SODIUM AND POTASSIUM BALANCE*

(1) IN RELATION TO PERIODIC PARALYSIS AND (2) IN A CASE OF PYELONEPHRITIS WITH MALIGNANT HYPERTENSION

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Reversible temporary muscular paralysis including periodic paralysis has frequently been reported in association with disturbances of potassium metabolism. It is clear that paralysis may occur with a low, a normal or a raised serum-potassium concentration and in any individual attack the following possibilities arise:

1. *Hypokalaemia*
   - (*a*) Diminished intake + excessive gastro-intestinal loss of potassium.
   - (*b*) Potassium-losing renal diseases.
   - (*c*) Primary aldosteronism.
   - (*d*) Classical familial periodic paralysis.
   - (*e*) Sporadic periodic paralysis.
   - (*f*) Periodic paralysis with associated thyrotoxicosis.
   - (*g*) Miscellaneous: Diabetic acidosis during treatment, alkalosis, P.A.S. intoxication etc.
2. *Normokalaemia*
   - (*a*) Salt Lake City type of familial periodic paralysis.
3. *Hyperkalaemia*
   - (*a*) Scandinavian type of familial periodic paralysis (adynamia episodica hereditaria).
   - (*b*) Chronic renal disease.
4. Serum-potassium level unknown (? hypokalaemia).
   - (*a*) Pa Ping or Kiating paralysis (? barium poisoning).

We wish to report (1) a study of a case of sporadic periodic paralysis, and (2) a case of pyelonephritis and superimposed malignant hypertension, with hypokalaemia, but without paralysis, in which there was renal sodium wastage and an increased aldosterone excretion in the urine.

CASE OF PERIODIC PARALYSIS

Generally speaking information on balances in periodic paralysis is meagre, and scant attention had been paid to the state of sodium metabolism in this disorder, until Conn suggested that there was an intracellular sequestration of sodium prior to the attack and a naturesis succeeding the attack and that the disease should be treated with a low-salt regime after preliminary de-salting.

The subject of the present study was C., a 17-year-old White male from Knysna district, who had had periodic attacks of paralysis 2-3 times a week since the age of 6 years. There was no family history of similar attacks, but his father is said to have suffered from epilepsy. The attacks varied in duration from a few minutes to several hours and they were most frequently nocturnal in onset; exertion on the preceding day appeared to be a precipitating factor in some instances. Their character varied from mild aching in muscles with slight loss of motor power to complete paralysis from the neck down, although cranial nerves and diaphragm were never involved. Consciousness, the special senses and sensation

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were not involved, although the acts of micturition and defaecation were in abeyance during the severe attacks.

Observation in hospital confirmed that the attacks varied from a subclinical form, in which loss of motor power of the extensors of the leg and abductors of the shoulder was detectable on objective testing, to profound paralysis with inability to turn in bed. Generally muscles were painful and the face appeared puffy. The attacks were both spontaneous and could be induced by a large carbohydrate meal, by glucose loading, and by insulin administration. In the attacks the serum-potassium concentration fell precipitously; in one of the induced attacks it was noted that the serum-sodium concentration had also fallen slightly. With the attacks both urinary sodium and potassium excretion diminished. The expected electrocardiograph changes of hypokalaemia were repeatedly observed. The cerebrospinal-fluid potassium concentration also fell, while the cerebrospinal-fluid pressure was considerably elevated. Biopsy of the vastus muscles showed a pronounced vacuolar change, and muscle analysis on the 30th day of a low-sodium diet showed the intracellular sodium concentration to be raised and the potassium concentration, if anything, reduced, although a higher figure was obtained during an attack.

In an attempt to test Conn's suggestion that a period of desalting and low-salt intake might alleviate the condition, the patient was placed on a diet containing approximately 26 mEq. of sodium and 110 mEq. of potassium. A period of high intake (208 mEq. of sodium) followed before reverting to the initial low-sodium intake.

