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Water and electrolyte balance in subjects with a permanent ileostomy

H J KENNEDY, E A S AL-DUJAILI, C R W EDWARDS, AND S C TRUELOVE

From the Nuffield Department of Clinical Medicine, John Radcliffe Hospital, Oxford, and St Bartholomew's Hospital, London

SUMMARY Water and electrolyte balance has been studied in 39 patients with a permanent ileostomy, who had had a proctocolectomy for ulcerative colitis. The findings have been compared with those in 39 healthy subjects who were matched for age and sex. The ileostomists were found to lose excessive quantities of water and sodium in the ileostomy effluent compared with the corresponding losses in normal faeces. The mean plasma total protein and albumin concentrations were increased in the ileostomists suggesting a state of chronic dehydration. The daily urinary output of sodium was low and the output of potassium was high. The urinary pH was low. The ileostomists had raised mean concentration of aldosterone in the plasma ($p < 0.001$) and it is suggested that this is responsible for the body's partial compensation for the depletion of sodium and water, including the so-called ileostomy adaptation.

For many years salt and water depletion has been recognised as a complication of the early post-operative period in patients with an ileostomy. Gallagher and his colleagues¹ described episodes of salt and water depletion occurring in patients with well established ileostomies. Later work suggested that even apparently healthy patients with an ileostomy have persistent depletion of sodium and water.^{2,3} Turnberg and his colleagues⁴ reported that their patients had normal extracellular and total body water volumes, although they did find that total exchangeable sodium and potassium were reduced. As the serum electrolytes were normal in these subjects, they concluded that there must be an intracellular depletion of sodium and potassium. Moreover, despite evidence for sodium conservation by the kidney and intestine in patients with an ileostomy, plasma aldosterone concentrations have been found to be normal in almost all of them^{4,5} but the numbers studied were small. These conflicting observations prompted us to investigate the water and electrolyte balance and acid:base status of a large group of ileostomists, using a group of normal subjects matched for age and sex as controls.

Methods

SUBJECTS

The patients studied were 39 ileostomists in whom a proctocolectomy had been performed for ulcerative colitis, with less than 10 cm of terminal ileum being resected. All the ileostomists were in good general health and were leading normal lives. The ileostomy had been established for at least one year, the average duration being five years.

The studies that were made on samples of blood, urine, and ileostomy fluid were as follows.

BLOOD

Every patient had samples of venous blood collected to measure the plasma concentrations of sodium, potassium, chloride, bicarbonate, urea, creatinine, calcium, phosphate, total protein, and albumin. These variables formed part of the biochemical profile measured on a Vickers M300 Discrete Analyser. Blood pH was determined by taking a sample of arterialisated venous blood from a vein on the dorsum of a hand. Before the sample was taken, the hand was held in hot water for five minutes and no tourniquet was used in order to avoid venous stasis. The samples were placed in ice and analysed within 15 minutes using a Radiometer Acid-Base Laboratory. This technique for obtaining measure-

ments of blood pH has been well validated.⁶⁻⁸ Finally, ordinary venous blood samples were collected to determine plasma renin activity and plasma aldosterone concentration in the resting state after the patients had been recumbent for half an hour and another sample was taken four hours later when the patient was ambulant. The blood for the measurement of renin activity was collected into sodium EDTA, separated in a cold centrifuge and the plasma stored at -20°C . Plasma renin activity was measured using a radioimmunoassay for angiotensin 1 and was expressed as pg of angiotensin 1 generated per millilitre of plasma per hour of incubation.⁹ The plasma aldosterone concentrations were determined by a highly specific radioimmunoassay method.¹⁰

URINE

Each patient collected a 24 hour sample of urine into a preservative and the sample was refrigerated. A Technicon SMA linked to a Vickers SP120 was used to measure the concentrations of urinary sodium, potassium, urea, creatinine, calcium, and phosphate. The pH of the urine was determined with a Pye Unicam pH meter.

