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Interesting Case

Severe hyperkalaemia in association with diabetic ketoacidosis in a patient presenting with severe generalized muscle weakness

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Introduction

Diabetic ketoacidosis (DKA) is an acute, life-threatening metabolic complication of diabetes mellitus. Hyperglycaemia, ketosis (ketonaemia or ketonuria) and acidosis are the cardinal features of DKA [1]. Other features that indicate the severity of DKA include volume depletion, acidosis and concurrent electrolyte disturbances, especially abnormalities of potassium homeostasis [1,2]. We describe a type 2 diabetic patient presenting with severe generalized muscle weakness and electrocardiographic evidence of severe hyperkalaemia in association with DKA and discuss the related pathophysiology.

Case

A 65-year-old male was admitted because of impaired mental status. He was a known insulin-treated diabetic on quinapril (20 mg once daily) and was taking oral ampicillin 500 mg/day because of dysuria which had started 5 days prior to admission. He was disoriented in place and time with severe generalized muscle weakness; he was apyrexial (temperature 36.4°C), tachycardic (120 beats/min) and tachypneic (25 respirations/min) with cold extremities (supine blood pressure was 100/60 mmHg). An electrocardiogram (ECG) showed absent P waves, widening of QRS ('sine wave' in leads I, II, V5 and V6), depression of ST segments and tall peaked symmetrical T waves in leads V3–V6 (Figure 1).

Blood glucose was 485 mg/dl, plasma creatinine 5.1 mg/dl (reference range (r.r.) 0.6–1.2 mg/dl, measured by the Jaffe method), urea 270 mg/dl (r.r. 11–54 mg/dl), albumin 4.2 g/dl (r.r. 3.4–4.7 g/dl), sodium 136 mmol/l (r.r. 135–145 mmol/l), chloride 102 mmol/l (r.r. 98–107 mmol/l), potassium 8.3 mmol/l (r.r. 3.5–5.4 mmol/l), phosphorus 1.6 mmol/l (r.r. 0.8–1.45 mmol/l) and magnesium 0.62 mmol/l (r.r. 0.75–1.25 mmol/l). A complete blood count revealed leukocytosis (12 090/μl with 90% neutrophils), haematocrit 0.42, erythrocyte sedimentation rate 45 mm/h and C-reactive protein was 32 mg/l. Calculated plasma osmolality was 360 mOsm/kg. Plasma aminotransferases, albumin, lactic dehydrogenase, creatinine kinase and troponin I levels were all within normal limits. There was glucosuria and ketonuria, but urine microscopy was normal. A rapid arterial blood gas analysis showed plasma pH 7.07, pCO_2 49.3 mmHg, pO_2 62 mmHg and bicarbonate 13.7 mmol/l, with an anion gap of 20.2 mmol/l (normal range 5–11 mmol/l).

The patient was immediately resuscitated with normal saline and given intravenous insulin at 6 U/h. Ampicillin was continued intravenously (500 mg q6h). Blood haematology and biochemistry results obtained 2 h later revealed haematocrit 0.38, white blood cells 9020/μl, glucose 234 mg/dl, creatinine 2.7 mg/dl, urea 185 mg/dl, sodium 135 mmol/l, potassium 5.5 mmol/l, phosphorus 0.86 mmol/l and magnesium 0.58 mmol/l. There were no ECG abnormalities, except for sinus tachycardia. A repeat arterial blood gas analysis with the patient on oxygen showed plasma pH 7.24, pCO_2 25 mmHg, pO_2 96.4 mmHg and bicarbonate 10.3 mmol/l. Twelve hours later, these values were pH 7.30, pCO_2 26.7 mmHg, pO_2 93 mmHg, bicarbonate 13.2 mmol/l and plasma potassium had returned to normal (4.8 mmol/l). The patient was fully alert and mobile. He had an uneventful recovery and was discharged after 11 days with normal renal function and plasma electrolyte concentrations.

