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SAFETY EVALUATION OF ULTRASOUND-GUIDED PERCUTANEOUS NEPHROLITHOTRIPSY

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Abstract

The aim of the study was to evaluate the efficacy and outcomes of ultrasound-guided percutaneous nephrolithotripsy (PCNLT) in the treatment of patients with large renal pelvic stones. We studied the results of PCNLT in 138 patients operated for kidney stones from 2018 to 2024. Seventy patients (group 1) underwent the operation under combined ultrasound and radiologic control, and 68 (group 2) under ultrasound control only.

Patients with large pelvic stones larger than 2.2 cm requiring a single puncture access were included in the study. The comparative analysis evaluated operative time, number of intra- and postoperative complications, blood loss and hospitalization time. Percutaneous access was successfully performed in all patients. Postoperative complications (exacerbation of chronic pyelonephritis, macrohematuria) were observed in 14.3% of patients in group 1 and 14.7% in group 2. There was no bleeding requiring blood transfusion and injuries of neighboring organs. The efficacy of PCNLT in Group 1 was 95.7%, additional interventions were used in 3 (4.3%) patients. In group 2 the efficacy of PCNLT was 94,1%, 4 (5,9%) patients underwent additional remote lithotripsy. There were no significant differences in PCNLT efficacy, blood loss volume and hospitalization time. In case of large stones of the pelvis and sufficient expansion of the renal cavity system PCNLT can be performed under ultrasound control, which allows to reduce the radiation load on the patient and medical personnel.

Keywords: Percutaneous nephrolithotripsy, kidney stones, urolithiasis, nephrolithiasis.

Introduction

Percutaneous nephrolithotripsy (PCNLT) remains the method of choice in the surgical treatment of patients with large and coral-like kidney stones [1-5]. An important stage of PCNLT is undoubtedly the creation of percutaneous access to the calyx-pelvic segment, which is most often performed under radiologic control. The continuous use of fluoroscopy in frequent percutaneous renal interventions can lead to various complications for medical personnel due to prolonged exposure of the thyroid, gonads, bone marrow and eye function [6-9]. The most unprotected part of the body, exposed to the constant influence of X-rays during PCNLT, is the eyes of urologists. Therefore, prolonged fluoroscopy during percutaneous surgeries may be the cause of cataract development [10, 11]. However, according to the International Commission on Radiation Protection, the limit of radiation exposure to the eyes of an operated surgeon ends when 1200 percutaneous kidney surgeries are performed within one year, and the total radiation dose is about

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150 millisievert[12]. According to the results of the studies conducted by this committee, the average radiation dose during PCNLT is about 0.125 millisievert.

To reduce the risk of the above complications of fluoroscopy, some authors suggest performing percutaneous nephrostomy and nephrolithotripsy under ultrasound control [13-16]. The technique of ultrasound-guided puncture nephrostomy in pregnant women with upper urinary tract (UUT) urodynamics disorders has been described in detail [17]. In the English-language literature there are reports on ultrasound-guided PCNLT in patients with solitary large pelvic renal stones. We present the results of percutaneous stone removal using this technique in 68 patients.

Materials and Methods

From 2018 to 2024, PCNLT was performed in 1250 patients in State institution "Republican Specialized Scientific and Practical Medical Center of Urology", Uzbekistan, Tashkent.. This study is based on the results of PCNLT performed on 138 (11%) patients. Of these, 74 (53.6%) were men and 64 (46.4%) were women. The average age of the patients was 42.8 years. The patients were distributed into two groups. Seventy patients (group 1) underwent surgery under combined ultrasound and radiologic control, and 68 (group 2) under ultrasound control only. The study included patients with large pelvic stones larger than 2.2 cm, requiring only one percutaneous access, dilated calyx-pelvic segment, with body mass index less than 28 kg/m² (Table 1).

