# How Sweet It Is: Managing Hyperglycemic Emergencies

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PRESENTED BY
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PROVIDENCE ALASKA MEDICAL CENTER

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- No disclosures
- No COI

2

# Learning Objectives

- **By the end of this presentation the learner will be able to:**
  - identify two precipitating risk factors leading to hyperglycemic emergencies.
  - compare and contrast the clinical presentation of a patient with DKA and a patient experiencing HHS.
  - list three critical interventions for the management of the patient with a hyperglycemic emergency.

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# A bit about.....

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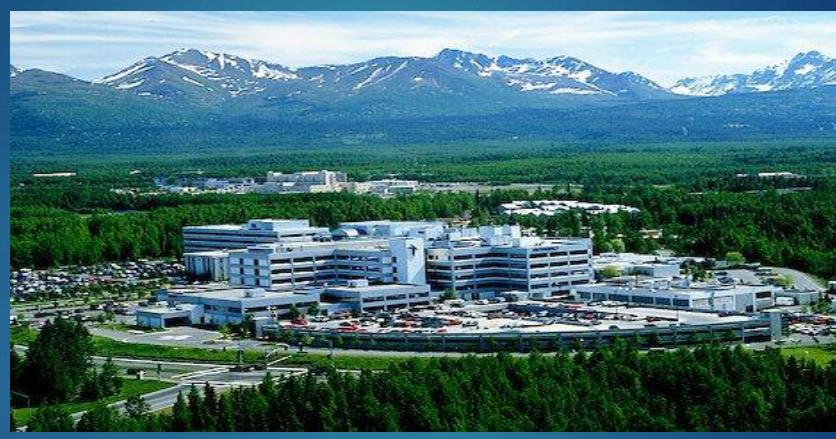

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# DM in US

- 34.2 million
  - 10.5% of the population
    - 21.4% undiagnosed

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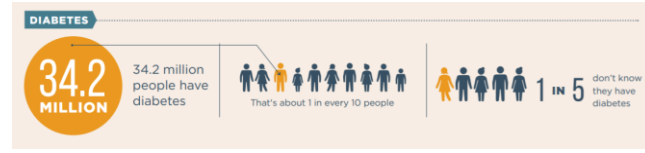


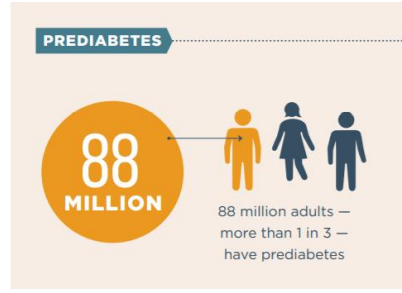


CDC, 2022

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## Number and Percentage of U.S. Population with Diagnosed Diabetes, 1958-2008

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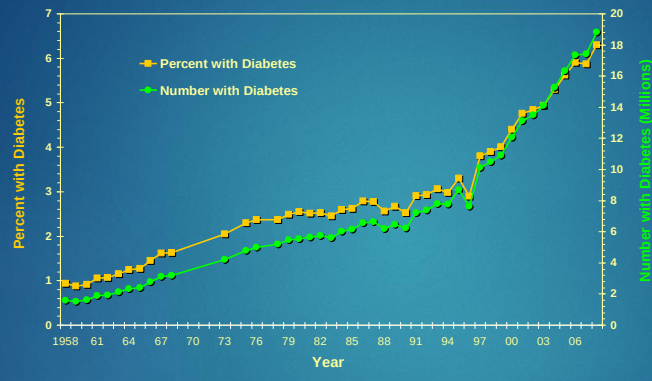
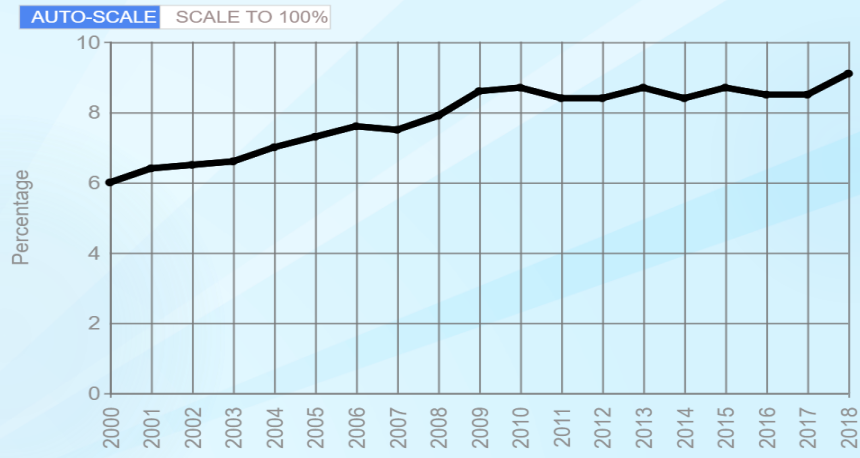



CDC's Division of Diabetes Translation. National Diabetes Surveillance System available at http://www.cdc.gov/diabetes/statistics