Discussion

Acid–base and potassium disturbances are common in patients with uncontrolled diabetes mellitus [1,2]. This was an interesting case of DKA presenting

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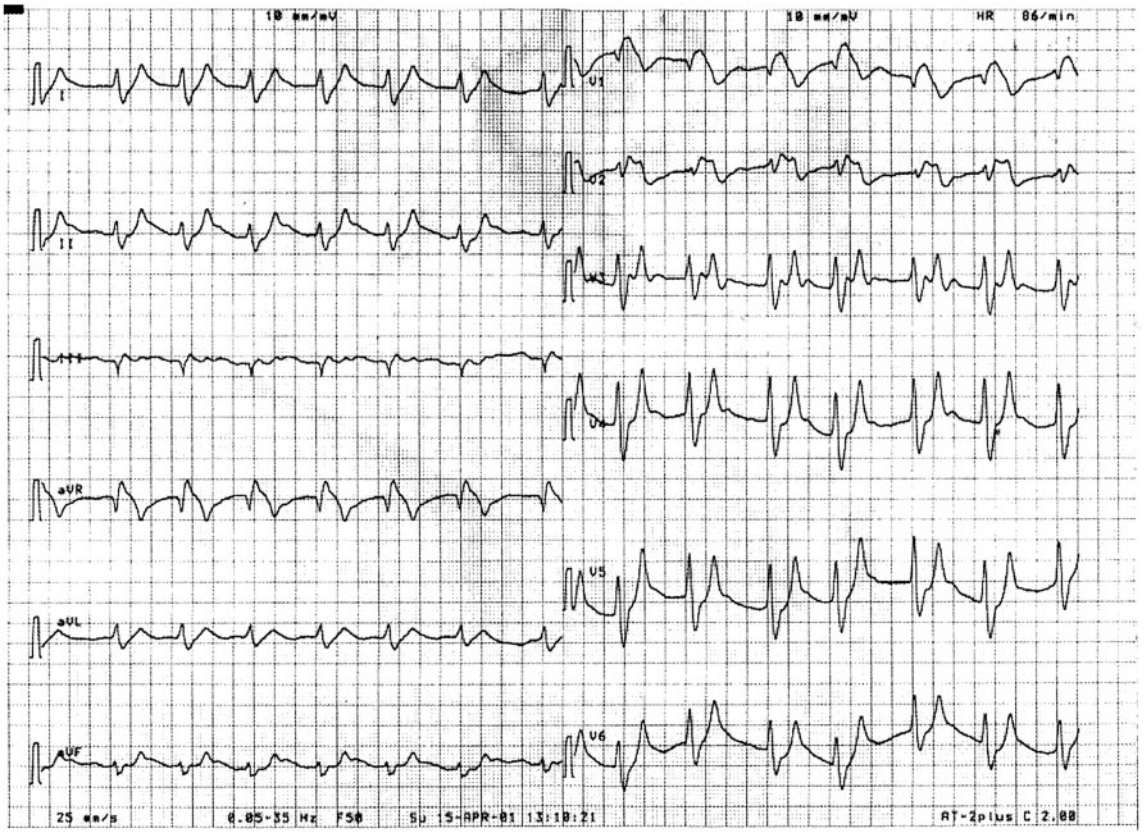

Fig. 1. Initial ECG performed at the Emergency Department at the University Hospital of Ioannina (serum potassium 8.3 mmol/l, pH 7.07).

as an emergency, with neurological symptoms and electrocardiographic changes associated with hyperkalaemia. Decompensated metabolic acidosis (as manifested by hypercapnia) and ECG abnormalities indicate the need for rapid intervention and a meticulous approach to management [1,2].

The development of metabolic acidosis causes a compensatory hyperventilatory response owing to stimulation of both the central and peripheral chemoreceptors. This increase in alveolar ventilation results in a drop in pCO_2, which tends to raise pH towards normal. In contrast to other causes of acidaemia, in cases of DKA it is the carotid body chemoreceptors that provide the major stimulus for respiration driven by a reduced pH. This means that hyperventilation is taking place earlier in DKA. However, in this case, pCO_2 was raised, suggesting inadequate respiratory compensation, which may have been related to profound hyperkalaemia. Potassium excess (>8 mmol/l) is associated with muscle weakness. The lower extremities are affected initially, the trunk and upper extremities being affected later [2]. Respiratory muscle involvement is rare and presents a life-threatening complication. In this case, respiratory muscle weakness was related to high plasma potassium levels adversely affecting the respiratory compensatory mechanisms. On the other hand, acidosis was aggravated by hyperkalaemia, which is known to induce a mild metabolic acidosis by impairing NH^+ production and excretion [2].

