

RESULTS OF EXTRACORPOREAL SHOCK WAVE LITHOTRIPSY IN PATIENTS WITH HIGH DENSITY KIDNEY CALCULI

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⊗ A study of the efficacy of extracorporeal shock wave lithotripsy (ESWL) in patients with urolithiasis with renal calculi of high-density (>1000 HU) and size less than 20 mm was carried out. A total of 18 patients underwent 54 ESWL sessions. The tolerability of the treatment was satisfactory. The best results were obtained in patients with structural heterogeneity of calculi with a difference in the density of different sections of the calculus according to multi-slice computer tomography data of more than 500 HU. Such calculi disintegrated more easily during ESWL.

⊗ **Keywords:** urolithiasis; extracorporeal shock wave lithotripsy; nephrolithiasis; calculi density.

РЕЗУЛЬТАТЫ ДИСТАНЦИОННОЙ ЛИТОТРИПСИИ У ПАЦИЕНТОВ С КОНКРЕМЕНТАМИ ПОЧЕК ВЫСОКОЙ ПЛОТНОСТИ

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⊗ Проведено исследование эффективности дистанционной литотрипсии у больных уролитиазом с конкрементами почек высокой плотности (более 1000 HU) и размером менее 20 мм. Всего 18 пациентам выполнены 54 сеанса дистанционной литотрипсии. Переносимость лечения была удовлетворительной. Лучшие результаты были получены у пациентов со структурной неоднородностью конкрементов при разности плотности различных отделов конкремента, по данным мультиспиральной компьютерной томографии, более 500 HU. Такие конкременты легче дезинтегрировались в процессе дистанционной литотрипсии.

⊗ **Ключевые слова:** мочекаменная болезнь; дистанционная литотрипсия; нефролитиаз; плотность конкрементов.

INTRODUCTION

Urolithiasis is a chronic recurrent disease and the second most common urological disease following urinary tract infection and inflammatory lesions. The etiology of urolithiasis focuses primarily on metabolic disorders, genetic factors, and urinary tract infection [1–3]. Epidemiological studies have revealed that urolithiasis was diagnosed in at least 3% of the population aged 20–40 years, and in the older age group, >70 years old, it was detected in one out of eight patients [4]. In urological hospitals, urolithiasis accounts for approximately 30%–40% of cases. The annual primary incidence of urolithiasis

is about 2000 people per 1 million of the population (about 0.2%), and in the absence of preventive measures, recurrence of lithogenesis within 3 years after removal of calculi was reported in one-third of patients [5, 6]. In the Republic of Kazakhstan, according to the Scientific Center of Urology and data obtained from the analysis of the chief urologists of the regions and districts from 2000 to 2015, urolithiasis ranked first among all urological diseases, and accounted for 33.9% of the cases [7]. Analysis of the incidence of urolithiasis in the Russian Federation from 2005 to 2016 showed an increase in the prevalence of urolithiasis; the increase in the number

of registered cases over the 12-year period was 34%, and increase in new recorded cases was 27.3% [8].

The implications of urolithiasis are determined by its high prevalence, a significant deterioration in the quality of life, frequent disability, and the development of severe complications followed by long periods of rehabilitation [9–11]. Surgical treatment is required to remove calculi from patients with urolithiasis, except in those with urate lithiasis, wherein conservative therapy is prescribed [12]. Due to the recurrent clinical course of urolithiasis in the post-operative period, metaphylaxis of lithogenesis is mandatory [13, 14].

A significant increase in the efficiency of treatment of patients with urolithiasis was noted during the last decades, which is associated with introduction of minimally invasive endourological methods, such as ureterorenoscopy with contact lithotripsy, percutaneous nephrolithotripsy, and laparoscopic nephrolithotomy, and the improvement of extracorporeal methods of treatment [15–17]. New surgical techniques for urolithiasis treatment have led to a significant decrease in the number of open surgeries performed in almost all large urological hospitals [18]. However, it should be considered that despite the success achieved, the results of surgical treatment of patients with urolithiasis were not always acceptable. In this regard, further improvement of minimally invasive methods of treating urolithiasis remains an urgent task of medicine.

