

DIABETIC KETOACIDOSIS— A LIFE THREATENING PROBLEM

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February 26, 2020



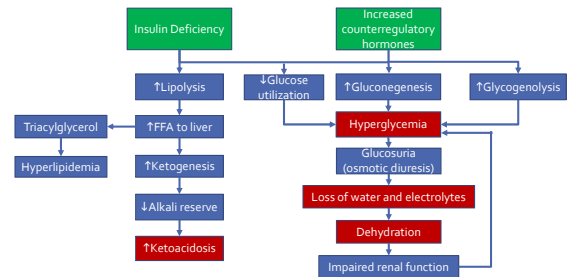
DISCLOSURE



OBJECTIVE

- State priorities in caring for patients with diabetic ketoacidosis (DKA)

Pathogenesis of DKA



Kilpatrick, A.E., Umpley, G.E., Miles, J.M., Fisher, J.N. Hyperglycemic crisis in adult patients with diabetes. Diabetes Care, 2009, 32:1330.

DKA Diagnostic Criteria

Lab	Mild DKA	Moderate DKA	Severe DKA
Arterial pH	<7.25–7.3	<7.0 to <7.24	<7.0
Serum Bicarb (mEq/L)	15–18	10 to <15	<10
Beta Hydroxybutyrate	Positive	Positive	Positive
Anion Gap	>10	>12	>12

DKA = elevated glucose + metabolic acidosis
Glucose usually greater than 250 mg/dL

Precipitating Factors of DKA

- Inadequate insulin
 - New diagnosis diabetes
 - Inappropriate adjustment of insulin
 - Insulin omission
- Acute illness
 - Infection (20–25%)
 - MI, stroke, pancreatitis
- Drugs
 - Second-generation antipsychotics
 - Cocaine
 - Cannabis
 - SGLT2 inhibitors



SGLT2 Inhibitors and DKA

- **SGLT2 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



Euglycemic diabetic ketoacidosis induced by SGLT2 inhibitors: possible mechanism and contributing factors. J Diabetes Investig. 2016; March: 703-135-138.

Clinical Features of DKA

DKA develops rapidly over a 24-hour period

- Hyperglycemia (early symptoms)**

 - Polyuria
 - Polydipsia
 - Weight loss
- As condition worsens**

 - Kussmaul respirations
 - Mental status changes
 - Seizures
 - Coma
- Ketoacidosis (early signs)**

 - Nausea
 - Vomiting
 - Abdominal pain
 - Hyperventilation

Initial Assessment for DKA

- Physical**

 - Vital signs
 - Airway, breathing and circulation (ABC) status
 - Mental status
 - What may have precipitated DKA
 - Volume status
- Labs/tests**

 - Serum glucose
 - Serum electrolytes (with anion gap)
 - BUN and creat
 - CBC
 - Leukocytosis common due to ketonemia
 - Betahydroxybutyrate
 - EKG
 - ABG (if substantial hypoxia suspected)
 - Hemoglobin A1c
 - Potential need for—
 - cultures to screen for infection
 - lipase
 - chest X-ray



DKA treatment requires...

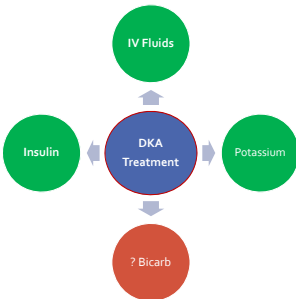
Urgency

Treatment needs to start immediately

Vigilance

Frequent monitoring of labs, glucose and fluids

Follow complex set of orders



IV Fluids

- LABS**
Q 2-4 hours

 - Electrolytes
 - BUN
 - Creat
- **Rehydrate**
 - Start with 1 liter bolus NaCl 0.9% over 1 hour....
 - then 250-500 ml/hr
 - **Fluids variance**
 - 0.45% NaCl for high Na
 - Verify rate for renal disease/dysfunction and heart failure
 - **When glucose 200 mg/dL**
 - change to D5 NaCl 0.45% 150-250 ml/hr

Why dextrose containing fluids?