6

# Percent Diagnosed with DM in US Adults ≥ 18 years

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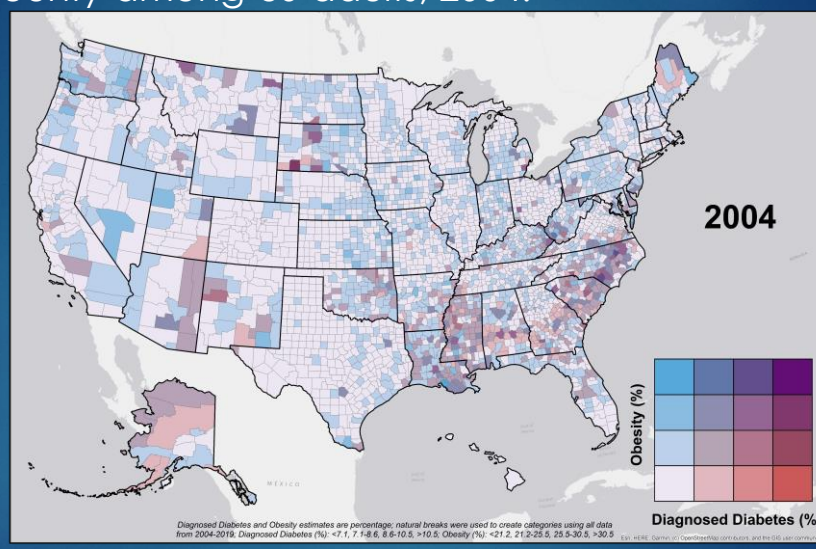
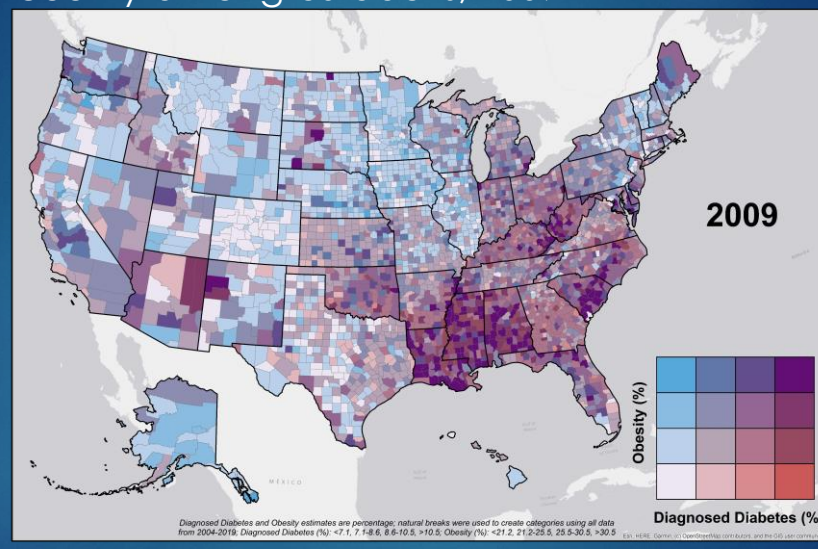
# Map of diagnosed diabetes vs obesity by county among US adults, 2004.




8

## Map of diagnosed diabetes vs obesity by county among US adults, 2009

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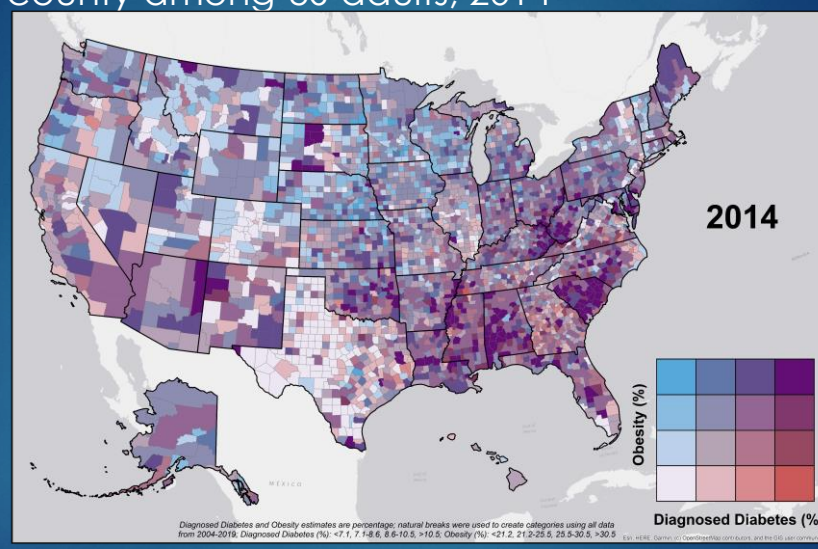
## Map of diagnosed diabetes vs obesity by county among US adults, 2014

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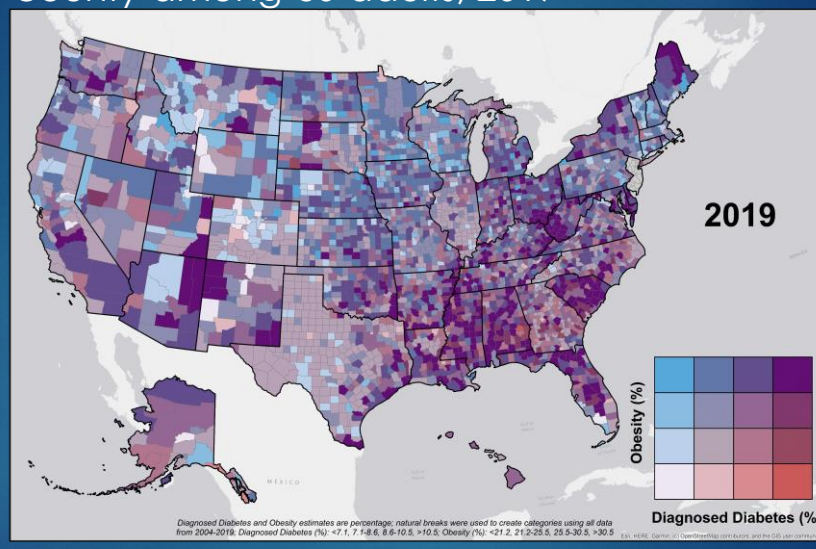
## Map of diagnosed diabetes vs obesity by county among US adults, 2019

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## Diabetes Mellitus

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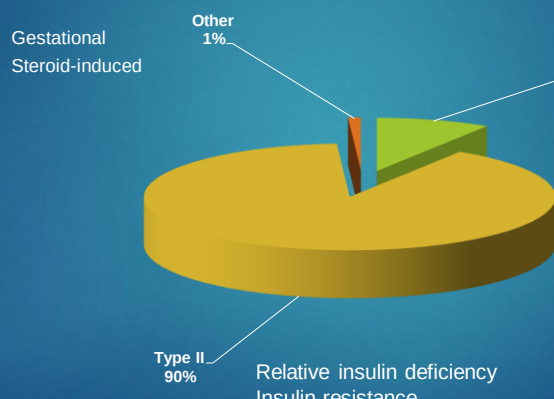


