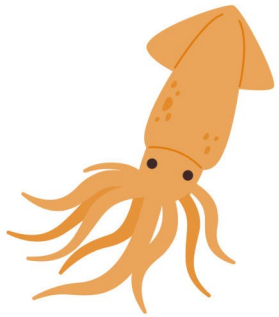
Closing the Gap: Optimizing DKA Treatment Through the SQuID Protocol



Presented by:

Tom Szwajnos, PharmD, MS

PGY2 Emergency Medicine Pharmacy Resident

Advocate Christ Medical Center

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Disclosures of Interest

The planner(s) and speaker(s) have indicated that there are no relevant financial relationships with any ineligible companies to disclose.

Abbreviations

- **ADA** – American Diabetes Association
- **AG** – Anion Gap
- **BG** – Blood Glucose
- **BMP** – Basic Metabolic Panel
- **D5W** – 5% Dextrose in Water
- **DKA** – Diabetic Ketoacidosis
- **ED** – Emergency Department
- **ESI** – Emergency Severity Index
- **GAD** – Glutamic Acid Decarboxylase
- **HHS** – Hyperglycemic Hyperosmolar State
- **IA** – Islet Antigen
- **ICU** – Intensive Care Unit
- **IV** – Intravenous
- **LOS** – Length of Stay
- **NIS** – National Inpatient Sample
- **NS** – Normal Saline (0.9% sodium chloride)
- **POC** – Point of Care
- **PRN** – As Needed
- **SQuID** – Subcutaneous Insulin for DKA
- **TDD** – Total Daily Dose
- **T1DM** – Type 1 Diabetes
- **T2DM** – Type 2 Diabetes

Objectives

At the end of this session, learners should be able to:

1. Identify the signs and symptoms of DKA using clinical laboratory findings
2. Outline current treatment algorithms and appropriate DKA treatment strategies
3. Select appropriate alternative DKA treatment strategies based on patient presentation

Diabetes

Diabetes is a metabolic disease resulting in inappropriately elevated blood glucose levels

There are several different classifications of diabetes but subdivided into two major categories: Type 1 and Type 2 diabetes

Common symptoms include increased thirst, frequent urination, blurry vision

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Type 1 Diabetes

- Results from autoimmune destruction of pancreatic β-cells
- Accounts for 5-10% of all diabetes cases
- Patients will often have low or undetectable levels of C-peptide
- Genetic and environmental factors as well as viruses have been associated with T1DM
- Treatment involves daily insulin administration

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ADA. Diagnosis & Classification of Diabetes. Diabetes Care. 2024;47(Suppl 1):S20–S42. doi:10.2337/dc24-S002

Type 2 Diabetes

- Results from decreased biological response to insulin
- Accounts for 90-95% of all diabetes
- Patients may have insulin levels that appear normal or elevated while maintaining elevated blood glucose levels
- Risk factors include genes and lifestyle factors
- Treatment includes lifestyle modifications and the use of antihyperglycemic medications
- Insulin resistance can improve with modifications but rarely returns to baseline

ADA. Diagnosis & Classification of Diabetes. Diabetes Care. 2024;47(Suppl 1):S20–S42. doi:10.2337/dc24-S002

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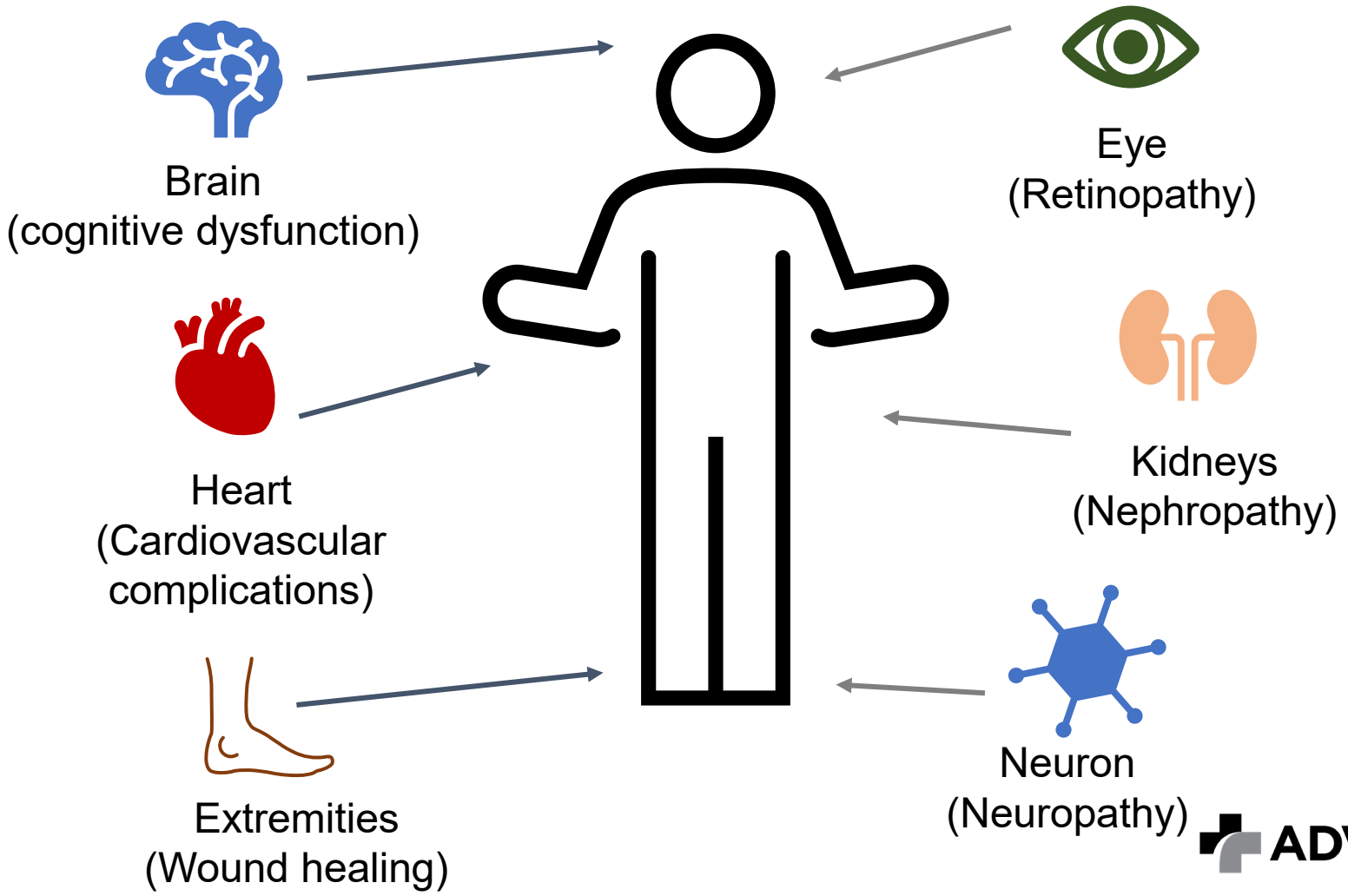
Complications of Diabetes



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Diabetic Ketoacidosis

Characterized by uncontrolled hyperglycemia, metabolic acidosis, and increased body ketone production

Life-threatening complication often seen with T1DM

The “Five I’s” of DKA precipitation

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Cade WT. Diabetes-related vascular disease in PT. Phys Ther. 2008;88(11):1322–1335. doi:10.2522/ptj.20080008

History of DKA

First described by Dr. Julius Dreshfeld in 1886 in the Bradshawe Lecture

Originally divided into 3 groups:

- Diabetic collapse or diabetic coma
- Alcoholic form or alcoholic ketoacidosis
- Acetonemic form resulting in acetone or fruity smell on breath

Common Symptoms noted:

- Altered mental status
- Reduced volume
- Acetones present in the urine; acetone like smell from patient; β-oxy-butyric acid
- Albuminuria
- Rapid breathing (Kussmaul breathing)

Dreschfeld J. Br Med J. 1886;2(1338):358–363. doi:10.1136/bmj.2.1338.358

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Treatment Recommendations in the 1800's

Prevention Focused

- Avoid excessive physical and mental exertion
- Prevent constipation with laxatives
- Avoidance of nitrogenous diets

DKA Treatment

- IV sodium chloride of sodium phosphate
- Blood transfusion
- Large doses of sodium bicarbonate
- Ether and camphor infused oxygen inhalation

Mortality

- Fatality rate approximately 90% as soon as 12-24 hours after presentation

Dreschfeld J. Br Med J. 1886;2(1338):358–363. doi:10.1136/bmj.2.1338.358

The Discovery of Insulin

Insulin first discovered in 1921 by Frederick Banting

J.B. Collip and John Macleod first administered insulin to a child in 1922

Patent sold for $1 to ensure broad access

Mortality decreased with to 60% in 1923, and 3%–10% by 1974

Current in-hospital mortality in developed countries <1%

American Diabetes Association. Diabetes.org. Published July 1, 2019
Eledrisi MS, Elzouki AN. *Saudi J Med Med Sci*. 2020;8(3):165–173. doi:10.4103/sjmms.sjmms_478_19

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DKA Epidemiology

Incidence of DKA

- 38% of hyperglycemic crises are DKA

DKA Recurrence

- 33.7% of people admitted with DKA had at least 1 hospitalization in the past year

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Umpierrez GE, Davis GM, ElSayed NA, et al. Diabetes Care. 2024;47(8):1257–1275. doi:10.2337/dci24-0032

