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Decreased absorption of ^{22}Na and ^{36}Cl in ileal reservoirs after exposure to urine

An experimental study in patients with continent ileal reservoirs for urinary or fecal diversion

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Summary. After urinary diversion to intestinal segments, reabsorption of chloride, ammonium, and hydrogen ions occurs, sometimes leading to hyperchloremic acidosis. The mucosa of ileal reservoirs exposed to urine show substantial atrophy, indicating a loss of absorptive capacity. In ten patients with urinary diversion via a continent ileal reservoir, the absorption of [^{22}Na] and [^{36}Cl] was studied after instillation for 15 min into the reservoir of a test solution containing 50 kBq [^{22}Na] and 50 kBq [^{36}Cl]. The activity of the radionuclides was determined in serum samples after 60 and 180 min and the fractions absorbed were calculated. Absorption of the two radionuclides was also calculated by comparison of the activities in samples of the test solution taken before and 15 min after instillation into the reservoir. The same investigations were performed in seven patients with continent ileostomy reservoirs. The study demonstrated a decreased capacity to absorb [^{22}Na] and [^{36}Cl] across the mucosa of the reservoirs exposed to urine compared to the mucosa of those exposed to feces. Due to the transformation of the ileal mucosa after exposure to urine, the risk for development of metabolic disturbances should be minimal after urinary diversion to a continent ileal reservoir.

Key words: Continent urinary diversion – Urinary reabsorbtion – Hyperchloremic acidosis – Villus atrophy – Absorbtion

A well-recognized complication of urinary diversion to intestinal segments is the development of hyperchloremic acidosis. This metabolic disturbance seems to be frequent after ureterosigmoidostomy [7, 9], but it also occurs in patients with ileal conduits, especially in those with impaired renal function [5, 6]. The metabolic problems are caused by reabsorption of chloride, ammonium and hydrogen ions from the urine by the intestinal segment. The degree of the metabolic disturbance is dependent on the area of mucosa exposed to the urine, the concentration of electrolytes in the urine, and the time of exposure [8].

When the low pressure ileal reservoir (Kock pouch) is used for collection of feces, transient morphological changes in the mucosa are noted, although after longer observation time the structure of the mucosa tends to normalize [15]. When the same reservoir is used as a receptacle for urine, the structural changes of the mucosa are much more marked, with the disappearance of villi and crypts in some areas where the flattened enterocytes have lost their microvilli and enzymatic activity. These changes do not seem to be transient [17]. It seemed logical, therefore, that the capacity to transport electrolytes across the mucous membrane of ileal reservoirs exposed to urine would decrease in parallel with the morphological changes. A few experiments in animals have been performed to study the absorption of water and electrolytes by small bowel mucosa after long-time exposure to urine [10, 18, 19], but to our knowledge there is only one detailed investigation of the electrolyte absorption in patients with various parts of the intestine incorporated into the lower urinary tract [16].

Therefore, an investigation was designed to study the absorption of Na^+ and Cl^- of the ileal reservoir mucosa in patients with urinary diversion via a continent ileal reservoir. For comparison, the same studies were also done in patients with continent ileostomy reservoirs.

Materials and methods

Studies were performed in ten patients with continent ileal reservoirs for urinary diversion (urostomy reservoir) and in seven patients with continent ileal reservoirs for fecal diversion (ileostomy reservoir; Fig. 1). All patients were in good general health with well functioning reservoirs. The postoperative observation time had exceeded 2 years for all patients (urostomy patients: mean 4.8 years, 2–10; ileostomy patients: mean 8.4 years, range 2–17). The volume capacity of both types of reservoir was about the same, 700 ml [2].

The patients were studied in the morning after an overnight fast to minimize the amount of urine or small bowel contents mixing with the test solution. Both kinds of reservoir were studied in the same

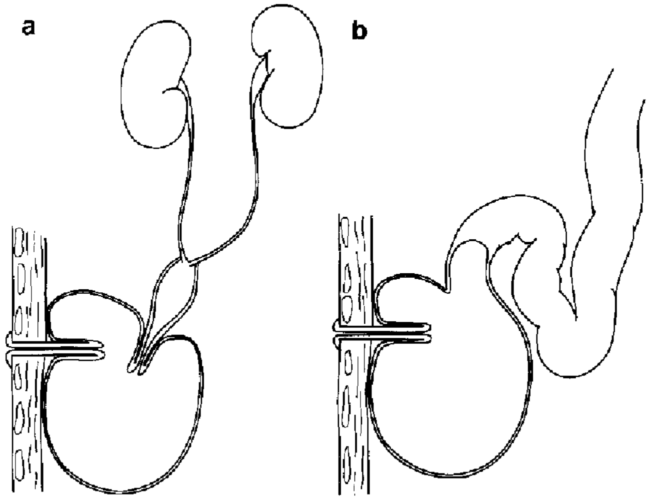

Fig. 1 a, b. Schematic representations of the continent ileal reservoir for urinary diversion (a) and fecal diversion (b)

way. After thorough rinsing of the reservoir with tap water, 50 ml saline containing 50 kBq [^{22}Na] and 50 kBq [^{36}Cl] were instilled into the rinsed lumen. A sample (2 g) was taken from the test solution to determine the concentration of the radionuclides prior to its instillation into the lumen and subsequent to its removal after 15 min. The volume of the recovered test solution was measured. In addition, the reservoir was rinsed twice using 100 ml of tap water each time, samples being taken from the rinsing fluid for activity measurements. Serum samples (2 g) were taken 60 and 180 min after evacuation of the test solution.