Choosing the appropriate treatment method for patients with urolithiasis is strictly individual and is performed considering the patient's somatic condition and medical history and the calculus density as well as its size and location [19, 20]. Extracorporeal shock-wave lithotripsy (ESWL) is vital among the treatment methods of urolithiasis. ESWL is considered the common method of choice for renal calculi up to 2 cm in size and with density up to 1000 HU [21, 22]. Larger and high-density calculi require an increased number of ESWL sessions, which increases the risk of kidney damage and ureteral obstruction [23]. However, the results of studies conducted in recent years have revealed that assessment of only the size and average density of calculi to predict effective fragmentation of calculi during ESWL is insufficient; additionally, other indicators are crucial, in particular, the calculus uniformity [24, 25].

This study aimed to evaluate the efficacy of ESWL on high-density calculi in patients with nephrolithiasis.

MATERIALS AND METHODS

This study included 18 urolithiasis patients who underwent ESWL in 2019 at the Urology Department of the Hospital of the Medical Center at the Department of Presidential Affairs of the Republic of Kazakhstan (Nur-Sultan). The inclusion criteria included the presence of single X-ray-positive calculi in the renal cavity system, up to 20 mm in size and, according to multispiral computed tomography (MSCT), of more than 1000 HU (maximum value 1600 HU). All patients were hospitalized on a scheduled basis and were examined in an outpatient setting according to treatment protocols for patients with urolithiasis.

ESWL was performed on a Dornier Gemini lithotripter (Germany), which comprises a shock-wave emitter, control panel, water supply system, and motorized multifunctional patient table equipped with a foot pedal control that enables the surgeon to change the patient's position in three planes directly during lithotripsy. Calculi were visualized with X-ray navigation using the C-arm. The User Interface Management Systems computer control center in the lithotripter enabled to remove accurately the calculus into the focal zone of the shock wave during the entire lithotripsy procedure. The electromagnetic shock-wave emitter (EMSE) was located on a special movable head, which provides a three-dimensional effect of waves on the calculus. The depth of shock-wave penetration reached 170 mm. When using this lithotripter, there were practically no restrictions on the patient's body weight.

ESWL was performed with patients under conditions of drug sedation. During each ESWL session, no more than 1500 pulses were generated at a frequency of 30–100 pulses per minute and a power of 3–13 units (20%–86% of the maximum lithotripter power). Lithotripsies with localization of calculi in the renal cavity system were performed every other day.

If the calculus size was more than 10 mm, a ureteral catheter stent no. 4–5 was placed in the patient according to the Charriere scale. If the calculus size did not exceed 10 mm, drainage of the upper urinary tract was not performed.

Control over the result of lithotripsy during the ESWL session was performed by fluoroscopy. The lithotripsy results were assessed the next day following the procedure, according to the plain urography data, as immediately after the ESWL session, it is difficult to assess the effect on the fluoroscopic image due to the “cloud” phenomenon represented by the presence of small fragments of calculi and dust around the calculus on the fluoroscopic image.

After ESWL, the antispasmodic, anti-inflammatory, and antibacterial therapies were prescribed to patients, taken into account the results of urine microbiological examination as well as herbal therapy.

RESULTS AND DISCUSSION

In 4 of 18 patients followed up, the calculi were localized in the renal pelvis; in 8, they were in the lower segment of the renal cavity system; in 4, the calculi were in the middle segment; and in 2, the calculi were located in the upper segment. Table presents the data on the localization and size of calculi.

In total, during the study, 54 sessions of ESWL were performed, with each of the 18 patients requiring three sessions of lithotripsy. Taken into account the use of adequate anesthesia, we used high-power lithotripter (up to 86%) at each ESWL session. Plain radiographs of the kidneys and urinary tract the day after the procedure showed either a group of calculus fragments or a whole conglomerate of fragments matched correctly in the form of an initial calculus. After the third session of ESWL for calculi of 8–10 mm in size, “dust” from microliths was determined on plain radiograph and neither calculus nor microliths were detected, and patients noted the presence of numerous microliths and calculus fragments in the urine. Moreover, calculi of 10–20 mm in size were fragmented after session 2 of ESWL, and after session 3, small fragments of calculus were detected on a plain radiograph in the pelvicalyceal system (PCS), which, during lithokinetic therapy, were excreted from the kidney PCS beside the catheter stent. In conservative lithokinetic therapy, the disintegrated calculus was eliminated without complications. In 3 of 9 patients with 10–20-mm calculi, small microliths up to 3 mm in size were registered in the renal cavity system. In four patients with 5–7-mm calculi located in the lower group of calices, follow-