DKA Epidemiology

DKA prevalence in children: 35.3% to 40.6%

DKA incidence in adults: affects about 5-8% of T1DM adults

Mortality of 0.38%

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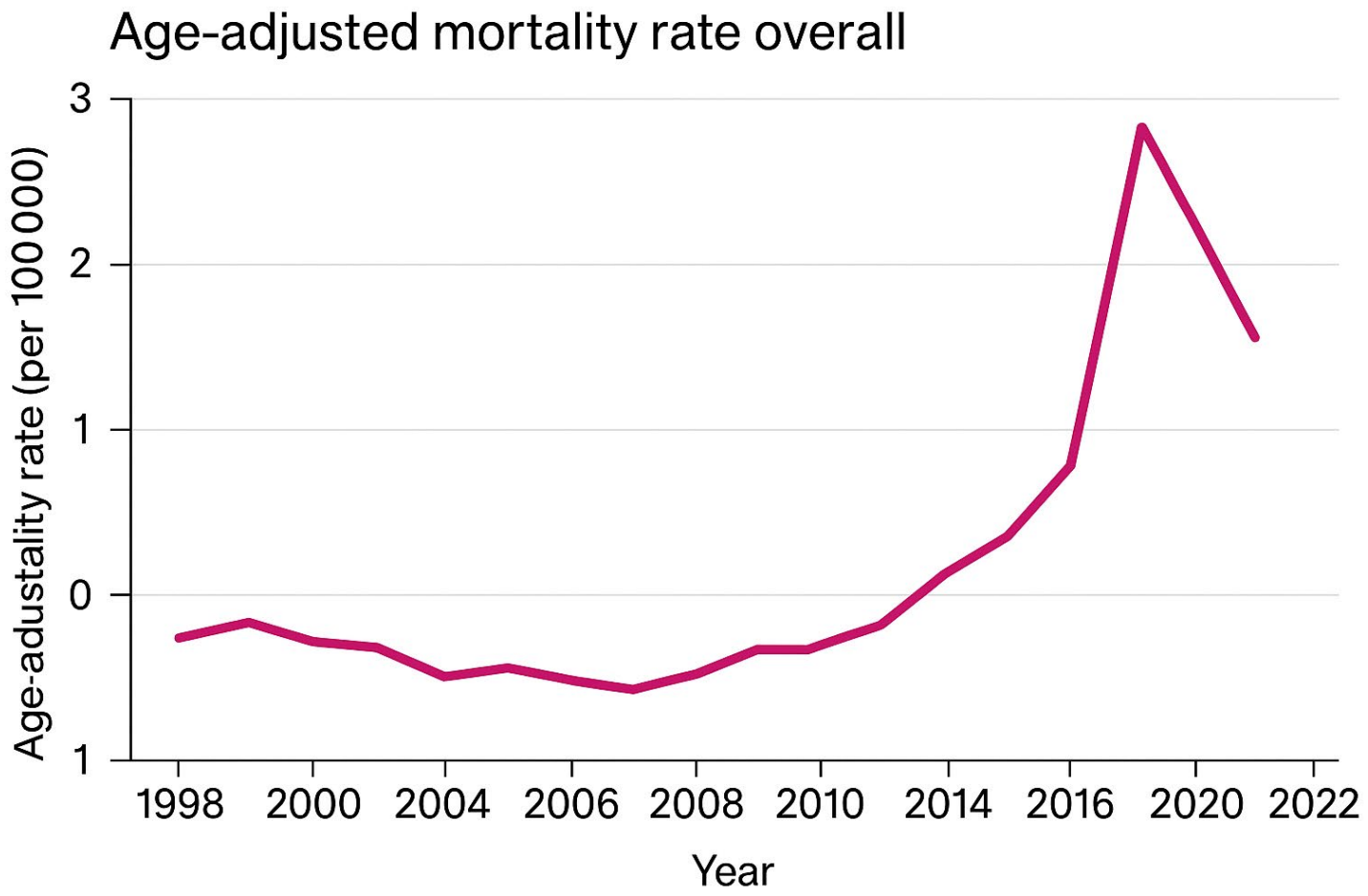
Virdi N, Poon Y, Abaniel R, Bergenstal RM. *Diabetes Technol Ther*. 2023;25(S3):S-75–S-84. doi:10.1089/dia.2023.0149

Increasing Mortality Trends



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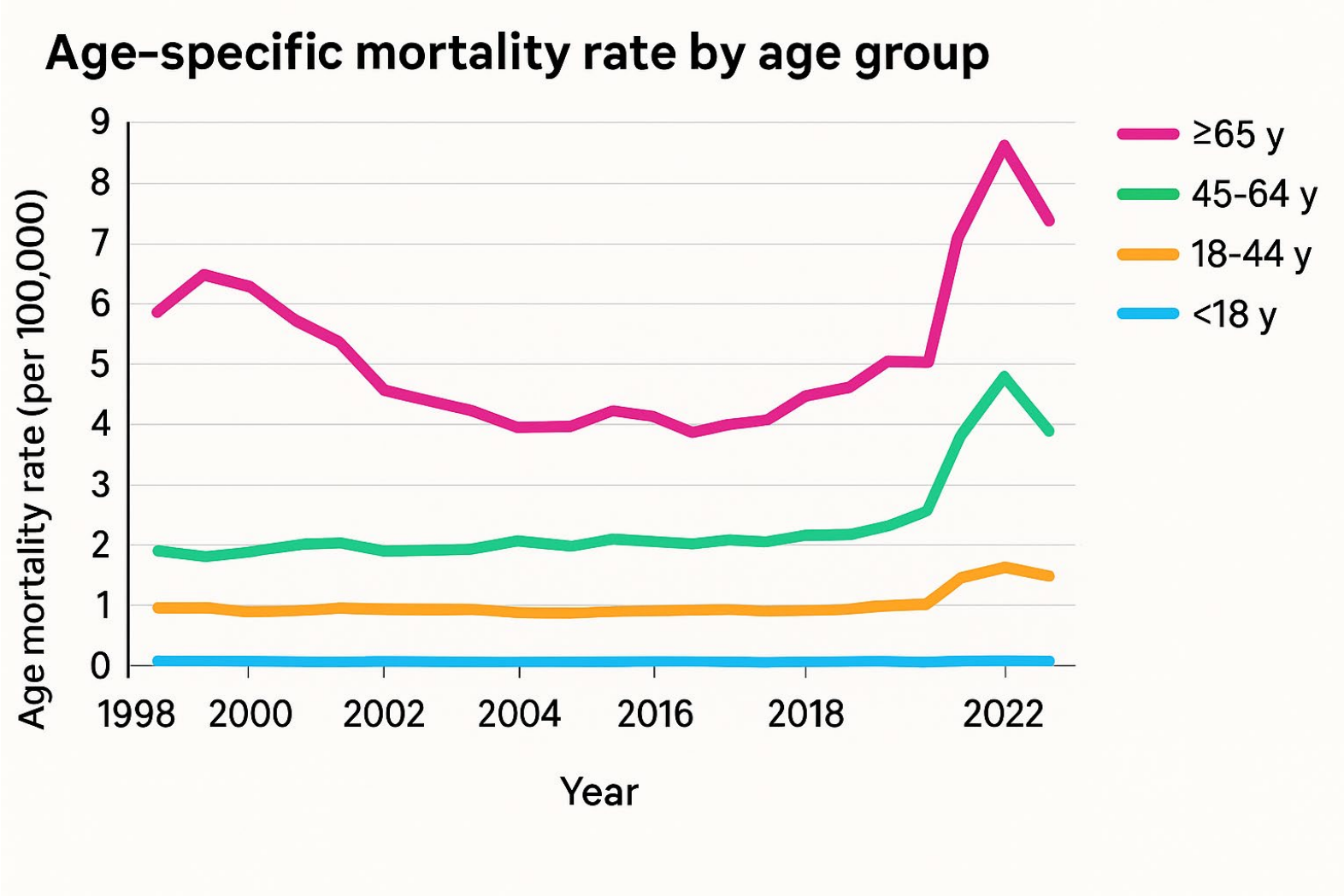
Crane MA, Lam A, Ekanayake E, et al. *JAMA*. 2024;331(5):440–442. doi:10.1001/jama.2023.26174

Increasing Mortality Trends by Age Group



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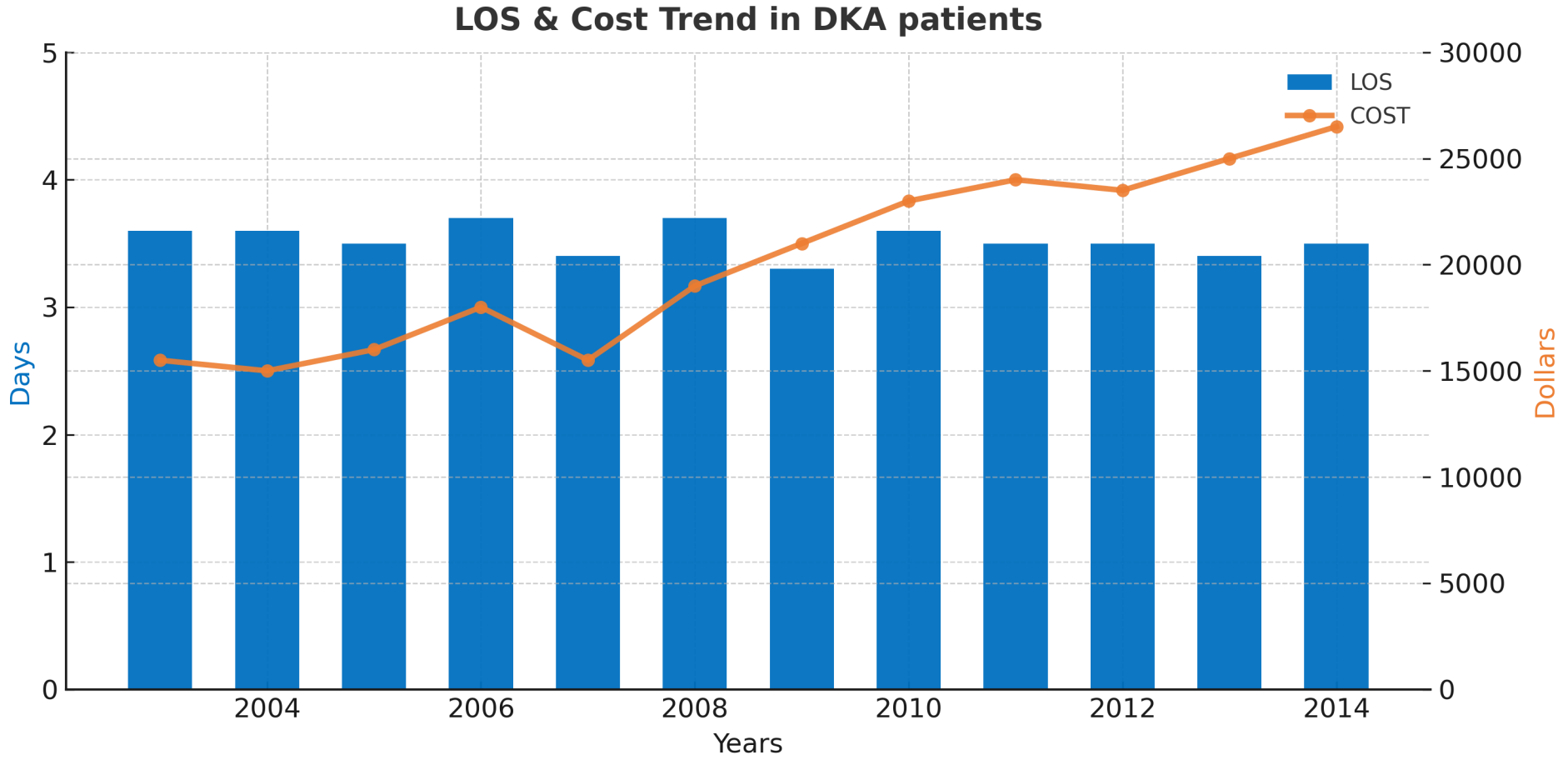
Crane MA, Lam A, Ekanayake E, et al. *JAMA*. 2024;331(5):440–442. doi:10.1001/jama.2023.26174

