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Laparoscopic Pyelolithotomy: The Optimal Drainage Method

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Abstract **The aim** of the study was to improve the treatment results of patients by improving the urinary tract drainage methods during laparoscopic surgery. **Introduction.** Percutaneous renal drainage is effective for most, if not all, obstructions, including intrarenal, ureteropelvic or ureteral obstructions. An alternative to percutaneous drainage is drainage through a ureteral catheter or a retrograde stent. The choice of antegrade or retrograde drainage of the upper urinary tract collecting system depends on the indication, health status and anatomy of the patient, as well as the preferences of both the patient and the physician. Using percutaneous renal access, surgical removal of upper urinary tract stones, urothelial tumors, obstructions, and calyceal diverticula can be performed. **Material and methods.** 45 patients who underwent laparoscopic pyelolithotomy at the Republican Specialized Scientific and Practical Medical Center of Urology in the period from 2012 to 2022 were selected for the study. The mean age of the patients was 34.2 ± 13.3 years (M±δ). There were 30 (66.7%) males and 15 (33.3%) females among them. In 26 (57.8%) patients, the surgery was performed on the left side, and in the remaining 19 (42.2%) ones - on the right. **Results.** To assess the efficiency and safety of upper urinary tract drainage, the duration of surgical intervention; the amount of intraoperative blood loss; the frequency of intra- and postoperative complications; the frequency of additional interventions; the severity of pain syndrome; the duration of the patient's stay in the hospital; the length of the incision; assessment of the patient's quality of life using an adapted Wisconsin questionnaire (WISQOL) were comparatively analyzed. During the study, the duration of surgical intervention was analyzed to assess the impact of nephrostomy drainage period during laparoscopic pyelolithotomy, as well as the time to relieve intraoperative complications associated with the drainage method. **Conclusion.** The developed technique for installing nephrostomy drainage during laparoscopic pyelolithotomy allows to install drainage on upper urinary tracts during the surgery itself, without involving additional specialists and equipment. This technique is not only safe for use in patients, but also reduces the duration of surgery and the frequency of postoperative complications, allows patients to get rid of drains at an earlier date and contributes to a rapid improvement of the life quality.

Keywords Laparoscopic pyelolithotomy, Therapeutic percutaneous nephrostomy, Drainage, Urinary tract, Ureteral catheter

1. Introduction

Using a new technique of combining upper urinary tract (UUT) drainage and ureteral intubation during laparoscopic pyelolithotomy, it is possible to drain effectively the UUT, maintain autonomy of ureteral intubation and remove all drainage through a single puncture on the patient's body.

Hillier repeatedly aspirated a young boy's hydronephrotic kidney to relieve symptoms for 4 years until his death at age 8 at Great Ormond Street Children's Hospital in London in 1865, [1-2]. It was the first description of percutaneous nephrostomy in the literature. Subsequently, there were several reports of diagnostic percutaneous renal aspiration, but it was not until Goodwin, Casey, and Wool in 1955 described percutaneous trocar nephrostomy for temporary drainage of hydronephrosis in 16 patients that therapeutic percutaneous nephrostomy was rediscovered [3]. Even then, the usefulness of percutaneous access to the upper urinary tract collecting system was limited by the drainage of obstruction [4-11], until Fernström and Johansson (1976) described percutaneous removal of kidney stones, called percutaneous nephrolithotripsy [12]. After it, percutaneous access to the upper urinary tract became the main diagnostic and therapeutic method.

Percutaneous renal drainage is effective for most, if not all, obstructions, including intrarenal, ureteropelvic, or ureteral ones. Although lower urinary tract obstruction is best treated with bladder drainage using a urethral catheter, secondary supravesical obstruction can be relieved by placement of a

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percutaneous nephrostomy tube if other measures did not provide adequate drainage [13-14,10].

An alternative to percutaneous drainage is drainage through a ureteral catheter or a retrograde stent. The choice of antegrade or retrograde drainage of the upper urinary tract collecting system depends on the indication, health status and anatomy of the patient, as well as the preferences of both the patient and the physician [14].

