

Pelvic small intestine reservoirs of a new type

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A – research concept and design; B – collection and/or assembly of data; C – data analysis and interpretation; D – writing the article; E – critical revision of the article; F – final approval of the article

Aim. To improve the results of surgical treatment for patients with severe non-cancerous diseases of the colon by developing and implementing the new type of pelvic small intestine reservoirs.

Materials and methods. A new type of pelvic small intestine reservoirs has been developed and introduced into clinical practice to improve processes of intestinal digestion, absorption, anal retention after radical surgery for ulcerative colitis, Crohn's disease with total colon involvement, familial adenomatous polyposis. Each of the reservoirs has been adapted to anatomical relationships between the small intestine and the debuccalized surgical anal canal depending on a radical surgery extent and a functional state of the small intestine. Pelvic small intestine reservoirs of a new type were used in 39 patients of the main study group, 21 (53.8 %) men and 18 (46.2 %) women. The patients' age ranged from 21 to 43 years. The comparison group consisted of 42 patients. The patient groups were identical in terms of sex, age, diagnosis and complications of the underlying disease. Patients in the comparison group differed in that they underwent the well-known "J"-shaped pelvic small intestine reservoir procedures.

Results. The number of postoperative complications was statistically significantly higher in patients of the comparison group due to acute and chronic complications, 33.2 % and 10.4 %, respectively. Indicators of intestinal digestion, absorption and anal retention were statistically significantly better in the majority of patients of the study group. The number of patients with I (mild) degree of pathological post-colectomy syndrome was significantly higher in the study group, and the number of patients with diarrheal syndrome and secondary anal incontinence syndrome was significantly lower. Positive results after the introduction of a new type of pelvic small intestine reservoirs were obtained by applying the following basic principles of their formation: the use of only known factors of physiological delay in the passage of contents through the small intestine, preservation of the small intestine wall anatomical integrity, location of the small intestine reservoir at a certain distance from the upper border of the rectal sphincters, as well as the reasonable expediency of choosing a method of forming the pelvic small intestine reservoir depending on the patient's anatomy.

Conclusions. The use of physiological factors of delayed passage of the contents in the small intestine, small intestine wall anatomical integrity preservation in the formation of pelvic small intestine reservoirs of the new type, the reservoir location at a certain distance from the upper border of the rectal sphincters has resulted in significant improvements in the functions of intestinal digestion, absorption, and anal retention. Practical application of the new type of pelvic small intestine reservoirs has helped to significantly decrease the incidence of postoperative complications from 33.2 % to 10.4 %, increase the number of patients with post-colectomy syndrome of the I (mild) degree from 47.4 % to 86.4 %, reduce the number of patients with diarrheal syndrome from 55.3 % to 8.1 %, and secondary anal incontinence syndrome from 36.8 % to 5.4 %.

Keywords:

ulcerative colitis, Crohn's disease, familial adenomatous polyposis, surgical treatment, pelvic small intestinal reservoirs, functional outcomes.

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Тазові тонкокишкові резервуари нового типу

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Мета роботи – покращити результати хірургічного лікування пацієнтів із приводу тяжких непухлинних захворювань товстої кишки шляхом розроблення та впровадження тазових тонкокишкових резервуарів нового типу.

Матеріали і методи. Розроблено та впроваджено в клінічну практику тазові тонкокишкові резервуари нового типу, що використали для покращення перебігу процесів кишкового травлення, всмоктування, анального тримання після радикальних операцій, виконаних із приводу виразкового коліту, хвороби Крона товстої кишки, при тотальному ураженні, родинному аденоматозному поліпозі. Кожен із резервуарів адаптований до анатомічних зв'язків між відрізками тонкої кишки та демукозованого хірургічного анального каналу залежно від обсягу радикальної операції та особливостей функціонального стану тонкої кишки. Тазові тонкокишкові резервуари нового типу використали у 39 пацієнтів основної групи дослідження (21 (53,8 %) чоловік і 18 (46,2 %) жінок). Вік пацієнтів становив 21–43 роки. До групи порівняння залучили 42 пацієнтів. За статтю, віком, діагнозом і ускладненнями основного захворювання групи хворих зіставні. Пацієнти групи порівняння відрізнялися тим, що у них формували відомий J-подібний тазовий тонкокишковий резервуар.