Healthcare Associated Costs



ADVOCATE HEALTH

Desai D, Mehta D, Mathias P, et al. *Diabetes Care*. 2018;41(8):1631–1638. doi:10.2337/dc17-1379

Healthcare Associated Costs

The average length of hospital stay for patients with DKA slightly decreased

Mean hospital charges per patient increased by 40% from 2003-2017

The total aggregate cost for hospitalizations with DKA increased by nearly $3 billion

Desai D, Mehta D, Mathias P, et al. *Diabetes Care*. 2018;41(8):1631–1638. doi:10.2337/dc17-1379

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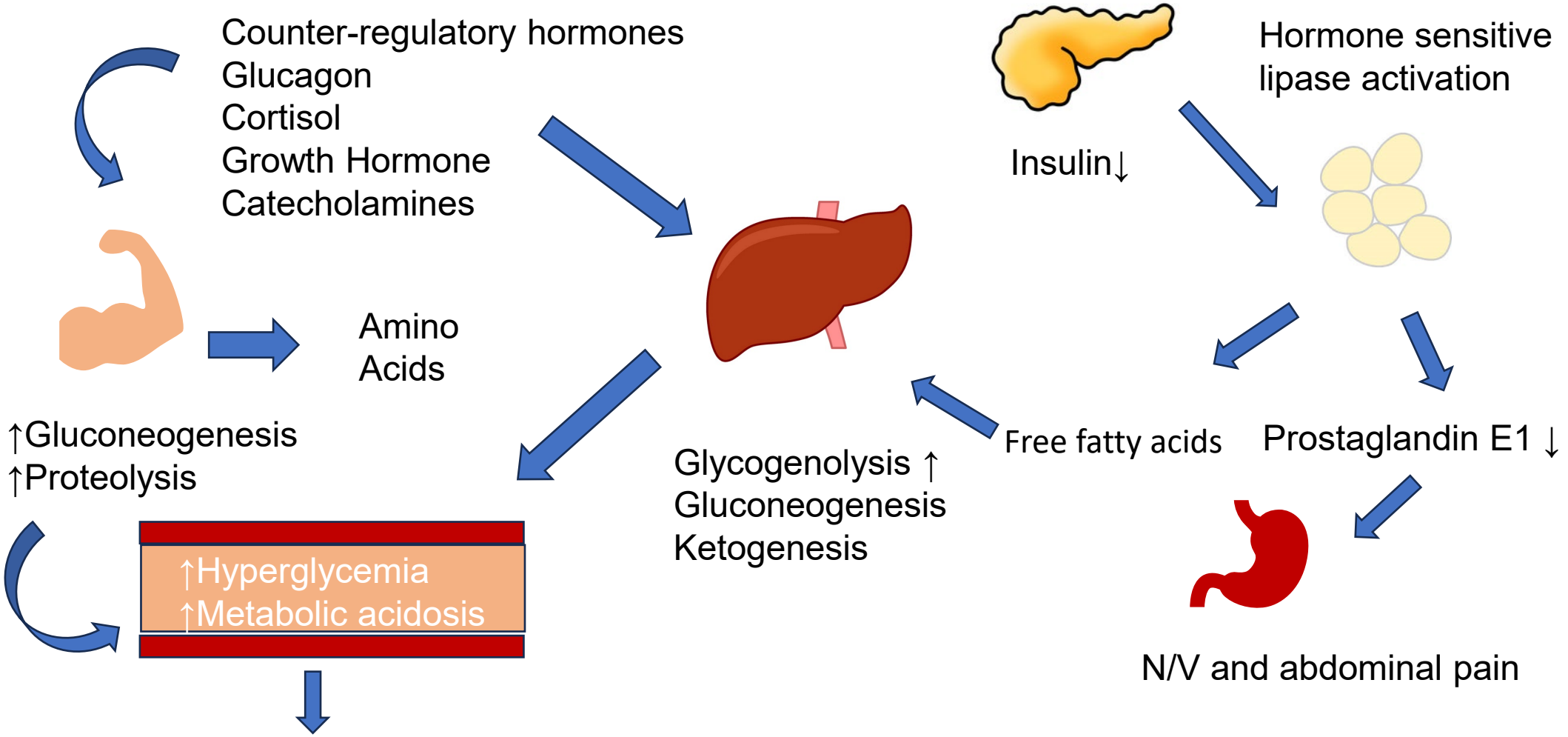
Healthcare Associated Costs

ICU admission

Frequent lab monitoring

1:1 Nursing care

Pathophysiology of DKA



El-Remessy AB. *Endocrines*. 2022;3(4):801–812. doi:10.3390/endocrines3040066

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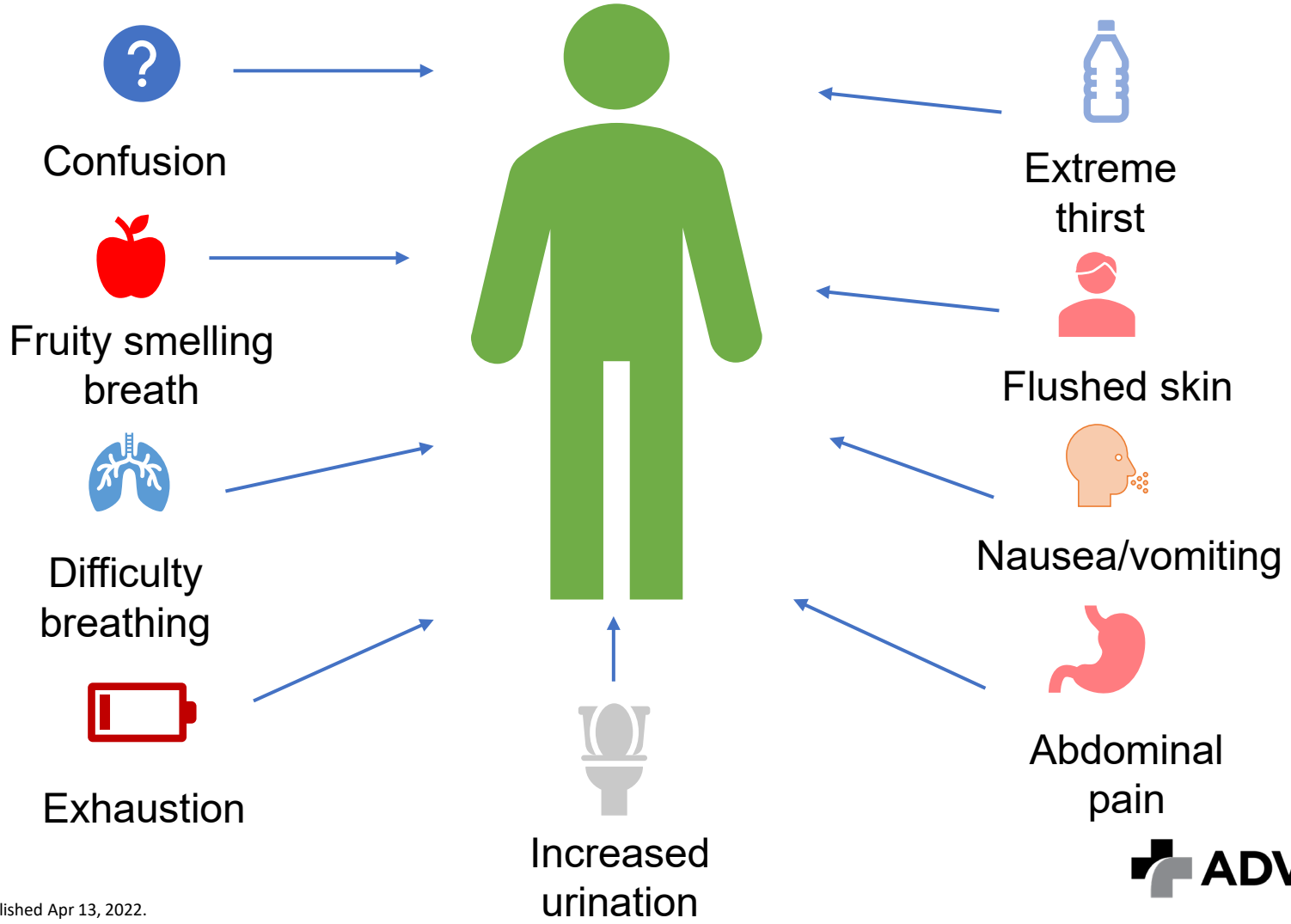
Signs and Symptoms of DKA



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Everyday Health Editors. EverydayHealth.com. Published Apr 13, 2022.

Causes of Symptoms

- Confusion
- Fruity smelling breath
- Kussmaul respirations
- GI upset
- Flushed skin
- Exhaustion
- Extreme thirst and polyuria

Modern Diagnosis of DKA

- Hyperglycemia or history of diabetes
- Ketosis
- Metabolic acidosis

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Umpierrez GE, Davis GM, ElSayed NA, et al. *Diabetes Care*. 2024;47(8):1257–1275. doi:10.2337/dci24-0032

DKA vs. HHS

Clinical/Lab Findings	DKA	HHS
Onset	Rapid (hours to 1-2 days)	Gradual (several days to weeks)
Blood glucose	200-600 mg/dL	>600 mg/dL
Ketones	Present	Absent
pH	<7.3	≥7.3
B-hydroxybutyrate	≥3.0 mmol/L	<3.0 mmol/L
Bicarbonate	<18 mmol/L	≥15 mmol/L
Osmolality	Moderately elevated	Severely elevated (>320 mOsm/kg)
Neurological symptoms	Mild to moderate confusion	Severe confusion, seizures, coma

Umpierrez GE, Davis GM, ElSayed NA, et al. *Diabetes Care*. 2024;47(8):1257–1275. doi:10.2337/dci24-0032
Dhatariya K, Mustafa O, Stathi D. *Endotext* [Internet]. Updated Jun 10, 2025. Accessed Oct 1, 2025. https://www.ncbi.nlm.nih.gov/books/NBK279052/

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Changes in DKA Diagnosis

Diagnostic Criteria	2009 Consensus Statement	2024 Consensus Report
Blood glucose	Glucose >250 mg/dL	Glucose ≥200 mg/dL OR History of diabetes, irrespective of presenting glucose values
Ketosis	Serum ketones: positive Urine ketones: positive	β-hydroxybutyrate ≥ 3 mmol/L OR Urine ketone strip ≥ 2+
Metabolic Acidosis	pH ≤7.3 Bicarbonate ≤18 mmol/L Anion gap >10	pH <7.3 with or without bicarbonate <18 mmol/L

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Rodriguez Alvarez P, San Martin VT, Morey-Vargas OL. *Cleve Clin J Med*. 2025;92(3):152–158. doi:10.3949/ccjm.92a.24089

