Comparative Analysis of Secretory and Reabsorbing Activity of Ileal and Sigmoid Mucosa, Employed for Urinary Bladder Intestinoplasty

V. I. Kirpatovsky, M. N. Tillashajhov, S. A. Golovanov, and V. V. Drozhzheva

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In experiments on rats we studied reabsorption and secretory activity of the mucosa in isolated segments of the ileum and sigmoid colon used for urinary bladder intestinoplasty after cystectomy. Ileal mucosa was found to retain high metabolic activity under changed conditions. It reabsorbs urea, creatinine, potassium, sodium, chlorine, phosphorus, calcium, glucose, and uric acid from the urine and secretes magnesium, iron, and proteins into the urine. Sigmoid mucosa appeared to be less active in terms of reabsorption of the studied urine metabolites, but more actively secreted calcium and magnesium into urine and additionally secreted sodium. It was accompanied by an increase in blood concentrations of urea, creatinine, glucose, phosphorus, magnesium (only for sigmoid colon) and development of hypoproteinemia. These findings are important for investigation and prevention of metabolic complications after urinary bladder intestinoplasty.

Key Words: *urinary bladder intestinoplasty; metabolic disorders*

Some pathologies (urinary bladder cancer, interstitial cystitis, neurogenic urinary bladder, *etc*.) can be associated with the necessity of total or partial urinary bladder extirpation and enlargement of the residual reservoir. Various parts of the bowel serve as the main source of material for cystoplasty [1,2,4,6]. Preserved functional activity of the bowel mucosa displaced to the urinary system creates conditions for the development of metabolic disorders, due to absorption of urine component into the blood and secretion of important metabolites into the urine and their elimination from the body. Some authors reported the development of transient and permanent, requiring medical intervention, metabolic disorders (hyper- or hypochloremic acidosis, hypokalemia, hypercalciuria, hyperammonemia, *etc*.) after different types of urinary bladder intestinoplasty [3,8-10].

Institute of Urology, Ministry of Health and Social Development of the Russian Federation, Moscow, Russia. ***Address for correspondence:*** vladkir@post.ru. V. I. Kirpatovsky

There is no agreement concerning the relationship between the frequency of metabolic disorder development and portion of the gut used for cystoplasty. One authors report higher frequency after ileoplasty, and others believe that frequency is higher after using the colon [5,7,11,12]. Discrepancy in data can be explained by the fact, that the intensity of metabolic disorders is affected by several factors, *e.g*. metabolic activity of bowel mucosa and area and duration of its contact with the urine.

Here we compared metabolic consequence from contact of the urine with segments of ileum and sigmoid colon of different length.

MATERIALS AND METHODS

The study was carried out in acute experiments using white mongrel rats (n=20) of both sexes weighting 260-280 g. Under thiopental anesthesia, the abdominal cavity was opened and a segment of the ileum adjacent to the ileocecal angle or a segment of the sigmoid colon 2 or 4 cm in length were separated and ligated at both ends. We defined minimal length as small as 2 cm, because it constitutes about 10% of total rat bowel length; approximately the same ratio is used in most enteroplasty techniques (resection of 40-50 cm from the total length of 4.5-5.0 m). In another series of experiments, two-fold longer bowel segments were used (4 cm), which simulated techniques with more extensive resections (for example, Kock method), to assess the importance of minimization of bowel mucosa contact with the urine. Autologous urine (1 or 2 ml, depending on the segment length) was injected by puncture into the bowel lumen. For evaluation of glucose reabsorption activity, glucose was added to the urine to a concentration of 6 mmol/liter, since native urine does not contain this metabolite. Three hours after the urine was evacuated from the isolated bowel segment, changes in its volume and biochemical content in comparison with baseline values were estimated. Moreover, blood from the caudal vein was sampled before urine injection and 3 h after urine contact with bowel mucosa for evaluation of changes in biochemical characteristics. Measurements were performed on automated biochemical analyzer ADVIA-1200 using original kits. Metabolite concentration measured by the analyzer was converted into absolute values taking into account the volume of the urine before and after 3-h contact with the bowel. Baseline metabolite content in absolute values was compared with that after 3-h contact with the mucosa and percent of changes was calculated.

