Acute Hyperkalemia

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"Acute Hyperkalemia"

As distinct from chronic hyperkalemia, acute hyperkalemia is defined as a potassium result above the upper limit of normal, not known to be chronic.

Prevalence of hyperkalemia
- U.S.: 3.6% - K > 5.0 mmol/L
- Switzerland: 8.8% - K > 4.5 mmol/L, the upper limit of normal

Singer AJ et al.,
A retrospective study of emergency department potassium measurements
Clin Exp Emerg Med. 2017

Pfortmüller CA et al.,
Hyperkalemia in the emergency department
Eur J Intern Med. 2013
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**Q7:** WHAT ARE THE OPTIMAL METHODS FOR MEASUREMENT OF ACUTE HYPERKALEMIA, AND THEIR ACCURACY (E.G., STUDIES ON ACCURACY OF POINT-OF-CARE TESTING VERSUS LABORATORY [SEROLOGY] MEASUREMENT)?

**Central Laboratory vs Point of Care (POC)**

<table>
<thead>
<tr>
<th>Specimen type</th>
<th>Central Laboratory (XMC)</th>
<th>Point of Care (POC) (XMC)</th>
<th>Mean bias (95%CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Serum</td>
<td>4.2±0.55</td>
<td>3.77±0.44</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Whole blood</td>
<td></td>
<td></td>
<td>0.43 (0.38–0.48)</td>
</tr>
</tbody>
</table>

- Coagulation
  - K is released from thrombocytes during blood clotting
- "Pseudohyper K": Hyper K due to thrombocytosis

Zhang et al. Analysis of bias in measurements of potassium, sodium and hemoglobin by an emergency department-based blood gas analyzer relative to hospital laboratory autoanalyzer results. PLoS One. 2015

**Q11:** WHAT ARRHYTHMIAS ARE ASSOCIATED WITH HYPERKALEMIA, AND AT WHAT POTASSIUM THRESHOLD?

**ECG Changes in Hyperkalemia**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Relative risk for adverse event (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T wave inversion</td>
<td>6.77 (2.05–2.05)</td>
</tr>
<tr>
<td>PR prolongation</td>
<td>4.31 (2.05–2.05)</td>
</tr>
<tr>
<td>QT prolongation</td>
<td>4.74 (2.05–2.05)</td>
</tr>
<tr>
<td>Bradycardia (HR&lt;50 bpm)</td>
<td>12.29 (6.03–22.57)</td>
</tr>
<tr>
<td>Junctional rhythm</td>
<td>7.46 (3.22–17.97)</td>
</tr>
<tr>
<td>Ventricular tachycardia</td>
<td>7.67 (4.20–13.9)</td>
</tr>
<tr>
<td>Ventricular fibrillation</td>
<td>NA</td>
</tr>
<tr>
<td>2nd Degree heart block</td>
<td>6.92 (4.88–9.82)</td>
</tr>
</tbody>
</table>

**Adverse events**: symptomatic bradycardia, VT/VF, CPR, and/or death

- Slow depolarization affects
  - PR amplitude
  - PR length
  - QRS duration
  - bundle branch
  - fascicular blocks
- Fast repolarization affects
  - ST segment
  - T wave amplitude/shape


**Frequency of ECG abnormalities**

**ECG findings in hyperkalemia and adverse event**
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Calcium for hyperkalemic ECG changes
• Mechanism
  – Ca directly antagonizes the membrane effects of hyper K: “membrane stabilization”
  – Ca accelerates Ca dependent conduction in depolarization
• Indication: wide QRS complexes (depolarization problem)

<table>
<thead>
<tr>
<th>Calcium</th>
<th>Ca delivery</th>
<th>Dose</th>
<th>Preferred Ca source</th>
<th>Risk of extravasation</th>
</tr>
</thead>
<tbody>
<tr>
<td>CaCl₂</td>
<td>270mg(13.5mEq) / g</td>
<td>0.5g to 1.0g</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Ca Gluconate</td>
<td>90mg(4.5mEq) / g</td>
<td>1.0g</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

Hyperkalemic ECG changes
• ECG changes in hyperkalemia are associated with a variety of change.
  – peaked T wave / prolonged PR / wide QRS / P wave disappearance
• The sequence is reported to be peaked T waves, prolonged PR interval, progressive widening of QRS complex, followed by “sine wave” patterns, ventricular fibrillation and asystole.
• ECG manifestations may be difficult to determine, particularly with superimposed underlying structural heart disease and/or ischemia. Furthermore, there is great variability between studies in who interpreted the ECG, how proximal in time potassium levels and ECG were measured, and whether ECGs were compared to prior ECGs.
• We recommend continuous cardiac monitoring as well as performing a 12-lead ECG.