Результати. Значно більшою і статистично достовірною була кількість післяопераційних ускладнень у пацієнтів групи порівняння, зокрема діагностовано 33,2 % гострих і 10,4 % хронічних ускладнень. У більшості пацієнтів групи дослідження зафіксовано значно кращі та статистично достовірні показники функції кишкового травлення, всмоктування та анального тримання. У групі дослідження вірогідно більше пацієнтів із I (легким) ступенем патологічного постколектомічного синдрому, достовірно менше хворих із діарейним синдромом і синдромом вторинної анальної інконтиненції. Позитивні результати після впровадження тазових тонкокишкових резервуарів нового типу одержали завдяки використанню таких основних принципів їх формування, як застосування лише відомих чинників фізіологічної затримки просування вмісту по тонкій кишці, збереження анатомічної цілісності стінки тонкої кишки, розташування тонкокишкового резервуару на певній відстані від верхньої межі сфінктерів прямої кишки, а також завдяки обґрунтованій доцільності вибору способу формування тазового тонкокишкового резервуару залежно від особливостей анатомічних зв'язків відрізка тонкої кишки та відрізка демукозованого хірургічного анального каналу, особливостей функціонального стану тонкої кишки.

Ключові слова:

виразковий коліт, хвороба Крона, родинний аденоматозний поліпоз, хірургічне лікування, тазові тонкокишкові резервуари, функціональні результати.

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Висновки. Використання фізіологічних факторів затримки просування вмісту по тонкій кишці, збереження анатомічної цілісності стінки тонкої кишки під час формування тазових тонкокишкових резервуарів нового типу, розташування резервуару на певній відстані від верхньої межі сфінктерів прямої кишки сприяло істотному покращенню функцій кишкового травлення, всмоктування, анального тримання. Впровадження в клінічну практику тазових тонкокишкових резервуарів нового типу сприяло значному зменшенню частоти виникнення післяопераційних ускладнень (з 33,2 % до 10,4 %), збільшенню кількості пацієнтів із постколектомічним синдромом I (легкого) ступеня (з 47,4 % до 86,4 %), зменшенню кількості пацієнтів із діарейним синдромом (з 55,3 % до 8,1 %), синдромом вторинної анальної інконтиненції (з 36,8 % до 5,4 %).

Pelvic small intestine reservoirs are formed after the largest radical sphincter-preserving operation in colon surgery – colectomy with ultra-low anterior rectal resection and mucosectomy of the surgical anal canal [1,2,3,4]. This operation is performed in severe non-tumorous diseases of the colon: familial adenomatous polyposis, ulcerative colitis, Crohn's disease of the colon with total lesions in the presence of chronic complications, or severe clinical course in accordance with clearly defined indications [1,2,3,4,5]. The expediency of forming small intestine reservoirs after colon removal is due to the need to improve the processes of intestinal digestion and absorption in order to prevent severe forms of post-colectomy syndrome occurrence.

The formation of the well-known "J"-shaped pelvic small bowel reservoir is accompanied by quite frequent postoperative complications: failure of the reservoir sutures and the reservoir-anal anastomosis, significant disorders of intestinal digestion, absorption, anal retention due to the reservoiritis occurrence, decreased tone of the rectal sphincters, frequent bowel movements, diarrhea, and significant loss of liquid chemistry [1,4,6,7,8]. The main reason for the occurrence of complications and these pathological conditions is due to a decrease and sometimes loss of contractile capacity of the reservoir walls, its static load on the rectal sphincters, especially during periods of cavity filling with contents [1,3,8,9]. Reduction or loss of contractile function is caused by disorders of innervation and blood supply to the "J"-shaped reservoir walls which result from the known features of its formation technique [1,6,8,9].

Given these negative consequences of the well-known "J"-shaped pelvic small intestine reservoir formation, a new type of pelvic small intestine reservoir has been developed.

Aim

To improve the results of surgical treatment for patients with severe non-cancerous diseases of the colon by developing and implementing the new type of pelvic small intestine reservoirs.

Materials and methods

The authors include in the concept of "new type pelvic small intestine reservoir" a new anatomical structure created in the terminal part of the small intestine without violating the anatomical integrity of its walls for physiological delay of the content movement, rather than its accumulation, in order to improve the processes of intestinal digestion and absorption. Thus, the new type of pelvic small intestine reservoir is a structure that is more functional than anatomical.

