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Diabetic Ketoacidosis in Adults

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Presenter Disclosures

- Presenter: Dr. Jessica Ross

- Relationships with commercial interest: not applicable

Disclosure of Commercial Support

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- Potential of conflicts of interest:
  - Not applicable.
  - The presenter has not received honoraria and the financial supporter does not benefit from the sale of products discussed in this program.

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- This CME program and its material is peer reviewed and all the recommendations involving clinical medicine are based on evidence that is accepted within the profession; and all scientific research referred to, reported, or used in the CME/CPD activity in support or justification of patient care recommendations conforms to the generally accepted standards.

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Objectives

By the end of this presentation, the learner will:

- Understand the pathophysiology of Diabetic Ketoacidosis (DKA)
- Recognize, investigate and confidently diagnose DKA in adults
- Be familiar with current treatment guidelines and preprinted orders
- Be aware of recent research and controversies in the field

Statistics

- > 140,000 visits per year
- > 1 billion dollars per year
- Average length of hospital stay 3.4 days[1]
- Mortality in adults <1%[2]
- Type I (53%), Type II (39%)[3]

1. Centers for Disease Control. Diabetes Public Health Resource. 2009.
2. Hux et al. Diabetes in Ontario: An ICES Practice Atlas. 2003.
3. Balasubramanyam et al. New profiles of diabetic ketoacidosis. Arch Int Med. 1999; 159:2317-2322.

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“We elves try to stick to the four main food groups: candy, candy canes, candy corns and syrup.”

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Case scenario

- 34 year-old male
- New diagnosis type II diabetes
- Indulging in Christmas goodies
- 2-day history of increased thirst, urination, dysuria
- Today onset of nausea, vomiting, very little urinary output

- Medications: Metformin 500mg BID, Perindopril 8mg, ASA 81mg

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Examination

- Vitals: HR 140, RR 34, BP 70/40, 36.4C
- Glucometer: high
- EKG: sinus tachycardia
- Urinalysis: 4+ ketones, 2+ leukocytes, + nitrites, + blood

“SON of a NUTcracker!”

“I’m a cotton-headed ninny-muggins”

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Pathophysiology

- **Insulin deficiency**
    - (NO insulin or SOME insulin with large counter-regulatory hormone surge)
- **Ketogenesis** (fat breakdown)
- **Hyperglycemia** (decreased utilization, protein/glycogen breakdown)
- Ketones and Glucose cause an **osmotic diuresis**
- Serum ketones and osmoles rise in dehydration

Diagnostic criteria

- Glucose > 14 mmol/L
- Ketonemia
- pH <7.3
- Anion gap > 12 mmol/L
- Bicarbonate <15 mmol/L

Goguen et al. Hyperglycemic emergencies in adults. Canadian Journal of Diabetes. 2013; 37(S1): S72-S76.
American Diabetes Association. Hyperglycemic crises in diabetes. Diabetes Care. 2004; 27(S1): S94-S102.

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Laboratory Investigations

- CBC: Hb 145 g/dL, leuks 23.3, plt 381
- Na 133, K 2.9, Cl 103
- Cr 144, BUN 17
- Glucose 29.7 mmol/L
- Serum ketones
- ABG: pH 7.1, pCO2 23, PO2 95, bicarbonate 11

Treatment

- ABCs
- Fluid resuscitate with normal saline
- Consider foley if very dehydrated
- Replace potassium
- Treat the underlying cause
- Administer insulin
- Give dextrose

Goguen et al. Hyperglycemic emergencies in adults. Canadian Journal of Diabetes. 2013; 37(S1): S72-S76.
American Diabetes Association. Hyperglycemic crises in diabetes. Diabetes Care. 2004; 27(S1): S94-S102.

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Quiz!

When do I start my insulin infusion?

1. After my initial fluid bolus
2. Once my glucose level is confirmed at >14 mmol/L
3. Once my potassium is confirmed at >3.3 mmol/L
4. Hmmm... can I phone a friend (Randy Wax) ?
5. Easy! Consult my pre-printed order set

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Treatment

- ABCs
- Fluid resuscitate with normal saline
- Consider foley if very dehydrated
- Replace potassium
- Treat the underlying cause
- **Administer Insulin *** only if K >3.3-3.5**
- Give dextrose once glucose <14

Goguen et al. Hyperglycemic emergencies in adults. Canadian Journal of Diabetes. 2013; 37(S1): S72-S76.
American Diabetes Association. Hyperglycemic crises in diabetes. Diabetes Care. 2004; 27(S1): S94-S102.

