Abnormal Potassium

National Pediatric Nighttime Curriculum
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Learning Objectives

After finishing this module trainees will:

- Differentiate between pseudohyperkalemia and hyperkalemia
- Recognize signs and symptoms of hyperkalemia and hypokalemia
- Describe steps in hyperkalemia and hypokalemia managment

Pretest Question 1. **Muscle weakness and cardiac arrhythmias are symptoms that can be seen with**

A. hyperkalemia
B. hypokalemia
C. both hyperkalemia and hypokalemia
D. neither hyperkalemia nor hypokalemia

Pretest Question 2. Which of the following concerning EKG changes associated with hyperkalemia should worry you THE MOST:

A. Sine wave pattern

B. Tall peaked T waves

C. Loss of P wave with tall peaked T waves

D. Widened QRS

Intern Case

It is 5AM on a lovely Saturday morning. You have finally laid down your head when a text message comes through your pager:

“Lab called. Critical K of 6.9 on 3014. Cydni”

Patient in 3014 according to your sign-out:

9 mo old previously healthy full term girl admitted ~24hrs ago with RSV+ bronchiolitis

Meds: oxygen (1/2L NC), albuterol trial, and prn tylenol

O/N: NTD

What do you do?

A. Go back to sleep. If they really want something from you, they'll call back. Plus the sign-out said "NTD." Besides 6.9 is really not THAT high. It's probably hemolyzed anyway… Zzz
B. Call or walk over to 3014 to get more information and to close the communication loop
C. Call your senior

As you walk over to 3014, some questions you ask yourself:

Why were labs being checked this morning?

What is the normal K range?

What signs and symptoms might you expect if the child had hyperkalemia?

Is this lab result valid? What are possible causes of pseudohyperkalemia? Which ones might apply to your patient?

Additional information from Cydni the bedside RN

Clinical information: Child has been improving and RN believes will go home later today. Now on 1/4L NC, doing well with bulb suctioning and better PO intake. Albuterol found to be helpful. Fluids (D5 1/2NS w/ 20meq KCl) running at just ¼ maintenance with urine output of 2.2 ml/kg/hr. Afebrile. Vitals nl for age. Child is now sleeping (after finally being comforted after heel stick and blood draw) and had never seemed weak to the RN. Actually he kicked the phlebotomist quite vigorously.

Recent labs: cbc on admission nl. Renal function panel on admission significant only for slightly elevated BUN and BUN:Cr ratio. K on admission was 4. Full renal function panel this morning is normal with the exception of K which is indeed at 6.9.

Are you more or less worried? What do you want to do?

A. Redraw the K. If so how?
B. Order an EKG
C. Call the lab to clarify whether hemolysis was seen
D. Check with your senior
E. Take the K out of pt's IVF
F. Do nothing

It's now 5:30 AM

Dawn is breaking outside and you are looking forward to signing out your patients and heading home for some well deserved sleep when another message comes through your pager…

"Lab called. Now K 3.2 on 3014. Cydni"

What do you do now?

A. Throw your pager against the wall. This was supposed to be the one an only “NTD overnight” patient. Arrrrg!
B. Call or walk over to 3014 to get more information and to close the communication loop
C. Call your senior

As you are picking up the phone or walking over back to 3014, some questions you ask yourself:

Why-oh-why did we check and then recheck the K?

What is that normal K range again?

What signs and symptoms might you expect if the child had hypokalemia?

What are the possible causes of hypokalemia? Which ones could apply to your patient?

How worried are you? What do you want to do?

A. Redraw the K. If so how?
B. Order an EKG
C. Call the lab to clarify whether hemolysis was seen
D. Check with your senior
E. Do nothing

How this story ends…

IVF shut off prior to rounds after pt drank a big bottle of formula

Pt discharged home on room air the next day

Follows up with PCP in 3d. Doing better though still coughing

No further electrolytes checked for >10yrs and counting….

20/20 Hindsight

Is there any feedback you would like to give to the bedside nurse? Your senior? To your fellow intern when signing out in the morning? How could things go better next time?