Changes in Fluid Management

Fluid	2009 Consensus Statement	2024 Consensus Report
Type	0.9% NaCl during the first hour 0.45% NaCl indicated if serum sodium is high or normal with 0.9% NaCl continued if serum sodium low Change to dextrose 5% with 0.45% NaCl when glucose reaches 200 mg/dL	0.9% NaCl or balanced crystalloid solutions Add dextrose 5% or 10% when glucose reaches <250 mg/dL
Volume	15–20 mL/kg/hour or 1–1.5 L in the first hour Subsequently, 250–500 mL/hour	500–1,000 mL/hour during the first 2–4 hours Subsequently, adjust rate as clinically appropriate
Time to correction of estimated fluid deficit	24 hours	24-48 hours

ADVOCATE HEALTH

Rodriguez Alvarez P, San Martin VT, Morey-Vargas OL. *Cleve Clin J Med*. 2025;92(3):152–158. doi:10.3949/ccjm.92a.24089

Changes in Insulin Management

Insulin	2009 Consensus Statement	2024 Consensus Report
Initial	0.1 units/kg regular insulin in IV bolus, followed by 0.1 units/kg/hour regular insulin OR 0.14 units/kg/hour regular insulin	Moderate and severe DKA: 0.1 units/kg/hour (consider 0.1 units/kg IV bolus if IV access is delayed) of regular insulin Mild and moderate DKA: Subcutaneous rapid-acting insulin 0.1 units/kg every 1 hour or 0.2 units/kg every 2 hours
Initial glucose goal for dextrose initiation	< 200 mg/dL	<250 mg/dL
Maintenance after dextrose initiation	Decrease insulin infusion to 0.02-0.05 units/kg/hr until resolution	Decrease insulin infusion to 0.05 units/kg/hr until resolution
Glucose goal until resolution	150-200 mg/dL	15-200 mg/dL

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Rodriguez Alvarez P, San Martin VT, Morey-Vargas OL. *Cleve Clin J Med*. 2025;92(3):152–158. doi:10.3949/ccjm.92a.24089

Changes in Potassium Management

Potassium	2009 Consensus Statement		2024 Consensus Report	
Low	< 3.3 mEql/L	20–30 mEq/hour KCl and postpone insulin therapy until serum potassium > 3.3 mEq/L	< 3.5 mEq/L	10–20 mEq/hour KCl and postpone insulin therapy until serum potassium > 3.5 mmol/L
Normal	3.3–5.2 mEq/L	20–30 mEq KCl in each liter of IV fluid to maintain serum potassium of 4–5 mEq/L	3.5–5.0 mEq/L	10–20 mEq KCl in each liter of IV fluid to maintain serum potassium of 4–5 mEq/L
High	> 5.2 mEq/L	Do not give potassium but check serum potassium every 2 hours	> 5.0 mEql/L	Do not give potassium but check serum potassium every 2 hours

Rodriguez Alvarez P, San Martin VT, Morey-Vargas OL. *Cleve Clin J Med*. 2025;92(3):152–158. doi:10.3949/ccjm.92a.24089

DKA Classification

Clinical Findings	Mild	Moderate	Severe
Glucose (mg/dL)	>200	>200	>200
pH	>7.25 to <7.30	7.00 to 7.25	<7.00
Bicarbonate (mmol/L)	15-18	10 to <15	<10
Urine Ketones	Positive	Positive	Positive
B-hydroxybutyrate (mmol/L)	3 to 6	3 to 6	>6
Mental Status	Alert	Alert and/or drowsy	Stupor and/or coma

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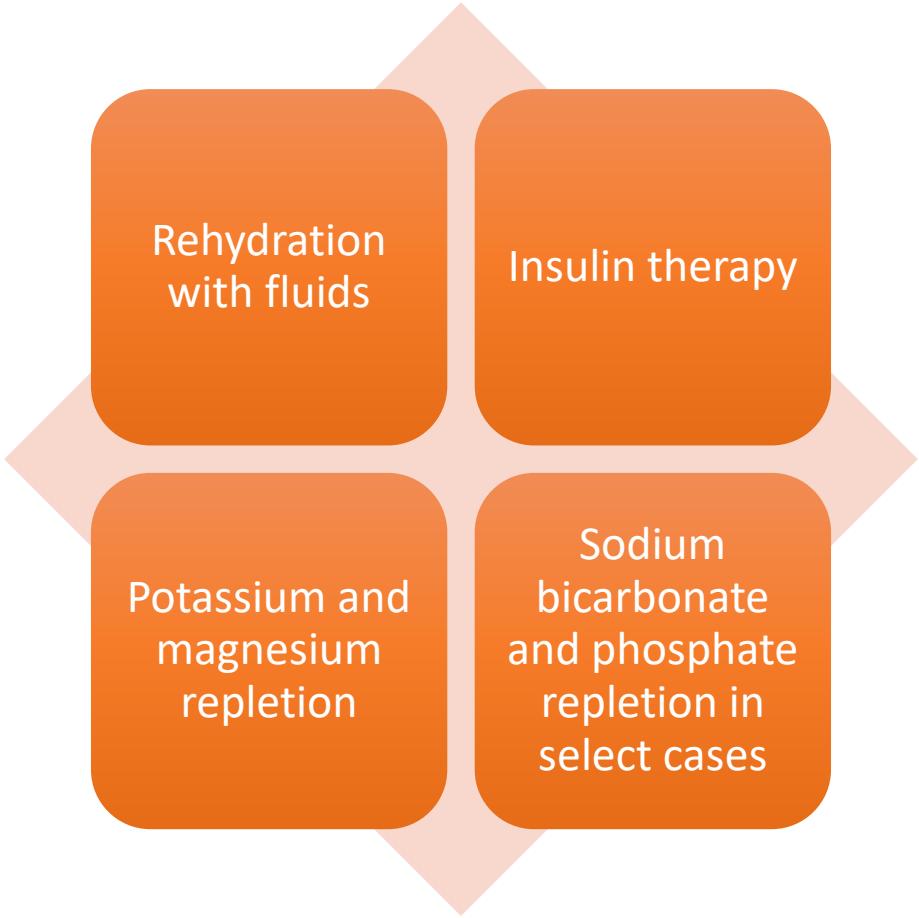
Umpierrez GE, Davis GM, ElSayed NA, et al. *Diabetes Care*. 2024;47(8):1257–1275. doi:10.2337/dci24-0032

ADA Treatment Algorithm



Umpierrez GE, Davis GM, ElSayed NA, et al. *Diabetes Care*. 2024;47(8):1257–1275. doi:10.2337/dci24-0032

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ADA Insulin Management: Mild DKA

0.1 units/kg rapid acting insulin as a subQ bolus

0.1 units/kg subQ every hour or 0.2 units/kg subQ every 2 hours if BG ≥250 mg/dL

When glucose <250 mg/dL decrease to 0.1 units/kg subQ every 2 hours

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Umpierrez GE, Davis GM, ElSayed NA, et al. *Diabetes Care*. 2024;47(8):1257–1275. doi:10.2337/dci24-0032

ADA Insulin Management: Moderate to Severe DKA

0.1 units/kg IV of insulin regular as a bolus if delay in infusion initiation

0.1 units/kg/hr IV insulin regular infusion

When glucose <250 mg/dL decrease insulin regular infusion rate to 0.05 units/kg/hr

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Umpierrez GE, Davis GM, ElSayed NA, et al. *Diabetes Care*. 2024;47(8):1257–1275. doi:10.2337/dci24-0032

Knowledge Check #1

Which clinical finding in a patient with suspected DKA would classify them as a severe case?

a. Positive urine ketones
b. Glucose of 540 mg/dL
c. pH 6.9
d. β-hydroxybutyrate of 4 mmol/L

AAH Midwest Inpatient Adult DKA Protocol Algorithm

7 potential algorithms for starting and titrating insulin infusions based on blood glucose levels

Blood glucose checked at least every 1 hour or more frequently as needed

Insulin infusion rate is typically titrated based on blood glucose trends

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DKA Resolution

ADA Consensus Report	AAH Midwest Guidelines
Plasma ketone <0.6 mmol/L	Anion gap has resolved
Venous pH ≥7.3	>2 hours since the first dose of long-acting insulin
Bicarbonate ≥18 mmol/L	
SubQ insulin once DKA has resolved and patient clinical improves	

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Transition to Subcutaneous Insulin

Weight-based estimate	• 0.5-0.6 units/kg/day for TDD • 0.3 units/kg/day TDD for patients at risk of hypoglycemia
Preadmission insulin requirements	• Consider TDD prescribed for outpatient use prior to admission • Adjust antihyperglycemic regimen based on lifestyle factors, glucose control, and medication taking habits
Hourly IV insulin requirements	• Summation of hourly insulin requirements to estimate TDD • May overestimate insulin needs
Long-acting insulin	• 0.15-0.3 units/kg subQ either once daily or divided into 2 doses

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Umpierrez GE, Davis GM, ElSayed NA, et al. *Diabetes Care*. 2024;47(8):1257–1275. doi:10.2337/dci24-0032

Knowledge Check #2

An IV insulin infusion, when used for treatment of DKA can be considered for discontinuation per the ADA when:

a. Immediately after the first dose of subcutaneous insulin
b. When the anion gap has resolved
c. At the time of discharge
d. 30 minutes after the first dose of subcutaneous insulin

Current Practice

SIGNIFICANT LOS

REQUIRES CONTINUOUS INSULIN INFUSION

REQUIRES ICU BED

ESTIMATED ASSOCIATED COST PER DKA ADMISSION ~$25,000

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New Insulin Treatment Approach

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Alternative Treatment Option

The SQuID protocol is a novel option for treating mild to moderate DKA

Utilizes subQ insulin lispro vs. insulin drip

Dosing is weight based and given at fixed intervals

IV fluids and electrolyte repletion

Standard blood glucose monitoring

Why was it proposed?

