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Water and electrolyte balance after ileal J pouch-anal anastomosis in ulcerative colitis and familial adenomatous polyposis

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Abstract. The water and electrolyte balance was studied in 31 patients with ulcerative colitis (UC) and 22 with familial adenomatous polyposis (FAP) who underwent staged surgery involving colectomy and ileal J pouch-anal anastomosis (IAA), preoperatively, after terminal ileostomy, after high ileostomy, and after ileostomy closure. Serum electrolytes did not differ between each surgical stage. After terminal or high ileostomy, daily urine volume and urinary sodium loss was significantly lower, and daily fecal weight and fecal sodium loss was significantly higher than preoperatively. After ileostomy closure, urinary and fecal sodium loss became closer to preoperative value. Daily urinary potassium loss was significantly higher and fecal loss was lower after terminal and high ileostomy than preoperatively and did not show a significant change after ileostomy closure. The urinary sodium to potassium ratio after ileostomy closure was lower than preoperatively, but was higher than that after terminal and high ileostomy. Plasma aldosterone and renin levels were only significantly increased after high ileostomy. These findings indicate that high or terminal ileostomy caused chronic dehydration, which was compensated for by activation of the renin-aldosterone axis, while the water and electrolyte balance became closer to normal after ileostomy closure following ileoanal anastomosis.

Résumé. Un bilan hydro-électrolytique a été établi chez 31 patients porteurs d'une recto-colite ulcéro-hémorragique et 22 porteurs d'une polypose familiale; tous avaient subi plusieurs temps chirurgicaux comprenant une colectomie et la confection d'une anastomose iléoanale avec une poche en J. Les dosages ont été réalisés à 4 péeriodes au cours du suivi chirurgical, en particulier en pré-opératoire, après la colectomie avec confection d'une iléostomie terminale, après l'anastomose iléo-anale sous couvert d'une iléostomie de protection et après fermeture de l'iléostomie de protection. Les taux sériques d'électrolytes ne diffèrent pas entre les 4 périodes chirurgicales. Après iléostomie terminale ou après iléostomie de protection, le volume urinaire quotidien et les pertes de sodium urinaire étaient significativement plus basses alors que le poids fécal quotidien et les pertes de sodium fécales étaient significativement plus élevées qu'en pré-opératoire. Après fermeture de l'iléostomie, les valeurs d'excrétion du sodium urinaire et fécal étaient voisines à celles de la valeur pré-opératoire. L'élimination journalière de potassium par les urinaires était plus élevée et les pertes fécales plus basses après iléostomie terminale et iléostomie de protection que celles observées en pré-opératoire; ces valeurs ne changeaient pas de manière significative après fermeture de l'iléostomie. Le rapport sodium/potassium urinaire après fermeture de l'iléostomie est abaissé par rapport à la valeur pré-opératoire mais demeure plus élevé qu'après iléostomie terminale et iléostomie de protection. Le taux d'aldostérone et le taux de rénine plasmatique étaient significativement augmentés après une iléostomie de protection. Ces données tendent à démontrer qu'une iléostomie terminale ou une iléostomie de protection favorisent une déshydratation chronique avec une perte sodique compensée par l'activation du mécanisme rénine-aldostérone.

The functions of the colon are conventionally categorized as absorption, secretion, transport, and intraluminal digestion. The normal colon absorbs 1 L of water and 100 mmol of sodium chloride daily [1]. Total colectomy with ileal J pouch-anal anastomosis (IAA) maintains the normal route of defecation while completely removing the colonic mucosa, and thus is widely used for patients with ulcerative colitis (UC) and familial adenomatous polyposis (FAP) [2, 3]. This procedure generally achieves a good quality of life without the need for a permanent stoma, and the reported range of stool frequency is 4.6–6 per day [4, 5].