***Absolute*** insulin deficiency
More prone to DKA

Relative insulin deficiency
Insulin resistance
More prone to HHS

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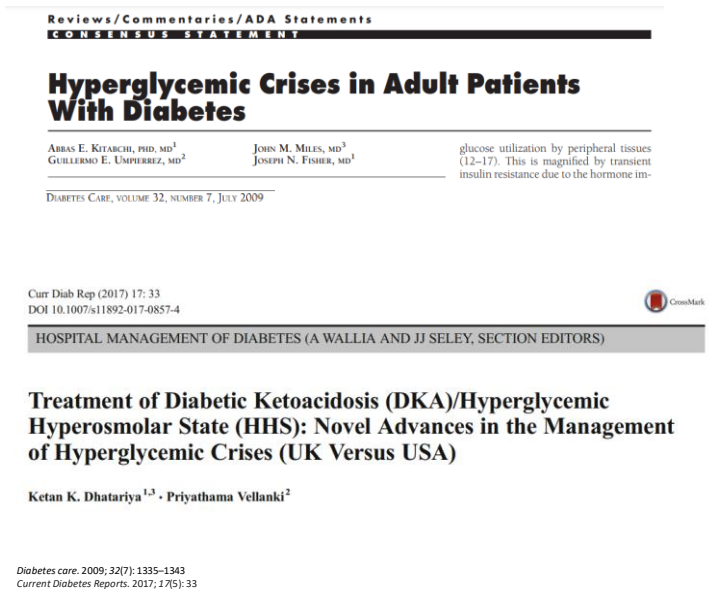

Reviews/Commentaries/ADA Statements
CONSENSUS STATEMENT

**Hyperglycemic Crises in Adult Patients With Diabetes**

Abbas E. Kitabchi, phd, md[1]
Guillermo E. Umpierrez, md[2]
John M. Miles, md[3]
Joseph N. Fisher, md[1]

glucose utilization by peripheral tissues (12–17). This is magnified by transient insulin resistance due to the hormone im-

Diabetes Care, volume 32, number 7, July 2009

Curr Diab Rep (2017) 17: 33
DOI 10.1007/s11892-017-0857-4

HOSPITAL MANAGEMENT OF DIABETES (A WALLIA AND JJ SELEY, SECTION EDITORS)

**Treatment of Diabetic Ketoacidosis (DKA)/Hyperglycemic Hyperosmolar State (HHS): Novel Advances in the Management of Hyperglycemic Crises (UK Versus USA)**

Ketan K. Dhatariya[1,3] · Priyathama Vellanki[2]

*Diabetes care.* 2009; *32*(7): 1335–1343
*Current Diabetes Reports.* 2017; *17*(5): 33

# Guidelines

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## Pathogenesis of Hyperglycemic Emergencies

- **Inadequate insulin**
  - Decreased insulin production - Undiagnosed DM
  - Failure to administer enough insulin
  - Increased insulin requirements
- **Concomitant elevation of counter-regulatory hormones**
  - Glucagon
  - Catecholamines
  - Cortisol
  - Growth hormone
  - Produced during periods of physical stress
  - Gluconeogenesis - increased hepatic glucose production

*Diabetes care.* 2009; *32*(7): 1335–1343
*Current Diabetes Reports.* 2017; *17*(5): 33
*Frontiers in Endocrinology.* 2017; 8( 106): 1-13
*Font. Clin Diabetes Healthc.* 2022;2.

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# Diabetic Ketoacidosis

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**Definition**

- Inadequate insulin
- Hyperglycemia
- Accumulation of ketones

**Mortality ~ 1 - 9% in experienced centers**

**More common in people with Type I DM**

**Can occur in people with Type II DM**

- Beta cells severely depleted
- Under stress of acute illness

*Diabetes Care.* 2009; *32*(7): 1335–1343
*Diabetes Care.* 2020; 43: 1057-1064
*Current Diabetes Reports.* 2017; *17*(5): 33
*BMC Endocrine Disorder.* 2020; 20: 182
*Frontiers in Endocrinology.* 2017; 8( 106): 1-13
*J Emerg Med.* 2020; 59: 373-383
*Font. Clin Diabetes Healthc.* 2022;2

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# DKA Precipitating Factors

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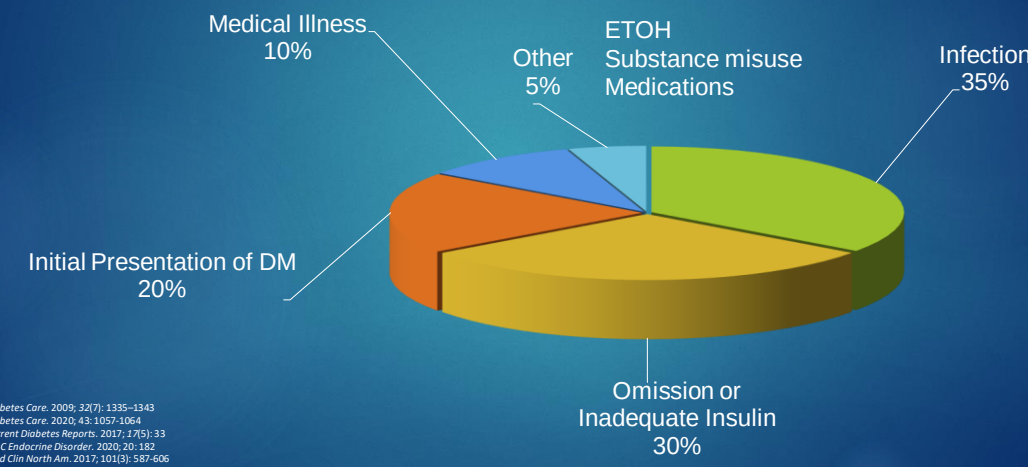


*Diabetes Care.* 2009; *32*(7): 1335–1343
*Diabetes Care.* 2020; 43: 1057-1064
*Current Diabetes Reports.* 2017; *17*(5): 33
*BMC Endocrine Disorder.* 2020; 20: 182
*Med Clin North Am.* 2017; 101(3): 587-606
*J Emerg Med.* 2020; 59: 373-383
*Font. Clin Diabetes Healthc.* 2022;2.