- Hyperglycemia is corrected faster than the acidosis
- Addition of dextrose to the fluids allows continued insulin administration until the ketonemia is cleared, while preventing hypoglycemia



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Insulin



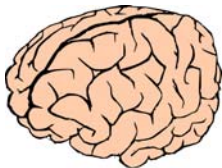
LABS

- Electrolytes
- Glucose Q 1-2 hours

- **Insulin Infusion** to restore and maintain GLUCOSE metabolism
- **Initial glucose goal** is 150-200 mg/dL
- Glucose rate of fall goal 50-70 mg/dL
- **Initial insulin dosing**
 - IV ibolusinsulin bolus: 0.1 units/kg (no for pediatrics)
 - Infusion rate: 0.1 unit/kg/hr
- **DO NOT START** infusion until confirmed K is ≥ 3.3 mEq/L
- To prevent life-threatening arrhythmias and respiratory weakness
- Provide K replacement before IV insulin started
- When glucose 200 mg/dL, infusion rate can decrease to 0.02-0.05 units/kg/hr
- Frequent glucose checks important for timely insulin adjustment and to avoid hypoglycemia

Cerebral Edema

- Rare complication in adults
- 20-40% mortality rate
- **PREVENTION**
 - Avoid excessive hydration
 - Avoid rapid reduction of glucose
 - Insulin infusion adjusted by "rate of change"



Potassium



LABS

Q 2-4 hours

- Electrolytes or K

- **Potassium replacement**
 - K replacement is to be initiated when serum level is—
 - Less than 3.3 mEq/L **before insulin infusion** started
 - Less than 5.3 mEq/L to **prevent hypokalemia**
- **Goal potassium** is between 4.0 and 5.0 mEq/L
- Best to add to current IV fluids (not bolus doses)
 - 20-40 mEq/L

Assess Need for Bicarbonate

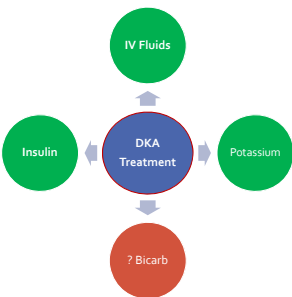


LABS

Q 2-4 hours

- Electrolytes

- **Bicarbonate replacement**
 - When pH is less than 6.9
- Monitor the potassium level as it may fall
 - More aggressive K replacement needed
- Used for patients with life-threatening hyperkalemia



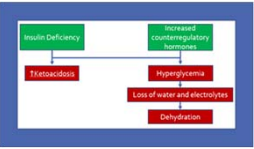
CASE
STUDY

Case Study-starting from ED

- Physical Assessment

 - Alert
 - Looking ill
 - Dry mucous membranes
- VS

 - Temp 98.5
 - Pulse 114 (tachy)
 - R 21
 - BP 159/79
- CXR clear
- EKG with peaked T waves, QRS intact.
- No clear signs of infection
- Uses cocaine



Labs-Time 1020

ISTAT-EC

STATISTICAL INFORMATION

Visible to patient: Not Released

Ref Range: 5/12/16 10:23

GLUCOSE/STAT: 65-105 mg/dL, 270 (H)

BUN/STAT: 8-23 mg/dL, 31 (H)

SODIUM/STAT: 135-145 mmol/L, 129 (L)

POTASSIUM/STAT: 3.5-5.0 mmol/L, 2.8 (H)

CHLORIDE/STAT: 96-107 mmol/L, 104

CO2,TOTAL/STAT: 23-31 mmol/L, 21 (L)

ANION GAP/STAT: 8-16 mmol/L, 26 (H)

PH/STAT: 7.35-7.45, 7.32 (L)

PCO2,VENOUS/STAT: 35-45 mmHg, 47 (H)

HCO3,VENOUS/STAT: 22-30 mmol/L, 20 (L)

BASE EXCESS: -2.0 to 2.0, -2.3 (L)

Ref Range: 5/12/16 10:19

SODIUM: 135-145 mmol/L, 129 (L)

POTASSIUM: 3.5-5.0 mmol/L, 2.8 (H)

CHLORIDE: 96-110 mmol/L, 94 (L)

CO2,TOTAL: 23-31 mmol/L, 21 (L)

ANION GAP: 8-16 mmol/L, 26 (H)

GLUCOSE: 65-105 mg/dL, 270 (H)

