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EVALUATION OF THE ROLE OF APPLICATION OF CONTACT LITHOTRIPSY IN LARGE OCCLUDING URETERAL STONES

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The study was devoted to the analysis of the effectiveness of contact lithotripsy and its comparison with the effectiveness of extracorporeal lithotripsy in patients with large (> 10 mm) ureteral calculi, accompanied by urinary tract obstruction. We also analyzed a group of patients who underwent lithotripsy in 2 surgical stages with preliminary stenting of the urinary tract. According to the results of the study, a shorter duration of pain syndrome and hematuria was noted in patients who underwent contact lithotripsy and achieved "stone free" state, compared with distance lithotripsy. When comparing the group's indicators with preliminary stenting of the ureters, it was noted that the duration of hematuria was shorter on average by 12%, pain syndrome was shorter on average by 16%. So, contact lithotripsy as a method of management of large urinary tract stones can be recommended as a 1st level therapy in the absence of contraindications to surgical treatment.

Key words: Contact lithotripsy, ureteral calculi, renal colic.

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ОЦІНКА РОЛІ ЗАСТОСУВАННЯ КОНТАКТНОЇ ЛІТОТРИПСІЇ ПРИ ВЕЛИКИХ ОКЛЮЗІЙНИХ КОНКРЕМЕНТАХ СЕЧОВОДУ

Дослідження було присвячене аналізу ефективності проведення контактної літотрипсії та порівняння її з ефективністю дистанційної літотрипсії у пацієнтів, які мають великі (>10 мм) конкременти сечоводів, що супроводжуються обструкцією сечових шляхів. Також проаналізована група пацієнтів, яким літотрипсію виконували у 2 оперативні етапи з попереднім стентуванням сечових шляхів. За результатами дослідження відмічено більш коротку тривалість болювого синдрому та гематурії у хворих, яким була виконана контактна літотрипсія та досягнутий стан «Stone free», у порівнянні з дистанційною літотрипсією, а порівнюючи показники групи з попереднім стентуванням сечоводів, відмічено, що тривалість гематурії у них була меншою в середньому на 12%, болювий синдром був коротшим в середньому на 16%. Отже контактна літотрипсія як метод менеджменту великих каменів сечових шляхів може бути рекомендована як терапія 1-го рівня при відсутності протипоказань до оперативного лікування.

Ключові слова: Контактна літотрипсія, конкременти сечоводу, ниркова колька.

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Urolithiasis, in the form of nephro – and ureterolithiasis, is one of the largest urological problems, due to the wide spread of urolithiasis in the world (12-15% of the general population) [6]. The cause of these conditions is metabolic hereditary and acquired diseases, anomalies in the development of the urinary tract and others. The formation of kidney stones and the possibility of their subsequent migration into the urinary tract determines the urgency of the problem, because if the calculus is unable to go out on its own, obstruction of the urinary tract occurs, accompanied by a violation of the outflow of urine from the kidney, the expansion of its calyx-pelvic system (development of hydronephrosis), the appearance of clinical signs of renal colic attack (pain in the projection of the kidney, vomiting, dysuria) [3, 5]. With late treatment, late seeking for medical help, situations of prolonged persistence of calculi in the urinary ducts may arise, which can cause progression of hydronephrotic transformation of the kidney, atrophy of the renal parenchyma, and, as a result, loss of kidney function. Also, damage by calculus of the mucous membrane of the urinary tract can contribute to the attachment of infectious agents, their spread retrograde to the renal pelvis and complications of the condition by the development of acute or chronic pyelonephritis, in which a violation of the filtration and excretory functions of the kidney occurs and a septic state may develop [9].

The treatment of urolithiasis has historically been very diverse, and, now, taking into account the European and American guidelines of recent years, pharmacological and surgical methods of influencing calculi have been proposed [7]. Pharmacological ones are used in the absence of acute impairment of the urinary tract patency, aimed at dissolving calculi and preventing their formation. Surgical methods include invasive types of operations: open method for removing calculi, endoscopic methods – contact lithotripsy (CLT) using mechanical, ultrasonic and laser lithotripters [1, 2] (energy is supplied directly to the stone under video control) and a non-invasive method – distance lithotripsy (DLT, SWL) in which in the projection of the location of the calculus, ultrasonic waves are focused.

Concrements of the urinary tract differ in size (small – up to 10 mm and large – more than 10 mm), as well as in density in Hounsfield units, which depends on their origin (calcium, urate, infectious, cystine). The efficiency and speed of various types of lithotripsy also depend on the density (the greatest effect with low-density stones, the least effect with high density). Each of these methods has its own advantages, disadvantages, complications [8].