In accordance with these provisions, the "Method for the formation of a small intestine reservoir after colectomy and rectal supraanal resection" was developed [10]. A component of the reservoir was a system of fixed anatomical bends

of the small intestine, created by the type of cycloreservoir using only serous-muscular sutures *Fig. 1*.

The system of anatomical bends consisted of three small intestinal loops arranged by a cycloreservoir type with a length of 12–14 cm, which corresponded to the longitudinal size of the terminal section of the small intestinal loops in operated patients. This reservoir was formed in such a way that its lower edge was proximal to 7–8 cm from the edge of the small intestine segment. This made it possible to form an ileo-endoanal anastomosis after the small intestinal graft was placed into the pelvic cavity together with the formed reservoir.

In the process of gaining experience in the formation of this reservoir, the authors encountered some atypical anatomical and functional conditions that increased the technical difficulties of forming the reservoir and limited the possibility of its use. The atypical anatomical and functional conditions were a reduction in the small intestinal length due to forced resection of its terminal section and "irritable bowel syndrome". Forced resection of the small intestine terminal part during colectomy with rectal ultra-low resection was most often performed in case of total Crohn's disease of the colon and terminal part of the small intestine. "Irritable small bowel syndrome" was manifested by hypermotility, hyperperistalsis of the small intestine, abdominal rumbling, significant loss of fluid from the ileostomy in the range of 1.5–2.0 liters in patients after colectomy and rectal resection of the obstructive type. Due to the reduction in the small intestinal length and the presence of "irritable bowel syndrome", it became necessary to develop a pelvic small intestinal reservoir, in which the physiological delay in the movement of the small intestine contents would be longer, and the processes of intestinal digestion and absorption would be more intense.

For this purpose, a "Method of forming a small intestine pelvic reservoir" has been developed [11]. The peculiarity of the technique of its formation was the use of two factors of delayed content movement: anatomical bends in the terminal part of the small intestine and a retaining valve located proximal to these bends *Fig. 2*.

The retaining valve of the original author's design was used [12]. Due to the two factors of delayed content movement, the reservoir was sufficiently adapted to the new anatomical relationships that arose after the radical stage of surgery, which was expanded by resection of the small intestinal terminal part and created favorable conditions for improving the process of intestinal digestion and absorption, including in the event of functional pathological conditions.

The main study group consisted of 39 patients who were operated on at the Coloproctology Centre of Ukraine, the main clinical base of the Department of Surgery No. 1 of Bogomolets National Medical University from 2014 to 2022 using the developed methods of forming the new type of pelvic small intestine reservoirs, 21 (53.8 %) men and 18 (46.2 %) women. The patients' age ranged from 21

