Emergencies in Nephrology

Hyperkalaemia

Mohan Shenoy
Consultant Paediatric Nephrologist
Royal Manchester Children’s Hospital
Hyperkalaemia

- Potassium most abundant intracellular cation
  - 100 - 150 mmol/l
- Absorption from GI tract is rapid and complete
- ECF concentration 3.5 – 5.5 mmol/l maintained by renal and extra-renal mechanisms
- Excretion mainly occurs via the kidney
- Dietary intake can vary
Table 1  Potassium content of selected foods

<table>
<thead>
<tr>
<th>Foods and drinks</th>
<th>Potassium content (mmol)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 small banana (85 g)</td>
<td>8.6</td>
</tr>
<tr>
<td>Blueberries (100 g)</td>
<td>1.9</td>
</tr>
<tr>
<td>White mushrooms (75 g)</td>
<td>8.1</td>
</tr>
<tr>
<td>Broccoli, cooked (75 g)</td>
<td>5.8</td>
</tr>
<tr>
<td>Green beans, cooked (75 g)</td>
<td>3.9</td>
</tr>
<tr>
<td>Onions, cooked (75 g)</td>
<td>1.5</td>
</tr>
<tr>
<td>French fries (150 g)</td>
<td>17.7</td>
</tr>
<tr>
<td>Parboiled rice (150 g)</td>
<td>2.2</td>
</tr>
<tr>
<td>Spaghetti, without egg (150 g)</td>
<td>2.3</td>
</tr>
<tr>
<td>Orange juice (200 ml)</td>
<td>7.9</td>
</tr>
<tr>
<td>Milk, full fat (200 ml)</td>
<td>7.7</td>
</tr>
<tr>
<td>Coca Cola (200 ml)</td>
<td>0.1</td>
</tr>
<tr>
<td>Potato crisps (20 g)</td>
<td>5.1</td>
</tr>
<tr>
<td>Milk chocolate bar (20 g)</td>
<td>2.4</td>
</tr>
<tr>
<td>White chocolate (20 g)</td>
<td>1.8</td>
</tr>
</tbody>
</table>
Hyperkalaemia: Causes

- Impaired excretion
  - CKD estimated GFR <15ml/min/1.73m²
  - Medications
  - Hypoaldosteronism
  - Congenital adrenal hyperplasia
<table>
<thead>
<tr>
<th>Drug</th>
<th>Mechanisms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amiloride</td>
<td>Blocking sodium channels of luminal membrane of principal cells</td>
</tr>
<tr>
<td>Spironolactone</td>
<td>Mineralocorticoid receptor antagonist (competing with aldosterone)</td>
</tr>
<tr>
<td></td>
<td>Inhibition of adrenal aldosterone biosynthesis</td>
</tr>
<tr>
<td>Cyclosporine, Tacrolimus</td>
<td>Inhibition of adrenal aldosterone biosynthesis</td>
</tr>
<tr>
<td></td>
<td>Induction of chloride channel shunt</td>
</tr>
<tr>
<td></td>
<td>Increasing potassium efflux from cells</td>
</tr>
<tr>
<td>Trimetoprim, Pentamidine</td>
<td>Blocking of sodium channels in the luminal membrane of principal cells</td>
</tr>
<tr>
<td>NSAIDs</td>
<td>Induction of hyporeninemic hypoaldosteronism through inhibiting renal prostaglandin synthesis</td>
</tr>
<tr>
<td>ACE inhibitors, Angiotensin-II receptor antagonists</td>
<td>Reduction in adrenal aldosterone biosynthesis through interrupting renin-aldosterone axis</td>
</tr>
<tr>
<td></td>
<td>Reduction in effective glomerular filtration rate</td>
</tr>
<tr>
<td>Beta blockers</td>
<td>Inhibiting renin secretion</td>
</tr>
<tr>
<td></td>
<td>Decrease in cellular potassium uptake</td>
</tr>
<tr>
<td>Calcium channels blockers (Nifedipine, Amlodipine)</td>
<td>Inhibition of adrenal aldosterone biosynthesis</td>
</tr>
<tr>
<td></td>
<td>Reduction in aldosterone secretion</td>
</tr>
<tr>
<td>Succinylcholine</td>
<td>Leakage of potassium out of cells through depolarization of cell membranes</td>
</tr>
<tr>
<td>Digoxin</td>
<td>Inhibition of $\text{Na}^+\text{K}^+-\text{ATPase}$</td>
</tr>
</tbody>
</table>
Hyperkalaemia: Causes

- Increased shift from ICF to ECF
  - Acidosis
  - DM
  - Acute cell tissue breakdown (rhabdomyolysis, tumour lysis syndrome)
  - Drugs (digoxin, beta blockers)
  - Hyperkalaemic periodic paralysis
Psuedohyperkalaemia

- High K in a child who is well and no underlying cause
- Sampling error (common)
- Excess alcohol on the skin
- EDTA contamination
Hyperkalaemia: Diagnosis

- Mild K 5.5 - 6.5
- Moderate 6.6 – 7.5
- Severe >7.5

- Remember hyperkalaemia is often asymptomatic until it is life-threatening!
ECG changes

Figure 5. Plasma potassium and ECG abnormalities

- 10.5+: Further QRS widening and ST depression
- 9.5+: QRS widening, ST depression, and peaked T wave
- 8.5+: Absent P wave, ST depression, and peaked T wave
- 7.5+: Prolonged PR interval, peaked T wave
- 6.5+: Normal
- 3.5+: ST depression, low amplitude T wave, and prominent U wave
- 2.0+: Further ST depression and prominence of U wave
- 1.0+: VT or VF, nodal rhythm, 1st AV block, and sinus bradycardia or arrest

*Modified from Williams GS et al. and Goldberger E*
Emergency Treatment of Hyperkalaemia