ing ESWL sessions, we revealed no complete disintegration of the calculi. In our opinion, the relatively unsatisfactory results of ESWL in these patients were associated with two factors. First, according to MSCT data, the calculi, in addition to being of high density, turned out to be relatively homogeneous. Second, the technical aspects of ESWL implementation contributed to the unsatisfactory results. Thus, calculi of 8–20 mm are ideally fully seen by the X-ray scope of the Dornier Gemini lithotripter (although we preliminarily entered data on the localization and size of the calculus in the program), and during an ESWL session, all the energy of the shock wave probably evenly strongly affects the entire calculus area. In lithotripsy of calculi up to 7 mm in the X-ray scope of the lithotripter, the calculus occupies a small area and, possibly, part of the energy passes by it.

Tolerance of ESWL was satisfactory in all patients, and no patient had renal colic. After ESWL, most patients noted moderate gross hematuria, which was short-term that lasted no more than 1 day.

Ureteral stent catheters were removed from patients 4–6 weeks after the last ESWL session. During the entire time until the stent removal, the patients continued herbal therapy with Canephron N in a standard therapeutic dosage. When prescribing the drug, its lithokinetic and nephroprotective effects, as well as the properties of the urinary tract antiseptics, were considered [26].

The analysis of ESWL results in patients with high-density calculi showed that the best results were achieved when the difference in the density of different parts of the calculus, according to MSCT, was >500 HU. Such calculi turned out to be more fragile and disintegrated more easily during the

Localization and size of calculi in patients with nephrolithiasis ($n = 18$)

Локализация и размеры конкрементов у больных нефролитиазом ($n = 18$)

Localization of calculi	Number of patients	Calculus size, mm
Renal pelvis	4	10–20
Upper segment of the kidney PCS	1	8–10
Middle segment of the kidney PCS	2	10–20
Lower segment of the kidney PCS	4	8–12
	4	5–7

Note. PCS – pelvicalyceal system.

ESWL process. In our opinion, it is the fragility of the calculus, and not its density, which is the second most important parameter after its size, which must be taken into account when choosing ESWL as a method of treating patients with nephrolithiasis. The calculus fragility is determined by the heterogeneity of its structure, which can be detected by layer-by-layer determination of the urolite density by MSCT.

Thus, despite the fact that ESWL is considered to be the most effective for urinary calculi of density up to 1000 HU, it can be used for calculi with a higher density. Our cases showed that the use of ESWL of high-density calculi under X-ray navigation can be applied successfully in patients with calculi of the renal cavity system of up to 20 mm in size and if their structure is heterogeneous. Calculi of 5–7 mm in size and with a monolithic structure with high homogeneity and, accordingly, low fragility are difficult to fragment effectively and disintegrate during ESWL. Long-term (at least 6 months) phytotherapy with Canephron N in a standard therapeutic dose is recommended in patients with high-density and high-uniformity calculi, as preparation for ESWL.

In support of these statements, we report two clinical examples.

Clinical case 1

Patient A, 63 years old, was admitted to the urology department with a diagnosis of urolithiasis and a calculus in the left kidney. Plain urography and

MSCT without contrast confirmed the diagnosis. In the upper segment of the PCS of the left kidney, a 9-mm calculus with a density of 1159 HU was identified. With the layer-by-layer determination of the density over the entire volume of the calculus on step-by-step sections, its heterogeneity was revealed, with difference in the density of individual sections of the calculus of more than 500 HU. Three lithotripsy sessions were performed. After session 2 of ESWL, defragmentation of the calculus was noted, and after session 3, no shadow of calculi or their fragments in the projection of the urinary tract was determined. The results of MSCT and radiography are presented in Figs. 1 and 2.