Q17:
WHAT IS THE OPTIMAL ALGORITHM FOR THE MANAGEMENT OF HYPERKALEMIA WITH RESPECT TO:

a. Setting for management
b. Treatment
c. Ongoing monitoring (i.e., frequency and duration)
d. Evaluation of current medications and potential changes in medications
e. Indication for dialysis

Limited evidence of NaHCO₃ for hyper K
The evidence for the use of bicarbonate in hyperkalemia is required and we do not recommend its use in monotherapy. If used in conjunction with other treatments, the possible effects on pH and extracellular volume may be cautiously considered in the treatment of the risk-benefit ratio for an individual patient.

Pharmacological interventions for the acute management of hyperkalemia in adults The Cochrane Collaboration 2015
Emergency interventions for hyperkalemia The Cochrane Collaboration 2005
Emergency interventions for hyperkalemic ECG changes The Cochrane Collaboration 2005
KDIGO Controversies Conference on Potassium Management “Acute Hyperkalemia” Group 5 draft

Ca Gluconate
10ml (850mg)
7.85mg of Ca


<ref>Elliott et al. Management of patients with acute hyperkalemia CMAJ 2010</ref>

<ref>Emergency interventions for hyperkalemia The Cochrane Collaboration 2005</ref>

<ref>Emergency interventions for hyperkalemic ECG changes The Cochrane Collaboration 2005</ref>

<ref>Emergency interventions for hyperkalemia The Cochrane Collaboration 2005</ref>

<ref>KDIGO Controversies Conference on Potassium Management “Acute Hyperkalemia” Group 5 draft</ref>
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Change in plasma K with treatment for (anuric) dialysis patients

- Plasma K(mEq/L)
  - Baseline (normal range)
  - Post-treatment


Regulation of renal K secretion

- NaHCO₃ and Furosemide

1. Distal tubular Na delivery
2. Distal tubular flow
3. Lumen electronegativity
4. Aldosterone
5. Serum K concentration

Cortical Collecting Duct

Lumen electronegativity: HCO₃⁻ > Cl⁻
K secretion: NaHCO₃ > NaCl

NaHCO₃ solutions

- Hypertonic NaHCO₃ (7%)
  - Solution
  - Na⁺ (mEq/L)
  - Cl⁻ (mEq/L)
  - HCO₃⁻ (mEq/L)
  - 833
  - 833
  - 833

- Hypertonic NaHCO₃ (8.4%)
  - Solution
  - Na⁺ (mEq/L)
  - Cl⁻ (mEq/L)
  - HCO₃⁻ (mEq/L)
  - 1000
  - 1000
  - 1000

- Isotonic NaHCO₃ (1.26%)
  - Solution
  - Na⁺ (mEq/L)
  - Cl⁻ (mEq/L)
  - HCO₃⁻ (mEq/L)
  - 150
  - 150
  - 150

- Normal saline
  - Solution
  - Na⁺ (mEq/L)
  - Cl⁻ (mEq/L)
  - HCO₃⁻ (mEq/L)
  - 154
  - 154
  - 154

Case

- HPI
  - A 55 y.o male is brought to the ED by family due to worsening muscle weakness. He has been feeling feverish for a week and took NSAIDs for several times. Has had weakness in his legs and difficulty in walking since yesterday. Then, he started feeling weak in his arms, too.
  - Does not complain of any pain or numbness.
  - Denies any history of trauma.