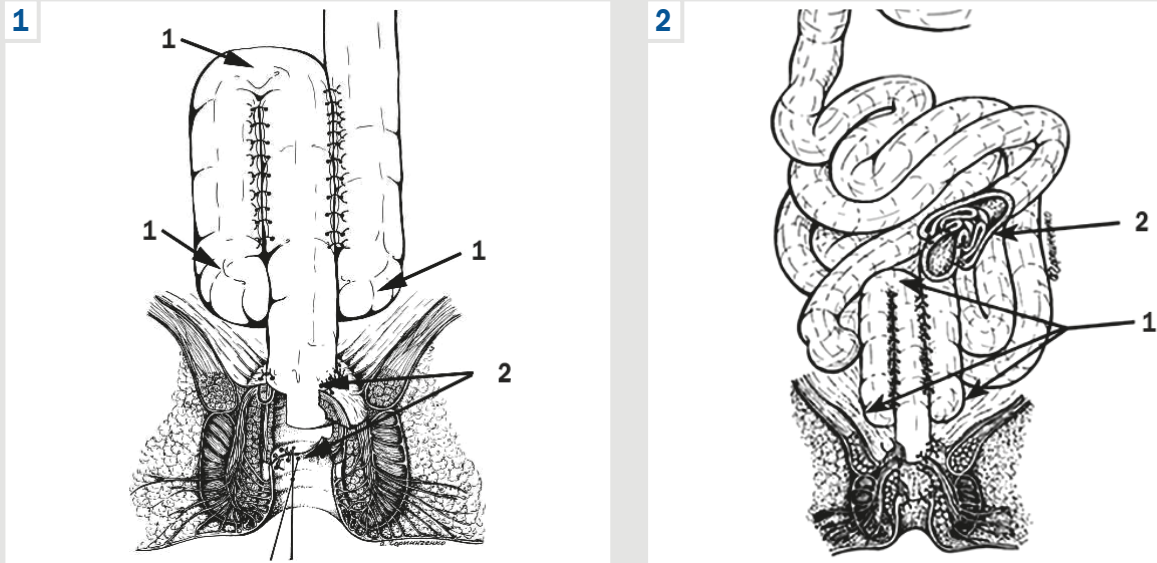


Fig. 1. The method of forming a small intestine reservoir after colectomy and rectal supraanal resection. **1:** system of fixed anatomical bends of the small intestine; **2:** site of ileo-anal anastomosis.

Fig. 2. Formed pelvic small intestine reservoir. **1:** fixed bends in the terminal part of the small intestine by the type of cycloreservoir; **2:** section of the retaining valve.

to 43 years. Ulcerative colitis was treated in 16 (41.1 %) patients, Crohn's disease with total colon involvement – in 7 (17.9 %), Crohn's disease with total colon and terminal small intestine involvement – in 4 (10.3 %), and familial adenomatous polyposis – in 12 (30.7 %). Complications of the underlying disease occurred in 22 (56.4 %) patients. Acute complications occurred in 10 (25.6 %), including peritonitis due to colonic wall perforation – in 5, bleeding into the intestinal lumen in – 3, and toxic colonic dilatation – in 2. Chronic complications occurred in 14 (35.8 %): stricture – in 4, internal intestinal fistulas – in 3, external fistulas – in 3, severe dysplasia – in 3, chronic paracolic inflammatory infiltrate – in 2, malignancy – in 2. Two patients had two chronic complications and one patient had three.

Concomitant diseases: hypertension, obesity, diabetes mellitus, superficial varicose veins of the lower extremities, essential thrombocytopenia, hypertension, obesity were diagnosed in 16 (41.1 %) patients.

The radical stage of surgical intervention in 9 (23.1 %) patients of the main group with acute complications consisted of colectomy, rectal resection of the obstructive type. In 1 (2.6 %) patient, this radical surgery was complemented by resection of the small intestinal terminal part due to its damage by Crohn's disease. Obstructive surgery was completed with the formation of a rectal stump and a Brooke-type ileostomy. Colectomy with ultra-low anterior resection of the rectum and mucosectomy of the surgical anal canal were performed in 17 (43.6 %) patients. This operation was supplemented with an enforced resection of the small intestinal terminal section with a length of 15–120 cm in 14 (35.9 %) patients. Indications for resection of the terminal small intestine were Crohn's disease of this area in 4 patients, a significant risk of relapse – in 7 patients, ascending ileitis in ulcerative colitis – in 3 patients.

After the radical stage, the reconstructive and restorative stage of surgical treatment was performed. It involved

the formation of the pelvic small intestine reservoir, its placement together with a small intestinal graft into the pelvic cavity, and the formation of an ileo-ileoanal anastomosis. Primary reconstructive and restorative surgery was performed in 29 (74.3 %) patients, secondary – in 10 (25.7 %). The secondary stage of surgery was done in 12–14 months, exclusively after obstructive colectomy with rectal resection. The rectal stump resection, mucosectomy of the surgical anal canal were performed, and a pelvic small intestinal reservoir of an appropriate design was formed depending on the anatomical relationship between the small intestinal segments and the surgical anal canal.

The design of the pelvic small intestine reservoir and ileo-anal anastomosis in all operated patients was “switched off” by forming a diverting loop ileostomy for the healing period within 2–4 months. Each of the developed pelvic small intestine reservoirs was maximally adapted to the anatomical relationships that arose after different volumes of radical surgery. Thus, in 17 (43.6 %) patients with typical anatomical relationships between the small intestine and the debuccalized surgical anal canal, a reservoir with only one factor of delayed content movement was used, namely, fixed anatomical bends of the small intestine.

In 14 (35.8 %) patients with atypical anatomical relationships between the small intestine and the debuccalized anal canal, pelvic small intestine reservoir with two factors of delayed content movement was used, namely, fixed anatomical bends and a retention valve located proximal to these bends. This pelvic small intestine reservoir with two factors of delayed content movement through the small intestine was also formed in 4 patients with irritable bowel syndrome.