Table №1

Characteristics of patients		
Indications	1-Group	2- Group
Male / Female	36-34	38-30
Body mass index kg/m2	28(25-32)	24(24-32)
Stone size, cm	2,5(2,2-3,6)	2,4(2,2-3,2)
Side: left/right	36/34	36/32
Single pelvic stones n(%)	66(94,3)	65(95,6)
Stone of pelvis and calyx n(%)	4(5,7)	3(4,4)

The diagnosis of nephrolithiasis was established based on the patient's complaints, anamnesis and objective status, and the results of special examination methods. In addition to ultrasound, radioisotope studies of the kidneys and excretory urography, all patients underwent spiral computed tomography with 3D-reconstruction. The above-mentioned methods allowed to determine the size and density of the stone, its stereometric location, changes in the morphofunctional state of the kidneys and urinary tract system, angioarchitectonics of the kidney. Renal function was evaluated on the basis of dynamic scintigraphy data. Antibacterial therapy was performed before surgery in the presence of inflammatory changes in urine samples.

All patients were operated on by several teams of surgeons who had experience in performing more than 1000 PCNLTs at the time of the study. First, cystoscopy with ureter catheterization was performed. Under endoscopic control, a 6 or 7 Ch catheter was placed as high as possible so that its distal end was located in the pelvis or upper cup. Fluoroscopy was not performed during ureteral catheterization, and the indicator of adequate localization of the catheter in the calyx-pelvic

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segment was active urine secretion through it. In case of sufficient dilation of the calyx-pelvic segment, puncture and fistula dilatation can be performed without preliminary ureteral catheterization. However, a retrograde catheter allows the introduction of a sterile solution to relatively dilate the calyx-pelvic segment before its puncture. In addition, it is a good reference point when performing nephroscopy, excludes migration of small fragments into the ureter, reduces trauma to the pyeloureteral segment with forceps. After ureter catheterization, the endoscope was removed and a Foley catheter was placed in the bladder. Then the patient was turned on the abdomen, ultrasound of the operated kidney was performed, and the optimal point for the puncture of the calyx-pelvic segment was determined. Using ultrasound, the distance from this point on the skin to the renal cavity was measured. This distance was further used to determine the depth of bougie conduction to the calyx-pelvic segment during dilatation of the puncture fistula. Sterile physiologic solution was injected through the ureteral catheter, which allowed relative dilatation of the calyx-pelvic segment before puncture. Then, under ultrasound control using an ultrasound nozzle, the PNS was punctured through the middle or lower cup. In most cases the puncture was performed under the XII rib, and only in 6 patients with a left kidney stone it was performed in the twelfth intercostal space. Active release of retrogradely injected liquid with indigo carmine by the needle indicated its adequate presence in the calyx-pelvic segment. The moment of needle passing through the cup into the pelvis is of great importance during the puncture of the calyx-pelvic segment, which facilitates the subsequent installation of the string. Further under ultrasound control a super rigid guide was installed along the needle. Dilatation of puncture access was performed with Amplatz boujets. At that, the depth of bougering did not exceed the predetermined distance from the skin to the renal cavity. When dilating the puncture channel, only several bujas (usually 16, 22, 26 Ch) were used consecutively, and each dilator was performed under ultrasound control. However, for urologists with little experience in percutaneous renal interventions, we recommend performing stepwise bougie dilation of the puncture access. The rigid string was not removed after insertion of the Amplatz shroud and remained as a safety guide.

Examination of the calyx-pelvic segment was performed with a rigid nephroscope 24 Ch, ultrasonic lithotripter was used for stone disintegration. At calyx-pelvic segment end of the operation, ultrasound of the kidney was performed to exclude residual stones of the calyx-pelvic segment. Then under the control of nephroscope the distal end of Amplatz casing was placed deeper into the pelvis. The endoscope was removed, a balloon catheter was passed through the casing, its balloon was inflated. Only after that the casing was removed, which provided adequate installation of nephrostomy drainage and reliable drainage of the renal calyx-pelvic segment. The nephrostomy was fixed to the skin, the patient was turned on his back. In the postoperative period antibacterial and infusion therapy was performed. Urethral and ureteral catheters were removed the next day after surgery. On the 2nd or 3rd day a review radiography of the urinary tract and antegrade pyeloureterography were performed. In the absence of residual stones and adequate ureteral patency, the nephrostomy drainage was removed and the patient was discharged for outpatient treatment. During the comparative analysis the operative time, blood loss volume, hospitalization time, number of intra- and postoperative complications were evaluated.

