Survival after cardiopulmonary arrest with extreme hyperkalaemia and hypothermia in a patient with metformin-associated lactic acidosis

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SUMMARY

Potassium levels are regularly used as a prognostic factor to cease resuscitation in significant hypothermia. In this case report, we highlight how survival is still possible with extreme hyperkalaemia in severe hypothermia. We present a case of a 65-year-old Caucasian man who presented with metformin associated lactic acidosis. On presentation he had potassium of 9.1 mmol/l and a temperature of 31.5°C. Cardiopulmonary resuscitation was commenced when he went into asystolic arrest. This presentation would commonly make attempts at resuscitation futile with a 100% death rate. However, with appropriate management this patient's condition improved and survival was possible. We provide evidence that survival is possible in profound hyperkalaemia and hypothermia. Effective cardiopulmonary resuscitation with early haemofiltration can be successful.

BACKGROUND

Case series have previously reported potassium levels to be a prognostic marker of survival in hypothermia and cardiopulmonary arrest.[1 2] Only one previous case has been reported to have survived when potassium levels were more than 9 mmol/l.[3]

Hypothermia can cause electrolyte imbalances, primarily hyperkalaemia. This is secondary to cell death from cell-membrane damage, protein dysfunction or crystallisation of intracellular and extracellular water.[4]

Hyperkalemia, in itself, can then cause significant arrhythmias.[5 6] These include sinus bradycardia, sinus arrest, slow idioventricular rhythms, ventricular tachycardia, ventricular fibrillation and asystole.

Metformin toxicity causing lactic acidosis is a well-recognised complication with a mortality of up to 50%.[7 8] Its postulated mechanism is via the conversion of glucose to lactate in the small intestine[9] and inhibition of hepatic gluconeogenesis from lactate, pyruvate and alanine.[10]

We present a case of a patient with metformin-associated lactic acidosis, who went into cardiopulmonary arrest with a severe hyperkalaemia of 9.1 mmol/l and profound hypothermia of 31.5°C.

CASE PRESENTATION

A 65-year-old gentleman, with type 2 diabetes mellitus on metformin, stage 3 chronic kidney disease and New York Heart Association class 2 heart failure, presented to our emergency department with increasing dyspnoea and lethargy precipitated by melaena. His relevant medications included premixed insulin, atenolol, trandolapril, frusemide and spironolactone. He was also on warfarin for paroxysmal atrial fibrillation.

On presentation, he had a junctional rhythm with a rate 56 beats/min, blood pressure of 60/20 mm Hg and a respiratory rate of 36/min. He then developed complete heart block followed by asystole. Cardiopulmonary resuscitation was started. Along with adrenaline as per the advanced life-support protocol, 100 ml of 8.4% sodium bicarbonate and 6.8 mmol/l of calcium was administered. Return of spontaneous circulation occurred after 10 min.

Arterial blood gas analysis prior to his arrest showed a significant lactic acidosis and hyperkalaemia. His tympanic membrane temperature measured via infrared radiation was 31.5°C. The result of his blood analysis was pH 6.63 (normal: 7.35–7.45), pCO_2 27 mm Hg (normal: 35–45) and lactate 13.1 mmol/l (normal: 0.5–2.0).

In addition, he was found to be hypoglycaemic with a blood sugar level of 2.7 mmol/l. Laboratory results revealed anaemia with a haemoglobin of 6.0 g/dl, a severe coagulopathy (international normalised ratio (INR) >8.6 and activated partial thromboplastin time (APTT) 125 s) and a significant acute kidney injury with a creatinine of 881 µmol/l and urea of 48.2 mmol/l. Creatine kinase was 106 U/l (normal: less than 171 U/l).

He was subsequently transferred to our intensive care unit on an adrenaline infusion and commenced on continuous veno-venous haemofiltration for a total of 72 h. Active warming to normothermia was achieved over 24 h. The patient's chemical profile also improved significantly during this time: pH 7.31, potassium 5 mmol/l and lactate 5.7 mmol/l.

OUTCOME AND FOLLOW-UP

On day 3, the patient had regained his premorbid function and was discharged from the intensive care unit. There were no neurological deficits and his renal function had recovered back to baseline. His metformin was ceased prior to discharge back into his community.

DISCUSSION

Hyperkalaemia is a known prognostic factor for mortality in patients with temperatures less than 32°C.[1 2] Patients who have previously survived have had potassium levels less than 6 mmol/l. Only one previous patient who suffered a cardiorespiratory arrest and had a potassium level more than 9 mmol/l survived.[3] In that case, cardiopulmonary bypass was required.

Hypothermia itself usually produces hypokalaemia by shifting potassium into cells.[11 12] Lactic acidosis is also unlikely to increase potassium levels.[13 14] Instead, the cause of this patient's hyperkalaemia was multifactorial: a combination of decreased arterial blood volume depletion and pharmacotherapy. Blood volume depletion causes renal hypoperfusion and impaired potassium secretion into the tubular lumen.[15] In addition, his combination therapy of an ACE inhibitor and spironolactone would have decreased aldosterone release, further reducing potassium secretion by the kidneys.[16 17] This is in contrast to the population group commonly presenting with hypothermia and hyperkalaemia: young to middle-aged men, where the cause of hypothermia is either via an avalanche or drowning. The mechanism of hyperkalaemia in these cases is thought to be transfer of cellular potassium into the extracellular fluid following death before cooling.[1 2] This likely explains the different prognostic outcomes.

The immediate treatment of hyperkalaemia in this patient involved calcium, sodium bicarbonate and continuous veno-venous haemofiltration. Calcium directly antagonises the membrane actions of potassium.[18] Sodium bicarbonate works by raising the pH and causes release of hydrogen ions from cells as part of a buffering reaction. This, in turn, moves potassium intracellularly to maintain electroneutrality. Early renal replacement therapy allows for the continual removal of potassium and correction of acidosis, plus the ability for gentle active warming.

Sodium bicarbonate and early renal replacement therapy are also considered to be treatment options for metformin-associated lactic acidosis. Metformin-associated lactic acidosis is rare, with an incidence of less than 5.1 cases per 100 000 patient years.[19] It has a reported mortality of 45%.[20] The use of sodium bicarbonate, however, is recommended only when the pH is less than 7.1, even in the presence of severe hyperkalaemia. This is to manage the adverse effects of severe acidaemia, which can cause haemodynamic instability.[21] No benefit has been shown in the case of pH being greater than 7.1.[22]

Our choice of renal replacement therapy was continuous veno-venous haemofiltration. The primary benefit was that it offered better cardiovascular stability than haemodialysis.[23 24] This was important as the patient arrived in our intensive care unit with circulatory shock requiring inotropic support and would have been unable to tolerate the large fluid shifts involved with haemodialysis. The downside of continuous veno-venous haemofiltration is that the clearance of drugs are less compared to haemodialysis.[25 26] There is currently no evidence that says one modality is more advantageous than another. Given that neither lactate nor plasma metformin concentrations were of prognostic significance of survival,[20] we believe that the choice of modality should be based on haemodynamic stability alone.

Learning points

- Survival after cardiopulmonary arrest is possible in profound hyperkalaemia and hypothermia. It calls into question again the use of a potassium level more than 9 mmol/l as an absolute cut-off for withholding resuscitation.
- Management of these patients should include sodium bicarbonate and early continuous veno-venous haemofiltration to correct hyperkalaemia and severe acidosis.
- Renal replacement therapy also has the benefit of allowing gentle active warming.

Competing interests None.

Patient consent Obtained.

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