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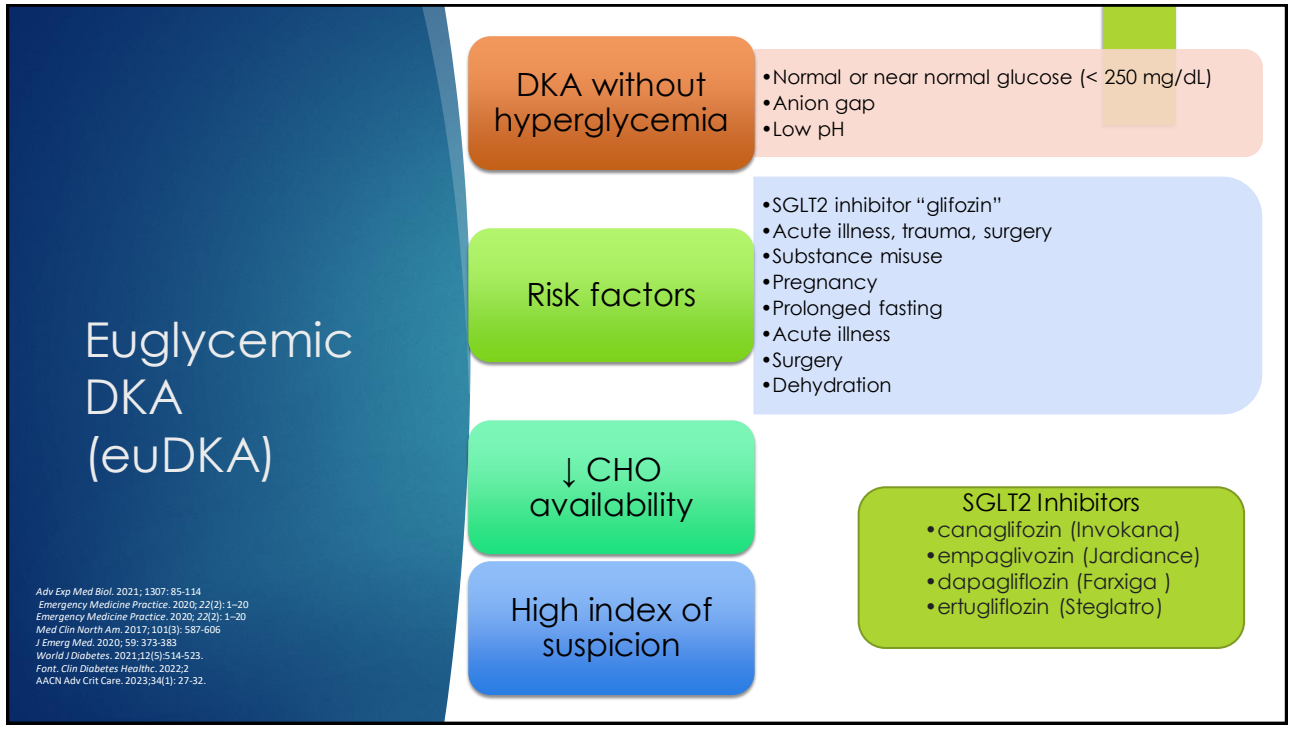
Euglycemic DKA (euDKA)
DKA without hyperglycemia
•Normal or near normal glucose (< 250 mg/dL)
•Anion gap
•Low pH
Risk factors
•SGLT2 inhibitor "glifozin"
•Acute illness, trauma, surgery
•Substance misuse
•Pregnancy
•Prolonged fasting
•Acute illness
•Surgery
•Dehydration
↓ CHO availability
High index of suspicion
SGLT2 Inhibitors
•canaglifozin (Invokana)
•empaglivozin (Jardiance)
•dapagliflozin (Farxiga )
•ertugliflozin (Steglatro)
Adv Exp Med Biol. 2021; 1307: 85-114
Emergency Medicine Practice. 2020; 22(2): 1–20
Emergency Medicine Practice. 2020; 22(2): 1–20
Med Clin North Am. 2017; 101(3): 587-606
J Emerg Med. 2020; 59: 373-383
World J Diabetes. 2021;12(5):514-523.
Font. Clin Diabetes Healthc. 2022;2
AACN Adv Crit Care. 2023;34(1): 27-32.

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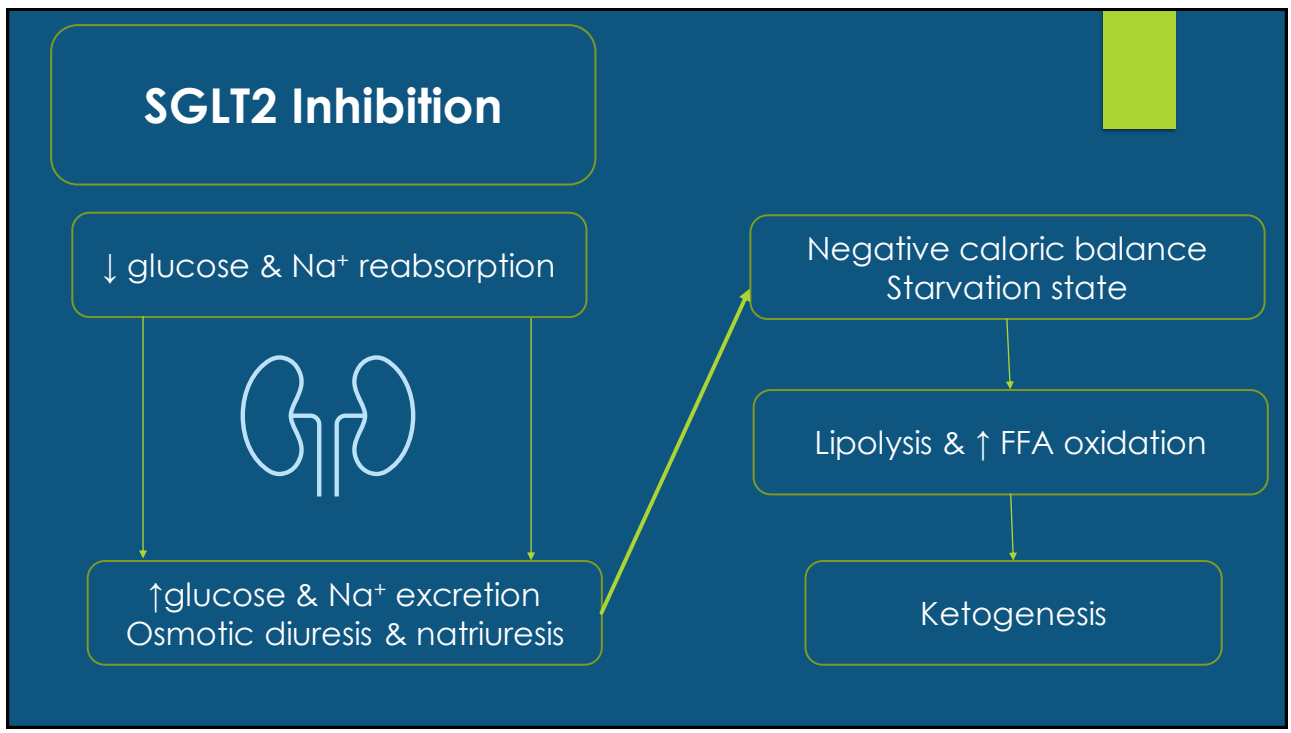
SGLT2 Inhibition
↓ glucose & Na+ reabsorption
↑glucose & Na+ excretion
Osmotic diuresis & natriuresis
Negative caloric balance
Starvation state
Lipolysis & ↑ FFA oxidation
Ketogenesis

