

(i) Bradycardia.
 - Bradycardia is an ominous complication of hyperkalaemia and these patients pose several dilemmas. Firstly, there is no widely available guidance for the use of calcium salts for bradycardia induced by hyperkalaemia. As bradycardia is listed as a potential adverse effect of calcium salts, there may be reluctance to use calcium salts even in the context of severe hyperkalaemia.
 - The response to atropine is usually poor and temporary pacing may be considered although there is some evidence to suggest a reduced efficacy of temporary pacing in this setting
 - A universal recommendation is difficult in the face of little evidence, but haemodialysis usually resolves the bradycardia without the need for cardiac intervention.

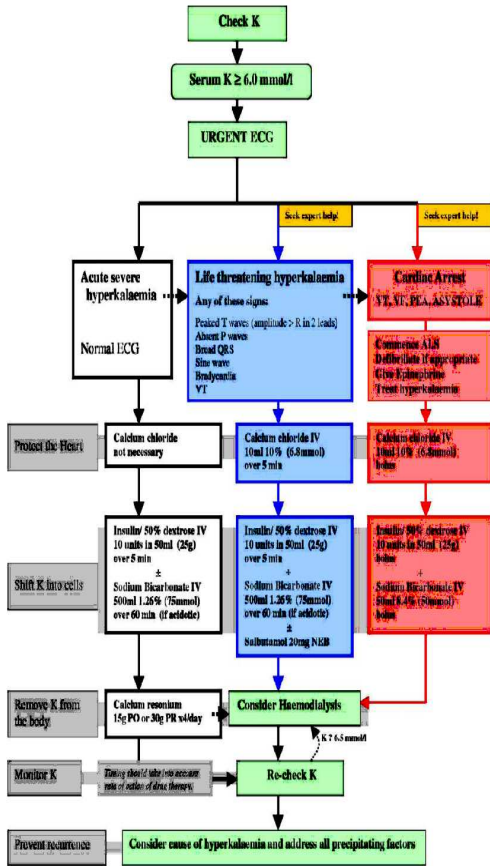
(ii) Asystole.
 - The outcome of asystolic cardiac arrest due to hyperkalaemia is usually fatal unless the serum potassium can be returned to normal. Despite this, there are several reports of successful resuscitation in patients presenting with or developing asystole as a result of severe hyperkalaemia. Dialysis was necessary during the course of cardiopulmonary resuscitation (CPR) in most of these cases to lower the serum potassium.

(iii) Ventricular tachycardia.
 - Ventricular tachycardia (VT) is a recognised manifestation of hyperkalaemia but it is more commonly reported in association with hypokalaemia. It has also been suggested that the presence of a broad complex tachycardia induced by hyperkalaemia may be misinterpreted as VT instead of a sine-wave pattern.

(iv) Ventricular fibrillation.
 - Ventricular fibrillation (VF) is often presented as the natural transition from a sine-wave pattern in the presence of extreme hyperkalaemia (K > 8.0 mmol/l). Analogous to resuscitation for hypothermia, it is important to recognise that defibrillation is frequently unsuccessful until the serum potassium is controlled and CPR should be prolonged.

(v) Pulseless electrical activity (PEA).
 - Any electrolyte disorder may present as PEA, including hyperkalaemia. There are few reports in the literature of successful resuscitation with PEA as the presenting rhythm of cardiac arrest. In each case, prolonged resuscitation was required.

Arrhythmogenic effects	ECG changes	Arrhythmia
Less negative RMP	Peaked T-waves	Sinus node suppression
Inactivation of fast Na ⁺ channels	Widening of P-wave and QRS complex	AV block
Slowed conduction velocity		VF



K - potassium; IV - intravenous; NEB - nebulised sodium bicarbonate; PO - oral; PR - per rectum; ESRF - end-stage renal failure

Figure 2 Emergency treatment algorithm for hyperkalaemia in adults.

arrhythmias

general

- Hyperkalaemia is the most common electrolyte disorder associated with potentially life-threatening arrhythmias and cardiopulmonary arrest.
 - It is defined as a serum potassium concentration above 5.0 mmol/l and may be classified as mild (K 5.0-5.9 mmol/l), moderate (K 6.0-6.4 mmol/l) or severe (K=6.5 mmol/l).
 - A potassium concentration above 10.0 mmol/l is usually fatal unless emergency treatment is readily instituted, however survival with extreme hyperkalaemia (K 14 mmol/l) has been reported.

pseudohyperkalaemia

- Pseudohyperkalaemia, also known as spurious hyperkalaemia, is defined as a difference between serum and plasma potassium greater than 0.4 mmol/l.
 - It should be suspected in patients with hyperviscosity syndromes such as polycythemia rubra vera, in the absence of ECG changes despite severe hyperkalaemia and when sample storage has been prolonged or inadequate.
 - rarely pseudohyperkalaemia may occur due to malposition of the arterial cannula resulting in a high shear rate and haemolysis.

hyperkalaemia [created by Paul Young, 17/12/07]

causes

Drugs	ACE-inhibitors – e.g. ramipril, captopril Angiotensin Receptor Blockers – e.g. losartan NSAIDs – e.g. ibuprofen, diclofenac Beta-blockers – e.g. atenolol K ⁺ supplements – e.g. oral or IV replacement K ⁺ sparing diuretics – e.g. spironolactone Antibiotics – e.g. trimethoprim Anaesthetic agents – e.g. suxamethonium
Renal and metabolic diseases	Acute renal failure Chronic renal failure Type 4 renal tubular acidosis Metabolic acidosis
Diet	Foods with high potassium content Fasting – relative lack of insulin Salt substitute – 'Lo salt'
Endocrine disorders	Addison's Disease Hyporeninaemia Insulin deficiency/Hyperglycaemia
Haematological disorder/ Massive Cell Death	Tumour lysis syndrome Rhabdomyolysis Massive blood transfusion Massive haemolysis – mechanical cell damage
Others	Hyperkalaemic periodic paralysis Pseudo-hyperkalaemia Abnormal erythrocytes Thrombocytosis Leucocytosis

ACE: angiotensin converting enzyme; K⁺: potassium; NSAIDs: non-steroidal anti-inflammatory drugs; IV: intravenous.

symptoms

- Patients may present with weakness progressing to flaccid paralysis, paraesthesia, depressed deep tendon reflexes or respiratory difficulties. However, the absence of these symptoms should not lead to a false sense of security if the clinical history suggests a high risk of an electrolyte disturbance.

ECG changes

Potassium (mmol/l)	MAJOR ECG CHANGES
5.5	Tall, peaked (tent) T waves [T wave larger than R wave in more than 1 lead]
6.5	
7.0	Prolonged PR interval Flattened or absent P waves
7.5	
8.0	Widened QRS [greater than 0.12 seconds] Sine wave pattern (S and T waves merging) Bradycardia Ventricular tachycardia
8.5	
>9.0	

High risk of Cardiac arrest

There is some degree of overlap of ECG features in hyperkalaemia. As serum potassium rises above 7 mmol/l, more than one abnormality may be present. The risk of cardiac arrest increases with rising serum potassium and the presence of ominous ECG signs indicated above.