For calculi up to 10 mm, treatment protocols are defined depending on the level of urinary tract occlusion, but with large calculi (> 10 mm), there are no clear criteria for choosing treatment methods, because large calculi are often associated with prolonged persistence in the urinary tract, inflammatory changes in the wall of the ureters, the addition of a concomitant infection. That is why it is relevant to continue research aimed at identifying indications, contraindications, and the safety of using various methods of managing calculi at their large sizes.

The purpose of the study was to investigate the possibilities of contact laser lithotripsy in the treatment of large ureteral calculi, to assess the safety of the method, possible risks of surgical interventions, intraoperative and postoperative complications.

Materials and methods. The study included 36 patients aged 18–65 years with large ureteral calculi (more than 10 mm / diameter), clinical manifestations of urinary tract obstruction. They were divided into 3 groups. The 1st group included patients who were operated with using contact laser lithotripsy, in whom the “stone free” state was achieved during one surgical intervention. Group 2 – patients who at the first stage required ureteral stenting and the state of “stone free” was achieved during the second stage of surgery. Group 3 – patients who underwent extracorporeal lithotripsy (DLT). The study did not include patients with impaired blood coagulation function, history of malignant neoplasms, terminal conditions, decompensation of carbohydrate metabolism.

All patients were surveyed using a visual analogue scale (VAS) of pain at the time of hospitalization, and the approximate history of the onset of an attack of renal colic was assessed. The scope of the preoperative examination included computed tomography of the retroperitoneal organs to clarify the level of urinary tract occlusion, the size of calculi, general clinical tests (blood, urine, biochemical, coagulogram, blood group).

Contact lithotripsy (CLT) was performed with a 20 Wt holmium laser at the surgical department of the 3rd City Clinical hospital in Poltava. Patients who underwent extracorporeal lithotripsy were observed on an outpatient basis in the outpatient department of the 3rd City Clinical Hospital. Surgical interventions were performed under spinal anesthesia with bupivacaine spinal heavy 5 mg/ml. Informed consent was taken from all patients for the processing of their data in the study, as well as consent to treatment and surgery.

Intraoperatively during CLT, we assessed the possibility of performing “stone free” surgery at the same time, if there was no such possibility, or there were risk factors in the patient that could provoke damage to the ureter, then a ureteral stent was installed from the renal pelvis into the bladder under ultrasound control. Such patients were referred to the 2-nd group. Second surgical intervention in the 2-nd group was carried out in 7-10 days, it consisted of withdrawal of the stent and the performance of CLT.

After surgery, on days 1, 3, 5, pain syndrome was assessed by VAS, temperature reaction, general urine analysis was monitored for the presence of hematuria until it stopped. All patients in the postoperative period were prescribed antibacterial oral drugs of a group of fluoroquinolones («ofloxacin» 500 mg 2 t/d for 5 days) and a combined herbal drug «kanefron», 2 tablets 3 t/d within 1 month. Patients of group 3 after SWL were additionally prescribed drotaverine 40 mg 3 t/d and tamsulosin hydrochloride 0.4 mg once a day to facilitate the elimination of calculus fragments. Also, the next day after the operation and at 7, 14, 21 days, ultrasound of the kidneys was performed to determine the dynamics of hydronephrosis. The necessity of prescribing additional treatment (analgesics) in patients of all groups was also assessed.

Clinical trial data were statistically processed by the method of variation statistics using Student's t-test, determination of arithmetic mean values of indices, confidence intervals and probability values (p) was performed using the computer programs Microsoft Excel 2016 and Statistica 13. Specificity, sensitivity and accuracy of the study were calculated using generally accepted formulas.

Results of the study and their discussion. As a result of our research, we obtained the following data: Localization of the calculus was used to identify its occlusion site in the upper, middle or lower third of the ureter. The distribution according to the localization of calculi and their sizes by groups was as follows: in the 1-st group – 5 in the upper third (average size 16 ± 1.8 mm); 3 – in the middle third (average size 14 ± 1.46 mm); 4 – in the lower third (average size 13 ± 1.75 mm).

In group 2 there are: 6 – in the upper third (average size 16.5 ± 1.95 mm); 4 – in the middle third (average size 13 ± 1.65 mm); 2 – in the lower third (average size 12 ± 1.3 mm). In group 3 of extracorporeal lithotripsy – 4 – in the upper third (average size 15.2 ± 2.1 mm); 4 in the middle third (average size 14.6 ± 1.7 mm); 4 – in the lower third (average size 11.6 ± 0.8 mm).