However, total colectomy with IAA results in loss of the absorptive function of the colon. The postoperative pathophysiological changes after this procedure have been investigated with respect to its effect on bowel function

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[4, 6], liver function [7], renal function [7], bile composition [8], and the serum amylase level [9]. The water and electrolyte balance after IAA has also been studied in comparison with that in normal individuals and ileostomy patients [10]. It is our policy to use a 3-stage procedure for the treatment of UC and a 2-stage procedure for FAP, and we have found that some patients develop severe dehydration during the period when they have a diverting ileostomy and recover quickly after stomal closure. Accordingly, the purpose of the present study was to investigate the water and electrolyte balance after IAA in comparison with that preoperatively, after terminal ileostomy, and after high ileostomy.

Patients and methods

Operative technique

Our method of performing total colectomy with IAA has been reported in detail previously [2, 3].

In brief, all UC patients underwent a 3-stage procedure. The first stage was total colectomy with the creation of a mucous fistula and the fashioning of an ileostomy within 10 cm of the terminal ileum. This was followed 3 months later by mucosal proctectomy, IAA, and the fashioning of a defunctioning high ileostomy 60 cm from the terminal ileum. Closure of the ileostomy was performed after another 3 months.

All FAP patients underwent a 2-stage procedure. The first stage involved total colectomy, mucosal proctectomy, IAA, and the fashioning of a high ileostomy. This was followed by closure of the ileostomy after 3 months (Fig. 1).

Subjects

Changes of the water and electrolyte balance were studied in 31 UC patients (102 specimens) and 22 FAP patients (51 specimens) who underwent the above procedures (Table 1). Among them, 13 UC patients and 7 FAP patients were studied sequentially in all of the following stages: preoperatively, after terminal ileostomy, after high ileostomy, and after ileostomy closure.

The patients were grouped as follows:

1. A preoperative UC group of 26 patients.
2. A preoperative FAP group of 18 patients.
3. A terminal ileostomy group of 24 UC patients admitted for the second-stage operation after a mean duration of 106.5±9.3 days (mean±SEM) with a functioning stoma. These patients all had stomas fashioned by end-loop ileostomy within 10 cm of the terminal ileum.
4. A high ileostomy UC group of 28 UC patients who had previously undergone IAA and were entered into this study at the time of admission for stomal closure. Their stomas were located 50 to 70 cm from the end of the ileum and the mean duration of stomal function was 117.8±7.3 days.
5. A high ileostomy FAP group of 22 patients with a mean stomal functioning time of 102.6±6.3 days.
6. A group of 24 UC patients who had remained healthy for 115.9±14.3 days after stomal closure.
7. A group of 11 FAP patients who had gone 124.5±14.9 days since stomal closure.

During the study period, no steroid therapy was given to any patients, except those in the preoperative UC group (23.4±3.5 mg of predonine/day at sample collection). The clinical profiles of these groups are shown in Table 2. All patients gave informed consent to participation in this study.

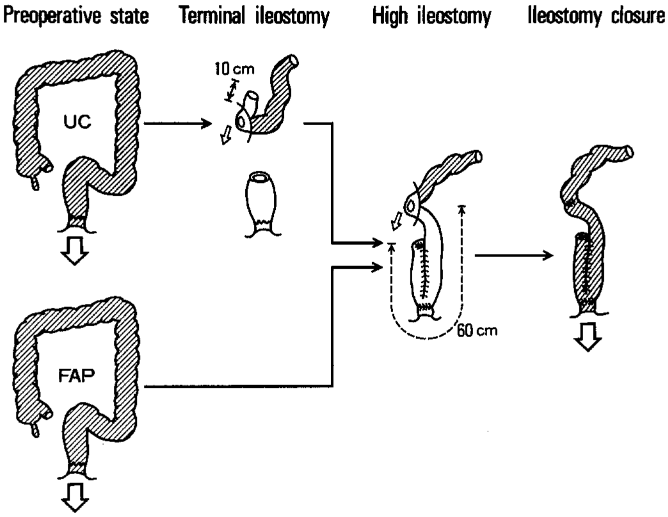

Fig. 1. Diagram of the staged procedure used for ileal J pouch-anal anastomosis

Table 1. Number of subjects studied at each operative stage

	Preoperative	Terminal ileostomy	High ileostomy	IAA
UC (n=31)	13	13	13	13
	4	4	4	–
	6	–	6	6
	3	3	–	–
	–	4	4	4
	–	–	1	1
FAP (n=22)	7	–	7	7
	11	–	11	–
	–	–	4	4

Methods

Fasting blood samples were taken at 7 A.M. for the determination of serum electrolytes and plasma aldosterone and renin activity.