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# HHS

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- Previously known as HHNK, HHNC
- Less common than DKA
- Mortality rate 5 – 20%
- Mean age of onset – 7th decade of life

*Adv Exp Med Biol. 2021; 1307: 85-114*
*Diabetes Care.* 2009; *32*(7): 1335–1343
*Diabetes Care.* 2020; 43: 1057-1064
*Current Diabetes Reports.* 2017; *17*(5): 33
*BMC Endocrine Disorder.* 2020; 20: 182
*J Emerg Med.* 2021; 61: 365-375
*Font. Clin Diabetes Healthc.* 2022;2

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# HHS Precipitating Factors

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- Inadequate insulin secretion
  - Usually with type 2 diabetes
  - Onset slow as beta cell function diminishes
  - 20% have no Hx DM – delays recognition
- Often in older adults in LTC facility
  - Chronically ill or disabled
  - Altered thirst mechanism
  - Lack of ability to take care of themselves
- Acute illness - stress response – most common
- Medications

*Adv Exp Med Biol. 2021; 1307: 85-114*
*Diabetes Care.* 2009; *32*(7): 1335–1343
*Diabetes Care.* 2020; 43: 1057-1064
*Current Diabetes Reports.* 2017; *17*(5): 33
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*Med Clin North Am.* 2017; 101(3): 587-606
*J Emerg Med.* 2021; 61: 365-375
*Font. Clin Diabetes Healthc.* 2022;2.

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# Medications

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- Affect blood glucose levels
  - Thiazides
  - Phenytoin
  - Glucocorticoids
  - Beta blockers
  - Calcium channel blockers
  - Catecholamines
  - Loop diuretics
  - Quetiapine (Seroquel)
  - Risperidone
  - Olanzapine

*Adv Exp Med Biol. 2021; 1307: 85-114*
*Diabetes Care.* 2009; *32*(7): 1335–1343
*Diabetes Care.* 2020; 43: 1057-1064
*Current Diabetes Reports.* 2017; *17*(5): 33
*BMC Endocrine Disorder.* 2020; 20: 182
Am Fam Phys. 2017; 96:729-736.
*Med Clin North Am.* 2017; 101(3): 587-606

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# 8 I's

Adv Exp Med Biol. 2021; 1307: 85-114

- **Insulin**: deficiency/insufficiency
- **Iatrogenic**: steroids, thiazides, atypical antipsychotics
- **Infection**: most common
- **Ischemia**: gut, foot
- **Infarction**: ACS, stroke
- **Inflammation**: acute pancreatitis, cholecystitis
- **Intoxication**: alcohol, cocaine
- Infant on board

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# Pathophysiology

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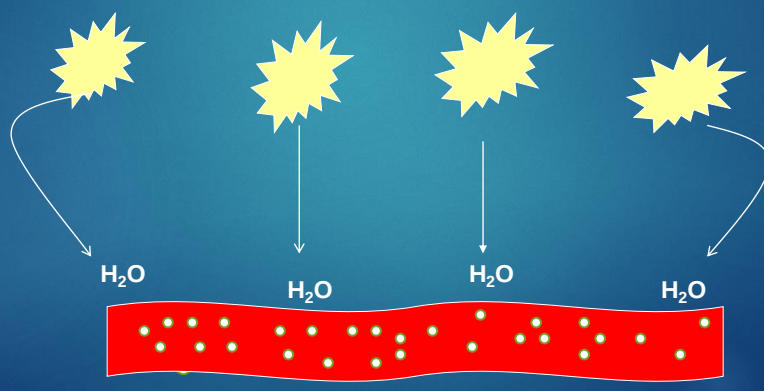
High serum glucose level → osmotic gradient → fluid moves out of cells & interstitial space → osmotic diuresis

**Dehydration**

**Electrolyte loss**




*Adv Exp Med Biol.* 2021; 1307: 85-114
*Frontiers in Endocrinology.* 2017; 8( 106): 1-13
*Emergency Medicine Practice.* 2020; *22*(2): 1–20
*Emergency Medicine Practice.* 2020; *22*(2): 1–20
*J Emerg Med.* 2020; 59: 373-383
*J Emerg Med.* 2021; 61: 365-375
*Font. Clin Diabetes Healthc.* 2022;2

23

# Serum Sodium

24

- Usually present with a low serum $Na^+$
  - Pseudo-hyponatremia
  - Sodium-poor intracellular fluid moves into vascular space
- Normal or increased serum $Na^+$ indicates profound dehydration

*Diabetes care.* 2009. *32*(7), 1335–1343
*Current Diabetes Reports.* 2017, *17*(5), 33
*Frontiers in Endocrinology.* 2017, 8( 106), 1-13
*J Emerg Med.* 2020; 59: 373-383
*J Emerg Med.* 2021; 61: 365-375

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# Corrected Serum $Na^+$

- Add 1.6 mEq to $Na^+$ value for each 100 mg/dL glucose over 100
- Example: Blood glucose = 600 mg/dL