Quick Potassium Basics

- 98% of K is intracellular
- 2% extracellular and tightly controlled at 3.7-5.2 mEq/L

	Mild-to-Moderate	Severe
Hyperkalemia	6-7 mEq/L	>7 mEq/L and/or symptomatic
Hypokalemia	3-3.4 mEq/L	< 2.5-3 mEq/L and/or symptomatic

PSEUDOHYPERKALEMIA

Lab findings of **falsely** elevated serum K due to K movement out of the cells during or after a blood draw. Suspect in an asymptomatic patient with no apparent cause for K elevation

- Lysis of rbc
- Specimen deterioration (cooling, prolonged storage)
- ↑wbc, ↑plt
- Drawing blood downstream from a vein into which K is infusing
- **Trauma:** forcible expression of blood (milking a heel stick)
- **Exercise:** fist clenching with blood draws

HYPOKALEMIA CAUSES

I. Shifting of K into intracellular space

A) Alkalosis
B) Insulin
C) ↑ Beta-adrenergic activity

II. ↑ K losses (↓ total body K)

A) **GI track**
B) **Urine**
C) Sweat

III. ↓ K intake (↓ total body K): rarely the only cause

Hypokalemia Signs and Symptoms

Resolve with hypokalemia correction

I. Muscle

A. **Ascending Weakness**

B. **Ischemia:** cramping, rhabdomyolysis, myoglobinuria.

II. Cardiac

A. Conduction abnormalities and arrhythmias

B. EKG Changes:ST segment depression and prominent U wave

HYPOKALEMIA TREATMENT

I. Investigate and manage underlying causes
II. Investigate and manage any coexisting alkalosis and/or ↓ Mg
III. Replace K if needed

Senior Case

It is 7PM. You have just finished getting sign-out and are in the team room waiting to staff 2 new admissions with an intern when your second intern mentions in passing a critical lab result on pt AL: K of 8.5. She had asked the nurse to have it redrawn--since in her experience an elevated K is not real. But since she ran into you, she's just letting you know. And by the way, that nurse keeps paging and paging about this patient. Doesn't he realize how busy we are?

Patient AL according to your sign-out

14 y/o male with CP, autism, severe DD, nonverbal, non-ambulatory admitted ~2hrs ago due to dehydration. Has been screaming, refusing to eat or drink, and vomiting for past 3d. The admitting team thought it was early gastroenteritis vs gastritis possibly with a behavioral component

Meds: prn ketorolac, tylenol, morphine. Some meds for sleep and behavior.

O/N: Check on electrolyte panel. Pt got 2L of NS in the ED and still looked “dry” to your colleague

What should you do?

A. Finish staffing new admissions. Your intern seems to have things under control. Thank her for keeping you in the loop and ask her to page you with repeat K.
B. Go see the patient with your intern
C. Discuss initial treatment/evaluation recommendations with your intern and check on his/her progress
D. Notify your attending

As you walk over to the room, some questions you ask yourself and your intern:

What are this child's risk factors for hyperkalemia?

What signs and symptoms might you expect if the child had hyperkalemia?

How will you evaluate for them?

AL Update

T: 36.7 HR: 150 BP: 100/70 RR: 10 sat 100%. Still no urine. Parents believe he had a slightly wet diaper early in the morning (>12hrs ago). Has been getting MIVF since 2L NS in the ED (~2hrs). Was screaming uncontrollably so got a dose of ketorolac and morphine which seems to have helped. Parents and RN very worried about pt.

Tachycardic, wimpering, dry MMM, cap refill ~4sec.

Rest of the renal function panel significant for BUN of 35 and Cr of 1.7 and bicarb of 13

What next?

Are you more or less worried?

What do you want to do now: what orders do you want to write?

How do you divide the work between you, intern, bedside nurse?

How do you deal with admissions piling up?

When do you notify the attending?

AL Update

Interventions

- Another 1L NS
- K and ketorolac stopped

Patient

- HR down to 135. Cap refill 3 sec. Still moaning. Otherwise unchanged

Study Results

- EKG: Peaked T waves, no P waves, widened QRS
- Repeat K: 8.5. Lab comments that specimen NOT hemolyzed
- Foley in: small amounts of dark red urine
- CK: nl Phos: 6

What next?

Are you more or less worried?

What do you want to do now: what orders do you want to write?

When do you notify the attending?

When do you notify the PICU? Nephrology?