As a rule, the retrograde route of drainage is preferable to the antegrade one [15]. However, in upper collecting tract obstruction complicated by infection, drainage is an emergency, and in many such cases percutaneous rather than retrograde drainage is superior [16].

Percutaneous nephrostomy tubes and retrograde ureteral stents are generally equivalent in their ability to relieve fever in patients with upper urinary tract obstruction and acute urinary tract infection [17-18], but in a particular patient, circumstances may dictate a preference for one approach over another. Retrograde ureteral stent placement requires regional or general anesthesia, whereas a percutaneous nephrostomy tube can be placed under a local anesthesia. Because the percutaneous approach has a higher initial success rate than the retrograde approach, in cases where the collecting system is dilated, it may be preferable in patients requiring rapid intervention. Conversely, untreated coagulopathy is a contraindication to percutaneous access, but ureteral stents can be safely placed in patients taking anticoagulants.

In rare cases, percutaneous renal access is needed solely for diagnostic purposes, for example, for the Whitacker test, which is an invasive but very accurate test for differentiating obstructive hydronephrosis from non-obstructive one [19]. Percutaneous renal access can be performed to facilitate the instillation of chemotherapeutic agents for urothelial lesions of the upper urinary tract or agents for chemolysis of kidney stones, including the administration of antifungal drugs for renal bezoars.

Using percutaneous renal access, it is possible to perform surgical removal of upper urinary tract stones, urothelial tumors, obstructions, and calyceal diverticula [20]. The use of percutaneous drainage of the upper urinary tract after various surgical interventions is widespread. However, based on the situation after surgery, the surgeon must decide which drainage means to use [21].

2. Material and Methods

45 patients who underwent laparoscopic pyelolithotomy at the Republican Specialized Scientific and Practical Medical Center of Urology in the period from 2012 to 2022 were selected for the study. The mean age of the patients was 34.2 ± 13.3 years (M±δ). There were 30 (66.7%) males and 15 (33.3%) females among them. In 26 (57.8%) patients, the surgery was performed on the left side, and in the remaining 19 (42.2%) ones - on the right. During the preparation for laparoscopic surgery, all patients were performed general and biochemical blood tests, tests to determine the Rh factor, HIV infection, syphilis, hepatitis B and C and blood group, the prothrombin index, Lee-White blood clotting time and the Duke bleeding time test. Blood serum urea and creatinine levels were used to determine the functional state of the kidney. Reference values for normal urea levels were considered to be 2.8-7.2 mmol/l, and for creatinine in men - 70-115 µmol/l, for women - 44-80 µmol/l.

Laparoscopic surgeries were performed using endovideosurgical equipment and instruments from KARL STORZ (Germany), an electrosurgery device ARC 400 (BOWA Medical, Germany) and an ultrasonic scalpel Hormonic Scalpel Gen04 (Ethicon, USA). An Ethicon ultrasonic scalpel was used for each patient. The handle of the ultrasound scalpel was connected to the Hormonic Scalpel Gen04 generator. Urinary tract ultrasound was performed on ultrasound devices "Affinity 50G" (Philips, Netherlands) and "Sonix SP" (Ultrasonix, Canada).

A special electronic patient examination card was developed to identify significant clinical, laboratory and instrumental parameters. It contained passport information, objective data, complaints, comorbidities, data of laboratory and instrumental methods of investigation, methods of surgical treatment and their results, as well as other significant features. The whole card was realized as an electronic database on a personal computer (Excel 2019 Mac).

The quantitative features were coded binary (Yes, No), and gradations were introduced for qualitative signs. The necessary data arrays for the study were formed by filtering the initial information matrix according to the given conditions. Methods of graphical analysis (box histograms, quantile plots) and mathematical methods (Shapiro-Wilk criterion, Kolmogorov-Smirnov criteria) were used to test the distribution of the trait for normality.