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Results

Percutaneous access was successfully performed in all 138 patients. Postoperative complications (exacerbation of chronic pyelonephritis, macrohematuria) treated by conservative treatment were observed in 14.3% of patients of the 1st group and in 14.7% of the 2nd group.

The results of the study showed that the groups did not differ statistically significantly in terms of the effectiveness of surgery, blood loss volume, and hospitalization time (Table 2). There was no bleeding requiring blood transfusion and injuries of neighboring organs. The efficiency of PNL for patients of group 1 amounted to 95.7%. Additional interventions (remote lithotripsy) were used in 3 (4.3%) cases. In group 2 in 64 (94,1 %) patients the stone was completely removed and 4 (5,9 %) patients underwent remote lithotripsy for residual stones. According to the data of dynamic scintigraphy, normalization of urodynamics of urinary tract system and improvement of kidney function were noted in all patients.

Here is a clinical observation of successful PCNLT of a stone under ultrasound control.

A 36-year-old woman was admitted to our clinic on 15.10.2019 with complaints of pain in the right lumbar region. According to ultrasound and excretory urography revealed a large stone of the right kidney pelvis, enlargement of its cavity system. Taking into account the large size of the stone, its localization in the pelvis and enlargement of the cavity system, it was decided to perform PCNLT on the right side under ultrasound control. After catheterization of the ureter in the abdominal position under ultrasound control, a puncture of the calyx-pelvic segment through the lower cup was performed. The puncture channel was boughed up to 26 Ch with a string, and an Amplatz shroud was placed. At nephroscopy a large stone of the pelvis was visualized. Contact lithotripsy was performed, large fragments were removed. At the control ultrasound of the kidney, there were no residual stones. There were no intra- and postoperative complications.

On the 2nd day a review radiography of the urinary tract and antegrade pyeloureterogram were performed on the right side of the kidney; there were no residual stones in the projection of the urinary tract, the patency of the urinary tract was good. Nephrostomy drainage was removed, and the patient was discharged for outpatient treatment.

In this clinical case, PCNLT under ultrasound control allowed complete removal of a large stone of the pelvis without the use of fluoroscopy.

Table№2

Characteristics of patients		
Indications	Indications	Indications
Average operation time min	60(40-90)	65(45-96)
Operation efficiency %	95,7	94,1
Volume of blood loss ml	246(330-500)	230(220-450)
Duration of hospitalization days	4,7(3,6-7,8)	4,6(3,4-8,4)
Complications %	14,3	14,7
Residual stones %	4,3	5,9

Discussion

Correct puncture of the calyx-pelvic segment and percutaneous access formation are important factors in achieving good results in calyx-pelvic segment. Frequent use of fluoroscopy during percutaneous access creation may be the cause of various complications on the part of medical

personnel associated with the effect of rays on the function of the thyroid gland, gonads, bone marrow and eyes. In addition, J. Loree et al. [18] experimentally established that prolonged fluoroscopy induces various molecular changes in animal tissues, including carcinogenic ones. Therefore, when creating puncture access during PCNLT, an alternative control is needed to minimize the use of fluoroscopy.

