Hypokalaemia and refractory asystole complicating diabetic ketoacidosis, lessons for prevention

Salman Abdulaziz,[1] Ousama Dabbagh,[2] Mohamed Ousama Al Daker,[3] Imad Hassan[1]

[1]Department of Internal Medicine, King Abdulaziz Medical City, King Fahad National Guard Hospital, Riyadh, Saudi Arabia
[2]Division of Pulmonary, Critical Care and Environmental Medicine, University of Missouri, Columbia, Missouri, USA
[3]Division of Endocrinology, Department of Internal Medicine, King Abdulaziz Medical City, King Fahad National Guard Hospital, Riyadh, Saudi Arabia

Correspondence to
Dr Salman Abdulaziz,
dr-salman@hotmail.com

To cite: Abdulaziz S, Dabbagh O, Al Daker MO, *et al*. *BMJ Case Reports* Published online: 5 December 2012 doi:10.1136/bcr-2012-007312

SUMMARY

Summary We report a unique case of diabetic ketoacidosis in which a relatively low potassium level on admission was associated with consequent life-threatening and refractory arrhythmia secondary to inappropriate use of intravenous insulin and bicarbonate therapy. The latter was reversed by rapid bolus potassium injection. Although we do not advocate this approach in every case, we emphasise that a bolus injection of potassium may be life saving in such cases. The lessons from this case have led to multidisciplinary meetings and modification of the institute's diabetic ketoacidosis clinical pathway.

BACKGROUND

Severe hypokalaemia may precipitate profound and life-threatening cardiac complications including arrhythmia and asystole. It has also been cited in the literature as an important cause to consider in resuscitation-refractory cardiac arrest.[1] Slow potassium infusion over an extended period of time is the recommended therapeutic modality for parenteral potassium replacement, yet more rapid potassium injections may be warranted in special circumstances.[2 3]

In this report, we describe the case of a 23-year-old woman, who had a cardiac arrest secondary to severe hypokalaemia complicating diabetic ketoacidosis because of the aggressive use of bicarbonate therapy. Full recovery after successful resuscitation followed bolus replacement of potassium via central venous injections. We additionally report on mandatory changes and amendments to the hospital's diabetic ketoacidosis clinical pathway that were introduced in the wake of the complicated clinical course this patient had.

CASE PRESENTATION

A 23-year-old woman presented to the emergency room with a history of generalised fatigue and decreased level of consciousness. She had 2 weeks history of polyuria, polydipsia, weight loss and a cough productive of yellow sputum. Medical history was negative.

On examination, the patient looked ill, drowsy (Glasgow Coma Score, GCS = 10/15), in respiratory distress and was dehydrated. Vital signs examination revealed an oral temperature of 36.5°C, a regular pulse of 110/min, blood pressure of 135/85 mm Hg with significant postural drop and a respiratory rate of 24/min oxygen saturation (SaO_2) was 85% on room air. The jugular venous waves were not visible and heart sounds were normal. Respiratory system examination was normal apart from right-sided lower zone coarse crackles. There were no meningeal signs, focal or other neurological abnormalities. Abdominal and gynaecological examinations were similarly normal.

INVESTIGATIONS

Her laboratory investigations on admission are shown in table 1.

The patient was in severe metabolic acidosis with pH 6.90, $PaCO_2$ 21.1 mm Hg, PaO_2 50.0 mm Hg and $HCO3^-$ 4.1 mmol/l. Her electrocardiogram showed sinus tachycardia with no QT-interval prolongation.

TREATMENT

The patient was initially given 1 l bolus of isotonic saline followed by an average of 1 litre of isotonic saline per hour; however, potassium chloride was added soon to the intravenous fluid. Four units intravenous bolus of regular insulin was given followed by a 4 units/h regular insulin infusion.

She was electively intubated owing to low oxygen saturation and low GCS. Potassium chloride 40 mEq/1 of normal saline was started at a rate of 100 cc/h. Hundred millilitres of 8.4% sodium bicarbonate intravenous bolus was given to correct the acidosis.