Mild to moderate increases in serum potassium occur frequently with DKA [2,3]. However, severe hyperkalaemia is uncommon and is likely to be a consequence of acidosis, insulin deficiency, hyperosmolality, severe dehydration and renal potassium retention [2,3].

It is well documented that the buffering of excess hydrogen ions in cells leads to potassium movement into the extracellular fluid in order to maintain electoneutrality. This is true in metabolic acidosis caused by accumulation of mineral acids (normal-anion gap, hyperchloraemic acidosis), but is less likely to occur in the organic acidoses, such as DKA [2]. Thus, the acidaemia could not explain the severe hyperkalaemia noted in this patient. In DKA, the combination of insulin deficiency and the hyperglycaemia-induced hyperosmolality frequently leads to hyperkalaemia, even though the patient may be markedly potassium-depleted owing to potassium losses in the urine secondary to osmotic diuresis [1,2]. Insulin promotes potassium entry into cells. When circulating insulin is lacking, as in DKA, potassium moves out of cells, thus raising plasma potassium levels even in the presence of total body potassium deficiency [2,3]. Furthermore, an elevation in plasma osmolality causes osmotic water movement from the cells into the

extracellular fluid, which is paralleled by potassium movement out of the cells.

Most of urinary potassium is derived from potassium secretion in the distal nephron, particularly by the principal cells in the cortical collecting tubule. This process is mainly influenced by two factors: aldosterone and the distal delivery of sodium and water [2]. In cases of severe volume depletion, the ability to handle a potassium load is impaired due to decreased distal fluid delivery, which can diminish potassium secretion despite the hypovolaemia-induced secondary hyperaldosteronism [2]. Notably, in our patient the administration of an angiotensin-converting enzyme inhibitor (namely quinapril) can limit the aldosterone release, thus aggravating the hyperkalaemia. These drugs can reduce the concentrations of circulating angiotensin II and diminish the intra-adrenal angiotensin II, which can mediate part or most of the stimulating effect of hyperkalaemia [2,4]. Hyporeninaemic hypoaldosteronism (presenting as asymptomatic hyperkalaemia in patients with long-standing diabetes mellitus) could result in a further increase in potassium levels. However, this was not true in the present case, as the patient's plasma creatinine, urea, potassium, chloride and bicarbonate levels restored to normal upon discharge [2,3].

Pre-renal azotaemia in patients with DKA is primarily due to volume depletion and/or relative hypotension leading to reduced glomerular perfusion and impairment of renal function [1,2]. However, creatinine levels may not always securely predict the status of hydration and the target towards fluid resuscitation. Elevated serum creatinine levels in patients with uncontrolled diabetes mellitus should be evaluated in the light of baseline values. Methodological problems must be considered because certain substances may interfere with the assay (especially colorimetric assays), thereby artefactually increasing serum creatinine levels. Enzymatic assays, which lack this interference, may be more advantageous on these occasions.

References

1. Elisaf MS, Tsatsoulis AA, Katopodis KP, Siamopoulos KC. Acid–base and electrolyte disturbances in patients with diabetic ketoacidosis. *Diabetes Res Clin Pract* 1996; 34: 23–27
2. Rose BD, Post TW. *Clinical Physiology of Acid–Base and Electrolyte Disorders*, edn 5. McGraw-Hill, New York, 2001; 578–646 and 888–930
3. Halperin ML, Kamel SK. Potassium. *Lancet* 1998; 352: 135–140
4. Siamopoulos KC, Elisaf M, Katopodis K. Iatrogenic hyperkalemia—points to consider in diagnosis and management. *Nephrol Dial Transplant* 1998; 13: 2402–2406

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