.7↑	<0.6
BUN	13	6-20
Creat	1.33↑	0.5-0.9
WBC	7.0	4.5-13
A1c	10.1↑	≤6.4

Labs/Imaging

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Case Study 2

History

- **Has not received diabetes self-management education**
- **Has a glucose monitor. Not monitoring regularly.**
- **14-hour workdays**
- **Does not eat meals consistently and often poor choices**

History

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Case Study 2 Treatment:
IV Fluids and K Replacement

- IV Fluids
- IV Insulin
- Electrolytes
- +/- Bicarbonate
- Laboratory monitoring

Time	IV Fluids	K values
Admission Day		
0700	NaCl 1000 ml bolus	4.2
0830	D5.45 NaCl at 125 ml/hr	4.6
1130	D5.45 NaCl with 20 K at 200 ml/hr	3.8
1430	D5.45 NaCl with 40 K at 125 ml/hr	
1600	+Lactated Ringers 2000 ml bolus (sepsis protocol)	4.0

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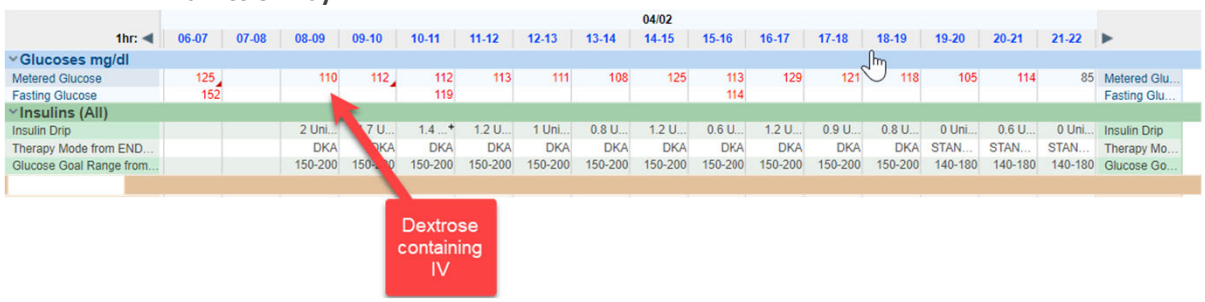
Case Study 2 Treatment:
IV Insulin

- IV Fluids
- IV Insulin
- Electrolytes
- +/- Bicarbonate
- Laboratory monitoring

Was the K in a safe range to start the insulin infusion?

Admission Day



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Case Study 2 Treatment:
Laboratory monitoring

- IV Fluids
- IV Insulin
- Electrolytes
- +/- Bicarbonate
- Laboratory monitoring

Time	CO2 (Bicarb)	Anion Gap	Venous pH
Admission Day			
0700	<10↓	Unable to calculate	7.16↓
1100	<10↓	Unable to calculate	
1500	<10↓	Unable to calculate	
1800	14	13	

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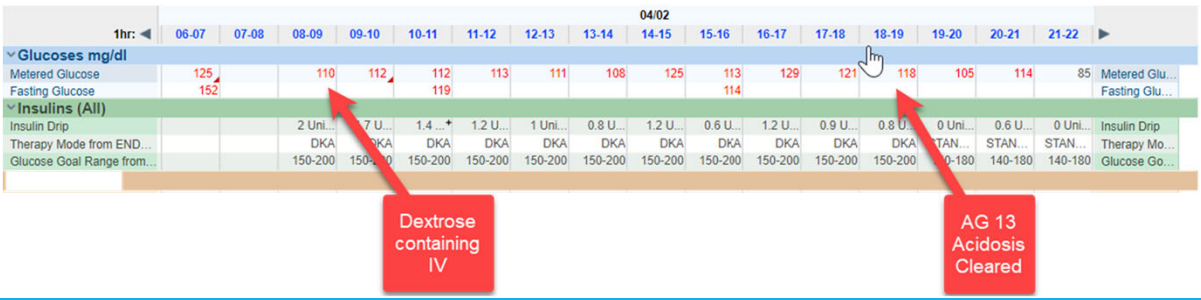
Case Study 2 Treatment:
Acidosis cleared

- IV Fluids
- IV Insulin
- Electrolytes
- +/- Bicarbonate
- Laboratory monitoring

Moved to standard insulin infusion treatment

Admission Day



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Case Study 2: Euglycemic DKA resolved

When patient resumed eating, discontinued IV fluids and insulin infusion

Transitioned patient to SQ insulin plan

Basal insulin glargine

Prandial insulin aspart

Correction insulin aspart

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Case Study 2: Discharge Planning

Instructed on insulin administration

- Discharged on basal, fixed prandial and correction dosing

To see endocrinologist outpatient

- Pending labs to identify if had type 1 diabetes

Verified if patient had insulin and monitoring supplies

- Had glucose meter, test strips and lancets
- Prescribed insulin and insulin pen needles

DID NOT RESUME EMPAGLIFLOZIN

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Questions?

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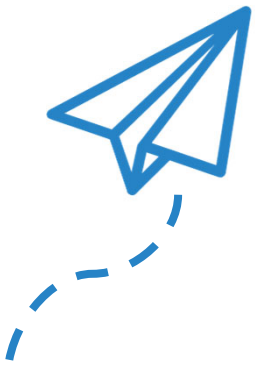
Contact Information

Faith Pollock, APRN, CNS, CDCES, BC-ADM
Diabetes Clinical Nurse Specialist
Allina Health, Abbott Northwestern Hospital
Email: faith.pollock@allina.com

Zach Taylor, APRN, CNS
Diabetes Clinical Nurse Specialist
Allina Health, Abbott Northwestern Hospital
Email: zachary.taylor@allina.com



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