RESULTS

Volume of the urine injected into the segment of the ileum was not changed, whereas in sigmoid colon segment it increased almost 2-fold (Table 1). These differences were probably determined by the reaction of sigmoid colon wall to hyperosmotic urine resulting in water translocation from the bowel circulation into its lumen by the concentration gradient.

Active reabsorption of the urea and creatinine was observed in both the ileum and sigmoid colon (this process was more pronounced in the sigmoid colon). Moreover, urine and mucosa contact area (length of the bowel segment) did not affect the intensity of reabsorption.

Marked reabsorption of electrolytes (potassium, sodium, chlorine, calcium, and phosphorus) was found in the ileum and this reabsorption also was not affected by mucosa and urine contact area, except for calcium, which more actively reabsorption in short bowel segment (compared to that in the long segment). In the sigmoid colon, only potassium, phosphorus and chlorine were reabsorbed, whereas sodium and calcium,

TABLE 1. Changes in Biochemical Composition of the Urine Injected into Isolated Bowel Segment (%; *M*±*m*)

Parameter	Ileum		Sigmoid colon	
	2 cm	4 cm	2 cm	4 cm
Changes in volume of injected urine	0	0	80	110
Urea	-58±4	-73±6*	-41±3$^+$	-36±3$^+$
Creatinine	-43±3	-39±2	-25±2$^+$	-26±2$^+$
Potassium	-84±5	-89±6	-39±5$^+$	-46±6$^+$
Sodium	-35±3	-45±5	36±5$^+$	45±7$^+$
Chlorine	-79±8	-83±10	-8±2$^+$	-9±4$^+$
Calcium	-44±13	-14±6*	57±8$^+$	116±15*$^+$
Phosphorus	-43±4	-40±5	-15±4$^+$	-14±3$^+$
Magnesium	109±12	132±14	87±10	294±47*$^+$
Iron	823±98	2188±277*	152±23$^+$	261±29*$^+$
Uroproteins	1428±166	1660±143	1594±136	1045±102
C-reactive protein	1020±54	1150±62	463±89$^+$	313±67$^+$
Glucose	-97±1	-98±1	-11±2$^+$	-28±3*$^+$
Uric acid	-50±3	-62±5	-18±2$^+$	-20±2$^+$

Note. From $p<0.05$ to $p<0.001$ compared to: *2-cm bowel segment; $^+$ileum.

TABLE 2. Changes in Biochemical Parameters of the Blood 3 h after Urine Injection into Isolated Segment of Ileum or Sigmoid Colon (mmol/liter; *M*±*m*)

Parameter	Baseline values	Ileum		Sigmoid colon	
		2 cm	4 cm	2 cm	4 cm
Urea	8.5±0.6	12.1±0.6*	$16.9 \pm 0.7^{*x}$	14.2±0.8*	$10.5 \pm 0.8^{*x+}$
Creatinine	0.069±0.005	0.109±0.009*	0.082±0.006*	0.110±0.004*	0.109±0.005*
Potassium	6.2±0.2	5.9±0.1	6.0±0.2	5.9±0.1	5.6±0.2
Sodium	145±2	147±2	147±1	145±1	145±2
Chlorine	106±2	109±2	108±1	104±2	104±3
Calcium	2.43±0.12	2.55±0.10	2.71±0.17	2.40±0.09	2.73±0.11
Phosphorus	1.80±0.04	3.11±0.21*	2.53±0.19*	2.67±0.14*	$4.71 \pm 0.37^{*+}$
Magnesium	1.16±0.15	1.08±0.11	0.99±0.07	2.45±0.19*	2.53±0.22*
Iron	32.8±9.2	37.4±5.3	26.9±3.7	38.5±7.1	30.2±4.4
Glucose	6.58±0.11	15.04±2.08*	11.30±1.87*	18.24±1.65*	16.06±2.16*
Bilirubin	4.4±0.3	4.0±0.2	4.8±0.3	5.0±0.2	4.6±0.2
Uric acid	0.090±0.004	0.094±0.003	0.098±0.003	0.079±0.003	0.087±0.003
Total protein, mg%	76.5±2.4	81.92±3.3	$64.4 \pm 2.2^{*x}$	67.0±2.5*	$59.0 \pm 1.9^{*x}$
Albumin, mg%	32.9±1.9	39.6±2.1	$24.4 \pm 1.1^{*x}$	30.6±2.0	25.4±1.5*
C-reactive protein, mg%	63.37±1.3	61.29±1.1	65.23±1.4	62.21±0.9	60.10±1.1