The use of IV insulin infusions require: ICU admission, frequent lab monitoring, and 1:1 nursing ratio

ED and hospital boarding delays and ICU capacity constraints

Safe alternative for mild DKA that does not require ICU admission

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The SQuID Protocol (Griffey, et al. 2023)

Trial Design	
Prospectively-derived quasi-experimental study evaluating the impact of the SQuID protocol	
Intervention	
SQuID protocol vs. traditional IV insulin regular infusion for DKA	
Inclusion Criteria	**Exclusion Criteria**
• Patients presenting to the ED • Diagnosis of mild or moderate DKA	• Diagnosis of severe DKA • Pregnancy • Severe infection • MI • AMS • Active comorbidities

Griffey RT, Schneider RM, Girardi M, et al. *Acad Emerg Med*. 2023;30(8):800–808. doi:10.1111/acem.14685

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SQuID Severity Index

Clinical Findings	Mild	Moderate	Severe
Glucose (mg/dL)	>300	>300	>300
pH	7.25 to 7.30	7.00 to 7.24	<7.00
Bicarbonate (mmol/L)	15-18	10-14	<10

Griffey RT, Schneider RM, Girardi M, et al. *Acad Emerg Med*. 2023;30(8):800–808. doi:10.1111/acem.14685

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Outcomes Studied

Primary Outcome	
Operational Impact: ED LOS and ICU admissions in post-intervention period	
Secondary Outcomes	
Fidelity Impact	**Safety Impact**
• Confirming implementation and effectiveness while assessing impacts of the intervention	• The frequency of hypoglycemic events requiring rescue dextrose

Griffey RT, Schneider RM, Girardi M, et al. *Acad Emerg Med*. 2023;30(8):800–808. doi:10.1111/acem.14685

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SQuID Protocol

Collect serum K, initiate insulin

K ≥ 3.5

2L 0.9% NaCl bolus followed by 0.45% NaCl

@150 ml/hr

Administer insulin lispro via SQuID pathway

Check BG every 2 hours

Check BMP every 4 hours

Initiate long-acting insulin once AG <16

Griffey RT, Schneider RM, Girardi M, et al. *Acad Emerg Med*. 2023;30(8):800–808. doi:10.1111/acem.14685

SQuID Protocol

Insulin Initiation and Titration	
Blood Glucose >250	1. Administer insulin lispro 0.2 units/kg subQ 2. Continue 0.45% NaCl at 150 ml/hr
First Blood Glucose <250	1. Administer insulin lispro 0.1 units/kg subQ 2. Decrease 0.45% NaCl to 50 ml/hr until protocol is complete 3. Add D5W based on parameters below: • BG 200-250: Start D5W at 100 ml/hr • BG 150-199: Start D5W at 150 ml/hr • BG 100-149: Start D5W at 200 ml/hr • BG <100: Start D5W at 250 ml/hr and notify provider

Griffey RT, Schneider RM, Girardi M, et al. *Acad Emerg Med*. 2023;30(8):800–808. doi:10.1111/acem.14685

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SQuID Protocol

D5W Titration and Hypoglycemia Management	
Subsequent BG after D5W initiated	1. Administer insulin lispro: 0.1 units/kg 2. After D5W is initiated, titrate D5W q2h with each blood glucose check as follows: • BG >250:↓D5W rate by 50 ml/hr • BG 200-250: <-> D5W at the same rate • BG 150-199: ↑D5W rate by 50 ml/hr • BG 100-149: ↑ D5W rate by 100 ml/hr • BG <100: ↑ D5W to 250 ml/hr
BG <70	1. Assess Patient: • Able to take PO: 15g of fast acting carbohydrate • Unable to take PO/IV access: D10W 250 ml over 15 min • Unable to take PO/NO IV access: 1 mg glucagon IM 2. Recheck BG q15min and repeat protocol until BG >100

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Griffey RT, Schneider RM, Girardi M, et al. *Acad Emerg Med*. 2023;30(8):800–808. doi:10.1111/acem.14685

Baseline Demographics

	Post-Intervention		Historical Controls	
	SQuID (n=78)	Traditional (n=99)	Pre-intervention (n=163)	Pre-COVID (n=161)
Age (years)	41.5 (30.3-52.0)	55.0 (40.5-66.5)	49.0 (30.5-61.0)	48.0 (31.0-61.0)
ED Disposition				
Admit	69 (88.5)	93 (93.9)	146 (89.6)	133 (82.6)
Discharge	9 (11.5)	0 (0.0)	8 (4.9)	10 (6.2)
Other	0 (0.0)	6 (6.1)	9 (5.5)	18 (11.2)

*Data reported as median (IQR) or n (%)

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Griffey RT, Schneider RM, Girardi M, et al. *Acad Emerg Med*. 2023;30(8):800–808. doi:10.1111/acem.14685

Baseline Emergency Severity Index (ESI)

Emergency Severity Index (ESI)				
	Post-Intervention		Historical Controls	
	SQuID (n=78)	Traditional (n=99)	Pre-intervention (n=163)	Pre-COVID (n=161)
1	0 (0.0)	4 (4.0)	5 (3.1)	2 (1.2)
2	55 (70.5)	72 (72.7)	125 (76.7)	127 (78.9)
3	23 (29.5)	22 (22.2)	31 (19.0)	31 (19.3)
4	0 (0.0)	0 (0.0)	2 (1.2)	0 (0.0)
5	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)

*Data reported as n (%)

Griffey RT, Schneider RM, Girardi M, et al. *Acad Emerg Med*. 2023;30(8):800–808. doi:10.1111/acem.14685

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Results

Value	SQuID (n=73)	Traditional (n=28)	Pre-intervention (n=163)	Pre-COVID (n=161)
Glucose tests/hr	1.0 (0.8-1.1)	1.0 (0.8-1.1)	1.0 (0.9-1.2)	1.0 (0.8-1.1)
Rescue dextrose	2 (2.7)	1 (3.6)	2 (2.3)	0 (0.0)
ED LOS (hrs)	**8.9 (6.5-11.5)**	**11.9 (9.6-18.6)**	**10.3 (7.7-12.9)**	**12.5 (8.7-19.3)**

*Data are reported as n (%) or median (IQR)

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Griffey RT, Schneider RM, Girardi M, et al. *Acad Emerg Med*. 2023;30(8):800–808. doi:10.1111/acem.14685

Study Conclusion

Adherence to proper glucose monitoring remained unchanged between the two groups

Risks of hypoglycemia and need for rescue dextrose was similar for both the SQuID and IV group

ED LOS decreased compared to the traditional cohort by 3 hours, 1.4 hours, and 3.6 hours for the postintervention, preintervention, and pre-COVID periods, respectively

The SQuID protocol observed trended toward a decrease in ICU admission

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Griffey, et al. (2023)

Limitations:

- Single-center trial
- High-volume ED with limited ICU bed
- Total patient/institution cost was not studied
- Provided relatively limited baseline information
- Utilized dedicated inpatient observation units

Strengths:

- Prospective trial with included retrospective cohort
- Defined algorithm to prevent variability based on provider clinical judgment
- Showed feasibility in caring for these patients on non-ICU floors
- Demonstrated that patient safety/monitoring was not reduced while using this protocol
- Provided comparisons from multiple time points

DKA Outcomes

Outcome	SQuID I			
ED LOS	↓			
ICU Admissions	↓			
Time to DKA Resolution	Not measured			
Hypoglycemia	↔			

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SQuID II (Griffey, et al. 2025)

Trial Design	
Prospective cohort study over 1 year in patients with mild to moderate DKA	
Intervention	
The SQuID protocol vs. traditional (IV insulin infusion) protocols	
Inclusion Criteria	**Exclusion Criteria**
• Glucose >300 mg/dL • Ketones >1.1 mmol/L • Mild to moderate DKA	• Diagnosis of severe DKA • <18 years old • Chronic comorbidities • AMS

Griffey RT, Schneider RM, Girardi M, et al. *Acad Emerg Med*. 2025;32(1):61–71. doi:10.1111/acem.15020

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Outcomes Studies

Fidelity	Clinical Effectiveness	Operational Effectiveness	Safety
• Time from documented blood glucose ≤250 mg/dL to administration of dextrose containing fluid administration • Time from anion gap closure to administration of glargine	• Time to anion gap closure of ≤16 • Time on either IV or SQuID protocol	• ED LOS • Time to bed request • ICU admission rate	• Episodes of hypoglycemic events (glucose <70 mg/dL) requiring dextrose rescue

Griffey RT, Schneider RM, Girardi M, et al. *Acad Emerg Med*. 2025;32(1):61–71. doi:10.1111/acem.15020

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Baseline Demographics

	SQuID (n=62)	Traditional (n=22)	P-value
Age (years)	42 (27,56)	52 (41, 59)	0.11
ED Disposition			
Discharged From ED	6 (10)	1 (5)	<0.001
Admitted to Observation Floor	43 (69)	1 (5)	
Admitted to Medical Floor	13 (21)	2 (9)	
Admitted to ICU	0 (0)	18 (82)	
Hospital LOS (h)	47 (28, 86)	102 (69, 161)	0.001

*Data reported as median (IQR) or n (%)

Griffey RT, Schneider RM, Girardi M, et al. *Acad Emerg Med*. 2025;32(1):61–71. doi:10.1111/acem.15020

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Protocol Efficacy

Outcomes	SQuID vs. IV insulin	Median Difference (hr)	95% CI	P-value
Time to anion gap closure	**Shorter with SQuID**	**-1.4**	**-3.5 to -0.7**	**0.04**
Time on protocol	**Shorter with SQuID**	**-10.3**	**-22.7 to -5.6**	**<0.001**
Rescue dextrose administration	5 (8%) vs. 4 (18%)	10%	-3.1% to 10%	0.17

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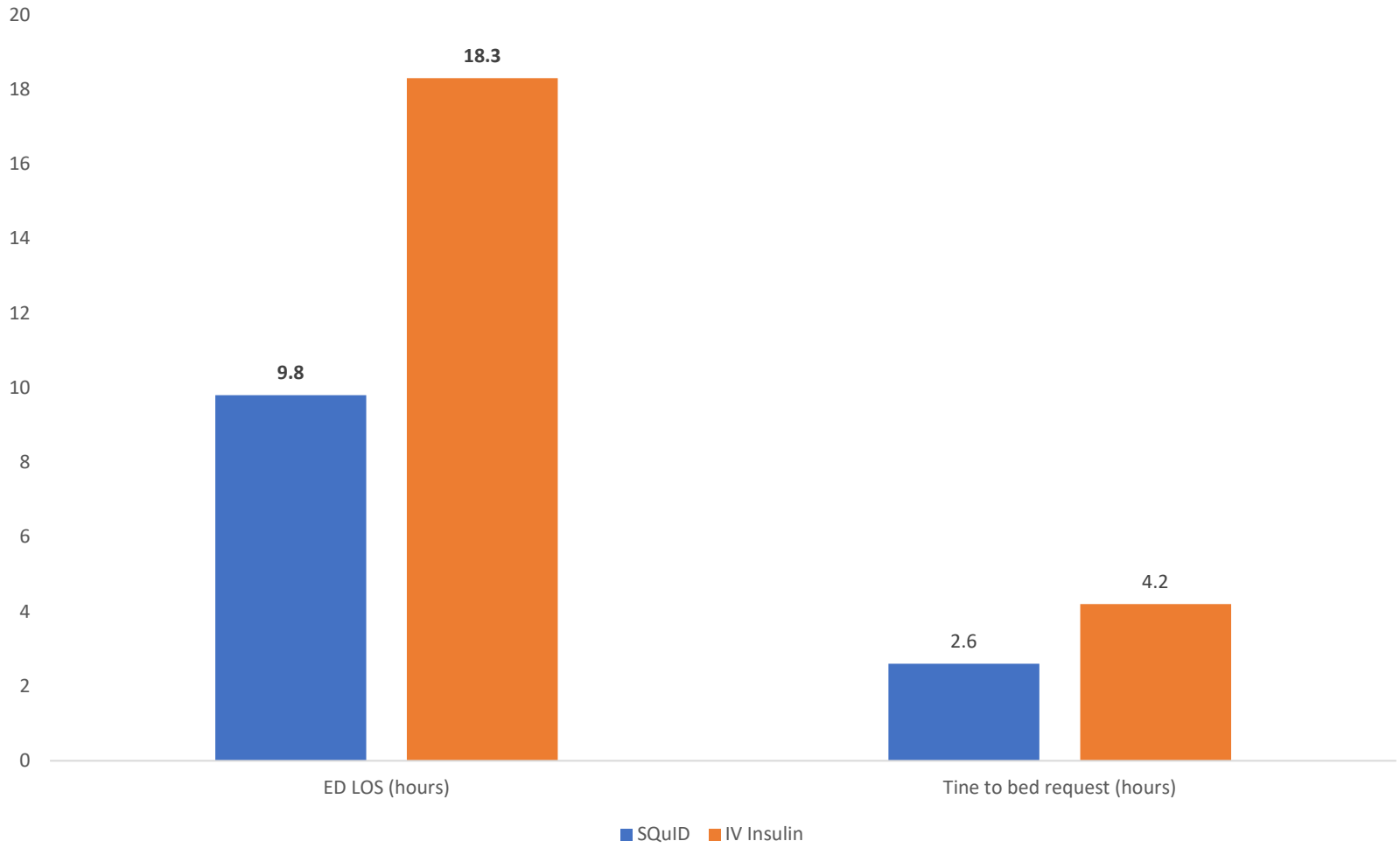
Griffey RT, Schneider RM, Girardi M, et al. *Acad Emerg Med*. 2025;32(1):61–71. doi:10.1111/acem.15020