The results were illustrated graphically and are divisible into 3 phases:

(*a*) Low Sodium Intake: During the initial period of observation (56 days) attacks could be induced with both glucose and glucose and insulin. On the 41st day the administration of 1,000 mg. of chlorothiazide resulted in the loss of 270 mEq. of sodium. Thereafter no overt attacks of paralysis occurred—nor could they be induced by glucose and insulin loading, or the administration of tolbutamide or of 1·0 mg. of 9α fluorohydrocortisone.

(*b*) High Sodium Intake: During the second phase (59 days) of salt loading the attacks recurred, including both spontaneous and induced attacks—9α fluorohydrocortisone induced an attack, and an extremely severe attack lasting 48 hours followed a water-load test. Chlorothiazide did not abolish the attacks.

(*c*) Low Sodium Intake: During the final low-salt period (26 days) attacks occurred with greater frequency although on the whole with lesser intensity. Chlorothiazide therapy did not prevent the repetition of attacks. Supplementation with KCl was necessary.

On supplementary KCl plus moderate sodium restriction and chlorothiazide once a week he had remained in relatively good health with approximately one mild attack per week.

In general there appeared to be considerable sodium retention before the attack with subsequent release of the retained sodium, although such retention did occur without the development of an attack. A diet of 26 mEq. of sodium with added chlorothiazide appeared to be beneficial at first but after salt loading this diet plus chlorothiazide failed to abolish attacks.

Urinary excretion of potassium during the same period showed an irregular behaviour and until dietary intake and faecal potassium are plotted judgment must be reserved.

Aldosterone figures are not yet to hand and further studies are planned in the near future, in particular the effect of a high-protein diet.

CASE OF RENAL DISEASE AND ALDOSTERONISM WITHOUT PARALYSIS

The second patient reported illustrated the difficulty of differentiating primary aldosteronism with secondary renal disease from a primary renal disease with sodium and potassium wastage and secondary aldosteronism.

P. was a 47-year-old Coloured female who presented with a 2-months history of severe headache and failing vision, frequency and dysuria. Six years before, a single blood-pressure reading during an admission for pelvic peritonitis was recorded as 170/110 mm. Hg. She was a sick-looking female with an old left Bell's palsy and slight facial hirsuties. Bodily configuration was normal. There was no oedema.

The blood pressure was 300/160 and the heart showed marked left ventricular enlargement. Examination of the fundi revealed numerous exudates, haemorrhages and marked papilloedema. The urine was usually slightly acid in reaction. Specific gravity on 12 hours fluid deprivation was 1012. Proteinuria was constant and a gross pyuria was present. Coliform organisms were cultured from the urine.

17-Ketosteroid and 17-ketogenic steroid excretion was within normal limits but 3 aldosterone estimations varied between 20 and 30 μg. per 24 hours. There was evidence of renal wastage of potassium.

The initial serum potassium was 2·7 mEq./l. but there was no alkalosis.

Balance data confirmed the renal wastage of potassium with phases of marked sodium loss also in the urine and the easy correction of the hypokalaemia by potassium loading. Possible explanations of the balance data were discussed.

Complete right and partial left adrenalectomy was performed, and revealed nodular hyperplasia of both adrenal glands. Renal biopsy showed evidence of bilateral pyelonephritis with superimposed changes of malignant nephrosclerosis. The post-operative course was stormy, with the development of uraemic pericarditis. The patient appeared to be improving, when she died suddenly, the cause of death being a pontine haemorrhage. The remainder of the left adrenal gland also showed nodular hyperplasia.

It has been stated that exploration of the adrenal glands is necessary before the diagnosis of primary aldosteronism can be excluded; but the implication that primary aldosteronism can be excluded in this way is fallacious, for after operation and autopsy, and even with evidence of adrenal hyperplasia and a raised urinary aldosterone, we are still unable to state whether this alteration in the adrenal glands is primary, or secondary to pyelonephritis with wastage of sodium. The latter on balance of evidence appears more likely.

It is claimed that paralysis need not be present in primary aldosteronism. The absence of paralysis in this case, with hypokalaemia, is readily attributable to the fact that serum potassium was only moderately reduced. In addition, prolonged renal sodium wastage with a depleted intracellular sodium content may have contributed.