The comparison group consisted of 42 patients whose radical stage of surgical intervention consisted of only colectomy, ultra-low anterior resection of the rectum, and mucosectomy of the surgical anal canal. There were no

cases of the terminal part of the small intestine resection indicating more favorable conditions for the reconstructive and restorative stage of surgical treatment which involved the formation of the traditional "J"-shaped pelvic small intestine reservoir and a reservoir-anal anastomosis. The construction of the reservoir and anastomosis was also "disconnected" by a diverting loop ileostomy for the period of its healing. There was no significant difference between the two groups of patients in terms of age, sex, diagnosis of the underlying disease, complications, comorbidities, which allowed us to consider them representative according to the specified comparison criteria.

In both patient groups, standard clinical, laboratory and instrumental methods of examination were used to diagnose postoperative complications and determine the functional results of surgical interventions. Among the special studies, the radiological method of monitoring the transit time of the barium sulfate mixture through the small intestine and the duration of contrast retention in the formed reservoir was used. To assess the condition of the mucous membrane of the formed reservoir and the ileo-endoanal anastomosis, anoscopy was done. Anosphincterometry was performed to determine the rectal sphincter tone. The processes of intestinal digestion and absorption were assessed based on the results of a coprological examination as well as body weight was measured by a medical scale. Digital data were statistically processed using the software package StatSoft Statistica 6.0.

Results

Postoperative complications in patients of both groups are shown in *Table 1*.

According to the data presented in *Table 1*, postoperative complications occurred in 4 (10.4 %) patients of the main group. Of these, 3 (7.7 %) had early complications and 1 (2.6 %) had late complications. Among the early postoperative complications, a pelvic cavity abscess was diagnosed in 2 patients, and an external fistula of the ileo-endoanal anastomosis – in 1 patient. These abscesses were opened and drained on the 9th and 11th day of the postoperative period, respectively, through a contraperture created to remove drains from the pelvic cavity. In both cases, the abscesses occurred after secondary reconstructive and restorative operations due to abscessing of pelvic hematomas after mobilization and rectal stump removal.

An external fistula that opened into the perineum also occurred in a patient after secondary reconstructive surgery due to technical difficulties in forming the ileo-endoanal anastomosis. Prolonged, ineffective conservative treatment of the fistula for two months was the reason for the anal stump extirpation along with the ileo-endoanal anastomosis. The operation was completed with the formation of the lifelong Brook-type ileostomy. In the late postoperative period, 1 year and 2 months after the surgical treatment completion, 1 patient operated on for familial adenomatous polyposis and a tumor of the mid-ampullary rectum developed ischemic reservoir due to metastasis of the neoplastic process to the mesentery of the small bowel graft. This patient also underwent the anal stump extirpation together with the ileo-endoanal anastomosis, and the lifelong Brook-type ileostomy was formed.

The number of postoperative complications in patients of the comparison group was significantly higher and statistically significant, due to acute and chronic complications: suture failure of the classical "J"-shaped pelvic small intestine reservoir and the reservoir-anal anastomosis, reservoiritis, anastomotic strictures. It should be noted that the anal stump extirpation with the reservoir and the reservoir-anal anastomosis was performed in 5 (11.9 %) patients of the comparison group. Of these, 3 were due to suture failure of the reservoir and anastomosis, and 2 – due to external fistulas of the reservoir-anal anastomosis. There were no cases of postoperative mortality in both groups.

Functional outcomes were determined by studying individual indicators of the main functions of the digestive tract: intestinal digestion, absorption, defecation, anal retention. The results were evaluated 1 year after completing all stages of surgical interventions. During this period, the condition of the operated patients was relatively stabilized, as well as the digestive system was adapted to new anatomical relationships that arose after the radical and reconstructive-restorative stages of the surgical treatment. The study results are presented in *Table 2*. Functional outcomes were not studied in 6 patients. Of these, 4 were in the comparison group and 2 were in the main group after the anal stump extirpation and removal of the small bowel reservoir.

According to the data presented in *Table 2*, the indicators of intestinal digestion and absorption functions, namely, weight of chyme in the stool and the number of stools per day corresponding to the physiological norm upper limit for healthy persons, were observed in the vast majority of the main group patients and in a significantly fewer patients of the comparison group. The difference in the number of patients with these indicators was statistically significant. The coprological examination results also indicated a more favorable course of intestinal digestion and absorption in the main group patients.