- PMH
  - HTN, DM and CKD stage 3 (eGFR: 34ml/min/1.73m²)
  - Admitted for CAD s/p PTCA 3 yrs ago
  - Admitted for CHF 1yr ago

Medications

- Aspirin 81mg daily
- Lisinopril 10mg daily
- Spironolactone 50mg daily
- Carvedilol 2.5mg daily
- Amlodipine 10mg daily
- Lisinopril 10mg daily
- Insulin glargine 20U, R S-5-S-5

Case

- Physical examination
  - VS: Temp 37.2°C, BP 118/60, HR 98, RR 22 (POx: 98% on RA)
  - General: Alert, oriented, pleasant, white female in no apparent distress, lying comfortably in bed.
  - HEENT: neck was supple
  - Lungs: trachea was central, air entry equal, no rhonchi or creps
  - Heart: nl S1&S2, 2/6 systolic M @ Lt sternal border
  - Abdomen: a median laparotomy scar that was well-healed and showed no dehiscence or hernias.
  - Extremities: pulses were equal in all limbs, (+) mild pitting edema
  - Neuro: CN intact
  - Motor: Upper: proximal 5/5 and distal 5/5
  - Lateralizing:
  - Sensory: intact
  - Cerebellar sign: negative
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Case

Laboratory data

On admission
Blood
Na⁺ 130 mEq/L
K⁺ 6.8 mEq/L
Cl⁻ 111 mEq/L
BUN 94 mg/dL
Cr 2.7 mg/dL

1M ago @ clinic
Blood
Na⁺ 135 mEq/L
K⁺ 4.8 mEq/L
Cl⁻ 108 mEq/L
BUN 44 mg/dL
Cr 1.7 mg/dL

In summary

• 55 yo M with HTN, DM, CAD s/p PTCA and CKD stage 3 on ACE-I and spironolactone came in a few days h/o fever and worsening weakness, who was found to have K 6.8.

Treatment of Hyperkalemia

<table>
<thead>
<tr>
<th>Therapy</th>
<th>Mechanism</th>
<th>Onset</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcium salts</td>
<td>Antagonize membrane effects</td>
<td>1-3 min</td>
<td>30-60 min</td>
</tr>
<tr>
<td>Insulin</td>
<td>Potassium redistribution</td>
<td>30 min</td>
<td>4-6 hr</td>
</tr>
<tr>
<td>β₂-Adrenergic agonist</td>
<td>Potassium removal</td>
<td>30 min</td>
<td>2-4 hr</td>
</tr>
<tr>
<td>NaHCO₃</td>
<td></td>
<td>30-60min</td>
<td></td>
</tr>
<tr>
<td>K-binders (SPS etc.)</td>
<td>Potassium removal</td>
<td>1-2 hr</td>
<td>4-6 hr</td>
</tr>
<tr>
<td>Hemodialysis</td>
<td></td>
<td>Immediate</td>
<td>Until HD completed</td>
</tr>
</tbody>
</table>

Questions to be answered to manage acute hyperkalemia

• True hyperkalemia?
  ➔ R/Oed Hemolysis
• Vital sign (make sure arrhythmia not happening)
  ➔ Temp 37.2℃, BP 118/60, HR 98, RR 22
• Glucose?
  ➔ Glu 140 mg/dL
• HCO₃⁻?
  ➔ HCO₃⁻ 14
• Urine output?
  ➔ some, but not measured
• ECG?
  ➔ Peaked T wave

Management for acute hyperkalemia for this case (opinion)

1. Place continuous cardiac monitor / ECG.
2. Give Ca gluconate 10ml (1 ampule) IV over 2-5 minutes.
3. Give 10U Insulin + 50% Dextrose 50ml.
4. Give Furosemide 100mg IV and NaHCO₃ at 200ml/hr.
5. Place Foley and monitor urine out put closely.
6. If urine output < 100ml/hr, will consider emergent HD (HD Ns called in).
Take home messages

- Serum K is slightly higher than that in plasma or whole blood due to K release from coagulation, which is clinically ignorable in normal situations.
- ECG changes in hyperkalemia is divided to depolarization abnormalities (prolonged PR / wide QRS / P wave disappearance) and repolarization abnormalities (peaked T wave).
- Ca is indicated for depolarization abnormalities in hyper K.
- Continuous cardiac monitoring is more important than ECG alone in hyper K.
- IV Isotonic NaHCO₃ (1.26%) and Furosemide use could be considered for hyper K, if acidosis and good urine output exist (opinion!).