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Treatment

Insulin

- low dose is safe and effective
- 0.1-0.14 U/kg/hour starting dose
- limited data to advise initial bolus[6]
- **hold until potassium is >3.3-3.5**
- SC insulin may be safe and effective for uncomplicated DKA[7]

6. Kitabchi AE et al. Is a Priming Dose of Insulin Necessary in a Low-Dose Insulin Protocol for the Treatment of Diabetic Ketoacidosis? Diabetes Care. 2008; 31(11):2081-5.
7. Mazer M et al.Is Subcutaneous Administration of Rapid-Acting Insulin as Effective as Intravenous Insulin for Treating Diabetic Ketoacidosis?Annals of Intensive Care 2011, 1:23

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Treatment

Bicarbonate

- Consideration of IV sodium bicarbonate administration for severe acidosis
- Guidelines suggest at pH <6.9-7.0
- No evidence for improved clinical outcomes in DKA[8,9]
- Potential risks including cerebral edema

8. Duhon B et al. Intravenous sodium bicarbonate therapy in severely acidotic diabetic ketoacidosis. Ann Pharmacotherapy. 2013 (Jul/Aug); 47: 970-975.
9. Chua HR et al. Bicarbonate in diabetic ketoacidosis - a systematic review. Annals of Intensive Care. 2011;1:23 .

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Case resolution

Buddy

- Fluid resuscitation with normal saline
- 40 mmol/L KCl in 1L NS over 2 hours
- Insulin withheld until K > 3.3
- Insulin infusion given with D5W per protocol
- Transitioned to subcutaneous insulin once eating
- Started on antibiotics for his UTI
- Inpatient consultation from diabetic educators
- Discharged home with family physician follow-up

Pitfalls...

Pearls...

- Negative serum ketones, no acidosis, normal serum bicarbonate... can this patient still have DKA?

- Normal anion gap... what about this patient?

Goguen et al. Diabetic ketoacidosis: challenging cases. Endocrinology rounds. 2008; 8 (8) 1-6.

Pearls

- No acidosis?
  - Metabolic alkalosis (HCO_3^- production) can mask ketosis (equivalent H^+)
  - Look for an anion gap
- No ketones?
  - Volume contraction shifts acetone and acetoacetate to beta-hydroxybutyrate (unmeasured)
- Nomal anion gap?
  - Every 10 g/L reduction in albumin, corrected anion gap decreases by 2.3 mmol/L

“I just like to smile. Smiling’s my favourite.”

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Early Detection

- Triage: onset and duration of symptoms, history, mental status, objective data
- Bed allocation from triage: cardiac monitor
- Medical directives: IV insertion, capillary blood glucose, ECG, IO access
- Rapid diagnostics: UA, STAT electrolytes, VBG, magnesium, phosphate, serum osmolality. Point of care testing for ketones at triage

Arora, Sanjay, MD et al; Diabetes Care; Diagnostic Accuracy of Point of Care Testing for Diabetic Ketoacidosis at Emergency Department Triage; Apr 2011; 34, 4.

Initial assessment

- A: assess and stabilize airway, supplemental O2
- B: Kussmaul respirations
- C: arrhythmia, hemodynamic status
- D: mental status, differential diagnoses
- Pain: abdominal pain

McNauthon, Candace, MD et al; Clinical Diabetes; Diabetes in the Emergency Department: Acute Care of Diabetes Patients; Nov 2011; 29,2.

Order set pearls

- Correct fluid loss
- Correct acidosis (by correcting hyperglycemia)
- Correct electrolyte imbalance

- **CDA recommends maintaining glucose between 12 - 14 mmol until anion gap is 12 or less to prevent hypoglycemia**

Current Insulin Infusion Rate				D5 Rate
Glucose (mmoL/L)	**0 to 5 units/hour**	**6 – 10 units/hour**	**11 or greater units/hour**	**D5W (mL/hr)**
Less than 4	Stop Insulin; follow Hypoglycemia protocol. Call MRP.			250
4 – 5	Decrease Rate by 50%, measure Glucose in one hour			225
5.1 – 7.8	No Change	Decrease rate 2 units/hr. if glucose is falling		200
7.9 – 11.1	2 units IV bolus and increase rate 1 unit/hour		No change	175
11.2 – 13.9	4 units IV bolus and increase rate 1 unit/hour	4 units IV bolus and increase rate 2 units/hour	4 units IV bolus and increase rate 3 units/hour	150
14 – 16.7	8 units IV bolus and increase rate 1 unit/hour	8 units IV bolus and increase rate 2 units/hour	8 units IV bolus and increase rate 3 units/hour	100
16.8 – 19.4	10 units IV bolus and increase rate 1 unit/hour	10 units IV bolus and increase rate 3 unit/hour	10 units IV bolus and increase rate 4 unit/hour	50
Greater than 19.4	12 units IV bolus and increase rate 2 unit/hour	12 units IV bolus and increase rate 4 unit/hour	12 units IV bolus and increase rate 6 unit/hour	25

Order set pitfalls

- PPO doesn't specifically indicate to HOLD insulin until potassium level is verified
- Start or don't start the D5W?
- But what if patient requires fluid restriction?
- What if patient is on insulin pump?

