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ВАЖНОСТЬ ТРАНСУРЕТРАЛЬНОЙ УРЕТЕРОЛИТОТРИПСИИ ВЫПОЛНЯЕМОЙ БЕЗ РЕНТГЕНКОНТРОЛЯ ПРИ ЛЕЧЕНИИ КАМНЕЙ МОЧЕТОЧНИКА

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Аннотация: В данной статье обсуждается важный вопрос – важность выполнения трансуретральной уретеролитотрипсии при камнях мочеточника без рентгенконтроля. Основным методом лечения симптоматических камней мочеточника является трансуретральная уретеролитотрипсия, которая обычно выполняется под рентгеновским контролем. Однако, ассоциированные с облучением риски осложнений не всегда оправдывают получаемые от его применения преимущества, что обосновывает изучение результатов этого этого вмешательства без использования рентгеновских методов. Отмечено, что рентгенологический контроль, несмотря на свою высокую информативность, сопряжен с рядом рисков, включая потенциальные стохастические и канцерогенные эффекты. Авторы пришли к выводу, что выполнения трансуретральной уретеролитотрипсии без рентгенконтроля является альтернативным методом, который надежно снижает риск облучения пациентов и медицинских работников, сохраняя при этом эффективность и безопасность.

Ключевые слова: *Трансуретральная уретеролитотрипсия (ТУУЛТ), хирургия мочекаменной болезни, радиационная безопасность, рентгенобезопасная хирургия.*

SIYDIK NAYI TOSHLARINI DAVOLASHDA RETNGEN NAZORATISIZ BAJARILADIGAN TRANSURETRAL URETEROLITOTRIPSIYANING AHAMIYATI

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Annotatsiya: Ushbu maqola muhim mavzuga, ya’ni siydik nayi toshlarida rentgen nazoratisiz bajariladigan ureterolitotripsiyaning ahamiyatiga bag’ishlangan. Sшmptomatik siydik yo'llari toshlarini davolashning asosiy usuli transuretral ureterolitotripsi bo‘lib, u odatda rentgen nurlari nazorati ostida amalga oshiriladi. Biroq, radiatsiya bilan bog‘liq asoratlar xavfi har doim ham rentgen usullaridan foydalanmasdan ushbu aralashuv natijalarini o‘rganishni oqlaydigan foydalarni oqlamaydi. Rentgen nazorati o‘zining yuqori ma’lumotlarga ega bo‘lishiga qaramay, bir qator xavflar, jumladan, potensial stoxastik va kanserogen ta’sirlar bilan bog‘liq. Mualliflar ishonchli tarzda rentgensiz bajarilgan transuretral ureterolitotripsiyaning, samaradorlik va xavfsizlikni saqlagan holda bemor va tibbiyot xodimlari uchun radiatsiya xavfini kamaytiragan alternativ usul ekanini xulosa qilishgan.

Kalit so‘zlar: *Tranuretral ureterolitotripsiya (TUULT), urolitiyaz uchun jarrohlik, radiatsiya xavfsizligi, rentgen nurlari bilan xavfsiz jarrohlik.*

THE IMPORTANCE OF TRANSURETHRAL URETEROLITHOTRIPSY PERFORMED WITHOUT X-RAY CONTROL IN THE TREATMENT OF URETERAL STONES

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Abstract: This article discusses an important issue – the importance of performing transurethral ureterolithotripsy for ureteral stones without X-ray control. The main method of treating symptomatic ureteral stones is transurethral ureterolithotripsy, which is usually performed under X-ray control. However, the risks of complications associated with radiation do not always justify the benefits obtained from its use, which justifies studying the results of this intervention without the use of X-ray methods. It is noted that X-ray control, despite its high information content, is associated with a number of risks, including potential stochastic and carcinogenic effects. The authors concluded that performing transurethral ureterolithotripsy without X-ray control is an alternative method that reliably reduces the risk of radiation exposure to patients and health care workers, while maintaining efficacy and safety.