Analyzing the data of anamnesis and pain syndrome, it was revealed that the severity of pain syndrome was higher in patients with calculi of the lower and middle third of the ureter, probably depending on the characteristics of the innervation of the ureters and bladder, and also directly correlated with the duration of persistence of the calculus: the longer the duration of the disease, the shorter the severity of the pain syndrome. In 3 patients (2 of the 2-nd and 1 of the 1-st group), no pain syndrome was noted, their requests for medical help arose for reasons not related to renal colic or were due to preventive examination. According to statistical processing, the size of the calculus did not correlate with the severity of the pain syndrome.

When analyzing deviations in laboratory studies, attention is drawn to the severity of changes in the general analysis of urine (erythrocyturia, leukocyturia, slight proteinuria) in patients with calculi localization in the lower third of the ureter ($p < 0.05$). This trend is observed in patients of all three groups (table 1). In patients with localization in the middle (58%) and upper (70%) third, changes in the general analysis of urine are much less pronounced, up to the complete absence of these pathological manifestations (table 1). This is probably due to the denser wedging of the stone in the upper and middle third, the complete absence of urine flow on the affected side and, in this case, obtaining a urine analysis from a healthy kidney.

A biochemical blood test showed abnormalities in the metabolism of nitrogen compounds (creatinine), and these abnormalities were statistically correlated with the time of stone standing – more than a month ($p < 0.05$) and the age of patients – more than 50 years ($p < 0.05$). At the same time, in our study, the maximum creatinine value was $187 \mu\text{mol/L}$, and in 50% of patients the indicator was within the reference norms. This shows the compensatory capabilities of the body, in conditions of a blockage of one kidney, for a long time it can provide a full homeostasis of metabolism.

When analyzing changes in the general blood test, the parameters of the course of acute or chronic inflammation were assessed (the number of leukocytes, a change in the leukocyte formula with an increase in the number of neutrophilic leukocytes, an increase in the erythrocyte sedimentation rate). We also paid attention to the parameters of blood erythrocytes and hemoglobin, since persistence of calculus can cause prolonged hematuria. The data are shown in Table 2, and when analyzing them, it was found that there was no statistical correspondence between the severity of the inflammatory reaction and the level of the calculus location, and its size. This indicates the non-specificity of the inflammatory response of the body to urinary tract obstruction, the nature of this response depends more on the reactivity of the macroorganism on the background of age, gender, existing concomitant diseases, the presence of an acute or chronic infectious process in the urinary tract, and not on the site of obstruction.

Table 1

Data of the general analysis of urine before surgery

Location of the calculus	Group 1	Group 2	Group 3
Erythrocyturia			
Upper third	“+”, “++”	“+”, “++”	“+”, “++”
Middle third	“+”, “++”	“+”, “++”	“+”, “++”
Lower third	“+++”, “++”	“+++”, “++”	“+++”, “++”
Leukocyturia			
Upper third	8 ± 4 p.v.f.	6 ± 2.5 p.v.f.	6.5 ± 3 p.v.f.
Middle third	14.5 ± 5 p.v.f.	13 ± 4.5 p.v.f.	16 ± 6.5 p.v.f.
Lower third	26 ± 6.5 p.v.f.	34 ± 5.5 p.v.f.	28 ± 6.0 p.v.f.
Proteinuria (g/L)			
Upper third	0.1 ± 0.012	0.15 ± 0.018	0.13 ± 0.022
Middle third	0.25 ± 0.095	0.21 ± 0.056	0.26 ± 0.048
Lower third	0.45 ± 0.061	0.51 ± 0.077	0.42 ± 0.053

Notes: “+” – up to 10-50 erythrocytes in the field of view; “++” – 50 – 1/2 in the field of view; “+++” – erythrocytes in the entire field of view.