ILEOSTOMY EFFLUENT

Each ileostomist also collected a 24 hour sample of ileostomy effluent. This was weighed and the volume was measured. Aliquots of the effluent were taken to determine the dry weight of each sample using a TECAM Dri-Block DR3-H and further aliquots were drawn up into a bladder syringe and injected into 12 2 ml Eppendorf centrifuge tubes. These tubes were spun at 12 000 rpm for 15 minutes in a microcentrifuge type-320 supplied by Burkard Scientific Sales Ltd, Rickmansworth, Hertfordshire. The centrifugation separated the solid component from the liquid part of the effluent. The supernatant was then pipetted from the 12 centrifuge tubes into two plain tubes which were stored at -20°C to await analysis. Subsequently the pH of the fluid was determined immediately after defrosting using the Radiometer ABL2 Acid-Base Laboratory. In addition, the sodium and potassium levels were measured as above.

DIETARY INTAKE

The fluid and food intake was recorded by the patients over the course of one week and the resulting information was used in conjunction with the values given in the McCance and Widdowson food tables¹¹ to perform a computer analysis of the dietary intake.

CONTROL SUBJECTS

The control group consisted of 39 healthy subjects

who were age- and sex-matched to the ileostomists. All of them had blood taken for the biochemical profile and determination of blood pH. They also had blood taken for resting and ambulant aldosterone and plasma renin activity determination. In addition, every subject collected a 24 hour sample of urine for the measurement of urinary electrolytes and pH. The methods used for the measurement of these variables were the same as those used for the samples collected from the ileostomists. The dietary intake was estimated in an identical manner to that of the ileostomists.

Results

The results of the plasma biochemical profile are shown in Table 1. There were no statistically significant differences between the two groups with the exception of total protein and albumin which were significantly raised in the ileostomists.

The plasma aldosterone values and renin activity were found to follow a log normal distribution and the results given in Table 2 are therefore expressed accordingly. The mean plasma aldosterone concentrations were significantly higher in the ileostomists than in the control group. The mean resting and ambulant renin activities were also raised in the ileostomists compared with those in the control group but the higher ambulant level was not statistically significant.

The results of the urinary analysis are given in Table 3. The mean 24 hour volume of urine in the ileostomists was lower than that in the control group but the difference was not statistically significant. These patients, however, were drinking on average 350 ml more fluid per day than the control subjects

Table 1 Results of plasma biochemical and pH estimation (mean \pm 1 SD) in group of ileostomists compared with group of healthy subjects matched for age and sex

Variable	Ileostomists (n=39)	Control subjects (n=39)
Sodium (mmol/l)	141.9 \pm 3.0	141.2 \pm 2.4
Potassium (mmol/l)	3.90 \pm 0.70	4.00 \pm 0.71
Chloride (mmol/l)	102 \pm 3	102 \pm 2
Bicarbonate (mmol/l)	27 \pm 3	26 \pm 2
Urea (mmol/l)	5.7 \pm 1.1	6.0 \pm 2.0
Creatinine (μ mol/l)	83 \pm 21	84 \pm 17
Calcium (mmol/l)	2.45 \pm 0.14	2.40 \pm 0.09
Phosphate (mmol/l)	0.98 \pm 0.20	0.88 \pm 0.16
Total protein (g/l)	74.8 \pm 4.8†	70.1 \pm 4.3
Albumin (g/l)	44.2 \pm 2.9*	42.7 \pm 2.2
Blood pH	7.39 \pm 0.02	7.40 \pm 0.02

Statistical significance of differences from control subjects

*p<0.02, †p<0.001.

Table 2 Mean log values of plasma aldosterone and renin activity (± 1 SD) in group of ileostomists compared with control group

	Ileostomists (n=39)	Control subjects (n=39)
Aldosterone (pg/ml log)		
Resting	2.19 \pm 0.25*	1.85 \pm 0.26
Ambulant	2.30 \pm 0.29*	1.96 \pm 0.28
Renin (pg/ml/h log)		
Resting	2.90 \pm 0.41†	2.65 \pm 0.42
Ambulant	3.18 \pm 0.41	3.02 \pm 0.43

Statistical significance of differences from control subjects based on Student's *t* test * p <0.001, † p <0.02.

(p <0.001) and this partially compensated for the additional loss of fluid in the ileostomy effluent.

The urine was more acidic in the ileostomists than in the control subjects and the ileostomists were conserving more sodium in their kidneys. The daily intake of sodium by the ileostomists was approximately 500 mg greater than that of the control subjects, but the difference was not statistically significant. The urinary loss of potassium was raised in the ileostomists and the sodium:potassium ratio was low.

The daily dietary intake of potassium was similar in the ileostomists and the control subjects.