Keywords: *Transurethral utreterolithotripsy(TUULT), surgery for urolithiasis, radiation safety, X-ray free surgery.*

Introduction: Urolithiasis affects up to 13% of the world's population [1]. Ureterolithiasis is the most common form of this disease, occurring in approximately 50% of cases [2]. According to the recommendations of the European Association of Urologists (EAU), transurethral ureterolithotripsy (TUULT) is indicated for stones located in the middle and lower third of the urinary tract. This procedure is usually performed under X-ray guidance. During TUULT, the patient is exposed to ionizing radiation from 2.5 to 100 mSv using X-rays [3]. In addition, during the procedure, healthcare workers are also exposed to radiation, the limit for which is considered safe is 50 mSv per year.

According to the International Commission on Radiological Protection, the “linear-unlimited model” indicates that even low doses of ionizing radiation have a risk of developing cancer. The total radiation dose received during the diagnostic, treatment, and follow-up period is significant, given the recurrent nature of urolithiasis [4]. Due to this concern, in recent years, it has become urgent for specialists to search for ways to not only reduce, but also completely eliminate radiation exposure to patients and staff.

Objectives: To assess the feasibility, safety, and effectiveness of an X-ray-free transurethral surgery for ureteral stones and to identify the main risk factors leading to failure.

Materials and Methods: Retrospective data on 39 patients who underwent X-ray-free TUULT for symptomatic ureteral stones between March 2024 and April 2025 were studied. The selection criteria were: patients older than 18 years, the presence of preoperative radiography and/or MSCT, the presence of a single ureteral stone, and the absence of other diseases of the upper urinary tract (tumors, kidney stones, developmental anomalies). All CT examinations were performed on a Philips Ingenuity (64 slices) with a 0.5 mm step.

Statistical analyses were performed using the Kolmogorov-Smirnov test using SPSS Statistics 22.0. Depending on the degree of normality, data were expressed as mean and standard deviation or median and quartiles. The overall incidence of complications and urinary tract injury was also determined. In addition to statistical data, multivariate analyses were performed to identify risk factors for failure of ureteroscopic treatment of ureteral stones, associated complications and, in particular, urinary tract perforation, as well as the duration of the operation. In addition, the main factors that increase the overall duration of the operation were identified.

Results: Demographic and clinical data of the patients, stone sizes are shown in Table 1. The mean stone size was 5.9±2.6 mm and the density was 673.2±184.0 HU. The mean operation time was 32.7±13.1 minutes, with a success rate of 87.2%. Ureteral injury was reported in 2.6%, and the overall complication rate was 12.8%, confirming the positive clinical effect of TUULT (Table 1).

Table 1. Patient characteristics.

Age		48 ± 12,8
Cases with pre-stenting, n		12
Surgery side (right/left)		23/16
Stone location, n (%)	Upper ureter	5 (12,8%)
	Mid ureter	6 (15,3%)
	Low ureter	18 (46,1%)
Stone density, HU		692 ± 125
Stone size		5,9 ± 2,8
Operation time, min		32 ± 18,2
Complication rate, n (%)		4 (10,2%)
Perforation of ureter, n (%)		1 (2,5%)

Multivariate analysis showed that the following factors influenced the outcome of TUULT in symptomatic stones: stone density, size, location, and presence of a ureteral stent ($p<0.05$). Stone density >885 HU was associated with a higher probability of incomplete removal (AUC=0.805; sensitivity 75.8%; specificity 79.2%). Stone size >7.6 mm was associated with an increased probability of failure (AUC=0.782) (Figure 1).

Complete removal was achieved in only 61.2% of cases with stones in the upper third, 84.4% in the middle third, and 95.9% in the lower third ($p<0.00001$).

TUULT success was 97.9% in patients with stent placement and 80.8% in those without stent placement ($p<0.05$). The risk of complications was related to density, location, stent presence, and duration of the procedure. The duration of the procedure was related to density ($r=0.413$) and stone location: 35.1±20.3; 30.8±11.7; 26.9±11.4 minutes in the upper, middle, and lower thirds, respectively ($p<0.001$).