Table 2

Data of laboratory tests before surgery

Name	Group 1	Group 2	Group 3
Blood leukocytes ($\cdot 10^9/\text{L}$)	8.6 ± 2.4	7.8 ± 1.8	9.2 ± 2.3
% neutrophilic leukocytes	68 ± 8.6	71 ± 7.2	74 ± 9.4
Erythrocytes of blood ($\cdot 10^{12}/\text{L}$)	3.9 ± 0.35	3.86 ± 0.22	4.1 ± 0.31
Blood hemoglobin (g/L)	132 ± 8	129 ± 6	134 ± 8
Creatinine ($\mu\text{mol/L}$)	127 ± 16.4	125 ± 20.8	116 ± 18.6

When performing surgical interventions after cystoscopy and visualization of the ureteral openings, the next stage was an attempt to introduce the ureteroscope into the ureter and move it to the obstruction site to perform contact lithotripsy and evacuation of fragments. If the attempt of advance the ureteroscope to the

stone was successful, then a laser fiber was applied to the calculus and laser lithotripsy was performed. The energy regimen of lithotripsy in each case was selected individually, depending on the density of the stone and was not the subject of research. The fragments were transferred with forceps into the bladder.

If, during cystoscopy, a small diameter of ureteral openings was visualized, which only passed with the nitinol string (1 mm), then in this case we used sequential introduction of the dilators with a diameter of 4-6-8-10 Fr, and further, if possible, up to the maximum diameter. Dilators were introduced according to the scale of divisions to the place of probable calculus location, then they were removed and an attempt was made to advance the ureterscope along the ureter. If, after these manipulations: a) the ureter is impassable, there is a feeling of obstruction and tension of the tissues during movement; b) hematuria appears, which interferes with the field of vision – then a decision was made to conduct stenting of the kidney past the calculus to eliminate its block and ensure the outflow of urine. First, under ultrasound control, a nitinol string was inserted into the renal pelvis, then we used Rush ureteral stents, 6 Fr in diameter, which were advanced along the string to the renal pelvis. During intraoperative ultrasound imaging of the stent in the kidney, the string was removed, and the free end of the stent remained in the bladder. Among the 24 operated patients, in 12 patients it was impossible to enter the ureter and to do further manipulations, so they were stented and assigned to the 2nd study group. Among these 12 patients, 50% had calculi in the upper third, 33.4% – with calculi in the middle third, 16.6% – with calculi in the lower third. So we can conclude that the chance of primary management of large calculi with the achievement of the “Stone free” state can most likely be expected when the occlusion is localized in the lower third, and the lowest probability of reaching a calculus is primarily when it is localized in the upper third.

In the case of reaching a calculus on the first attempt, in all patients with contact laser lithotripsy were revealed inflammatory changes in the ureteral wall. These changes were manifested in the form of hyperemia, the presence of desquamated areas of the mucous membrane, its bleeding, which manifested itself immediately after an attempt to move the calculus from the site of obstruction, as well as during its movements due to the action of the laser. The severity of destructive changes was directly proportional to the duration of persistence of the calculus before surgery: in the most severe cases, there was a continuous pressure ulcer of the stone (partially or circularly) into the mucous membrane with its destruction, in these cases the internal ureteral wall was represented by the muscle layer. The operations under such conditions were complicated by the obligatory presence of mucosal hemorrhage, which led to the loss of time and saline for adequate visualization, increased the intraoperative risks of ureteral perforation, its probable rupture or rupture, required a very gentle operating technique, and increased the duration of the operation by an average of 35 ± 8 minutes. At the end of the operation, to all patients we placed a Rush ureteral stent with a diameter of 6 Fr, which was taken out under local anesthesia with lidocaine “Cathelijell” within 14-21 days.

Patients of the 2-nd group underwent the second stage of surgery within 21 ± 2 days, which consisted of removing the stent, conducting subsequent ureteroscopy and contact lithotripsy. In all 12 cases, the ureter after stenting was wide enough to allow the ureterscope to pass in easily. There were no difficulties in performing this manipulation; in all cases, successful CLT was performed with the achievement of the “Stone free” state. At the same time, the ureteral wall in 100% of cases, compared with patients of the 1-st group, was less pronounced with inflammatory changes, no zones of large destruction of the epithelial cover were determined, and contact bleeding was significantly less, which contributed to clearer visualization, and a decrease in the operation time. After CLT, a 6 Fr stent was placed in this group, and was removed under local anesthesia on within 9-10 days.

Analyzing the course of the postoperative period in the 3-rd group of patients, it can be determined that the period of passage of calculi was 8 ± 2.5 days. 2 patients required additional CLT in the 5-day term due to the impaction of a stone fragment in the ureteral openings and an increased pain syndrome with an increased hydronephrosis. These “on demand” lithotripsies were performed without complications in 1 surgical appointment.