According to the results of X-ray control, the time of barium mixture transit through the small intestine and its retention in the reservoir was longer, but statistically insignificant, in the main group patients, namely, 5 hours ± 40 minutes in contrast to the comparison group patients – 3 hours 50 minutes ± 30 minutes ($p > 0.05$). The barium mixture retention in the reservoir was 4 hours 20 minutes ± 30 minutes and 3 hours 40 minutes ± 25 minutes ($p > 0.05$), respectively. *Fig. 3* illustrates the physiological delay in the barium mixture transition in the small intestine loops and in the formed reservoir.

According to the reservoirography, the reservoir was presacral in location with a shape largely resembling a removed rectal ampulla *Fig. 4*.

There was a significant increase in body weight as an integral indicator of intestinal digestion and absorption by 11.7 ± 1.9 kg in the main group patients and 5.6 ± 1.4 kg in the comparison group patients ($p < 0.005$).

The indicators of anal retention function were significantly better in the main group patients. The table shows a significantly higher number of patients with daytime anal incontinence and a statistically higher number of patients with nighttime anal incontinence in the comparison group compared to those in the main study group. These disorders of anal retention function were confirmed by the results

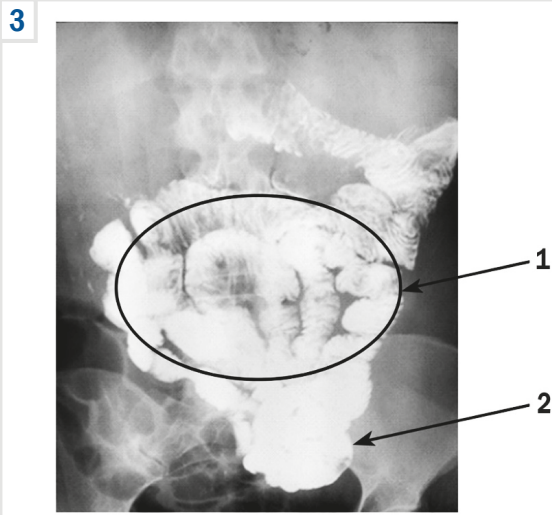


Fig. 3. Radiological monitoring of barium sulphate transition through the small intestine and pelvic small intestine reservoir 8 hours after oral administration. **1:** small intestine loops filled with a mixture of barium sulphate; **2:** a section of the pelvic small intestine reservoir.

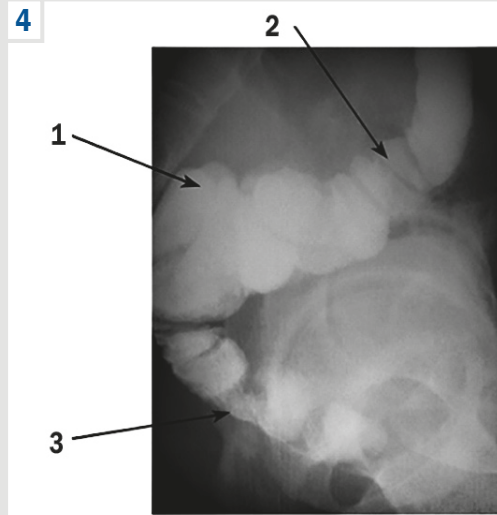


Fig. 4. Reservoiriogram (lateral projection) performed 2 years after the reservoir formation. **1:** small intestine reservoir; **2:** area of the retention valve; **3:** site of the ileo-endoanal anastomosis.

Table 1. Postoperative complications

Diagnosis / Complications	Patient groups			
	Main, n = 39		Comparison, n = 42	
	abs.	%	abs.	%
Early				
Abscess of the pelvic cavity	2	5.2	2	4.7
Failure of the reservoir and anastomosis sutures	–	–	3	7.1
External fistula	1	2.6	2	4.7
Late				
Reservoiritis	1	2.6	4	9.6
Stricture of the anastomosis	–	–	3	7.1
Total	4	10.4	14	33.2*

*: significant differences between indicators ($p < 0.001$).