OUTCOME AND FOLLOW-UP

Around 2 h after bicarbonate administration, the patient developed pulseless wide QRS complex ventricular tachycardia and cardiopulmonary resuscitation (CPR) was commenced. Ventricular fibrillation (VF) ensued for which a biphasic 150 J nonsynchronised DC shock was delivered. A 4 min asystole followed, for which a transcutaneous pacemaker was attached. Cardiopulmonary resuscitation was continued and magnesium sulphate, as well as calcium chloride, was infused. The patient briefly regained normal pulse before reverting back to VF followed by asystole. The latter was refractory to repeated epinephrine doses. Intravenous insulin infusion was discontinued immediately after hypokalaemia was suspected and stat potassium level was reported to be 1.7 mmol/l. A 40 mmol of KCl intravenous bolus was given immediately through the central line and this led to immediate reversal of asystole and a return to sinus rhythm.

The patient was then transferred to the intensive care unit. Insulin infusion was held till the potassium level reached 3.3 mmol/l, while the potassium infusion was running to correct hypokalaemia. (table 2) No more doses of bicarbonate were given. Intravenous Tazocin was started to treat possible aspiration pneumonia. Echocardiogram was normal and she did not have any further arrhythmias. Enteral nutrition was started after closure of the

Table 1 Patient's laboratory data at presentation

Electrolyte	Normal laboratory values	Patient investigations
Serum sodium (Na^+)	136–145	120 mmol/l
Serum potassium (K^+)	3.5–5.1	3.6 mmol/l
Serum chloride (Cl^-)	98–107	96 mmol/l
Serum bicarbonate ($HCO3^-$)	20–31	8 mmol/l
Blood urea nitrogen	2.1–7.1	5.5 mmol/l
Serum creatinine	53–97	166 μmol/l
Random blood glucose	4.1–5.9	74.5 mmol/l
Serum ketones	Negative	+++
Serum osmolality	275–295	348 mosmol/kg
HbA1c	4–6%	10.5%

HbA1c, glycated haemoglobin.

anion gap and intravenous insulin was switched to subcutaneous insulin-sliding scale. A period of 24 h after presentation, she was successfully weaned of sedation and extubated. She had an uneventful recovery with no residual neurological deficit. On the second day, she was transferred to the general ward where she stayed for 2 days. A multidisciplinary team consisting of an endocrinologist, diabetic educator and nutritionist oversaw her diabetes mellitus care and education. She was seen 2 weeks after discharge in the outpatient clinic and she appeared normal with no detectable neurological deficit.

DISCUSSION

Hypokalaemia, defined as a potassium level of less than 3.6 mmol/l, occurs in over 20% of hospitalised patients.[4] There are many causes of hypokalaemia, the commonest being increased losses classically from the gastrointestinal or urinary tract. Increased potassium translocation into the cells with increased availability of insulin or elevation of extracellular pH is another mechanism lowering the extracellular potassium level.

The clinical consequences vary in severity depending on the acuteness and degree of hypokalaemia. Mild degrees of the latter are usually asymptomatic while more severe degrees may lead to marked muscle weakness, ileus and cardiac dysrhythmia. Electrophysiologically, hypokalaemia is arrhythmogenic as it increases both cardiac automaticity and refractory period of action potential.[5]

Hypokalaemia in patients with diabetic ketoacidosis is multifactorial and is primarily related to increased renal losses (osmotic diuresis) possibly compounded by associated gastrointestinal losses (vomiting) and reduced oral intake.[6 7] However, low serum potassium on presentation is unusual (in spite of a total potassium deficit of around 3–5 mg per/kg), as insulin deficiency, hyperosmolality and acidaemia tend to maintain a normal or even a high extracellular potassium level.[6 7] Thus, hypokalaemia on presentation signifies a profound total potassium deficit and is considered a marker of a very severe ketoacidotic hyperglycaemic state.[6 7]

In our patient, the initial potassium level was 3.6 mmol/l. Stat insulin therapy followed by a bolus of bicarbonate to elevate extracellular pH led to further dramatic fall in serum potassium culminating in ventricular tachycardia and refractory asystole.

At the time the patient was on a continuous slow potassium-saline infusion, however, asystole was only reversed when a bolus of potassium chloride was injected centrally. Rapid intravenous infusions of potassium even in potassium-depleted patients are not recommended, as they are potentially dangerous.[2] A rate of 10–20 mmol/h is the generally recommended infusion rate. However, higher rates may be life saving in special circumstances, for example, in severe hypokalaemic muscle paralysis or in serious cardiac dysrhythmia as was the case with our patient.[8]

Lack of evidence regarding the benefit of bicarbonate therapy in patients with diabetic ketoacidosis makes its use limited to unusual cases with unstable haemodynamics.[9] This patient had a further drop of initial potassium after the administration of bolus bicarbonate injection culminating in refractory asystole.