Analysis of variance (ANOVA) was used to compare characteristics of three or more normally distributed groups. the Mann-Whitney U test was used for statistical analysis and comparison of groups with a non-parametric (non-normal) distribution. The Kruskal-Wallis test was used to compare characteristics of three or more groups with a non-parametric (non-normal) distribution. The hypothesis about the distribution law of the studied value was tested using the Pearson goodness-of-fit test or Chi-square. The level of statistically significant results was considered $p < 0.05$. Statistical data processing was carried out using StatPlus and IBM SPSS Statistics programs.

The aim of the study was to improve the treatment results of patients by improving the urinary tract drainage methods during laparoscopic surgery.

3. Results

19 (42.2%) patients had an active urinary tract infection (UTI) before surgery, 18 (40%) of them had a nephrostomy tube installed before surgery for urine diversion and treatment of UTI. Surgery was performed after the active

UTI had resolved.

All 45 patients were divided into 2 groups:

- Group I consisted of 18 patients who had a nephrostomy tube installed before the main operation;
- 27 patients in Group II had a nephrostomy tube installed during laparoscopic pyelolithotomy using the developed technique for installing drainage in the UUT.

The initial characteristics of patients in the 2 groups did not differ significantly (Table 1).

To evaluate the efficacy and safety of UUT drainage were comparatively analyzed the followings: the duration of surgery; amount of intraoperative blood loss; incidence of intra- and postoperative complications; incidence of additional interventions; severity of pain syndrome; length of hospital stay; length of incision; and assessment of patient quality of life using the adapted Wisconsin Questionnaire (WISQOL).

During the study we analyzed the duration of surgery to evaluate the impact of the duration of nephrostomy drain placement during laparoscopic pyelolithotomy and the time to manage intraoperative complications related to the drainage method.

The average duration of surgical intervention in Group I was 82.5 ± 16.5 minutes (M±δ; median 80; interquartile range - 20); and in Group II - 83.3 ± 15.6 minutes (M±δ; median 85; interquartile range - 17.5). The installation of nephrostomy drainage did not have a statistically significant effect on the duration of the surgery ($p > 0.05$). It is likely that the time spent on installing nephrostomy drainage in Group II was offset by the difficulty of removing a stone with a pre-installed nephrostomy in the pelvis in patients from the Group I.

Intraoperative blood loss and intraoperative complications were analyzed to evaluate the safety of the new technique of nephrostomy drainage installation during laparoscopic pyelolithotomy. The median volume of intraoperative blood loss in the group of patients who had a nephrostomy tube inserted beforehand was 65 ml (ICR = 37.5 ml), and in the group of patients who had the new technique of nephrostomy tube insertion approved was 30 ml (ICR = 20 ml) (Fig. 1).

Thus, statistically significant results in favor of the new nephrostomy tube placement technique were obtained ($p < 0.001$).

Table 1. The initial characteristics of patients who were performed laparoscopic pyelolithotomy

Parameter	Total number (n = 45)	Group I (n = 18)	Group II (n = 27)	χ^2; p* value
Mean age – M±δ; (years) median; (range); 95% CI	34.2 ± 13.3; 35; (18–61); 30.3–38.0	34.2 ± 14.0; 36; (18–61); 27.7–40.7	34.1 ± 13.0; 33; (18–57); 29.2–39.0	p = 0.4928
Sex:				
Males, number (%)	30 (66.7 %)	13 (72.2 %)	17 (62.9 %)	0.4167 p = 0.5186
Females, number (%)	15 (33.3 %)	5 (27.8 %)	10 (37.0 %)	
Body mass index – M±δ; median; (range); 95% CI	23.5 ± 3.4; 22.6; (17.9–33.1); 22.6–24.5	23.7 ± 3.5; 22.6; (20.2–33.1); 22.0–25.3	23.5 ± 3.4; 23.3; (17.9–33.0); 22.2–24.8	p = 0.4108
Number of patients with concomitant diseases (%); number of diseases	17 (37.8 %) 22	5 (27.8 %) 6	12 (44.4 %) 16	1.2763 p = 0.2585
Side affected/operated:				
Right	19 (42.2 %)	12 (66.7 %)	7 (25.9 %)	7.3482 p = 0.0067
Left	26 (57.8 %)	6 (33.3 %)	20 (74.1 %)	
ASA score, number (%):				
1	23 (51.1 %)	11 (61.1 %)	12 (44.4 %)	1.3811 p = 0.5013
2	17 (37.8 %)	5 (27.8 %)	12 (44.4 %)	
3	5 (11.1 %)	2 (11.1 %)	3 (11.1 %)	
Hydronephrosis stage according to SFU:				
2	30 (66.7 %)	11 (61.1 %)	19 (70.4 %)	0.4167 p = 0.5186
3	15 (33,3 %)	7 (38,9 %)	8 (29,6 %)	
Average stone size in mm – M±δ; median; (range); 95% CI	41.8 ± 7.8; 40; (29–62); 39.5–44.0	42.2 ± 7.2; 42; (31–62); 38.8–45.5	41.6 ± 8.3; 39; (29–62); 38.5–44.7	p = 0.4065