Operation Results



Griffey RT, Schneider RM, Girardi M, et al. *Acad Emerg Med*. 2025;32(1):61–71. doi:10.1111/acem.15020

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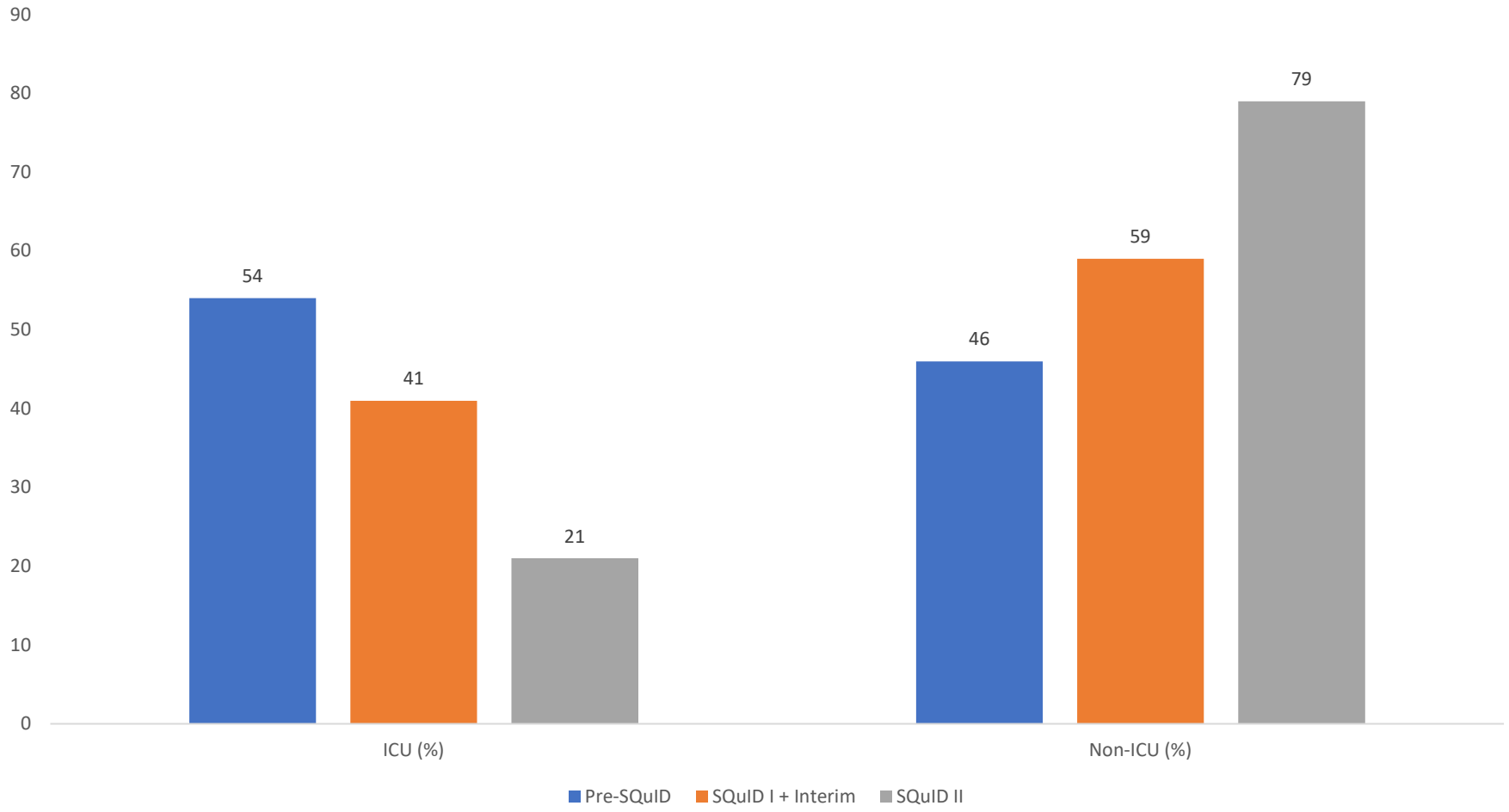
ICU Admissions



Griffey RT, Schneider RM, Girardi M, et al. *Acad Emerg Med*. 2025;32(1):61–71. doi:10.1111/acem.15020

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Study Conclusions

- 1.4 h shorter median time to AG closure
- 10.3 h shorter median time on protocol
- Shorter ED LOS in the SQuID group: 9.8 h vs. 18.3 h
- ICU admission rates decreased from 54% to 21% in SQuID II

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Strengths and Limitations

Study Limitations:

- Single-center study
- Relatively small sample size
- Patients not randomized and provider decision to treat via SQuID versus admit to ICU
- Costs associated with either protocol not studied
- Utilized dedicated inpatient observation unit

Study Strengths:

- Prospective trial design
- Studied additional outcomes such as time to anion gap closure, time to bed request, total time on either protocol
- COVID-19 pandemic not a confounder in this study as it was in SQuID I
- Reinforces the use of subcutaneous insulin for low to moderate DKA
- Continued to show a decline in ICU admission with SQuID protocol

DKA Outcomes

Outcome	SQuID I	SQuID II		
ED LOS	↓	↓		
ICU Admissions	↓	↓		
Time to DKA Resolution	Not measured	Not measured		
Hypoglycemia	↔	↔		

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Knowledge Check #3

A 45-year-old patient with T2DM presents to the ED with nausea and vomiting after not taking insulin for 2-3 days due to being on a work trip and forgetting his medications at home.

His pertinent labs are as follows:

BG: 345 mg/dL

pH 7.3

Bicarbonate: 15 mmol/L

Beta-hydroxybutyrate: 4 mmol/L

Mental status: alert

Knowledge Check #3

What regimen would you like to begin for this patient?

a) insulin lispro at 0.2 units/kg subQ
b) insulin regular at 0.05 units/kg/hr IV
c) insulin regular at 0.1 units/kg/hr IV
d) insulin regular 0.1 units/kg once IV

Pertinent Labs:

- BG: 345 mg/dL
- pH 7.3
- Bicarbonate: 15 mmol/L
- Beta-hydroxybutyrate: 4 mmol/L
- Mental status: alert

CRABI-DKA (2025)

Trial Design	
Retrospective cohort study conducted at an academic Level 1 trauma center emergency department	
Intervention	
SubQ insulin for DKA vs. IV insulin for DKA	
Inclusion Criteria	**Exclusion Criteria**
• DKA diagnosis • Glucose >250 mg/dL • Bicarbonate > 10 mmol/L • pH >7.0	• <18 years old • Euglycemic DKA (BG <250 mg/dl) • Critically-ill • Received high dose corticosteroids • Body weight >120 kg

Ibarra F Jr, Cruz M, Chinnock B, et al. *Ann Pharmacother*. Published online May 20, 2025. doi:10.1177/10600280251331967

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Outcomes Studied

Primary Outcome	
The percentage of individuals whose DKA resolved within 12 hours	
Secondary Outcomes	
• Time to DKA resolution	• Hospital length of stay
Safety Endpoints	
• Percentage of individuals who experienced hypoglycemia	• Percentage of individuals who experienced hypokalemia

Ibarra F Jr, Cruz M, Chinnock B, et al. *Ann Pharmacother*. Published online May 20, 2025. doi:10.1177/10600280251331967

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Baseline Demographics

Characteristic	SQ-DKA	IV-DKA	P-value
Age (y)	32 (25-43)	40 (29-51)	0.083
Glucose (mg/dL)	440 (374-545)	471 (371-559)	0.75
Bicarbonate (mmol/L)	15 (12-16)	13 (11-16)	0.25
Anion gap (mEq/L)	18 (16-20)	17 (15-18)	0.048
pH	7.3 (7.23-7.33)	7.26 (7.25-7.27)	0.34
BHB (mmol/L)	7.3 (5.0-9.0)	7.2 (5.2-8.4)	0.97
HbA1C (%)	11.5 (10.4-13.3)	11.2 (10-12.8)	0.57

*Values reported as median (IQR)

Ibarra F Jr, Cruz M, Chinnock B, et al. *Ann Pharmacother*. Published online May 20, 2025. doi:10.1177/10600280251331967