How this story ends…

EKG back to normal after 2 doses of Calcium

After 1hr K is 7.5 and pt transferred to PICU for hemodialysis

Diagnosed with nephrolithiasis which led to pain, emesis, decreased PO intake, severe dehydration, and renal failure

Pt undergoes lithotripsy

Transfers back to the floor then goes home in good condition

20/20 Hindsight

Is there any feedback you would like to give to the bedside nurse? The intern? The daytime senior when signing out in the morning? How could things go better next time?

HYPERKALEMIA CAUSES

I. Shifting of K into extracellular space

A. Tissue (lots of cells) damage: burns, crush injury, rhabdomyolysis, tumor lysis

B. Acidosis

C. Hyperosmolar states

D. Insulin deficiency

II. Impaired Renal Excretion (↑ total body K)

A. Renal insufficiency/failure

B. Endocrine: adrenal insufficiency, ↓ renin, ↓ aldosterone, pseudohypoaldosteronism

III. Iatrogenic

A. K in IVF or TPN

B. Medications: NSAIDS, ACE inhibitors, beta blockers, K sparing diuretics, trimethoprim, and many, many others

HYPERKALEMIA SIGNS AND SYMPTOMS

I. Muscle

A. Ascending muscle weakness and paralysis

B. Respiratory muscle weakness rare

II. Cardiac

A. Conduction abnormalities and arrhythmias

B. EKG Changes

1. Peaked T waves→

2. Loss of P wave→

3. Widened QRS →

4. Sine wave pattern

HYPERKALEMIA TREATMENT

I. Do no harm

A. Remove any K containing fluids

B. Remove any medications that could be contributing

II. Stabilize cell membranes: IV calcium

III. Drive K back into cells

A. Insulin and glucose

B. Albuterol

IV. Remove excess K from the body

A. Loop diuretics

B. Cation exchange resin: Sodium polystyrene sulfonate (Kayexalate)

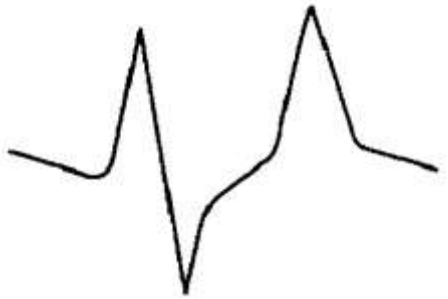
C. Hemodialysis

Post-Test Question 1. Options for managing hyperkalemia include all EXCEPT

A. Albuterol
B. Spiranolactone
C. Sodium polystyrene sulfonate (Kayexalate)
D. Insulin/glucose

Post-Test Question 2. **You ordered an EKG on a patient with an abnormal potassium and see peaked T waves with widened QRS complexes. Appropriate initial step in management include:**

A. 2 puffs albuterol MDI
B. 20ml/kg NS bolus
C. IV calcium
D. IV KCl
E. Kayexalate enema



Key Learning Points

- **Hyperkalemia** is a common potentially life threatening metabolic disturbance. It should be suspected in a patient with identifiable risk factors and/or signs and symptoms of hyperkalemia . **Pseudohyperkalemia** is a lab findings of **falsely** elevated serum K due to K movement out of the cells during or after a blood draw. It should be suspected in an asymptomatic patient with no apparent cause for K elevation

- Signs and symptoms of both hyperkalemia AND hypokalemia include skeletal muscle weakness and cardiac conduction abnormalities

- Hyperkalemia management includes stopping any exacerbating treatments, cardiac membrane stabilization, driving K intracellularly, and promoting K excretion. Hypokalemia management includes enteral or parenteral K repletion as well as correction of any coexisting alkalosis and/or hypomagnesemia

Suggested Reading and Resources

- **Sood, M.M., A.R. Sood, and R. Richardson, Emergency manamgent and commonly encountered outpatient scenarios in patients with hyperkalemia. Mayo Clin Proc, 2007. 82 (12):p. 1153-61. Available at:** http://www.mayoclinicproceedings.com/content/82/12/1553.full.pdf+html
- **Holladner-Rodriquez, J.C. and J.F.Calvert,Jr., Hyperkalemia. Am Fam Physician, 2006. 73(2): p. 283-90. Available at:** http://www.aafp.org/afp/2006/0115/p283.html
- **Gennari, F.J., Disorders of potassium hemeostasis. Hypokalemia and hyperkalemia. Crit Care Clin, 2002. 18 (2): p.273-88**