Clinical case 2

Patient T, 37 years old, was admitted to the urology department with a diagnosis of urolithiasis and a calculus in the left kidney. Plain urography and MSCT without contrast were performed, and the diagnosis was confirmed. In the pelvis of the left kidney, a 17-mm calculus with a density of 1210 HU was found. With the layer-by-layer determination of the density over the entire volume of the calculus, on step-by-step sections, its heterogeneity was revealed, with the difference in the density of individual sections of the calculus of more than 500 HU. Due to the size of the calculus of more than 10 mm, a ureteral catheter stent was placed inside patient. 3 sessions of lithotripsy were performed. After session 2 of ESWL, defragmentation of the calculus was

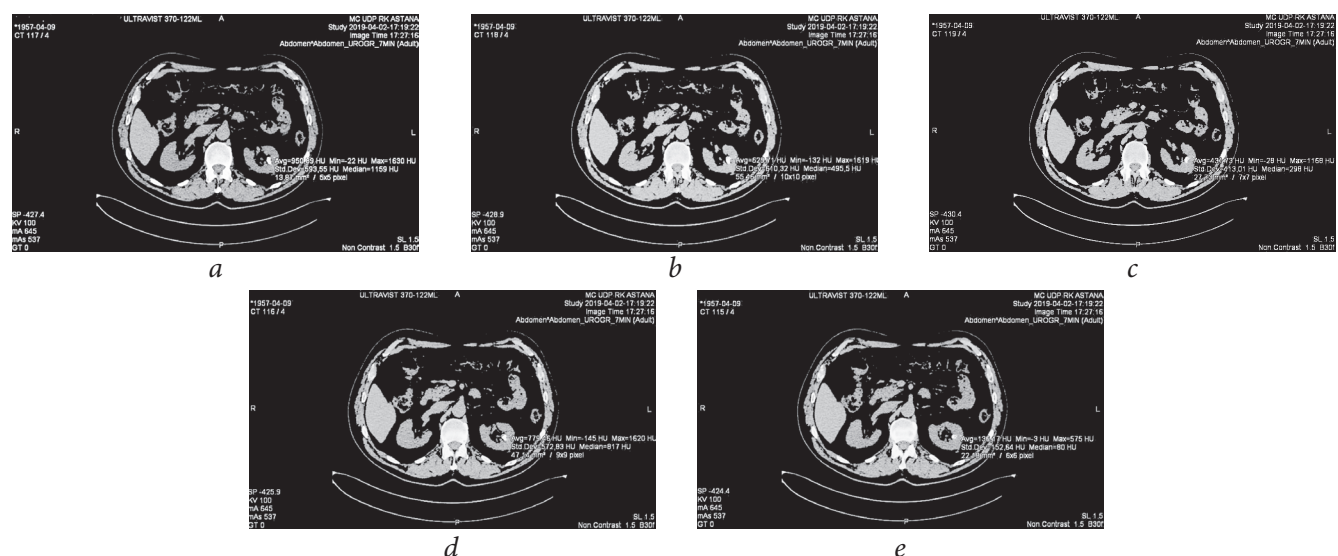


Fig. 1. Patient A., 63 years old. MSCT, layer-by-layer sections of calculi before ESWL: a – average density 1159 HU; b – average density 495.5 HU; c – average density 298 HU; d – average density 817 HU; e – average density 80 HU

Рис. 1. Пациент А., 63 года. Мультиспиральная когерентная томография, послойные срезы конкрементов до проведения ДЛТ: а — средняя плотность в срезе 1159 HU; б — средняя плотность в срезе 495,5 HU; в — средняя плотность в срезе 298 HU; д — средняя плотность в срезе 817 HU; е — средняя плотность в срезе 80 HU