- Identify and eliminate sources of K intake
- In the event of ECG changes, administer 10% calcium carbonate (or gluconate) 0.5ml/kg
- Nebulised salbutamol 5 – 10mg or IV 4-5mcg/kg
- If serum bicarbonate <20mmol/l, administer 8.4% sodium bicarbonate 1mmol/kg over 30 minutes
- Glucose 0.5g/kg (5ml/kg 10% dextrose) and insulin 0.1U/kg intravenous over 30 minutes
- Sodium polystyrene sulphonate 125-250mg/kg PO or PR, can be repeated 6-8 hourly
Before and after calcium carbonate
Emergency Treatment of Hyperkalaemia

- Identify and eliminate sources of K intake

- In the event of ECG changes, administer 10% calcium carbonate (or gluconate) 0.5ml/kg

- Nebulised salbutamol 5 – 10mg or IV 4-5mcg/kg

- If serum bicarbonate <20mmol/l, administer 8.4% sodium bicarbonate 1mmol/kg over 30 minutes

- Glucose 0.5g/kg (5ml/kg 10% dextrose) and insulin 0.1U/kg intravenous over 30 minutes

- Sodium polystyrene sulphonate 125-250mg/kg PO or PR, can be repeated 6-8 hourly
Hyperkalaemia: Case 1

- 8 yr male, CKD due to dysplasia, hypertension
- Admitted with vomiting illness
- Na 128, K 7.1, Ur 32, Cr 245 (baseline ~150), HCO3 14
- Management?
Hyperkalaemia case 1: Assessment

- Temperature, vomiting
- Diet
- Urine output
- Medications
  - Atenolol, enalapril
  - No h/o NSAID
- Weight loss – 1.5kg
Hyperkalaemia Case 1: Management

- Salbutamol neb 5mg x 2
- 0.9% saline 20ml/kg over an hour
- 1mmol/kg NaHCO3
- Stop ACEi
- Dietetic input

- K 4.8 in 6 hours
Hyperkalaemia: Case 2

- 5 yr girl attending respiratory clinic
- Has routine bloods: FBC, U&E, LFT, bone, CRP
- Na 120, K 8.5, HCO3 14, Ur 3.6, Cr 38, CoCa 1.5, Mg 0.3
- Diagnosis?
Psuedohyperkalaemia

- EDTA contamination
  - Common problem
  - Always obtain U&E sample prior to FBC
Case 3

• 7 day male infant
• Brought in unwell, poor feeding
• 15% weight loss, tachycardia, poor perfusion

• Na 121, K 7.9, HCO3 13, Ur 15.8, Cr 102, BM 4
Congenital Adrenal Hyperplasia

• Management
  • Fluid resuscitation with 0.9% saline
  • Hydrocortisone
  • Fludrocortisone
  • Salt supplements
Hyperkalaemia Case 4

- 34 week gestation, BWt 2.1kg (9\textsuperscript{th} centile)
- Admitted at 6 weeks of age with ‘funny spells’
- ?colic ?GOR ?seizure
- Bloods
  - Na 135, K 7.0, Ur 2.7, Cr 22, HCO3 19
↑K

Spurious
- Haemolysis
- Leucocytosis
- Thrombocytosis
- Familial
- Psuedohyperkalaemia

Impaired renal excretion

↓GFR

Normal GFR

Transcellular shift

- Acidosis
- Hyperglycaemia
- Hypertonicity
- Drugs
- Exercise
↑K

- Spurious
  - Haemolysis
  - Leucocytosis
  - Thrombocytosis
  - Familial
  - Pseudohyperkalaemia

- Impaired renal excretion
  - GFR

- Transcellular shift
  - Acidosis
  - Hyperglycaemia
  - Hypertonicity
  - Drugs

- Normal GFR
Case 4: Investigations

- Urine Na 15
- Urine K 12
- Fe Na 0.9%
- FeK 4%
Case 4: Evidence of impaired renal excretion

- TTKG – transtubular potassium gradient

- \[ \text{TTKG} = \frac{\text{UK}^+ \times \text{Posm}}{\text{Uosm} \times \text{PK}^+} \]

- >7 if hyperkalaemic and <2.5 if hypokalaemic

- TTKG was 4 when the serum \( K^+ \) 6.8

- Hyperkalaemia, acidosis, low renin

- Diagnosis?
Case 4: Diagnosis

- Gordon Syndrome or pseudohypoaldosteronism
- Father also had hypertension and K 6.5
- Genetic confirmation of diagnosis
Investigations

- Full blood count
- Hemolytic anemia
- HUS
- Thrombocytosis
- Infection & sepsis
- Acidosis
- Calculation of TTKG
- Acute and chronic renal insufficiency
- Rhabdomyolysis
- Hemolysis, tumor lysis
- Hemolysis, tumor lysis
- Diabetes mellitus
- Hyporeninemic hypoaldosteronism, pseudohypoaldosteronism
- Reduced enzyme activities in congenital adrenal hyperplasia

- Blood gas analysis
- Serum osmolality
- Creatinine, urea
- CK
- ALT
- LDH
- Glucose, glycosylated hemoglobin
- Renin, angiotensin, aldosterone
- Cortisol, 11-beta hydroxylase or 21-hydroxylase or 17-OH progesterone in plasma
Hyperkalaemia: Investigations

- Urine
  - Na
  - K
  - Cr
  - Urine protein creatinine ratio
  - Osmolality

- TTKG
Hyperkalemia: take home messages

- Asymptomatic until it is almost too late
- Commence salbutamol neb pending further evaluation
- Exclude spurious hyperkalaemia
- Correct dehydration and acidosis
- Review medications and diet (in CKD)

Lehnhardt, Kemper Ped Neph 2011