In recent years in the literature there appeared works on the possibility of performing PCNLT under ultrasound control. A. Basiri et al. [19] report a 94% success rate with ultrasound-guided renal cavity puncture. At the same time, in one third of operated patients, the dilation of the calyx-pelvic segment was insufficient for adequate puncture. Another factor increasing the success of puncture up to 100% was the retrograde injection of sterile solution through the inserted catheter, which significantly dilates the PNL and facilitates its puncture. A similar technique was used by M. Etemadian et al. [20], who indicate that for adequate puncture of the cup it is necessary to use an ultrasound scanner with a puncture tip. M. Desai et al. [16] testified: ultrasound-guided percutaneous access is well performed with a needle attachment, as the puncture line is adequately guided to the desired cup and the moment of puncture is clearly visible on the monitor. According to [14, 16], access to the PSC should be performed by an experienced urologist. W. Gamal et al. [13] reported 2 (5.3%) episodes of perforation of the calyx-pelvic segment during fistula dilatation with metal bougies, because it is difficult to control the passage of the bougie on the monitor. Therefore, they recommend the use of Amplatz Teflon bougies, which did not cause perforation of the calyx-pelvic segment. In [15], perforation of the calyx-pelvic segment during bujering with Teflon dilators occurred in 4 (8.5%) cases, despite the fact that patients with solitary pelvic stones were operated on, as well as in a series of patients by W. Gamal et al. Gamal et al. [13]. However, in patients in this group, the diameter of stones was larger (24-46 mm), and according to ultrasound of the kidney there was marked dilatation of the pelvis and the calyxes were slightly dilated. In X. Zou et al. [20], who operated on 92 patients, the need for repeat puncture occurred in 22.8% of patients, which is higher than the figures obtained by W. Gamal et al. Gamal et al. [13]. However, the majority (75%) of patients in this group had multiple and coral-like stones. W. Gamal et al. [13] used the second access only in 2 (5.8%) patients. During PNL, the X-ray arc was always available in the operating room, but there was no need for it. However, in another series of ultrasound-controlled PNL, radiologic control was needed in 2 of 47 patients [10].

W. Gamal et al. [13] successfully performed ultrasound-guided PNL in 8 patients with radiopaque stones. This fact indicates the advantages and results of ultrasound-controlled PNL for X-ray negative stones, which was also reported by M. Hosseini et al. [15]. In X-ray-negative stones PNL under radiologic control has no special advantage, because we can not control the crushing of the stone and the presence of fragments on X-ray, we see the stone only as a filling defect. Residual stones are clearly visible on ultrasound. To repeated PNL W. Gamal et al. [13] were resorted to in 6% of patients, and M. Hosseini et al. [15] - 6,4%. However, the size of stones in the patients operated on by them was comparatively larger. M. Osman et al. [14] reported the need for additional procedures (remote lithotripsy, repeated PNL, ureteroscopy) after primary PNL in 33% of patients, because most of them had coral-like stones. In our group, PNL was performed for single large pelvic stones, so remote lithotripsy was required in only 4 (5.9%) patients. A. Basiri et al. [18] stated a small number of intra- and postoperative complications: only 5 patients had an indication for hemotransfusion, and all of them had coral-like stones. The number of complications

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of PCNLT performed under ultrasound control recorded in patients operated by W. Gamal et al. [13] and us, was minimal, because the size of stones was smaller (less than 30 mm).

Thus, PCNLT performed under ultrasound control has such advantages as a high frequency of successful punctures of calyx-pelvic segment, possibility of intraoperative detection and monitoring of X-ray positive and X-ray negative stones, absence of X-ray load and possibility of visualization of organs located in the puncture zone. The factors determining the success of such operations include the size of the stone less than 30 mm, sufficient dilation of the calyx-pelvic segment, localization of the stone in the pelvis, use of the puncture nozzle and surgeon's experience. In this regard, we consider the surgeon's low experience, the presence of multiple and coral-like stones as a reason to refuse to perform PNL under ultrasound control.

Conclusion. Percutaneous nephrolithotripsy under ultrasound control of patients with large solitary stones of the pelvis and dilated calyx-pelvic segment is considered to be an effective method of treatment. It allows to perform PCNLT without using fluoroscopy and to reduce the radiation burden on the operating urologist.

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