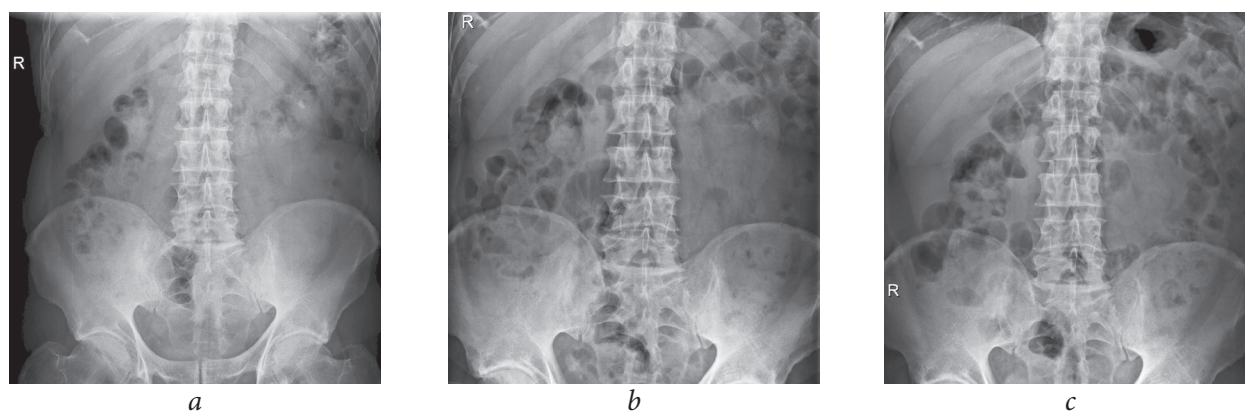


Fig. 2. X-ray study of the kidneys and urinary tract: *a* – before extracorporeal shock wave lithotripsy; *b* – after 2 sessions of extracorporeal shock wave lithotripsy; *c* – after 3 sessions

Рис. 2. Обзорная рентгенография почек и мочевых путей: *a* — до выполнения дистанционной литотрипсии; *b* — после двух сеансов дистанционной литотрипсии; *c* — после трех сеансов

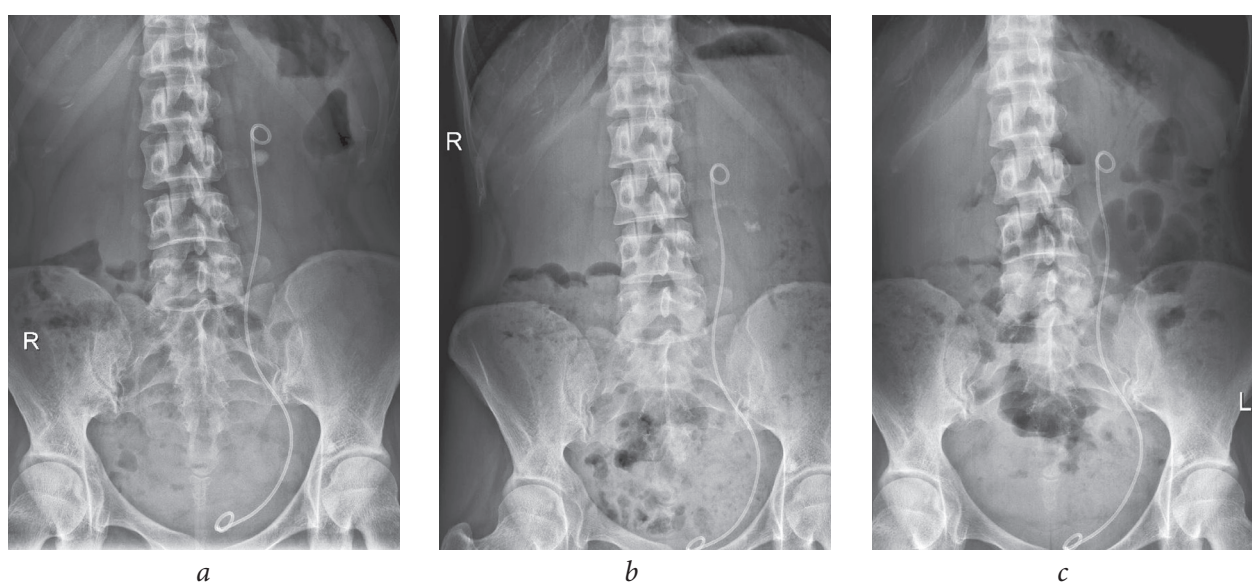


Fig. 3. Patient T., 37 years old. X-ray study of the kidneys and urinary tract; *a* – before extracorporeal shock wave lithotripsy; *b* – after 2 sessions of extracorporeal shock wave lithotripsy; *c* – after 3 sessions

Рис. 3. Пациентка Т., 37 лет. Обзорная рентгенография почек и мочевых путей: *a* — до выполнения дистанционной литотрипсии; *b* — после двух сеансов дистанционной литотрипсии; *c* — после трех сеансов

noted; after session 3, no shadows of calculi or their fragments were detected in the urinary tract projection (Fig. 3).

CONCLUSION

ESWL is the method of choice for the treatment of nephrolithiasis in patients with calculi of high density and low homogeneity. The ESWL efficiency is higher when the density difference in the calculus structure is more than 500 HU, according to MSCT results.

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