  Serum $Na^+$ = 130
- Corrected serum $Na^+$ = 1.6 X 5 = 8

  130 + 8 = 138

Am Fam Phys. 2017; 96:729-736.
*J Emerg Med.* 2020; 59: 373-383
*J Emerg Med.* 2021; 61: 365-375

25

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# DKA Pathophysiology

26

**Inadequate insulin**
- Cells are starving

**Gluconeogenesis**
- Breakdown of protein and fat
- Protein breakdown
  - ↑ urea production → ↑ osmotic diuresis & dehydration

**Release of free fatty acids**
- Unrestrained hepatic fatty acid oxidation
- Ketone body production
  - Acetoacetate
  - B-hydroxybutyrate
  - Acetone
- Metabolic acidosis

*Adv Exp Med Biol.* 2021; 1307: 85-114
*Frontiers in Endocrinology.* 2017; 8( 106): 1-13
*J Emerg Med.* 2020; 59: 373-383
*Font. Clin Diabetes Healthc.* 2022;2.

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## DKA Pathophysiology

- Dehydration →
- ↓ perfusion →
- Tissue hypoxia
- Anaerobic metabolism →
- Lactic acid production
- Worsening metabolic acidosis

*Diabetes care*. 2009. *32*(7), 1335–1343
*Current Diabetes Reports*. 2017, *17*(5), 33
*Frontiers in Endocrinology*. 2017, 8( 106), 1-13
*J Emerg Med*. 2020; 59: 373-383
*Font. Clin Diabetes Healthc*. 2022;2.

27

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## DKA Pathophysiology

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- Anion Gap – presence & severity of metabolic acidosis

$$[Na^+ - (Cl^- + HCO_3^-)]$$

Normal = 7 – 9 mEq/L

> 10 - 12 mEq/L indicates the presence of excess organic acids (ketone bodies)

Metabolic acidosis

DKA → Anion Gap > 20 mEq/L

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# Serum Potassium

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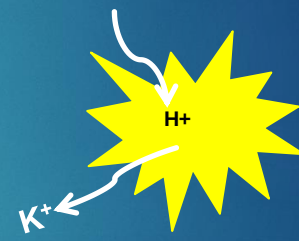
- May be falsely elevated
- Movement of $K^+$ out of cells
  - Solute drag
  - Acidosis → $H^+$ shift
- Total body $K^+$ may be low
- Watch $K^+$ as acidosis resolves




*Adv Exp Med Biol*, 2021; 1307: 85-114
*Frontiers in Endocrinology*, 2017; 8( 106): 1-13
*Med Clin North Am*. 2017; 101(3): 587-606

29

# Criteria for DKA

| | Mild | Moderate | Severe |
|---|---|---|---|
| **D**: glucose level | > 250 mg/dL | > 250 mg/dL | > 250 mg/dL |
| **K**: presence of ketones | Urine or serum + | Urine or serum + | Urine or serum + |
| **A**: acidosis | 7.25 – 7.30 | 7.0 to < 7.24 | < 7.0 |
| Anion gap | >10 | >12 | > 12 |
| Mental status | Alert | Alert or drowsy | Stupor/coma |

*Diabetes Care*. 2009; *32*(7): 1335–1343
*Current Diabetes Reports*. 201;, *17*(5): 33
*Frontiers in Endocrinology*. 2017; 8( 106): 1-13
*J Emerg Med*. 2020; 59: 373-383
*Font. Clin Diabetes Healthc*. 2022;2

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# HHS Pathophysiology

31

- Relative insulin deficiency
- Insulin resistance
- Increased production of glucose
  - Stress of acute illness
- Occurs slowly over days
- Extreme hyperglycemia
  - Usually > 600 mg/dL

*Diabetes care.* 2009; *32*(7): 1335–1343
*Current Diabetes Reports.* 2017; *17*(5): 33
*Frontiers in Endocrinology.* 2017; 8( 106): 1-13
*J Emerg Med.* 2021; 61: 365-375 .
*Font. Clin Diabetes Healthc.* 2022;2

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# HHS Pathophysiology

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- Increased serum osmolality
- ***Severe*** osmotic diuresis
- ***Profound*** dehydration
- Altered mental status
  - 25 – 50% comatose
- Ketosis and acidosis is mild or absent
  - Enough insulin to prevent lipolysis and ketosis

*Diabetes care.* 2009; *32*(7): 1335–1343
*Current Diabetes Reports.* 2017; *17*(5): 33
*Frontiers in Endocrinology.* 2017; 8( 106): 1-13
*J Emerg Med.* 2021; 61: 365-375
*Font. Clin Diabetes Healthc.* 2022;2

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# Diagnostic Criteria for HHS

33

- Blood glucose > 600mg/dL
  - Average ~ 1000 mg/dL
- Arterial pH >7.3
- Serum $HCO_3^-$ >15 mEq/L
- Serum osmolality > 320 mOsmol/kg
  - May be as high as 380
- Absent or mild ketonuria
- Mental status change

*Diabetes care*. 2009; *32*(7): 1335–1343
*Current Diabetes Reports*. 2017; *17*(5): 33
*Frontiers in Endocrinology*. 2017; 8( 106): 1-13
*J Emerg Med*. 2021; 61: 365-375
*Diab Med. 2020; 37*(12): 2001–2008
*Font. Clin Diabetes Healthc*. 2022;2

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# DKA versus HHS

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- DKA
  - Blood sugar >300 mg/dl; average 600 mg/dl
  - Evolves over 24 hours
  - Metabolic acidosis
    - $HCO_3^-$ <15 mEq/L
    - pH < 7.3
  - Kussmaul's respirations
  - Acetone excreted in lungs
    - Fruity breath
  - Ketones in urine and blood
- HHS
  - Blood sugar >600 mg/dl; average 1000 mg/dL
  - Higher serum osmolarity
    - > 320 mOsm
    - Altered LOC
  - More electrolyte imbalances
  - Evolves over days to weeks
  - More "normal" ABGs
    - pH > 7.30
  - Ketosis absent or mild

*Diabetes care*. 2009; *32*(7): 1335–1343
*Current Diabetes Reports*. 2017; *17*(5): 33
*Frontiers in Endocrinology*. 2017; 8(106): 1-13
*J Emerg Med*. 2020; 59: 373-383
*J Emerg Med*. 2021; 61: 365-375

