

Teaching Point (Section Editor: A. Meyrier)

Who is teaching ‘Fluid and Electrolytes’?

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Keywords: Addison’s disease; hyperkalaemia; hyponatraemia; metabolic acidosis

The nephrology teaching legacy is extensive. Claude Bernard, Carl Ludwig, Homer Smith, William Schwartz, Arnold Relman, Karl Gottschalk, Robert Narins, Jerome Kassirer, Mitchell Halperin and many others made their mark in the area of teaching the internal environment and its regulation, a discipline commonly termed ‘fluid and electrolytes’. Other medical specialties need these skills every day: critical care medicine, anaesthesiology, surgery, paediatrics and many others. However, the duty of teaching this material to medical students and house staff physicians is the purview of nephrologists. Thus, when other doctors cannot come to grips with these problems, we should become introspective and blame ourselves. We must insist that more time be devoted in medical school to house staff training, board examination preparation for medical specialties other than our own and to continuing medical education to pass this information on to younger colleagues. A recent patient underscored the lack of skills inherent in our own university house staff training programme in this regard.

The case

A 22-year-old woman presented to the emergency department complaining of weakness and vomiting for the past 10 days. She had Hashimoto’s thyroiditis treated with thyroxin 125 µg/day. Her blood pressure was 100/56 mmHg and abdominal tenderness in the lower abdomen was observed on deep palpation. The haemoglobin (Hb) was 142 g/L, creatinine 84 µmol/L and thyroid-stimulating hormone 0.11 µU/L. Urinalysis dipstick showed pH 5, ketones +4 and specific gravity 1.020. The sodium was 125 mmol/L, potassium 5.3 mmol/L, glucose 3.27 mmol/L and lactate 1.78 mmol/L. A venous blood gas sample revealed a pH of 7.17, PvO₂ 30 mmHg, PvCO₂ 28 mmHg and HCO₃ 11 mmol/L. The admitting physicians interpreted this constellation as ‘metabolic acidosis from vomiting’, ordered a chest roentgenogram (Figure 1) and an abdominal ultrasound examination. The ultrasound study showed that ‘acute appendicitis could not be ruled out’ and the appendix was laparoscopically removed. Pre-operatively, the patient received 1 L 0.9% saline and 500 mL 5% glucose

solution. Post-operatively, the patient showed little improvement and a nephrology consult was obtained on the morning of the second post-operative day when her serum sodium had decreased to 120 mmol/L. The consultant found a lethargic patient who promptly fainted in an upright posture. Laboratory values were ordered (Table 1).

The consultant recognized a correctly compensated metabolic acidosis without an elevated anion gap. Blood glucose values were invariably low. The patient appeared volume contracted, a point underscored by the increased creatinine and urea nitrogen values, as well as the orthostatic hypotension. The urine pH had been five on admission and was now six. The sum of urine sodium plus potassium greatly exceeded the urine chloride value, which caused the consultant to conclude that ammonium production in face of this metabolic acidosis might be decreased. Even though the patient was not hyperkalaemic, the consultant next calculated the transtubular potassium gradient from the relationship $TTKG = (U/P \text{ potassium}) / (U/P \text{ osmolality})$. The result was a modest value of 2.3. Later that day, when the serum potassium was 6.9 mmol/L, this procedure was repeated and yielded $TTKG = 1.2$. The consultant also recognized that the sum of urine sodium plus urine potassium greatly exceeded the serum sodium value in this patient with a negative free-water clearance. Could the syndrome of inappropriate anti-diuretic hormone be responsible for the hyponatraemia? The persistently low serum glucose values, the volume contraction, hypotension, non-anion-gap metabolic acidosis and exceptionally low TTKG results caused the consultant to speculate that Addison’s disease could be responsible. A telephone consultant to an endocrinologist raised the possibility of pituitary insufficiency. However, on the basis of volume contraction and how the patient dealt with potassium and hydrogen ion excretion, the nephrologist thought otherwise.

The consultant carefully inspected the patient again looking for pigmentary changes on the skin, mucous membranes, hand creases and scars. None were apparent. The hair distribution seemed normal; no excrescences could be obtained from the patient’s mammillae. Mild eosinophilia was not present. The consultant obtained blood samples for cortisol, adrenocorticotrophic hormone (ACTH), luteinizing



Fig. 1. Normal chest roentgenogram with a narrow cardiac silhouette consistent with Addison's disease.