Renin and aldosterone levels were measured using two-antibody radioimmunoassay (RIA) kits from Dainabbot (Tokyo, Japan) (Renin RIA Beads and Aldosterone RIA Kit II, respectively). All samples were analyzed in duplicate.

Forty-eight hour urine specimens were collected, the volume was measured, and the sodium, potassium, and chloride content was determined.

Stool or ileal effluent was collected for 48 h in each study. All patients except those after IAA were hospitalized and received a controlled 2,000 kcal diet (77 g protein, 45 g fat, and 300 g carbohydrate) with less than 10 g of sodium chloride [11]. Feces or ileostomy effluent was collected on 2 consecutive days after the controlled diet had been given for at least 3 days. Since the IAA group were outpatients, fecal samples were obtained while these subjects were on their normal diet. None of the subjects received intravenous infusion therapy or antibiotics during sample collection. Stool and ileal effluent samples were weighed and homogenized after collection. Then the dried homogenates were ashed in a Gallenkamp muffle furnace, at 500 °C for 36 h. The ash produced was dissolved in a 5-ml of 5 N hydrochloric acid, and the sodium and potassium content was determined by flame photometry. The coefficient of variation for ten separate determinations of sodium in a particular sample was 8.4% and that for potassium was 0.9%, and the daily fecal loss of these electrolytes was calculated [12].

Table 2. Profiles of the patients studied at each operative stage

	Preoperative	Terminal ileostomy	High ileostomy	IAA
UC				
No. of patients	26	24	28	24
Male	13	10	13	11
Female	13	14	15	13
Age (mean, years)	27.5	28.8	30.4	31.1
Age (range, years)	13–58	13–58	14–58	14–58
FAP				
No. of patients	18	–	22	11
Male	7	–	10	9
Female	11	–	12	10
Age (mean, years)	31.5	–	30.7	30.8
Age (range, year)	19–44	–	17–51	17–51

Statistical analysis

Data were assessed by the Mann-Whitney U-test and $P<0.05$ was considered to indicate a significant difference.

Results

Serum electrolytes showed no significant differences between the four operative periods that were studied (Table 3).

The daily urine volume and urinary loss of electrolytes are shown in Table 4. Daily urine volume showed a 16% reduction in the terminal ileostomy group, a 30% reduction in the high ileostomy UC group, and a 40% reduction in the high ileostomy FAP group when compared with the

Table 3. Serum electrolyte levels in each operative stage

	Preoperative	Terminal ileostomy	High ileostomy	IAA
UC				
No. of patients	26	24	28	24
Sodium (mmol/l)	141.5±0.6	140.3±1.7	140.8±0.5	142.5±0.5
Potassium (mmol/l)	3.9±0.1	4.0±0.1	4.0±0.1	4.1±0.1
Chloride (mmol/l)	104.9±0.7	107.0±0.5	106.3±0.5	106.1±0.6
FAP				
No. of patients	18	–	22	11
Sodium (mmol/l)	142.2±0.4	–	141.8±0.4	141.5±0.6
Potassium (mmol/l)	4.1±0.1	–	4.1±0.1	4.2±0.1
Chloride (mmol/l)	106.1±0.4	–	105.4±0.5	106.0±0.9