BUN: 8-23 mg/dL, 31 (H)

CREATININE: 0.7-1.3 mg/dL, 0.8 (H)

BUN/CREAT: 10-20 mg/dL, 13

RATIO: 100-200 mg/dL, 100 (H)

QIP: 0-100 mg/dL, 100 (H)

QIP: 0-100 mg/dL, 100 (H)

BETA: 0.0-0.5 mg/dL, 0.7 (H)

Lab

Mild DKA

Moderate DKA

Severe DKA

Arterial pH: <7.35-7.3

Serum Bicarb (mEq/L): 15-18

Beta Hydroxybutyrate: Positive

Anion Gap: >10

Insulin Deficiency

Increased counterregulatory hormones

Tissue acidosis

Hyperglycemia

Loss of water and electrolytes

Dehydration

IV Fluids

IV Fluids- Time 1020

1

NaCl 0.9% IV - Bolus

ONE TIME, Intravenous, Dose: 1000 mL bolus over 1 hour

2

NaCl 0.9% IV infusion

CONTINUOUS, Intravenous, Rate: 700 mL/hour for 2 hours

3

NaCl 0.9% IV infusion

CONTINUOUS, Intravenous, Rate: 120 mL/hr

2

NaCl 0.9% IV infusion

CONTINUOUS, Intravenous, Rate: 120 mL/hr

1

NaCl 0.9% IV infusion

CONTINUOUS, Intravenous, Rate: 120 mL/hr

3

NaCl 0.9% IV infusion

CONTINUOUS, Intravenous, Rate: 120 mL/hr

Insulin

Insulin- Time 1109

K=7.6

Sample Time

Time Entered

Flags

Glucose mg/dL

Oral

Calculated / Confirmed

Boles

Dextrose

Carbs

SubQ

Unconf / Conf

Meal

ERR

Goal Range mg/dL

Next Check Due Frequency

Miss Late Sample

Miss Late Entered

01-12-2016 11:09

01-12-2016 11:09

W

500

10.5

9

10.5

9

150-200

01-12-2016 11:30

0

01-12-2016 11:37

01-12-2016 11:38

W

457

10

10

150-200

01-12-2016 12:08

-2

01-12-2016 12:15

01-12-2016 12:16

W

500

16

21

16

21

150-200

01-12-2016 12:46

7

01-12-2016 13:01

01-12-2016 13:02

W

500

22

18

22

18

150-200

01-12-2016 13:32

15

01-12-2016 13:37

01-12-2016 13:38

W

388

11.5

11.5

150-200

01-12-2016 14:38

5

01-12-2016 14:41

01-12-2016 14:44

W

347

13

13

150-200

01-12-2016 15:44

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No delay in glucose check

Transfer to ICU

Transfer 1330

Potassium

Potassium

This replacement is recommended until this order set is discontinued.

1) Serum K >= 5.3: No replacement. Make sure no potassium is in IV fluids and no supplemental potassium is being given. Recheck potassium in 2 hours.

2) Serum K 4.5 - 5.2: 20 mEq of KCl/Liter should be in IV fluids.

3) Serum K 3.5 - 4.4: 40 mEq of KCl/Liter should be in IV fluids.

4) Serum K < 3.5: Continue with 40 of KCl/Liter and initiate site specific potassium replacement protocol (if applicable) via med line.

Goal K is between 4.0 and 5.0 mEq/L

Initial labs at 1020

PH/STAT	7.32	7.32 (L)
SODIUM	129	129 (L)
POTASSIUM	2.8	2.8 (H)
CHLORIDE	94	94 (L)
CO2,TOTAL	21	21 (L)
ANION GAP	26	26 (H)

Then at 1236 No K needed

SODIUM	135	135
POTASSIUM	5.3	5.3 (H)
CHLORIDE	102	102
CO2,TOTAL	21	21 (L)
ANION GAP	26	26 (H)

Bicarbonate

Initial labs at 1020

PH/STAT	7.32	7.32 (L)
SODIUM	129	129 (L)
POTASSIUM	2.8	2.8 (H)
CHLORIDE	94	94 (L)
CO2,TOTAL	21	21 (L)
ANION GAP	26	26 (H)

Bicarb given due to high K per notes, not because of pH

Sodium Bicarbonate Injection 50 mEq
Dose: 50 mEq EACH TIME PRN Route: IV
PRN Reason: pH < 7.35
PRN Comment: 6.9
Start: 01/12/16 10:20 End: 01/12/16 22:29
CA Admin Instructions:
Recheck arterial blood gas in 15 minutes. Call physician if pH remains less than 7.35
For treatment of DKA.