- Gosh they're long!!

What now?

- Disposition
- Basal SQ insulin
- Discharge instructions
- Sick day planning

Disposition

- Able to tolerate PO?
- Subcutaneous dose of basal insulin should be given 1 hour before insulin infusion is stopped. (0.2-0.3 U/kg/day in divided doses)
- Patients rarely meet criteria for discharge from ED.

Discharge Instructions

- Durham Region Diabetes Network:
    - *Charles H Best Centre (type 1 only)
    - *Diabetes Education Program (type 2)
    - *Centre for Complex Diabetes Care

Sick day planning

- SICK
- **S:** sugar (check frequently)
- **I:** insulin (keep taking basal, titrate short-acting)
- **C:** carbohydrate and fluids (try to keep carb intake as normal as possible, increase fluids)
- **K:** ketones (check)

SADMAN

- Stop taking if unable to tolerate PO:
- **S:** sulfonyureas
- **A:** ACE inhibitors
- **D:** diuretics, direct renin-inhibitors
- **M:** metformin
- **A:** angiotensin receptor blockers
- **N:** NSAIDs

Treatment

Normal or not-so-normal saline

- Correct shock state and normalize vitals
- Slow down infusion
- Potential risk of cerebral edema with 1/2 NS and rapid drop in serum osmolality
- Be aware hyperchloremia may occur and unresolving acidosis can prolong LOS

DKA vs HHS

Lab Value	DKA	HHS
glucose	↑	↑↑
anion gap	>10-12	no
serum osmolality	↑	↑↑ (really dehydrated)
sodium	↓	↑
bicarbonate	↓	↑
ketones	positive	negative
potassium	↑or↓	↑or↓

McDonald Lenahan, Christy, MSN RN and Holloway, Brenda DNSc. RN; Journal of Emergency Nursing; Differentiating between DKA and HHS; Aug 2014. jenonline.org

Thank you!

- Questions?

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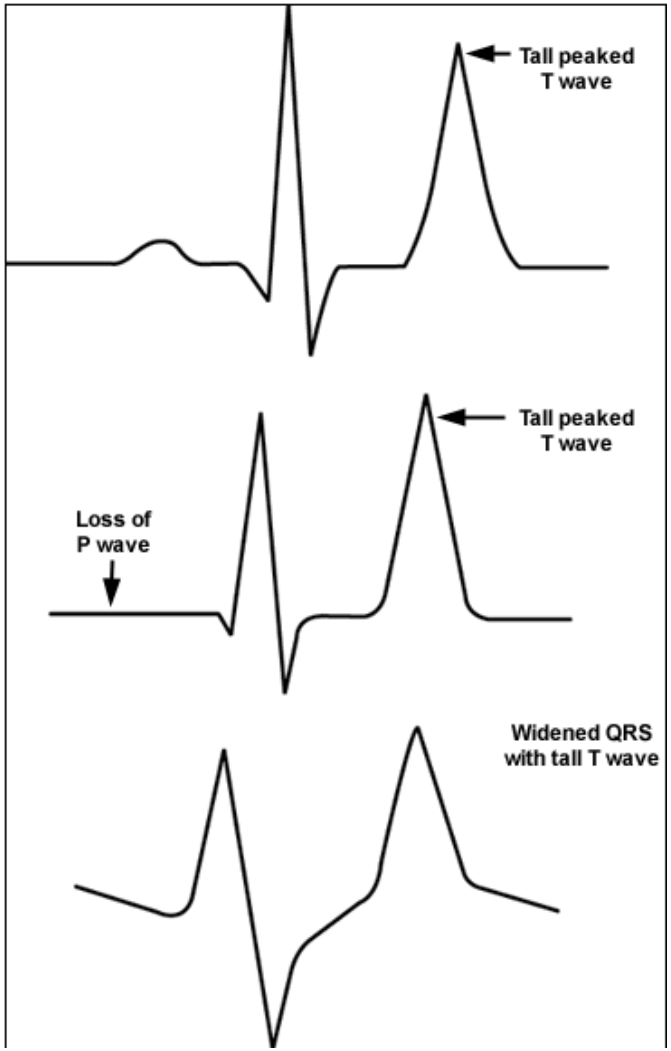
ECG findings Hyperkalemia