Table 2. Functional outcomes

Indicator values	Patient groups			
	Main, n = 37		Comparison, n = 38	
	abs.	%	abs.	%
The weight of the chyme in the faces				
350–450 g	34	91.8	16	42.1*
460–800 g	3	8.2	22	57.9**
Number of defecations per day				
3–5	31	83.8	12	31.5**
6–8	6	16.2	21	55.4**
9 times or more	–	–	5	13.1
Coprogram results				
Mushy consistence of the chyme	35	94.6	17	44.7*
Liquid chyme consistency	2	5.4	21	55.3**
Fiber presence	insignificant		moderate	
Extracellular starch	insignificant		moderate	
Changed muscle fibers	insignificant		moderate	
Neutral fat	insignificant		moderate	
Cases of anal incontinence				
Daytime	–	–	9	23.7
Nighttime	3	8.1	11	28.9**

*: significant differences between indicators ($p < 0.05$); **: significant differences between indicators ($p < 0.001$).

Table 3. Pathological syndromes

Pathological syndrome and its degree of severity	Patient groups			
	Main, n = 37		Comparison, n = 38	
	abs.	%	abs.	%
Degree I (mild) post-colectomy syndrome	32	86.4	18	47.4*
Degree II (moderate) post-colectomy syndrome	5	13.6	15	39.5**
Degree III (severe) post-colectomy syndrome	–	–	5	13.1
Diarrheal syndrome	3	8.1	21	55.3**
Secondary anal incontinence syndrome	2	5.4	14	36.8**

*: significant differences between indicators ($p < 0.05$); **: significant differences between indicators ($p < 0.001$).

of anosfintrometry performed 1 year after completing all stages of the surgical treatment.

The mean values of internal rectal sphincter tone (resting state) in the main and comparison groups were 39.0 ± 4.2 and 35.0 ± 6.3 mm Hg ($p > 0.05$), respectively, and external sphincter tone (with voluntary contraction) were 92.0 ± 3.8 and 88.0 ± 3.6 mm Hg, respectively ($p > 0.05$). The indicators of internal and external anal sphincter tone were significantly better in the main group patients approaching the lower physiological norm limit of similar indicators in healthy persons. However, differences in these indicators were statistically insignificant compared to the comparison group. This indicates that even a slight increase in rectal sphincter tone can contribute to improvements in anal retention function.

Based on the above study results of intestinal digestion, absorption, defecation, anal retention in operated patients after colectomy, ultra-low anterior resection of the rectum, mucosectomy of the surgical anal canal, formation of pelvic small intestine reservoirs, the following severity degrees of pathological syndromes are shown in Table 3.

The data in Table 3 indicate that degree I post-colectomy syndrome prevailed in the operated patients of both groups. However, the number of such patients in the main study group was significantly higher and, accordingly, the number of patients with degree II post-colectomy syndrome was significantly lower. Severe forms of post-colectomy syndrome were present only in 5 (13.1 %) patients of the comparison group. Also, the number of patients in the comparison group with diarrheal syndrome and secondary anal incontinence syndrome was significantly higher.

Discussion

The use of pelvic small intestine reservoirs of the new type has contributed to a significant reduction in the incidence of intra-abdominal postoperative complications, in the number of operated patients with moderate and severe post-colectomy, diarrheal, and secondary anal incontinence syndromes, improvements of functional outcomes, in particular, the processes of intestinal digestion, absorption, anal retention. These positive results were largely due to the technical peculiarities of forming pelvic small intestine reservoirs of the new type, the development and formation of which was guided by the following basic principles:

- the use of only known factors of physiological delay in the movement of small intestinal contents;
- preservation of the small intestine wall anatomical integrity;

– the location of the small intestine reservoir at a certain distance from the upper border of the rectal sphincters and the ileo-endoanal anastomosis.

The anatomical intestinal bends and retention valves were used as factors of physiological delay in the content movements. These factors in the formation of pelvic small intestine reservoirs ensured a delayed small intestinal transit of contents that increased the duration of their contact with the mucous membrane surface and thus resulted in improved intestinal digestion and absorption.

Preserving the anatomical integrity of the small intestine wall prevented the accumulation of contents in the reservoir, its pathological retention, fermentation and putrefaction processes and, as a result, inflammation in the reservoir walls – reservoiritis.