Note. From $p<0.05$ to $p<0.001$ compared to: *baseline values, ^{x}2-cm bowel segment, $^{+}$ileum.

alternatively, were secreted into the bowel lumen. The relationship between secretion intensity and mucosa—urine contact area was noted only for calcium: it was approximately 2-fold higher in the long segment in comparison with the short one. Magnesium and iron were intensively secreted into the lumen of both the ileum and sigmoid colon, but this process was more pronounced in the sigmoid colon. The length of bowel segment affected secretion rate for iron (for both sigmoid colon and ileum) and magnesium (only for sigmoid colon).

Massive protein secretion into the lumen of both small and large intestine was revealed in all experiments; in the small intestine this process did not depend on the segment length, while in the colon it was 1.5-fold more intensive in the short segment compared to long one.

Great differences were found in glucose reabsorption. It was almost completely reabsorbed in the ileum, while in the sigmoid colon activity of reabsorption was several fold lower and depended on the mucosa—urine contact area.

One more important finding of this study was active reabsorption of uric acid (more pronounced in the ileum), which can be a predisposing cause for lithogenesis in the urinary tract, particularly in bowel reservoir.

Thus, mucosa of the ileum and sigmoid colon exhibited high reabsorbing and secretory activity, moreover the ileum was more metabolically active than the sigmoid colon. Thereby it is important to assess the impact of this activity on biochemical parameters of the blood.

Some parameters reflecting homeostasis underwent significant changes (Table 2). The concentrations of urea and creatinine significantly increased, the increase in urea level depended on the mucosa—urine contact area. At the same time, electrolyte composition of the blood remained practically unchanged, except for phosphorus and magnesium (the concentrations of these ions increased). Active glucose reabsorption from the urine led to marked hyperglycemia even when urine was injected into the sigmoid colon, where glucose reabsorption was less intensive. Protein transudation into the bowel led to marked hypoproteinemia in experiments with urine injections into the long segments of both sigmoid colon and ileum. In parallel, blood level of albumins also changed.

Such parameters as bilirubin, uric acid, C-reactive protein levels, were not significantly affected and remained within the normal range.

Results of this investigation phase showed that the choice of intestine portion for urinary bladder plasty and its length can be essential for the development of metabolic disorders in the postoperative period. Ileac mucosa after transfer into changed conditions retains high metabolic activity, reabsorbs eliminated metabolites, and secretes certain compounds into the urea in the lumen. Sigmoid colon was less active, but also promoted changes in the homeostasis. Progressing imbalance is partially compensated by the organism due to functioning of kidneys, liver, and other organs, but some vital parameters (urea, creatinine, protein levels) considerably deviated from the normal, which attested to insufficiency of compensatory mechanisms. It should be noted that our experiment were performed on healthy animals with normal functions of the liver and kidney, but even they did not fully compensate progressing metabolic disturbances. In clinical practice, the functions of the liver and kidney are often disturbed in patients undergoing cystectomy and urinary bladder enteroplasty. In these cases, the risk of metabolic disorders increases.

We obviously take into account the fact that only "acute" phase of intestine mucosa—urine contact was studied, and that investigation of delayed metabolic consequences of urinary bladder enteroplasty are of great importance. However, we consider that even these findings suggest that the metabolic peculiarities of different regions of the intestinal tract should be taken into account when choosing the optimal operation technique reducing the risk of metabolic disorder to minimum.

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