Note: ASA – American Society of Anesthesiologists; SFU – Society of Fetal Urology; M – arithmetic mean; δ – standard deviation; 95% CI – 95% confidence interval; * The test compares the characteristics of patients in two groups (t-test, Mann-Whitney U test or Chi-square test).

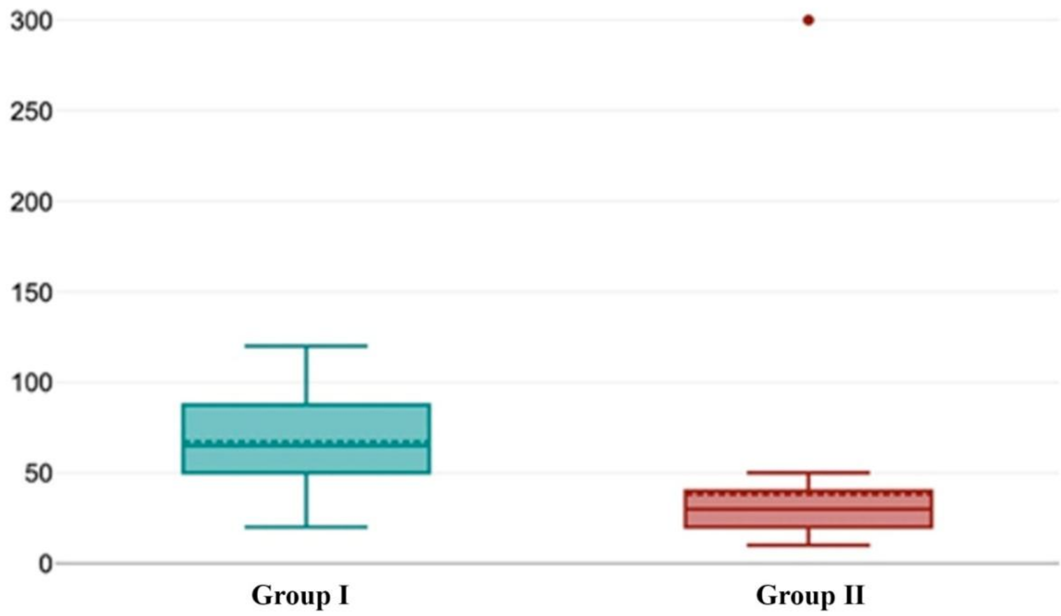

Figure 1. Boxplot of intraoperative blood loss in both groups of patients performed laparoscopic pyelolithotomy ($p < 0.001$)