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## euDKA Pathophysiology

### Diagnosis

- Blood glucose < 250 mg/dL
- Anion gap
- pH < 7.3
- Serum bicarbonate < 18 mgEq/L;
- Ketosis

### Precipitating factors

- SGLT2 inhibitors
- Substance misuse
  - ↓ CHO intake, liver dysfunction
- Pregnancy
  - Hypoinsulinemia & resp. alkalosis→ loss $HCO_3^-$
- Prolonged fasting

### Treatment:

- High index of suspicion
- IV Dextrose with insulin

*Adv Exp Med Biol*. 2021; 1307: 85-114
*Emergency Medicine Practice*. 2020; 22(2): 1–20
*Emergency Medicine Practice*. 2020; 22(2): 1–20
*Med Clin North Am*. 2017; 101(3): 587-606
*J Emerg Med*. 2020; 59: 373-383
*World J Diabetes*. 2021;12(5):514-523.
*CMAJ*. 2018;190:3766-8.
*Font. Clin Diabetes Healthc*. 2022;2.
AACN Adv Crit Care. 2023;34(1): 27-32.

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## Clinical Manifestations: Physical Exam

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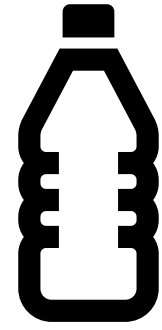
- Dehydration
  - Polyuria
  - Polydipsia
  - Tachycardia
  - Poor skin turgor
  - Dry buccal mucosa
  - Sunken eyeballs
  - Orthostatic hypotension
  - Hypotension
  - Prolonged capillary refill
  - Weakness



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# Clinical Manifestations: Physical Exam

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- Abdominal pain
  - More common with DKA
  - Correlates with severity of acidosis
  - Ketone have paralytic effect on smooth muscles
  - Relieved with reversal of dehydration
  - Consider other intra-abdominal pathology

*Diabetes care*. 2009; *32*(7): 1335–1343
*Current Diabetes Reports*. 2017; *17*(5): 33
*Frontiers in Endocrinology*. 2017; 8(106): 1-13
*Emergency Medicine Practice*. 2020; *22*(2): 1–20
*Emergency Medicine Practice*. 2020; *22*(2): 1–20
*J Emerg Med*. 2020; 59: 373-383

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# Clinical Manifestations: Physical Exam

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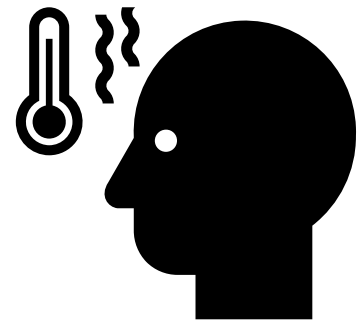
- Frequently afebrile
- Altered LOC
  - Cellular dehydration in CNS
  - More common with HHS
  - Confusion, somnolence, coma
  - Focal neurological signs (hemiparesis)
  - Seizures
  - Consider other neuro pathology if serum osmo is < 320 mOsm/kg



*Emergency Medicine Practice*. 2020; *22*(2): 1–20
*J Emerg Med*. 2020; 59: 373-383
*J Emerg Med*. 2021; 61: 365-375

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# euDKA Clinical Manifestations

NAUSEA

VOMITING

ABDOMINAL PAIN

FATIGUE

HYPERVENTILATION OR KUSSMAUL BREATHING

SOMNOLENCE OR CONFUSION

*World J Diabetes*. 2021;12(5):514-523.
*CMAJ*. 2018;190:E766-8.

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# Diagnostic Testing

40

- Serum glucose
- Chemistry panel
  - Na & K
  - Anion gap
- Serum β-OHB
- ABGs
  - Venous pH correlates
- Serum osmolality
- BUN/Cr
- Hgb $A_1C$

*Diabetes Care*.,2009; *32*(7):1335–1343
*Current Diabetes Reports*. 2017; *17*(5): 33
*Frontiers in Endocrinology*. 2017; 8( 106): 1-13
*Emergency Medicine Practice*. 2020; *22*(2): 1–20
*J Emerg Med*. 2020; 59: 373-383
*J Emerg Med*. 2001; 61: 365-375

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# Look for Causative Factors

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| | | | |
|---|---|---|---|
| CBC<br>•Mild leukocytosis due to ketosis<br>•> 25,000 or >50% bands highly suggestive of infection | Lipase & amylase | CT scan | CXR if pneumonia suspected |
| Blood, sputum, & urine cultures | UA & cultures | Cardiac enzymes | 12-lead EKG |

*Emergency Medicine Practice.* 2020; *22*(2): 1–20
*Med Clin North Am.* 2017; 101(3): 587-606
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*J Emerg Med.* 2021; 61: 365-375

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# Respiratory Support

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↓ LOC

Protect airway from aspiration

Intubation & mechanical ventilation

| | | | |
|---|---|---|---|
| Severe cases – usually HHS | Until metabolic derangements normalized | Avoid periods of apnea | Can result in worsening acidosis for DKA |

A
B
C
D

*Diabetes Care.* 2009; *32*(7): 1335–1343
Adv Exp Med Biol. 2021; 1307; 85-114
*Current Diabetes Reports.* 2017; *17*(5): 33
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*J Emerg Med.* 2021; 61: 365-375

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# Fluid Replacement

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| | |
|---|---|
| Severe dehydration | Fluid deficit up to **6** liters DKA<br>**9 -12** liters with HHS |
| Aggressive fluid replacement | |
| Goals | Reverse extracellular volume depletion<br>Restore renal perfusion |

*Diabetes care.* 2009.;*32*(7): 1335–1343
*Current Diabetes Reports.* 2017; *17*(5): 33
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# Fluid Replacement

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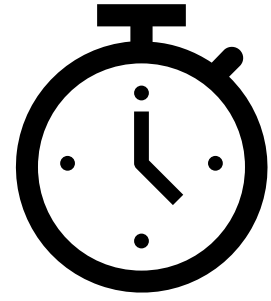
- IV fluid
  - Lowers blood glucose independent of insulin
  - Reverses hypotension
  - Improves tissue/organ perfusion
- Replace ½ fluid deficit over 1st 8 hours
- Then 2nd ½ over next 16 hours



*Diabetes Care.* 2009; *32*(7): 1335–1343
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*Font. Clin Diabetes Healthc.* 2022;2.