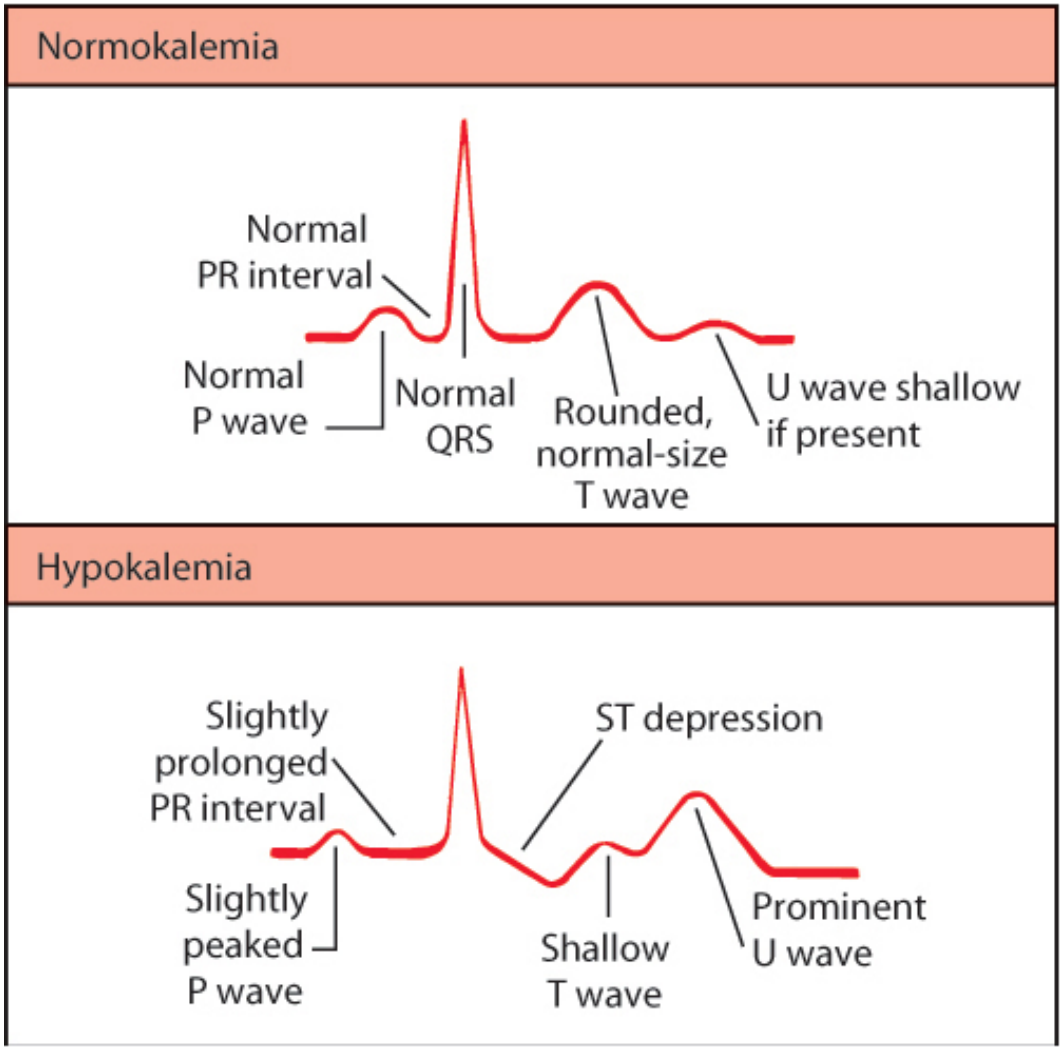


http://www.aafp.org/afp/2006/0115/p283.html

hyperkalemia

Same patient…

ECG findings Hypokalemia



http://www.fpnotebook.com/legacy/Renal/Potassium/Hypklm.htm

VBG vs ABG in DKA

- Potential harms of ABG:
  - pain, hematoma, arterial injury and thrombosis, embolism, infection, needlestick injury to healthcare worker
- pH:
  - ABG **0.02 pH units** > VBG
- Bicarbonate
  - ABG **1.88 mEq/L** < VBG
  - ABG **1.88 mEq/L** < VBG

Kelly AM. The case for venous rather than arterial blood gases in diabetic ketoacidosis. Emergency Medicine Australasia. 2006; 18:64-67.

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