Data are the mean±SEM

Table 4. Daily urine volume and urinary electrolyte loss in each operative stage

		Preoperative	Terminal ileostomy	High ileostomy	IAA
UC					
No. of patients		26	24	28	24
Urine volume (ml/day)		958±70	802±62 [a]	680±53 [a]	852±41
Sodium	(mmol/day)	85.1±8.0	68.3±8.3 [a]	34.5±5.2 [b]	126.1±14.1 [a]
	(mmol/l)	99.4±11.1	96.4±15.0	50.0±6.2 [a]	152.9±15.4 [a]
Potassium	(mmol/day)	28.7±4.4	47.5±4.2 [a]	57.1±4.3 [a]	53.0±8.5 [a]
	(mmol/l)	33.7±5.3	66.3±7.7 [a]	95.7±8.9 [b]	64.9±10.6 [a]
Chloride	(mmol/day)	88.0±7.4	77.8±7.4 [a]	47.0±3.4 [b]	122.2±7.4 [a]
	(mmol/l)	102.4±10.3	100.6±8.9	80.3±8.3 [a]	15.0±15.3 [a]
Sodium/potassium ratio		3.7±0.4	1.6±0.2 [a]	0.8±0.2 [b]	2.9±0.3
FAP					
No. of patients		18	–	22	11
Urine volume (ml/day)		1148±50	–	672±42 [a]	976±69
Sodium	(mmol/day)	140.9±8.5	–	30.4±4.0 [b]	147.3±0.6
	(mmol/l)	125.7±8.5	–	48.3±6.8 [b]	156.1±18.0
Potassium	(mmol/day)	41.5±4.1	–	56.5±4.6 [a]	53.3±5.9
	(mmol/l)	36.8±3.7	–	89.5±8.0 [b]	57.3±7.5
Chloride	(mmol/day)	135.0±8.8	–	42.8±4.9 [b]	131.8±20.7
	(mmol/l)	121.8±10.3	–	70.9±9.9 [a]	135.2±19.5
Sodium/potassium ratio		4.0±0.5	–	0.6±0.1 [b]	3.2±0.5

Data are the mean ±SEM
[a] $P<0.05$ vs. the preoperative period
[b] $P<0.01$ vs. the preoperative period

preoperative period. After ileostomy closure, the reduction of urine volume was only 10% in UC patients and 15% in FAP patients. Daily urinary loss of sodium and chloride after terminal ileostomy and high ileostomy was significantly lower ($P<0.05$, $P<0.01$, respectively) than in the preoperative period. After ileostomy closure, the loss was somewhat higher than in the preoperative period. Daily urinary loss of potassium was significantly higher ($P<0.05$) in the patients with terminal ileostomy and high ileostomy than preoperatively, but no significant reduction was noted after ileostomy closure when compared with the high ileostomy group. The changes of urinary electrolyte concentrations tended to occur in parallel with those of the daily urinary loss. The urinary sodium to potassium ratio was reduced to 1.6 in the terminal ileostomy group, 0.8 in the high ileostomy UC group, and 0.6 in the high ileostomy FAP group from 3.7 in the preoperative UC group and 4.0 in the preoperative FAP group. It recovered to 2.9 in the UC patients and to 3.2 in the FAP patients after ileostomy closure. The daily fecal or stomal effluent weight and the loss of electrolytes are presented in Table 5. The daily fecal or stomal effluent weight was increased 2.3-fold in the terminal ileostomy group, 3.6-fold in the high ileostomy UC group, and 5.2-fold in the high ileostomy FAP group compared with the preoperative value, but was reduced to 1.6-fold and 2.0-fold after ileostomy closure, respectively. Daily fecal loss of sodium was significantly higher ($P<0.01$) in the terminal ileostomy, high ileostomy UC, and high ileostomy FAP groups than in the preoperative UC and FAP groups. Following ileostomy closure, fecal loss of sodium was still high compared with preoperatively ($P<0.05$), but was significantly lower than after terminal ileostomy ($P<0.05$). In contrast, sodium loss showed no significant decrease after ileostomy closure.

Daily fecal loss of potassium was lower after terminal ileostomy and high ileostomy than in the preoperative period. After ileostomy closure, fecal potassium loss was still low. The fecal sodium to potassium ratio was markedly increased to 18.4 in the high ileostomy UC group and to 17.7 in the high ileostomy FAP group, and recovered to 8.7 in the UC patients and to 10.2 in the FAP patients after ileostomy closure.

The plasma aldosterone and plasma renin activity data obtained at rest are shown in Table 6. After high ileostomy, the plasma aldosterone and renin levels were significantly increased compared with those in the preoperative period ($P<0.05$).