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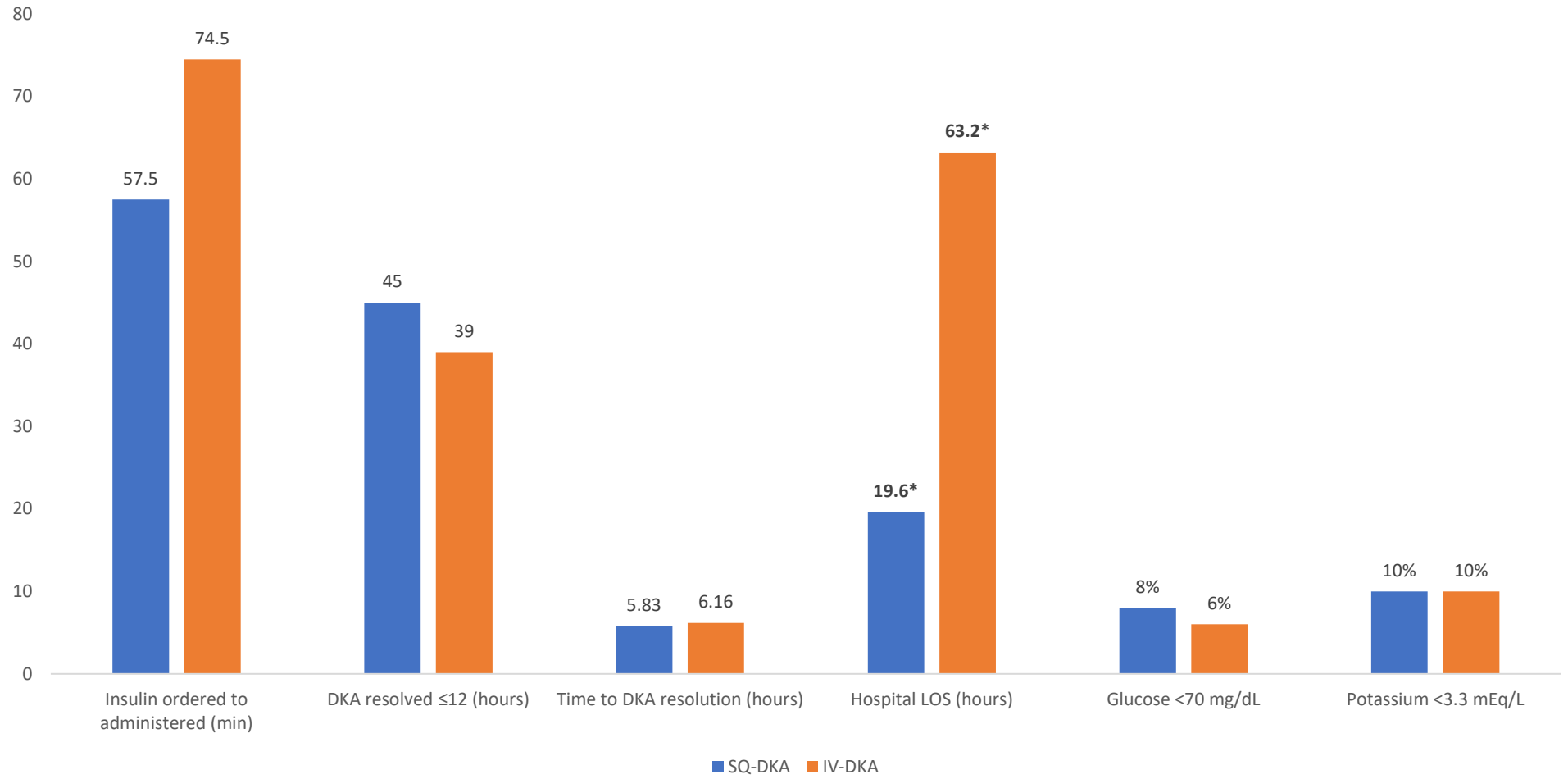
Results



*Indicate statistical significance

Ibarra F Jr, Cruz M, Chinnock B, et al. *Ann Pharmacother*. Published online May 20, 2025. doi:10.1177/10600280251331967

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Study Conclusions

The time from ordering to administering was trending short for subQ insulin vs. IV

The subQ protocol trended towards a faster resolution of DKA time

The hospital LOS was significantly shorter for the subQ protocol

Safety events were similar between both groups

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Strengths and Limitations

Limitations:

- Retrospective and single-center trial
- Relatively small sample size
- Did not measure ICU admission rates between groups
- Patients treated in ED observation unit where they may have received more focused care

Strengths:

- Demonstrated efficacy of subQ insulin while showing no compromise in safety
- Provided information on both time to resolution and LOS
- Observed significantly lower LOS on average of 2 days shorter
- Provided example order set for subQ for easier replication

DKA Outcomes

Outcome	SQuID I	SQuID II	CRABI-DKA	
ED LOS	↓	↓	↓	
ICU Admissions	↓	↓	↓	
Time to DKA Resolution	Not measured	Not measured	↓	
Hypoglycemia	↔	↔	↔	

ADVOCATE HEALTH

Stuhr, et al. (2023)

Trial Design	
Multicenter, retrospective cohort study	
Intervention	
SubQ insulin vs. IV insulin with an initial bolus and without an initial bolus	
Inclusion Criteria	**Exclusion Criteria**
• ≥18 years old • Primary diagnosis of DKA • Mild to moderate severity	• DKA unresolved prior to discharge • Transitioned to IV insulin due to subQ failure • Severe DKA • ESRD • Pregnancy/lactation

ADVOCATE HEALTH

Stuhr et al. J Emerg Med. 2023;65(3):e221–e228. doi:10.1016/j.jemermed.2023.06.004

Outcomes Studied

Primary Outcome	
• Time to DKA resolution	
Secondary Outcomes	**Safety Outcomes**
• Time to resolution of hyperglycemia • ICU LOS • Hospital LOS • DKA readmission within 30 days	• Incidence of hypoglycemia

ADVOCATE HEALTH

Stuhr et al. J Emerg Med. 2023;65(3):e221–e228. doi:10.1016/j.jemermed.2023.06.004

Baseline Characteristics

Characteristic	SQ (n=75)	IVB (n=62)	IVNB (n=120)	P-value
Age (mean), years	44.43	42.65	45.01	0.648
BMI (mean)	29.27	26.54	26.76	0.047
T1DM (%) T2DM (%)	48.0 48.0	63.9 31.1	46.7 48.3	0.220
A1c (%) <6.5& 6.6-10.0% 10.1-14% >14%	 0.0 25.9 60.3 13.8	 2.2 26.1 56.5 15.2	 1.9 36.5 50.0 11.5	0.650

ADVOCATE HEALTH

Stuhr et al. J Emerg Med. 2023;65(3):e221–e228. doi:10.1016/j.jemermed.2023.06.004

Baseline Laboratory Values

Lab Value	SQ (n=75)	IVB (n=62)	IVNB (n=120)	P-value
Blood glucose (mean), mg/dL	492.12	721.87	590.93	<0.001
pH	7.33	7.23	7.24	<0.001
Anion gap (mean)	20.87	25.10	25.50	<0.001
Lactate (mean), mmol/L	2.65	4.41	3.98	0.002
BHB (mean), mmol/L	3.58	3.89	3.84	0.450

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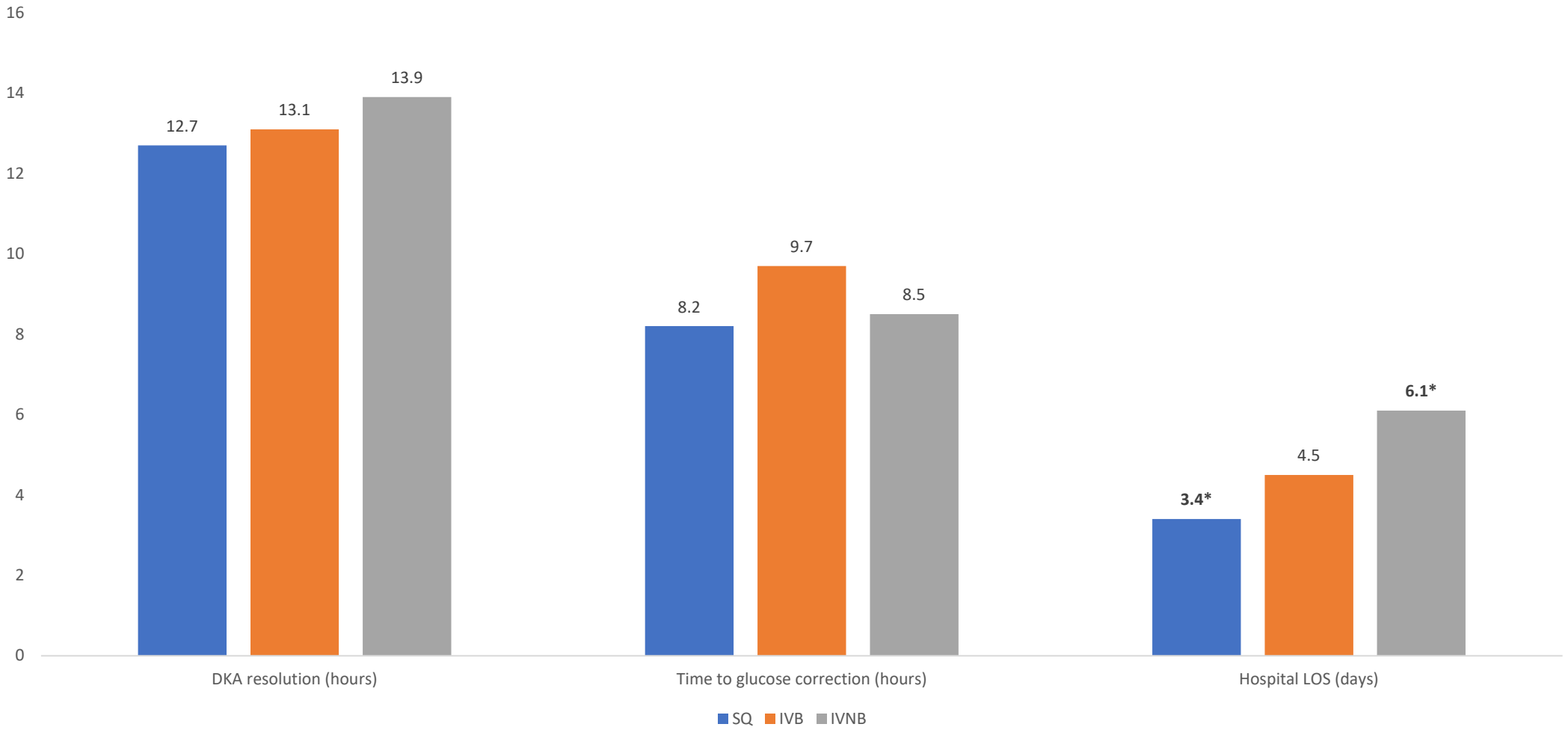
Stuhr et al. J Emerg Med. 2023;65(3):e221–e228. doi:10.1016/j.jemermed.2023.06.004