Evidently, hypokalaemia became the issue and the therapeutic plan was changed accordingly. Significant as it is, acidosis was no longer, and actually was never, the immediate threat to this patient's life. It was always hypokalaemia. Acidosis may have killed this patient over a few hours. Severe hypokalaemia could do it in minutes.

The lessons from this unusual case were discussed in multidisciplinary meetings including the practice guidelines committee. Changes to the hospital's Diabetic Ketoacidosis Clinical Pathway were made and incorporated into clinical practice. These

Table 2 Follow-up arterial PH, serum chemistry, IV insulin and potassium chloride infusion to the patient

Item	2 h after IV $NaHCO_3$	½ h after KCl inj	2 h after KCl inj	4 h after KCl inj	6 h after KCl inj	8 h after KCl inj	10 h after KCl inj	12 h after KCl inj	14 h after KCl inj	16 h after KCl inj(*)
Arterial pH	7.01	7.05	7.10	7.12	7.15	7.23	7.26	7.30	7.32	7.39
Serum Na^+ (mmol/l)	138	139	148	151	150	148	146	144	144	140
Serum K^+ (mmol/l)	1.7	1.8	2.4	2.3	4.0	3.8	4.4	4.0	4.1	4.5
Serum Cl^- (mmol/l)	112	114	120	121	118	113	112	110	108	110
Serum $HCO3^-$ (mmol/l)	13	12	6	6	8	14	15	16	22	23
Anion gap	13	13	22	24	24	21	19	18	14	7
Serum glucose (mmol/l)	50.7	50.2	37.0	36.8	32.4	14.2	8.9	12.4	10.5	13.5
Creatinine (μmol/l)	126	128	114	96	88	82	73	68	63	44
IV insulin infusion (unit/h)	–	–	–	–	6	3	1	3	2	3
IV KCl infusion (mEq/l)	80	80	60	60	40	40	20	40	20	20

IV, intravenous; KCl inj, potassium choride Injection.
*Time of intravenous insulin switch to subcutaneous form.

included clear advice on appropriate replacement dosages according to the level of serum potassium and the appropriate use of intravenous insulin and bicarbonate therapy.[10] In addition, the case was thoroughly discussed in several medical case conferences and clinical meetings. Furthermore, the limitations and possible serious consequences of the inappropriate use of bicarbonate therapy, insulin infusion and inadequate potassium repletion in diabetic ketoacidosis were emphasised.

Learning points

- Insulin deficiency, hyperosmolality and metabolic acidosis tend to maintain a normal or even a high extracellular potassium level.
- Hypokalaemia on presentation signifies a profound total potassium deficit, caution with intravenous insulin as well as bicarbonate therapy should be considered.
- Bicarbonate therapy should be considered only if the pH is less than 7.0 and the patient is haemodynamically compromised.

Competing interests None.

Patient consent Obtained.

REFERENCES

1 Ornato JP, Gonzalez ER, Starke H, *et al*. Incidence and causes of hypokalemia associated with cardiac resuscitation. *Am J Emerg Med* 1985;3:503–6.
2 Paulley JW. Hypokalaemia and cardiac arrest. *Lancet* 1965;191:218–19.
3 Eisenberg MS, Mengert TJ. Cardiac resuscitation. *N Engl J Med* 2001;344:1304–13.
4 Gennari FJ. Hypokalemia. *N Engl J Med* 1998;339:451–8.
5 Podrid PJ. Potassium and ventricular arrhythmias. *Am J Cardiol* 1990;65:33E–44E.
6 Kreisberg RA. Diabetic ketoacidosis: new concepts and trends in pathogenesis and treatment. *Ann Intern Med* 1978;88:681–95.
7 Adrogué HJ, Lederer ED, Suki WN, *et al*. Determinants of plasma potassium levels in diabetic ketoacidosis. *Medicine (Baltimore)* 1986;65:163–72.
8 Nicolis GL, Kahn T, Sanchez A, *et al*. Glucose-induced hyperkalemia in diabetic subjects. *Arch Intern Med* 1981;141:49–53.
9 Viallon AF, Zeni F, Lafond P, *et al*. Does the bicarbonate therapy improve the management of severe diabetic ketoacidosis? *Critic Care Med* 1999;27:2690–3.
10 Kitabchi AE, Umpierrez GE, Murphy MB, *et al*. Hyperglycemic crises in diabetes. *Diabetes Care* 2004;27:94–102.