Patients who required readmission because of dehydration are listed in Table 7. The incidence of dehydration after ileostomy closure was only 5.7% (2/35), while that after terminal ileostomy was 12.5% (3/24) and that after high ileostomy was 10.0% (5/50).

Discussion

The present study indicated that the water and electrolyte balance after IAA and ileostomy closure, but not after high or terminal ileostomy, closely resembled the normal preoperative situation.

Daily urinary loss of potassium after either type of ileostomy was higher than in the preoperative period, as reported by Kennedy et al. [13]. In addition, the urinary loss of potassium after ileostomy closure was not significantly reduced compared with that after high ileostomy. Santavirta et al. have reported that the daily fecal loss of potassium was significantly increased in IAA patients when compared with patients undergoing conventional ileostomy [10]. However, Brevinge et al. demonstrated that fe-

Table 5. Daily fecal or stomal effluent weight and loss of electrolytes in each operative stage

		Preoperative	Terminal ileostomy	High ileostomy	IAA
UC					
No. of patients		26	24	28	24
Fecal Weight	(g/day)	253±16.9	589±42 [a]	905±25 [a]	410±28 [a]
Sodium	(mmol/day)	17.4±1.7	69.5±4.0 [a]	103.6±2.8 [b]	43.1±2.4 [a]
	(mmol/l)	75.4±8.0	134.0±14.3 [a]	116.5±4.3 [a]	112.7±7.8 [a]
Potassium	(mmol/day)	10.5±1.1	6.9±0.6 [a]	6.9±0.6 [a]	5.4±0.4 [a]
	(mmol/l)	45.8±5.3	13.8±2.0 [a]	7.8±0.7 [b]	14.3±1.3 [a]
Sodium/potassium ratio		1.9±0.3	10.7±0.7 [b]	18.4±1.7 [b]	8.7±0.7 [b]
FAP					
No. of patients		18	–	22	11
Fecal Weight	(g/day)	174±18	–	908±30 [b]	347±42 [a]
Sodium	(mmol/day)	13.2±1.9	–	109.7±5.5 [b]	41.1±5.8 [a]
	(mmol/l)	71.0±6.0	–	124.3±8.6 [a]	122.7±17.1 [a]
Potassium	(mmol/day)	8.9±1.5	–	6.6±0.4 [a]	4.5±0.8 [a]
	(mmol/l)	52.0±7.2	–	7.5±0.5 [b]	16.5±4.3 [a]
Sodium/potassium ratio		1.8±0.3	–	17.7±1.4 [b]	10.2±1.3 [b]

Data are the mean±SEM
[a] $P<0.05$ vs. the preoperative period
[b] $P<0.01$ vs the preoperative period

Table 6. Plasma aldosterone and renin activity in operative each stage

	Preoperative	Terminal ileostomy	High ileostomy	IAA
UC				
No. of patients	26	24	28	24
Aldosterone (40–100 pg/ml)	74.3±13.5	135.4±13.1	430.1±62.5 [a]	114.0±11.0
Renin (0.7–2.8 ng/ml/hr)	3.7±0.8	3.9±0.4	5.5±0.7 [a]	2.3±0.3
FAP				
No. of patients	18	–	22	11
Aldosterone (40–100 pg/ml)	96.3±10.0	–	455.7±84.1 [a]	108.6±16.7
Renin (0.7–2.8 ng/ml/hr)	2.4±0.3	–	6.9±1.1 [a]	2.9±0.4

Data are the mean±SEM
[a] $P<0.05$ vs. the preoperative period

Table 7. Patients requiring readmission for dehydration after each operative stage