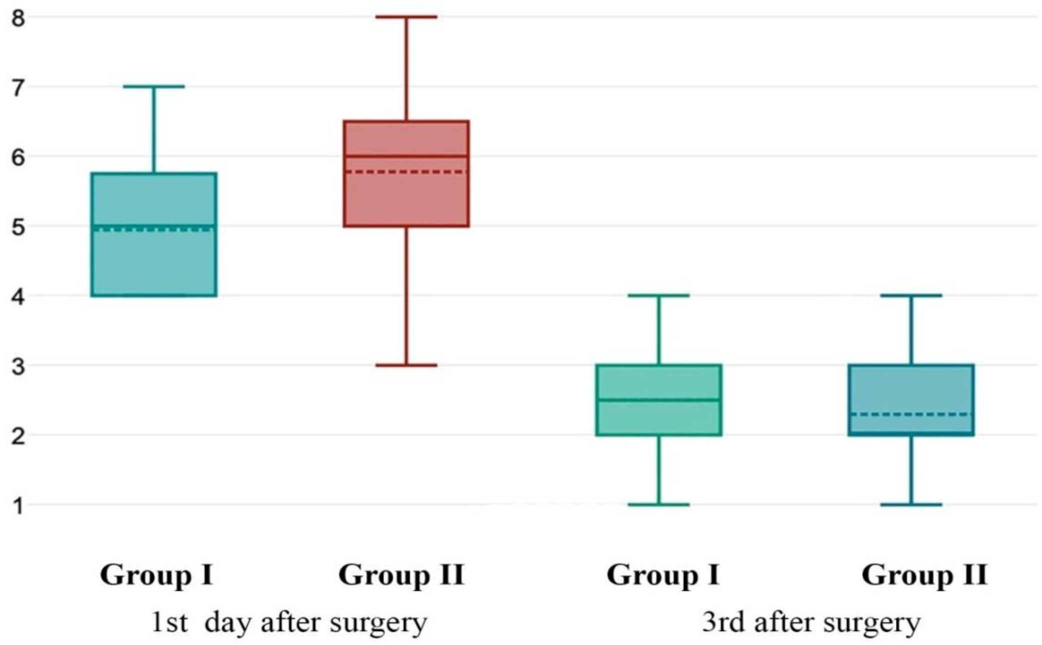

Figure 2. Boxplot of postoperative pain assessment using a visual analogue scale on days 1 and 3 after surgery comparing the two groups ($p < 0.001$ and $p = 0.22$)

The greater volume of blood loss in the group of patients who had a nephrostomy tube installed before the main operation was probably associated with inflammatory changes in the renal collecting system due to the presence of drainage. Inflammatory altered pelvis bleeds profusely during pyelolithotomy, and coagulation of the incision edges is undesirable due to the risk of tissue trophism loss.

In the Group II, during the installation of the nephrostomy tube, 1 (3.7%) patient experienced bleeding from the renal parenchyma of up to 300 ml, which was stopped by pulling the Foley balloon to the neck of the calyx. Still, the low rate of intraoperative complications shows the safety of this technique. No intraoperative complications were observed in patients of Group I.

The severity of the pain syndrome was assessed using the Visual Analog Scale, where 0 is no pain, and 10 is unbearable pain, assessed in all patients. Patients independently assessed postoperative pain on days 1 and 3 after laparoscopic pyelolithotomy. On the first day, the median score on the visual analogue scale in Group I was 5 (interquartile range = 1.75), and in Group II - 6 (interquartile range = 1.5), which was statistically different. More severe pain in Group II may be associated with trauma to the kidney, abdominal wall and lumbar region, where the nephrostomy was installed. However, on the 3rd day after surgery, the severity of pain in both groups became the same: in Group I, the median score on the visual analogue system was 2.5 (interquartile range = 1); and in Group II – 2 (interquartile range = 1), which was not statistically different (Fig. 2).

The contradiction in the initial conditions of patients in both groups does not allow us to confidently state that the installation of a nephrostomy during surgery is more painful, since the severity of pain on the visual analogue scale was not assessed in patients in the first group after percutaneous nephrostomy.

The length of the skin incision served as one of the parameters to assess the traumatic nature of the surgical intervention. We calculated the amount of skin incisions for trocars and drainages. The median incision length was 30.5 mm (interquartile range = 9.5) in Group I; and in Group II – 30 mm (interquartile range = 1.0). Statistical analysis (Mann-Whitney U test) showed that there was no significant difference in incision length between the groups ($p > 0.05$). The new method of installing nephrostomy drainage is as traumatic as the percutaneous method of installing nephrostomy.