5.3 (H) mEq/L Green K

Handoff from ED

1. Fluids

- What fluid
- What rate

2. Glucose

- Last glucose
- Current dosing of IV insulin
- Next glucose due time

3. Labs

- Last results
- Next set due time

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ICU DKA

Sample Time	Time Entered	Flags	Glucose mg/dL	DKA	Crits
01-12-2016 11:09			500	10.5	1
01-12-2016 11:09				10.5	1
01-12-2016 11:37			457	10	
01-12-2016 11:38				10	
01-12-2016 12:15			500	16	21
01-12-2016 12:16				16	21
01-12-2016 13:01			500	22	18
01-12-2016 13:02				22	18
01-12-2016 13:37			388	11.5	
01-12-2016 13:38				11.5	
01-12-2016 14:41			347	13	
01-12-2016 14:44				13	
01-12-2016 15:46			258	9.5	
01-12-2016 15:46				9.5	
01-12-2016 17:01			187	4.6	
01-12-2016 17:03				4.6	
01-12-2016 17:57			128	1.3	
01-12-2016 17:58				1.3	

Insulin

IV Fluids

Change to dextrose IV

Labs at 1640

SODIUM

Staff Range 135-145

142

POTASSIUM

Staff Range 3.5-5.0

4.4

CHLORIDE

Staff Range 98-109

111 (H)

CO2,TOTAL

Staff Range 23-31

14 (L)

ANION GAP

Staff Range 5-16

17

3) Serum K 3.5 - 4.4: 40 mEq of KCl/Liter should be in IV Fluids.

56 mEq KCl 0.46% infusion

Start 125 mL/hr From CONTINUOUS Runway IV

Stop 8:12:46 1:57 From 8:13:16 8:53:16

Change to modify this order to include frequency of CONTINUOUS when order is placed.

Volume: 1.000 mL

Dispensed Loc: 4400 MATERIALS

Last Action: 8:13:16 8:53:16

No K in IV

GREEN

ICU DKA

Sample Time	Time Entered	Flags	Glucose mg/dL	DKA
01-12-2016 18:59			117	1.2
01-12-2016 18:59				1.2
01-12-2016 20:01			141	1.8
01-12-2016 20:01				1.8
01-12-2016 21:13			153	2.2
01-12-2016 21:16				2.2
01-12-2016 23:26			121	0.8
01-12-2016 23:26				0.8
01-13-2016 01:15			151	1.8
01-13-2016 01:17				1.8
01-13-2016 03:15			191	3.2
01-13-2016 03:15				3.2
01-13-2016 04:10			154	1.7
01-13-2016 04:10				1.7
01-13-2016 05:08			174	2.6
01-13-2016 05:08				2.6
01-13-2016 06:16			182	3
01-13-2016 06:17				3

Off DKA Mode

Labs at 2010

SODIUM

Staff Range 135-145

143

POTASSIUM

Staff Range 3.5-5.0

4.6

CHLORIDE

Staff Range 98-109

113 (H)

CO2,TOTAL

Staff Range 23-31

17 (L)

ANION GAP

Staff Range 5-16

13

DKA resolved!

Post DKA Treatment

Transition to SQ insulin

- When tolerating nutritional insulin
- Give SQ BASAL insulin 2 hours before insulin infusion discontinued!

Diabetes Education

- If newly diagnosed
- Review what may have caused DKA
 - Omission of insulin doses
 - fear of hypoglycemia
 - limited finances
 - when ill
 - stress of chronic illness
 - poor focus or understanding
 - Insulin pump troubleshooting

Case Study Discharge Plan

Review what may have caused DKA

- Omission of insulin doses
- Poor focus of self-management
- Cocaine use

Diabetes Educator

- Self-management skills

Substance Abuse Counselor

Outpatient follow-up and resources





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REFERENCES

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