Results



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ADVOCATE HEALTH

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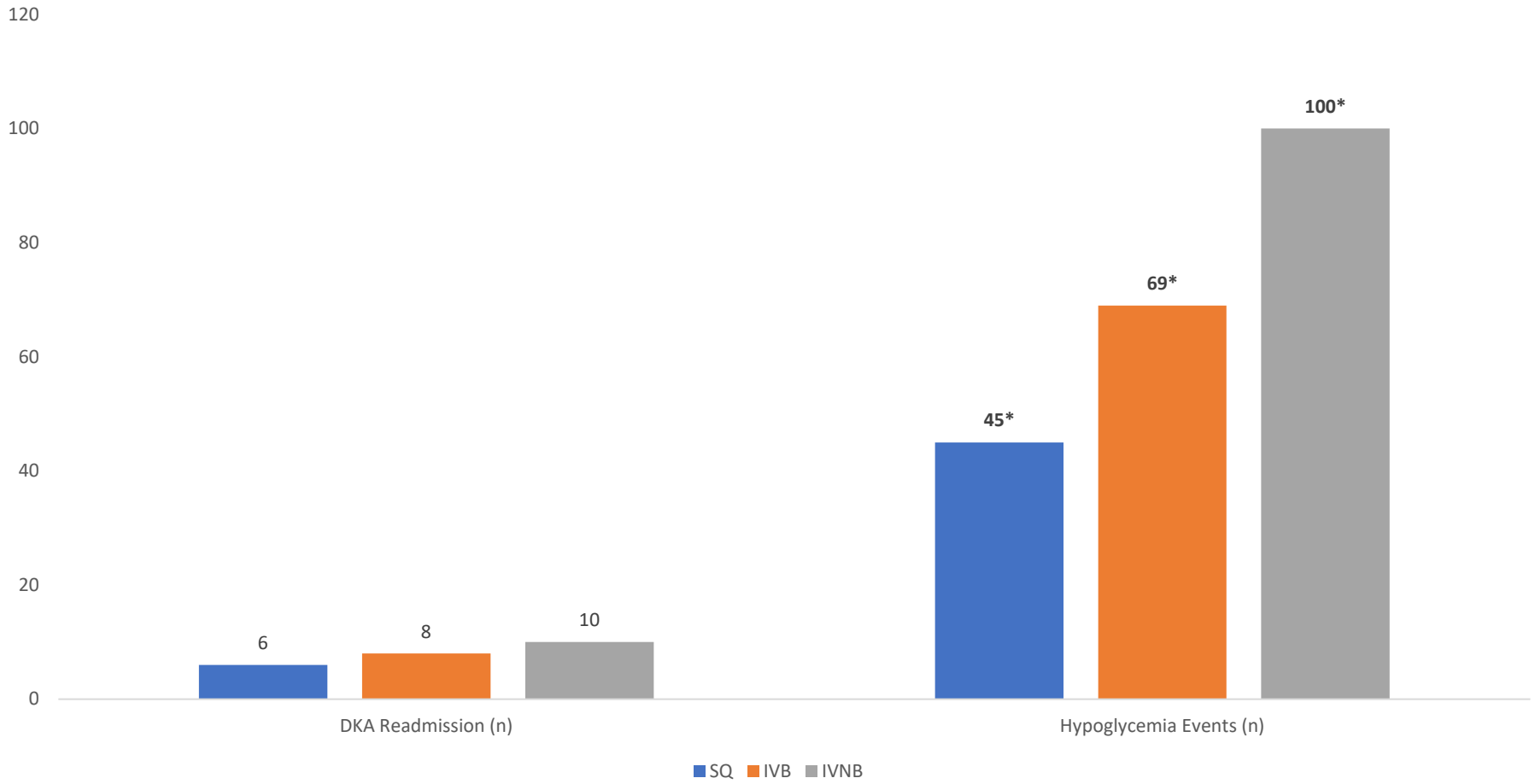
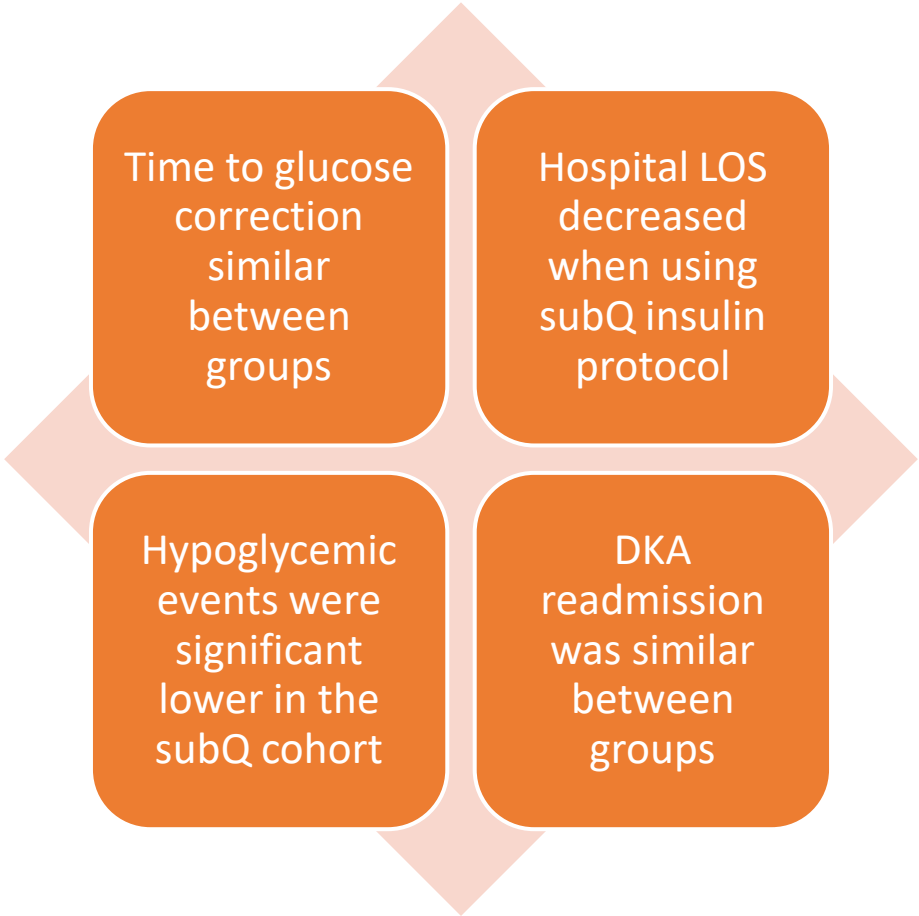


*Indicate statistical significance

ADVOCATE HEALTH

Stuhr et al. J Emerg Med. 2023;65(3):e221–e228. doi:10.1016/j.jemermed.2023.06.004

Study Conclusions



ADVOCATE HEALTH

Stuhr et al. J Emerg Med. 2023;65(3):e221–e228. doi:10.1016/j.jemermed.2023.06.004

Strengths and Limitations

Limitations:

- Study not randomized
- Patients in the subQ were less sick at baseline
- Relatively small sample size
- Did not provide ICU data on subQ group

Strengths:

- Multicenter trial
- Provided data on DKA readmission
- Provided further safety data
- Robust baseline characteristics descriptions

DKA Outcomes

Outcome	SQuID I	SQuID II	CRABI-DKA	Stuhr (2023)
ED LOS	↓	↓	↓	Not measured
Hospital LOS	Not measured	↓	↓	↓
ICU Admissions	↓	↓	↓	Not measured
Time to DKA Resolution	Not measured	Not measured	↓	↔
Hypoglycemia	↔	↔	↔	↓

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Overall Conclusions

While DKA mortality has improved over the past century, costs have continued to rise

General management requires IV insulin, ICU admission, and frequent monitoring and nursing resources

The SQuID protocol is an alternative for mild DKA to reduce costs and ICU admissions

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Case Example #1

A 22-year-old non-toxic appearing woman with type 1 diabetes presents to the ED with nausea, vomiting, and abdominal pain after missing her insulin for 2 days.

Vitals:
HR: 142 bpm
BP: 118/76 mmHg
RR: 24 (Kussmaul respirations noted)
Temp: 37.2°C
O2 sat: 98% RA
Alert and oriented

Labs:
BG: 410 mg/dL
pH: 7.15
Bicarbonate: 10 mmol/L
β-hydroxybutyrate: 4.5 mmol/L
K: 5.2 mEq/L

Case Example #1

Based on this patient's presentation, how would you classify their severity?

a) Mild DKA
b) Moderate DKA
c) Severe DKA

Labs:
BG: 410 mg/dL
pH: 7.15
Bicarbonate: 10 mmol/L
β-hydroxybutyrate: 4.5 mmol/L
K: 5.2 mEq/L

Case Example #1

Given that this patient is in moderate DKA, what insulin regimen should be started?

a) insulin lispro 0.1 units/kg subQ

b) insulin regular 0.1 units/kg/hr IV

c) insulin lispro 0.2 units/kg subQ

Case Example #1

The patient has a potassium of 5.2 mEq/L, what would be the most appropriate potassium repletion strategy?

a) No potassium repletion required at this time

b) 10-20 mEq/L of potassium in each liter of fluid

c) 40 mEq of potassium PO once

Case Example #1

A subsequent blood glucose resulted at 205 mg/dL, what would be the dose of insulin given at this time?

a) Hold dose of insulin until the next blood glucose check

b) Insulin lispro 0.1 units/kg subQ

c) Insulin lispro 0.2 units/kg subQ

Case Example #2

A 46-year-old man with T1DM presents after being found at home confused and lethargic. Family reports poor insulin adherence

Vitals:
HR: 152
BP: 96/62
RR: 32 (deep and rapid)
Temp: 37.0°C
O2 sat: 95% RA

Labs:
BG: 560 mg/dL
pH: 6.95
Bicarbonate: 7 mmol/L
β-hydroxybutyrate: 6 mmol/L
K^+: 3.7 mEq/L

Case Example #2

Based on this patient's presentation, how would you classify their severity?

a) Mild DKA
b) Moderate DKA
c) Severe DKA

Labs:
BG: 560 mg/dL
pH: 6.95
Bicarbonate: 7 mmol/L
β-hydroxybutyrate: 6 mmol/L
K^+: 3.7 mEq/L

Case Example #2

Given that this patient is in severe DKA, what insulin regimen should be started?

a) Insulin lispro 0.1 units/kg subQ
b) Insulin lispro 0.2 units/kg subQ
c) Insulin regular 0.1 units/kg/hr IV

Case Example #2

The patient has a potassium of 3.7 mEq/L, what would be the most appropriate potassium repletion strategy?

a) No potassium repletion required at this time

b) Replete potassium 10-20 mEq for each liter of fluid administered to maintain potassium between 4-5 mEq/L

c) 20 mEq potassium PO once

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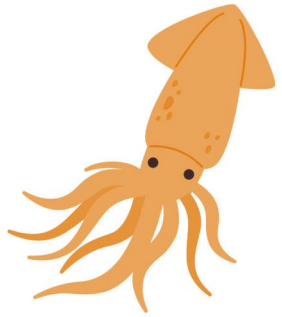
Questions?

Email: Thomas.Szwajnos@aah.org



Tom Szwajnos, PharmD, MS

10/29/2025