One of the methods for assessing the safety of a new technique for installing nephrostomy drainage during laparoscopic pyelolithotomy is to assess the incidence of postoperative complications. We classified postoperative complications according to the Clavien-Dindo classification. 7 (38.9%) patients in Group I had various postoperative complications. In 1 (5.5%) patient, the postoperative wound festered, which was manifested by the discharge of pus from the wound. Wound suppuration was eliminated using conservative methods (rinsing with antiseptics and administering broad-spectrum antibiotics). there was an exacerbation of urinary tract infection after surgery in 3 (16.7%) patients, which was manifested by an increase in body temperature > 37.5℃, general malaise, various dysuric phenomena and pain in the lumbar region on the affected side. All cases of UTI exacerbation were treated with conservative methods. 1 (5.5%) patient suffered from intestinal dysfunction for 4 days in the postoperative period. In this case, there was a decrease in gastrointestinal motility and the absence of chymus for more than 3 days. We used Metoclopramide 0.5% - 2.0 ml and Proserin 500 mcg - 1.0 ml subcutaneously to enhance gastrointestinal motility. 2 (11.1%) study participants had minor plexopathy, which was manifested by pain in the cervical-collar and shoulder region. This complication was associated with compression of the brachial plexus during positioning of the patient. Plexopathy was treated with conservative methods.

Postoperative complications were observed in 8 (29.6%) patients in the Group II: wound suppuration - in 1 (3.7%), exacerbation of UTI - in 2 (7.4%) patients, intestinal dysfunction - in 1 (3.7%) cases and minor plexopathy - in 3 (11.1%) study participants. One (3.7%) patient had hematuria, requiring longer drainage. All complications in the group of patients who had a nephrostomy tube installed during laparoscopic pyelolithotomy using the developed drainage installation technique were treated with conservative methods without the use of additional interventions. All complications that occurred during laparoscopic pyelolithotomy are classified into grade I of postoperative complications according to the Clavien-Dindo classification. However, static analysis (Chi-square) showed that there was no significant difference in the incidence of postoperative complications between the groups ($p > 0.05$) (Table 2).

Table 2. Characteristics of postoperative complications in patients who underwent laparoscopic pyelolithotomy

The complications degree	Characteristics of complications	Group I (n = 18)	Group II (n = 27)
Degree I	Wound suppuration	1 (5.5 %)	1 (3.7 %)
	Exacerbation of UTI	3 (16.7 %)	2 (7.4 %)
	Intestinal dysfunction	1 (5.5 %)	1 (3.7 %)
	Plexopathy	2 (11.1 %)	3 (11.1 %)
	Hematuria requiring longer drainage	0	1 (3.7 %)
	Total	**7 (38.9 %)**	**8 (29.6 %)**

4. Discussion

Summarizing the observational data, we can conclude that the new method of installing nephrostomy drainage does not affect the duration of the surgery, the severity of pain and the amount of painkillers, there was no difference in intra- and postoperative complications and in the length of hospital treatment, etc. All data is shown in Table 3.

5. Conclusions

The developed technique for installing nephrostomy drainage during laparoscopic pyelolithotomy allows you to install drainage on the UUT during the surgery itself, without involving additional specialists and equipment.

This technique is not only safe for use in patients, but also reduces the duration of the operation and the incidence of postoperative complications, allows patients to be relieved of drainage at an earlier stage and helps to quickly improve the life quality.

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The article is published for the first time and is part of a scientific work.