The location of the lower border of the small intestine reservoir at a certain distance, not less than 3–4 cm from the upper border of the rectal sphincters, allowed to avoid the load on the muscle structures of these sphincters by the reservoir walls, especially during the period of its filling with contents, thereby preventing the occurrence of secondary anal incontinence syndrome. At the same time, the content retention in the reservoir was due to the above-mentioned retention factors rather than by the rectal sphincter tonic contractions, which occurred in the classic J-shaped reservoir formation. The choice of the distance between the lower border of the reservoir and the upper border of the rectal sphincters of 3–4 cm was motivated by anatomical features, namely, the small diameter of the pelvic funnel and the impossibility of a lower reservoir location.

The peculiarity of using the methods of forming the new type of pelvic small intestine reservoirs was to adapt each of them to the anatomical relationships that arose between the segments of the debuccalized surgical anal canal and the terminal part of the small intestine after radical surgical interventions of different sizes, as well as the functional state of the small intestine.

Due to the above-mentioned particular technical aspects of the new type of pelvic small intestine reservoir formation, peculiarities of their use depending on the functional state of the small intestine, anatomical relationships between the small intestine segments and debuccalized surgical anal canal, the results obtained in the main group patients were significantly better compared not only to those in the comparison group patients, but also to the data of foreign authors' publications. In the study group patients, there was no suture failure of the small intestine reservoir, reservoir-anal anastomosis and pelvic sepsis at all. However, according to some foreign authors, this complication occurred in 9.5 % of patients, and pelvic

sepsis – in 5.5 % [13]. In the late postoperative period, according to some foreign authors, purulent reservoir occurred in 18.8 % of patients, stricture of the reservoir-anal anastomosis – in 5 %, internal or external fistulas communicated with reservoirs – in 20 % [14]. In the study group, these complications occurred in a much smaller number of patients: 2.6 %, 0.0 % and 2.6 %, respectively. Differences in most indicators were significant ($p < 0.005$). Similar data on the complications after the “J”-shaped pelvic small intestine reservoir formation have also been reported by other foreign authors [2,7,15,16,17,18].

Functional outcomes, namely, stool frequency as the most objective indicator of intestinal digestion and absorption after colectomy and ultra-low resection of the rectum, anal incontinence and urgency incontinence episodes were better, but insignificantly, in the study group patients compared to the data of some foreign publications. The frequency of bowel movements in the range of 6–8 times per day, disorders of defecation and anal retention function occurred in most of the operated patients [1,16]. In the study group, the frequency of bowel movements in the range of 3–5 times per day occurred in 83.8 % of patients. Bowel voiding 6–8 times per day was observed in 16.2 % of patients. Anal incontinence syndrome was observed in only 5.4 % of the operated patients.

Thus, a significantly lower incidence of postoperative complications in the early and late postoperative periods, significantly more favorable functional results in the main study group compared to the comparison group, as well as data published by foreign authors, indicate the advantage of the author’s methods of forming the new type of pelvic small intestine reservoirs, better perfection of the technical aspects of their formation compared to the classic “J”-shaped reservoir. It is important to justify the feasibility of choosing a method of forming a pelvic small intestine reservoir depending on the peculiarities of anatomical relationships between the small intestine and the segment of the debuccalized surgical anal canal, as well as the functional state of the small intestine.

Better functional outcomes in the study group patients, in particular, improved intestinal digestion, absorption, defecation, anal retention, led to a significantly higher number of the main group patients developing I (mild) degree post-colectomy syndrome ($p < 0.05$), and a significant decrease in the number of patients with moderate ($p < 0.001$) degree of the syndrome. Moreover, diarrheal and secondary anal incontinence syndromes were considerably better in a significantly larger number of the main group patients as compared to the comparison group ($p < 0.001$).

Conclusions

1. The use of physiological factors of delayed passage of the contents in the small intestine, small intestine wall anatomical integrity preservation in the formation of pelvic small intestine reservoirs of the new type, the reservoir location at a certain distance from the upper border of the rectal sphincters has resulted in significant improvements in the functions of intestinal digestion, absorption, and anal retention.

2. Practical application of the new type of pelvic small intestine reservoirs has helped to significantly decrease the incidence of postoperative complications from 33.2 % to

10.4 %, increase the number of patients with post-colectomy syndrome of the I (mild) degree from 47.4 % to 86.4 %, reduce the number of patients with diarrheal syndrome from 55.3 % to 8.1 %, and secondary anal incontinence syndrome from 36.8 % to 5.4 %.

Prospects for further research: to improve the technique of forming pelvic small intestine reservoirs.

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