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# Fluid Replacement

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- 0.9% NS
  - Initial resuscitation
  - Replaces extracellular fluid
  - Start at 15 – 20 ml/kg/hr
    - 1 – 1.5 L in 1st hour
  - Then 4 – 14 ml/kg/hr until BP normalizes
- 0.45% NS
  - When serum $Na^+$ normalizes
  - Replaces intracellular fluids

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# Insulin Therapy Goal

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Interrupt ketosis

Restores normal glucose uptake by cells

Steady ↓ in serum glucose of 50 – 75 mg/dL per hour

- Blood glucose should not fall too fast or too far
- Sudden and rapid lowering allows water to move very rapidly back into the cells
- Lead to vascular collapse
- Early volume replacement before

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# Insulin Therapy

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Initial IV bolus: 0.15 Units/kg regular insulin

Insulin infusion: 0.1 Units/kg/hr

- Short ½ life
- Titrate to achieve a steady decrease in blood glucose
- If serum $K^+$ < 3.3 hold insulin it is ≥ 3.5

Subcutaneous insulin

- Mild DKA

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# Insulin Therapy

48

| Monitor | Glucose | Adjust | Resolve |
|---|---|---|---|
| Monitor blood glucose hourly & prn | When blood glucose approaches<br>• 250 for DKA<br>• 300 mg/dL for HHS<br>• Add dextrose to IV fluid<br>• ¯ insulin infusion to 0.02 – 0.05 Units/kg/hr | Adjust insulin to maintain blood glucose<br>• 150 – 200 mg/dL in DKA<br>• 250 – 300 mg/dL in HHS | While dehydration & ketosis resolve |

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# Insulin Therapy

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## Transition to subcutaneous insulin

- After resolution of hyperglycemia, dehydration, hypotension, & acidosis
- Regain baseline mental status
- When able to take oral diet
- Overlap 1 – 2 hour overlap for long-acting insulins

## Known diabetics may return to previous regimen if it was controlling blood glucose

## Multi-dose insulin for insulin-naïve patients

## Use combination of long and short-acting insulins

- Basal-bolus regimens
- Proposed as more physiologic

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# Electrolyte Replacement

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## $K^+$ loss with diuresis

- May ↓ even further with insulin therapy & correction of acidosis
  - $K^+$ moves into cells
- Total $K^+$ deficit as high as 600 mEq

## Start $K^+$ replacement after 1st liter of IV fluid replacement

- 20 mEq/liter if serum level 3.5 – 5.5
- 40 mEq/liter if serum level < 3.5
- May also require IVPB

Hold insulin <3.3
Stop $K^+$ > 5.2

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# Electrolyte Replacement

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- $KPO_4^-$ Replacement
  - If $PO_4^-$ < 1 mg/dL
  - Cardiac dysfunction
  - Respiratory depression
  - Anemia
- Add 20 – 30 mEq $KPO_4^-$ to replacement fluids

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# Acidosis Correction

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## $NaHCO_3^-$ usually not administered

- Fluid replacement & insulin administration will interrupt the ketotic cycle

## $NaHCO_3^-$ may cause CNS acidosis if too aggressive

- Bicarb combines with $H^+$
- Dissociates to $CO_2$ and $H_2O$
- $CO_2$ diffuses freely through the blood-brain barrier causing cerebral acidosis and depression

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# Acidosis Correction

- $NaHCO_3^-$ if pH < 7.0
- Replace slowly
- Only correct to pH 7.0
- Replace $K^+$ concurrently to prevent hypokalemia
- Kidneys will conserve $HCO_3^-$ once fluid & electrolyte imbalances are corrected

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# Cerebral Edema

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Pathophysiology is poorly understood

Rapid fall in blood glucose → **Cerebral Edema** → Coma Death (21-24%)

Fluid moves rapidly into cells of CNS

Lower blood glucose slowly

Perform neuro assessment hourly & prn

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# Cerebral Edema

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- Symptoms:
  - Headache
  - Lethargy
  - Gradual ↓ in LOC
  - Cranial nerve palsies
  - Seizures
  - Pupil changes
  - Bradycardia
  - Elevation in BP
  - Respiratory arrest

- Treatment
  - Mannitol
  - HTS

*Adv Exp Med Biol*. 2021; 1307: 85-114
*Med Clin North Am*. 2017; 101(3): 587-606

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# Cerebral Edema

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- Prevention
  - Avoid excessive hydration and rapid reduction of plasma osmolarity
    - Max reduction 3 mOsm/kg $H_2O$ per hour
  - Gradually lower serum glucose
  - Maintain blood glucose 250 – 300 mg/dL until serum osmolality is normalized and mental status improved

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# Resolution of Hyperglycemic Emergency

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- DKA
  - Blood glucose < 200 mg/dL
  - Serum $HCO_3^-$ ≥ 15 mEq/L
  - pH > 7.30
  - Calculated anion gap < 12 mEq/L
- HHS
  - Normal serum osmolality
  - Regain normal mental status

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# Diabetic Sick Day Management

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| Usual basal insulin or oral anti-diabetic agents | Liberal fluid intake | Easily digestible CHO if unable to eat normal diet | Have family member check on them q 4 hrs | Early consultation with PCP |
|---|---|---|---|---|
|  |  | • Custard, pudding, cream soup, toast<br>• Gelatin, broth, juice, soda |  |  |

*Adv Exp Med Biol*. 2021; 1307: 85-114

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## Diabetic Regimen Adherence

- Complex issues
  - Knowledge deficit
  - Health beliefs
  - Culture
  - Mental health
  - Substance misuse
  - Financial resources
  - Insurance
  - Social support
- Consultations
  - Social services
  - Psychiatry
  - Discharge planner
  - Spiritual care
  - Registered Dietician

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## Summary

- Fluids, insulin, & electrolytes
  - How much?
  - How fast?
- Treat underlying illnesses
- Sick day management

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# Questions?

THANK YOU FOR YOUR ATTENTION!

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