Table 1. Laboratory values 2 days after admission

Serum values	
Sodium (mmol/L)	120
Potassium (mmol/L)	5.8
Chloride (mmol/L)	98
HCO ₃ (mmol/L)	12
Glucose (mg/dL)	48
Creatinine (mg/dL)	1.34
Urea nitrogen (mg/dL)	17
PaCO ₂ (mmHg)	27
PaO ₂ (mmHg)	105
pH	7.29
Cortisol (µg/dL)	3.1 (3.2 µg/dL after ACTH)
ACTH (pg/mL)	1250 (normal <40)
LH (IU/L)	<0.1
FSH (IU/L)	0.1 (under birth control pills)
Prolactin (µg/L)	27.3 (4.5–33)
Aldosterone (ng/L)	<25 (normal 25–340)
Renin (ng/L)	545 (normal 1.4–17.4)
Urine values	
Sodium (mmol/L)	135
Potassium (mmol/L)	29
Chloride (mmol/L)	69
Creatinine (g/L)	1.34
Osmolality (kg H ₂ O)	644
pH	6.0

hormone (LH), follicle-stimulating hormone (FSH), prolactin, insulin-like growth factor-1, renin and aldosterone. He then gave the patient intravenous ACTH and repeated the cortisol determination 30 min later. He also began a brisk 0.9% saline infusion and administered hydrocortisone and glucose.

Eight hours later, sodium level was 128, potassium 4.7, chloride 103 and HCO₃ 17 (all mmol/L). Urine sodium was 47, potassium 27 and chloride 74 (all mmol/L) and the osmolality 283 mosm/kg H₂O. The consultant recognized that the patient was now probably excreting ammonium and that the free-water clearance was now positive. On the next day, the sodium level was 130, potassium 4.1, chloride 102, HCO₃ 19 (all mmol/L), the glucose was 8.27

mmol/L, and the patient's Hb had decreased to 100 g/L. The consultant did not attribute the decrease in Hb to 'blood letting' but rather argued that restoration of volume was responsible (Figure 2), an opinion supported by a decrease in creatinine and urea nitrogen values. The pathologist observed 'fibrosis of the submucosa' in the appendix; a diagnosis that all parties were happy with, and following treatment, the patient felt much better. She thanked her surgeon for saving her life and left the hospital.

Comment

This patient entered the emergency department complaining of an illness lasting longer than a week. Her complaints were primarily those of weakness and vomiting. The physical findings were diffuse and although she was hypotensive, we could find no evidence that orthostatic blood pressure or heart rate measurements had been taken. Admitting laboratory information disclosed impressive hyponatraemia and a low blood sugar concentration. Venous blood gases revealed a metabolic acidosis. Chloride was not measured initially, probably because chloride is not considered an 'electrolyte' in Germany and is generally ignored by all but nephrologists. No attempt to work up the hyponatraemia or the hypoglycaemia was made. The ketosis was assigned to decreased food intake and the acidosis was erroneously attributed to 'vomiting'. When told that the patient probably had appendicitis by the radiologist, the surgeons dutifully removed that organ. The attending anaesthesiologists were evidently not troubled by the clinical or the laboratory constellation either.

The patient fortunately did not develop 'Addisonian crisis' and survived the operation. The consultant recognized the likely presence of Addison's disease and quickly tested the adrenal cortex clinically. The function of the zona glomerulosa appeared abnormal because potassium and hydrogen ion excretion were both perturbed. The combination of hyponatraemia, hyperkalaemia, mild hyperchloraemic metabolic acidosis and modest elevations in the plasma creatinine, blood urea nitrogen and haematocrit are classical findings of Addison's disease [1]. Our patient deviated from this picture in that hyperkalaemia was not a prominent feature, which is the case in about one-third of patients [1]. Gagnon and Halperin [2] studied an Addisonian patient with normokalaemia. In that patient, the estimated rate of renal potassium excretion was relatively high. Our normokalaemic patient had a TTKG <3. She did exhibit hyperkalaemia briefly in the hospital and her TTKG remained <2. The laboratory values that were eventually returned indicated that the patient had marked secondary hypoaldosteronism with the lowest aldosterone and highest renin values we have ever observed. The metabolic acidosis exhibited by our patient was also more marked than expected; we believe that the profound hypoaldosteronism contributed.