Table 3. Comparative analysis of the efficiency and safety of nephrostomy tube placement technique during laparoscopic pyelolithotomy

Parameter	Total number of patients (n = 45)	Group I (n = 18)	Group II (n = 27)	p* value
Surgery duration in minutes, M±δ; median; (range); 95% CI.	83.5 ± 15.8; 80; (60–130); 78.9–88.1	82.5 ± 16.5; 80; (65–130); 74.9–90.1	83.3 ± 15.6; 85; (60–120); 77.4–89.2	p = 0.6384
Intraoperative blood loss – M±δ; median; (range); interquartile range	49.8 ± 46.8; 40; (10–300); 40	67.2 ± 26.5; 65; (20–120); 37.5	38.1 ± 53.9; 30; (10–300); 20	p<0.001
Pain syndrome severity on a visual analog scale:				
On day 1, M±δ; median; (range); interquartile range	5.4 ± 1.1; 5; (3–8); 1	4.9 ± 0.9; 5; (4–7); 1.75	5.8 ± 1.1; 6; (3–8); 1.5	p<0.001
On day 3, M±δ; median; (range); interquartile range	2.4 ± 0.9; 2; (1–4); 1	2.5 ± 0.9; 2.5; (1–4); 1	2.3 ± 0.9; 2; (1–4); 1	p = 0.2236
Administration of Promedol 20 mg after surgery, number (%)	5 (11.1 %)	2 (11.1 %)	3 (11.1 %)	p = 1.0
Use of NSAIDs (Diclofenac) in the postoperative period in mg, M±δ; median; (range); interquartile range	171.7 ± 77.2;175; (75–325); 150	155.6 ± 80.7; 150; (75–300); 150	182.4 ± 74.3; 175; (75–325); 75	p = 0.2187
Use of NSAIDs (Analgin) in the postoperative period in mg, M±δ; median; (range); interquartile range	711.1 ± 749.1; 500; (0–2500); 1000	638.9 ± 723.7500; (0–2000); 1000	759.3 ± 847.7; 500; (0–2500); 1000	p = 0.6965
Cut length in mm, M±δ; median; (range); interquartile range	31.6 ± 5.2; 30; (20–40); 5	33.1 ± 5.5; 30,5; (20–40); 9.5	30.6 ± 4.9; 30; (20–40); 1	P = 0.1141
Intraoperative complications, number (%)	1 (3.7 %)	0	1 (3.7 %)	-
Postoperative complications, number (%)	15 (33.3 %)	7 (38.9 %)	8 (29.6 %)	P = 0.5186
Bed-days, days,M±δ; median; (range); 95% CI.	3.9 ± 0.8; 4.0; (3.0–5.0); 3.7–4.1	3.8 ± 0.6; 4.0; (3.0–5.0); 3.5–4.1	4.0 ± 0.9; 4.0; (3.0–6.0); 3.7–4.3	P =0.2353
Wisconsin Questionnaire Score (WISQOL)				
Before surgery: M±δ; median; (range); 95% CI.	68.7 ± 28.8; 55; (34–120); 60.3–77.1	102.1 ± 10.1; 102; (82-120); 97.4–107.0	46.5 ± 7.4; 45; (34–61); 43.7–49.3	p<0.001
On day 5: M±δ; median; (range); 95% CI.	94.5 ± 8.7; 95; (78–111); 92.0–97.0	90.1 ± 9.4; 91; (78–102); 85.8–94.4	97.4 ± 6.9; 98; (86–111); 94.8–100.0	p = 0.0023
On day 10: M±δ; median; (range); 95% CI.	80.4 ± 9.6; 82; (55–99); 77.6–83.2	82.6 ± 8.7; 83; (67–99); 78.6–86.6	78.9 ± 10.1; 82; (55–95); 75.1–82.7	p = 0.1730
One month later: M±δ; median; (range); 95% CI.	39.6 ± 5.1; 39; (32–56); 38.1–41.1	42.7 ± 6.1; 42; (32–56); 39.9–45.5	37.5 ± 2.8; 38 (33–42); 36.3–38.6	P = 0.0002

Note: NSAIDs – non-steroidal anti-inflammatory drugs; WISQOL – Winsconsin Stone Quality of Life Questionnaire; M – arithmetic mean; δ – standard deviation; 95% CI – 95% confidence interval; * (t-test, Mann-Whitney U-test or Chi-square).

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