When analyzing the severity of pain and hematuria in groups of patients, we obtained the following data:

Hematuria (Fig. 1) in patients of the 1-st group lasted on average 3.2 ± 1.2 days and was as more pronounced, as more damage to the ureteral mucosa was visualized intraoperatively, without a statistically significant correlation with the size or localization of the calculus. In 2-nd group of patients, postoperative hematuria (assessed after the second surgery) lasted 2.4 ± 0.8 days, which, in our opinion, is associated with the protective effect of the stent and early healing of most mucosal injuries caused by the persistence of calculus. In group 3, hematuria lasted 4.7 ± 2.1 days, which, in our opinion, was caused by the staged advancement of fragments of crushed calculi and periodic irritation of the mucous membrane.

Pain syndrome (fig. 2) in patients of the 1-st group lasted 2.2 ± 0.5 days, in patients of the 2-nd group – 1.5 ± 0.8 days, in patients of the 3-rd group – 4.1 ± 0.6 days.

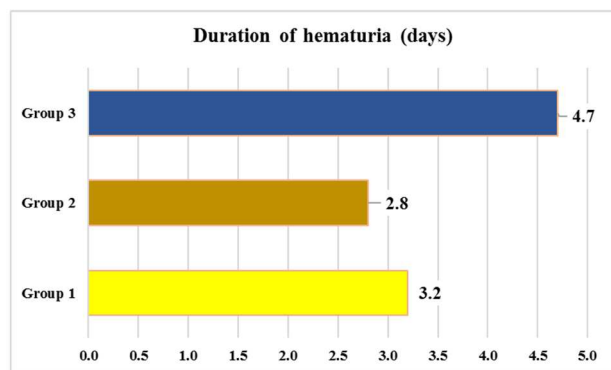


Fig. 1. Duration of hematuria

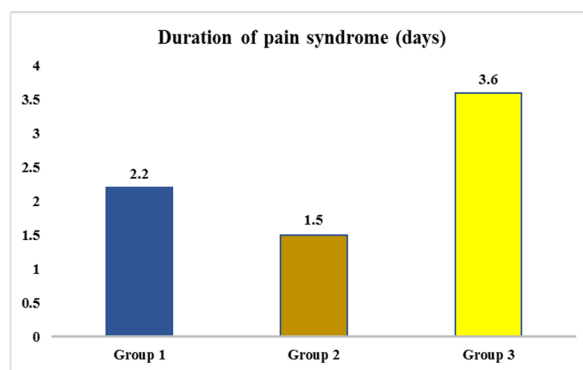


Fig. 2. Duration of pain syndrome

When analyzing the dynamics of decrease of renal pelvis hydronephrosis according to ultrasound data, it was found that in the 1-st group the duration of hydronephrosis was 2.2 ± 0.5 days, in the 2-nd group – 2.5 ± 0.3 days, in the 3-rd group – 3.6 ± 1.2 days. Comparable results of the 1-st and 2-nd groups show that hydronephrosis depends on the achievement of the “Stone free” state, which led to its longer definition in patients of the 3-rd group, and a slight predominance in the 2-nd group over the 1-st is explained by relaxation of the ureter against the background of the stent and the later activation of its contractile function.

The data obtained during the study were correlated with the studies of foreign authors (Yaxuan Wang, Xueliang Chang, Jingdong Li, Zhenwei Han) [9], which also showed a greater efficiency of contact lithotripsy compared to remote lithotripsy relatively to large ureteral calculi. Also it is confirmed the opinion about the need of stenting of the ureters when performing “complicated” lithotripsy, which is accompanied by trauma to the ureteral wall either by calculus or during surgery [4]. Also, after analyzing the available research, it is necessary to expand the patient population and further analyze the efficacy and safety of laparoscopic management of calculi and percutaneous nephrolithotripsy.

Conclusion

Analyzing the obtained data, it can be determined that contact laser lithotripsy is an effective method for treating large ureteral calculi, can provide the target level of “Stone free”, does not have significant serious postoperative complications, and has low rates of postoperative pain syndrome and hematuria. Ureteral stenting if it's impossible to reach calculus during primary surgery should be recommended as a routine method, as it provides satisfactory relaxation during the second stage surgery and also accelerates reparative processes in the ureter, thereby reducing postoperative pain and hematuria. Unlike contact lithotripsy, distance lithotripsy can be recommended for the treatment of large calculi in patients with concomitant diseases who have contraindications for anesthesia and surgery, because the procedure itself is not associated with operational risks, but has its drawbacks in the form of uncertainty in the time period for reaching the “Stone free” state, as well as a longer pain syndrome, the need for medication support and the possibility of the need for surgical correction.

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