Table 4 gives the results of the analysis of the ileostomy effluent. Wrong¹² used faecal dialysates to calculate the approximate values for normal faeces. He states that the normal loss of water in the faeces is less than 150 ml per day. Using this value, the loss of sodium in the faeces can be calculated to be 3.9 mmol/day and of potassium 12 mmol/day. The mean

Table 3 Mean urinary biochemical and pH values (± 1 SD) in group of ileostomies compared with those of healthy subjects

Variable	Ileostomies (n=39)	Control subjects (n=39)
24 hour urine volume. l	1.34 \pm 0.40	1.44 \pm 0.56
pH	5.29 \pm 1.04†	5.95 \pm 1.05
Sodium (mmol/day)	113 \pm 65*	142 \pm 59
Potassium (mmol/day)	79 \pm 25†	58 \pm 20
Urea (mmol/day)	324 \pm 97	309 \pm 91
Creatinine (mmol/day)	13.2 \pm 3.9	12.7 \pm 4.0
Creatinine clearance	116 \pm 41	107 \pm 35
Sodium:potassium	1.5 \pm 0.8‡	2.5 \pm 0.8
Calcium (mmol/day)	4.33 \pm 1.59	4.45 \pm 2.48
Phosphate (mmol/day)	25.02 \pm 7.34	24.97 \pm 10.59

Statistical significance of differences from control subjects

* p <0.05, † p <0.01, ‡ p <0.001.

Table 4 Mean ileostomy effluent values (± 1 SD) in group of ileostomists

Variable	Ileostomists
24-h volume (ml)	606 \pm 287
24-h weight (g)	644 \pm 297
24-h dry weight (g)	66 \pm 31
Sodium (mmol/day)	71 \pm 36
Potassium (mmol/day)	5.1 \pm 3.9
pH	7.1 \pm 0.9

faecal pH is 7.0 (range 6–8). By comparison with these data, it can be seen that the ileostomists investigated in the present study were losing about 500 ml more fluid per day and 65 mmol more sodium in the ileostomy effluent than would be lost in the faeces of a normal subject. The daily loss of potassium in the ileostomy effluent was less than half that in normal faeces. The pH of the ileostomy fluid was found to be similar to that of normal faecal dialysate

Discussion

The finding that the daily losses of sodium and water in the ileostomy effluent are much greater than in normal faeces is in agreement with many previous studies.^{13–18} The significantly raised mean plasma concentrations of total protein and albumin are strong evidence that subjects with a permanent ileostomy have a reduced plasma volume as a result of chronic dehydration.¹⁹

There is also evidence of increased renal conservation of sodium and water as has been reported previously.^{20 21} In addition, dietary analysis has shown a higher salt and water intake in the ileostomists than in the control subjects. All these blood and urinary changes suggest that there is a depletion of salt and water in ileostomists and that the body is attempting to compensate for this depletion. In this connection, Isaacs and his colleagues⁵ found normal levels of plasma aldosterone in six ileostomists and Turnberg and his coworkers⁴ found normal levels of plasma aldosterone and renin activity in most of their patients. The present study of a large group of ileostomists has shown a significantly raised mean level of plasma aldosterone in ileostomists when compared with healthy subjects matched for age and sex (p <0.001). The plasma renin activity was also raised in these ileostomists but the increase was not as marked.

There has been considerable discussion as to whether the ileum adapts to conserve more salt and water than normal in patients who have had a proctocolectomy with formation of ileostomy.^{15 17 22}

The difference between the results of the various studies that have been performed may well depend on the volume of intravenous fluid and oral supplements that the patients were given in the early postoperative period. Several investigators have shown that about 1500 ml per day of fluid enters the colon from the ileum in a normal subject.²³⁻²⁵ Therefore, the output of a well established ileostomy appears to be about a third of that which normally passes into the colon so that ileostomy adaptation may be presumed to have taken place. A number of theories have been proposed to explain such an adaptation. An increased output of anti-diuretic hormone had been suggested.²⁶ The ingestion of sufficiently large quantities of water to cause a considerable increase in urinary output, however, has not been shown to result in an increase in the volume of the ileostomy effluent.^{27 28} Therefore, it is unlikely that ileostomy adaptation is caused primarily by anti-diuretic hormone. An increased output of aldosterone, as has been shown in the present study, is perhaps a more likely explanation for ileostomy adaptation.

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