The activity of [^{22}Na] in the samples was measured in a gamma counter equipped with a 7.6-cm (diameter) × 7.6-cm NaI(Tl) well crystal (hole diameter 3 cm, depth ≈ 6 cm (Harshaw, The Netherlands) and a single channel pulse height analyzer (Elscint, Israel). The results were corrected for background. For determination of the activity of [^{36}Cl], 1 g of each sample was mixed with 14 ml of the scintillation solution Insta-Gel (Packard, The Netherlands) and the radioactivity was measured in a liquid scintillation counter (Nuclear-Chicago, Mark II, USA). Compensation was made for background and for counts from [^{22}Na]. No correction for quenching was made, because the quenching for the different samples was almost equal. The distribution volume used for Na^+ when calculating the absorption was 300 ml/kg body weight and for Cl^- 260 ml/kg body weight.

Electrolyte status was assessed by routine estimation of serum electrolytes, including chlorides, on samples of venous blood. Acid-base balance was assessed by capillary blood gas analysis. Student's t-test was used for statistical comparisons and P value of 0.05 or less was considered to be significant.

Results

The absorbed fraction of [^{22}Na] calculated from serum samples obtained 1 h after evacuation of the reservoir was 15% ± 3% (mean ± SD) for the urinary reservoirs and 29% ± 13% for the fecal reservoirs ($P < 0.01$). Calculated from the serum samples taken 3 h after evacuation of the test solution, the corresponding values were 13% ± 3% and 27% ± 15% ($P < 0.05$); Table 1). When the absorption was calculated from the samples of test solution, the fraction of [^{22}Na] absorbed from the reservoirs after 15 min was 12% ± 7% for the urinary reservoirs and 26% ± 14% for the fecal reservoirs ($P < 0.05$).

One hour after evacuation of the reservoir, the absorbed fraction of [^{36}Cl] calculated from the serum samples was 6% ± 6% for the urinary reservoirs and 20% ± 12% for the fecal reservoirs ($P < 0.01$; Table 1). Three hours after evacuation of the test solution, the corresponding figures were 7% ± 4% and 22% ± 11% ($P <$ 0.01). When using the samples of the test solution for

Table 1. The fraction of [^{22}Na] and [^{36}Cl] ions absorbed from the reservoir in ten patients with a continent urinary reservoir and in seven patients with a continent fecal reservoir after luminal instillation of 50 ml saline with 50 kBq [^{22}Na] and 50 kBq [^{36}Cl] for 15 min.

	Fraction of absorbed [^{22} Na] (%)		
	Calculated from serum samples		Calculated from test solutions
	1 h after evacuation	3 h after evacuation	
Urinary reservoirs (n = 10)	15 ± 3	13 ± 3	12 ± 7
Fecal reservoirs (n = 7)	29 ± 13 t = 3.26 $P < 0.01$	27 ± 15 t = 2.83 $P < 0.05$	26 ± 14 t = 2.63 $P < 0.05$
	Fraction of absorbed [^{36}Cl] (%)		
Urinary reservoirs (n = 10)	6 ± 6	7 ± 4	5 ± 5
Fecal reservoirs (n = 7)	20 ± 12 t = 3.47 $P < 0.01$	22 ± 11 t = 4.18 $P < 0.01$	18 ± 17 t = 2.43 $P < 0.05$

Values are mean ± SD. Absorption was calculated from serum samples 1 and 3 h after evacuation and from samples from the test solution.