The endocrine consultant did not come to examine the patient but suspected pituitary insufficiency because of the serum potassium concentration. A quick ACTH test and the subsequently delivered ACTH values ruled out pituitary insufficiency. Our otherwise vigilant consultant missed the fact that the patient ingested birth control pills, so that the LH and FSH determinations could have been spared. Most gratifying was the prompt response to treatment, namely hydrocortisone and volume expansion.

The chest roentgenogram revealed a slim cardiac silhouette which is characteristic of Addison's disease. We

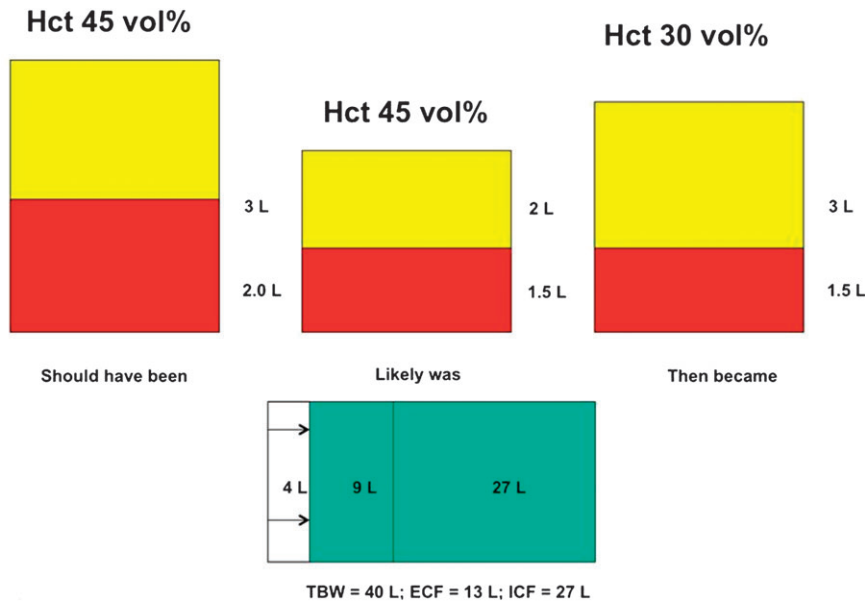


Fig. 2. The patient presented with a deceptively normal haematocrit despite numerous shock signs. The normal Hb and haematocrit (Hct) were interpreted as representing the normal relationship between red cells and plasma volume. We believe that marked volume contraction was present in a patient who was otherwise anaemic, as revealed by volume expansion.

were impressed by the decrease in Hb with treatment. She had entered with a haematocrit of 45 vol%. This value decreased to 30 vol%. Since haematocrit is equal to the red cell volume/total blood volume, we speculate that her extracellular fluid volume deficit could have amounted to ~30% of normal [3]. Shock should always be listed as problem number one. Venous acid-base balance measurements can be helpful in assessing $PvCO_2$ emanating from skeletal muscle. However, in our patient, the venous source was a matter of convenience rather than clinical decision-making. In any event, the $PvCO_2$ value was low.

We believe that our patient had Schmidt's syndrome. The coexistence of Hashimoto's thyroiditis and Addison's disease is now better known as autoimmune polyglandular syndrome Type II [4]. We performed immunological tests that showed the presence of adrenal antibodies along with characteristic autoantibodies of autoimmune thyroid disease. Our patient had no evidence of diabetes or gonadal failure.

Teaching points

(1) Nephrologists have a traditional teaching role for fluid and electrolytes. This patient exemplifies that we have failed in our mission.

(2) We believe that this patient is not an exception and that a concerted international effort is necessary for nephrologists to fulfil their traditional fluid and electrolyte teaching role.

(3) Hyponatraemia and acid-base disturbances must always be worked up, especially in patients being considered for surgery. Multitasking is the physician's obligation.

(4) Polyglandular syndrome Type II is common and frequently not recognized.

References

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Received for publication: 29.3.12; Accepted in revised form: 2.4.12