	Case no.	Age	Sex	Disease	Symptoms	Time after operation	Treatment	Urinary Na/K ratio
After terminal ileostomy	1	16	F	UC	Thirst fatigue	3 M	IV infusion Steroids	0.8
	2	22	M	UC	Loss of consciousness	1 M	IV infusion Steroids	0.5
	3	19	F	UC	Nausea anorexia	2.5 M	IV infusion Steroids	0.7
After high ileostomy	1	16	F	UC	Fatigue	2.5 M	IV infusion Steroids	0.7
	2	30	F	UC	Fatigue	1 M	IV infusion Steroids	0.4
	3	52	M	UC	Fatigue vomiting	1 M	IV infusion Steroids	0.1
	4	43	M	UC	Fatigue	3 M	IV infusion	0.3
	5	24	F	UC	Fatigue	1.5 M	IV infusion	0.4
After ileostomy closure	1	17	F	UC	Fatigue diarrhea	2 M	IV infusion Steroids	0.9
	2	39	M	FAP	Fatigue	3 M	IV infusion	0.5

IV = intravenous

cal potassium excretion did not change significantly after conversion from a conventional ileostomy to a continent reservoir ileostomy in patients on a defined constant diet [14]. Our study showed that the daily fecal loss of potassium was still low after IAA as Imajo has reported [15]. The decreased fecal loss of potassium after all stages of the surgical procedure reflected removal of the colon, with the potassium balance being maintained by increased urinary excretion.

Patients with a conventional ileostomy have been reported to show increased fecal loss of sodium and chloride and decreased urinary loss of these ions when compared with normal individuals [14, 16, 17], and these findings were confirmed in our study. The sodium concentration of the fecal and stomal effluent did not vary much in the patients terminal ileostomy, high ileostomy, and ileostomy closure, so the reduction of daily sodium loss after ileostomy closure might have been due to the reduction of fecal weight [18]. Daily urinary loss of sodium and chloride in the UC patients after IAA and ileostomy closure was also higher than in the preoperative UC group. This difference might have been due to steroid therapy in the preoperative group, as Hasner has reported that steroid administration reduces the urinary sodium loss [19]. In addition, diarrhea would have increased the fecal sodium loss of the preoperative UC group. As a result, the urinary sodium loss of the preoperative UC patients was lower than normal. However, that of the UC patients after IAA and ileostomy closure, similarly to that of the FAP patients after ileostomy closure, was almost within normal range.

We also assessed the water and electrolyte balance using the urinary and fecal sodium to potassium ratio, which is an indicator of sodium deficiency [20–22]. The urinary ratio was markedly lower and the fecal ratio was markedly higher after terminal and high ileostomy when compared with the preoperative patients, so there was significant urinary sodium retention in both ileostomy groups. Following ileostomy closure, the urinary sodium to potassium ratio recovered to the preoperative value. Delin et al. have reported that the earliest sign of salt depletion was near total inhibition of renal sodium excretion, which could precede activation of the renin-aldosterone axis in ileostomy patients, and that measurement of renin and aldosterone levels should only be used to evaluate the severity of sodium deficiency [23]. Our study showed that plasma aldosterone and renin activity levels were significantly increased after high ileostomy compared with the preoperative period group. However, after ileostomy closure the plasma aldosterone and renin activity levels were almost normalized. These findings suggest that the high ileostomy patients were in a state of chronic dehydration which was compensated for by activation of the renin-aldosterone axis.

Concomitant with these changes in the water and electrolyte balance, the patients with a high ileostomy were the most likely of any group to develop clinically significant dehydration (Table 7). Therefore, when treating UC and FAP patients with staged surgery, sufficient attention should be paid to their salt and a water needs, which may be assessed by measuring the sodium content and volume of a 24-h urine specimen while the patient has a diverting ileostomy. Ileostomy patients with a low urine volume should be advised to increase their fluid intake, while patients with a marked reduction in urinary sodium excretion should be advised to increase their salt intake. After ileostomy closure, IAA patients have a more physiological water and electrolyte balance, and less attention needs to be paid to these requirements. The urinary sodium to potassium ratio was very low (<1.0) in the patients who developed clinically significant dehydration (Table 7). This finding suggests that the urinary sodium to potassium ratio could be a useful indicator of sodium deficiency when following up UC patients in the outpatient clinic during staged surgery.

In conclusion, our data suggested that ileostomy closure after IAA tended to restore the water and electrolyte balance towards normal over the long term.

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