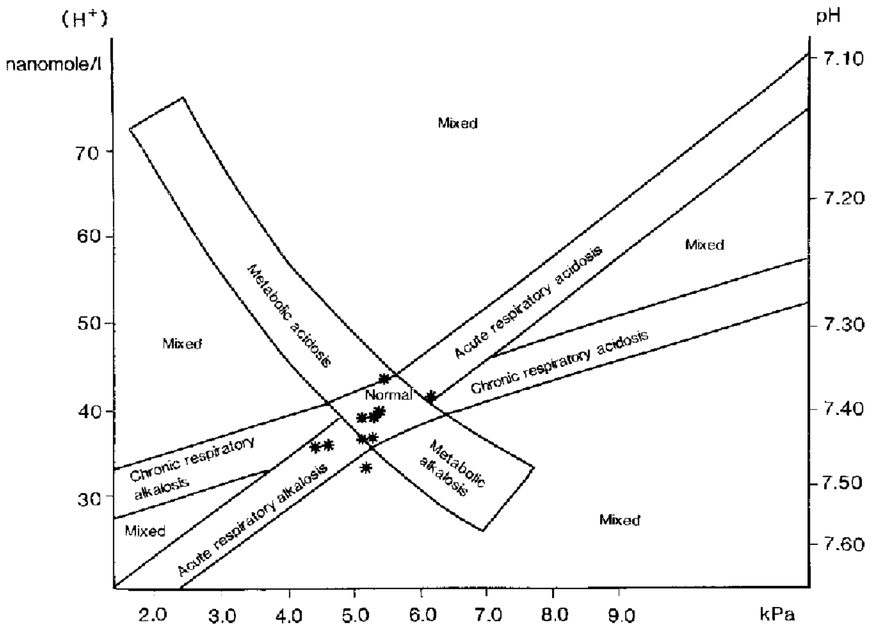

Fig. 2. Results of blood gas analyses in ten patients (*asterisks*) with continent ileal reservoirs for urinary diversion [from 11]

calculating the fraction of [^{36}Cl] absorbed during 15 min, a value of 5% ± 5% was obtained for the urinary reservoirs and 18% ± 17% ($P < 0.05$) for the fecal reservoirs.

The electrolytes were normal in the serum of all patients, and hyperchloremia (Cl^-/S: mean 98 mmol/l, range 93–104 mmol/l) was not seen in any of them. The blood gases did not show metabolic acidosis with respiratory compensation in any of the investigated patients (Fig. 2). Base excess was mean +0.7 mmol/l, range −1 to +4 mmol/l.

Discussion

The present study compares the capacity of ileum reservoirs exposed to either feces or urine to absorb sodium and chloride ions. The absorption of these ions was reduced in reservoirs exposed to urine.

The volume capacity of the urostomy and ileostomy reservoirs was approximately the same, indicating that the macroscopic surface available for absorption in both types of reservoirs was of the same size. The urostomy reservoirs were provided with an antireflux valve that prevented leakage of test solution to the afferent segment and the ureters. The ileostomy reservoirs were not equipped with antireflux valves but, since reflux to the afferent segment does not occur at filling volumes below 200 ml [1], it is reasonable to believe that reflux was not the reason for the larger absorption rate of both sodium and chloride ions in the ileostomy reservoirs. Furthermore, the volumes of the test solution recovered from the reservoirs after 15 min were the same for the urostomy and ileostomy reservoirs, again contradicting any significant reflux from the latter.

The present findings in humans that the capacity to absorb sodium and chloride ions from ileal reservoirs exposed to urine is considerably decreased compared to that occurring in ileal reservoirs exposed to feces are in agreement with earlier studies from our laboratory concerning the absorption of amino acids [20]. Our results are also supported by previous animal experiments showing a decreased absorption of electrolytes and water through ileal mucosa after exposure to urine [19] and by the experimental work of Sinatra and Weinberg and Kollias et al. who found that the absorption of sodium and iodine decreased after exposing small bowel mucosa to urine [10, 18]. More recently, the investigation by Nurse and Mundy showed a reduced absorption of electrolytes in patients with ileal segments incorporated into the lower urinary tract than in patients with cecocystoplasty [16].

This decrease of the absorptive capacity after exposing the ileal mucosa to urine is readily explained by the fact that ileal mucosa undergoes remarkable structural changes after exposure to urine, ultimately resulting in an atrophic mucosa with disappearance of microvilli and enzymatic activity [17]. The structure of the large bowel mucosa has been reported to be largely unaffected by exposure to urine [3, 13, 14] and, therefore, a change in its absorptive capacity caused by exposure to urine should not be expected.

The degree of metabolic disturbances after diverting urine to intestinal segments is, consequently, not only dependent on the area of the intestinal mucosa exposed to urine, the concentration of the electrolytes in the urine, and the time of exposure as stated by Eiseman and Bricker [8] but also to a significant degree on the structure of the intestinal mucosa.

The adaptation of the ileal mucosa from an "absorptive function" to a "storage function" in reservoirs exposed to urine obviously is the explanation of the low incidence of metabolic disorders in patients with ileal urostomy reservoirs [4, 12, 21]. In contrast to the findings reported by Nurse and Mundy that the majority of their patients, including those with ileocystoplasty, had metabolic acidosis with respiratory compensation, none of the ten patients in the present study revealed such metabolic abnormalities. Furthermore, hyperchloremia was not found in any of these patients.

Due to the reduced absorption of electrolytes in ileal urinary reservoirs, it seems that ileum is preferable to large bowel for storing urine, at least in patients with decreased kidney function and increased risk for metabolic disorders.

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