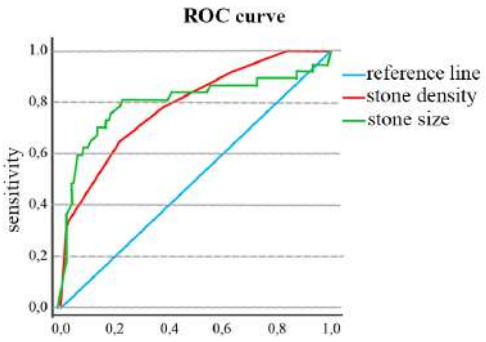

Figure 1. ROC curve of the diagnostic value of measuring stone density and size based on TUULT results.

Discussion: X-ray examination is used at almost all stages of TUULT: insertion of a guiding wire, placement of a ureteral stent, and also during retrograde ureteropyelography. Given the low incidence of intraoperative complications, the benefits of its use are not always justified [5]. Brisbane et al. describe a comparison of the results of retrograde stenting with and without radiographic guidance. The rate of successful stent placement was the same in both groups, and the operative time was significantly shorter in the group without radiographic guidance (62 min vs. 100 min, $p = 0.01$) [6].

In their work, Seklehner et al. demonstrated the low efficiency of retrograde pyelography in the treatment of ureteral stones, both for detecting perforations, which are eliminated by stenting at the end of the intervention, and for complete stone removal. The success rate of lithoextraction was 73% with retrograde pyelography and 86.8% without it. According to the authors, some fragments may have been transported up to the renal cystic system during contrast administration, which is supported by their results [7]. The International Commission on Radiological Protection recommends that specialists adhere to the following principles of radiation protection, including when performing ureteroscopy: justification, non-redundancy, and optimization [4]. The abbreviation ALARA, familiar to many endourologists, recommends the use of radiographic guidelines "as low as reasonably achievable," taking into account the ratio of radiation dose to the risk of complications associated with it. Taking into account the above principles, a number of publications present various tactics for reducing the final radiation exposure. Thus, Danilovich et al. showed the results of performing ureterolithotripsy for ureteral stones with a decrease in image quality as a result of manually reducing the radiation dose to 1/4 of the standard values by reducing the mAs (milliamperes per second) parameter. This tactic did not increase fluoroscopy time without compromising the success of the intervention. It is noteworthy that none of the specialists included in the study complained about the quality of the radiographic image during the procedure [8].

Another approach in accordance with the ALARA protocol is to reduce the time of fluoroscopy, as demonstrated in the work of Klarentgen Control et al. The use of fluoroscopy at the end of the procedure to assess the placement of the ureteral stent was limited to a few images. The total radiography time was reduced from 33.7 to 2.8 seconds ($p<0.05$).

Despite the significant reduction in radiation time, the authors believe that tactile sensations are sufficient for stent placement and use fluoroscopy only in cases of technical difficulties or suspicion of serious ureteral damage. The correct placement of the proximal end of the stent can be determined intraoperatively using ultrasound, and the distal end under endoscopic control [9].

In the modern literature, there is evidence that more complex endourological interventions have been successfully performed without X-rays, such as flexible ureteropyeloscopy under ultrasound guidance, percutaneous nephrolithotripsy, and endoscopic combined intrarenal surgery of kidney stones, which justifies attempts to perform TUULT without X-ray guidance [10-13]. In a randomized comparison, Deters et al. compared the results of endoscopic treatment of symptomatic ureteral stones up to 8 mm in patients with a similar appearance. 50 patients were divided into two groups depending on the use of X-ray guidance. According to the results, the complete absence of radiation did not lead to a decrease in the success rate of the procedure [14].

However, despite the encouraging results, it should be taken into account that the presentation facilitates the implementation of all stages of ureteroscopy, which may be a systematic error of the study.

Similar results were obtained in the work of Olgin et al. The success rate and complication rate of ureteroscopy for symptomatic ureteral stones were similar in the groups without radiographic guidance (92% vs. 92%, 4% vs. 4%), but the need for repeat intervention was higher in the group without radiographic guidance (4% vs. 8%) and the presence of ureteral stones was 6% higher. Although there were no statistically significant differences, the results of our study are consistent with the results of ureteroscopy in 39 patients with symptomatic ureteral stones.

Although the studies presented here have considered the outcome of this intervention in the cases of presentation, the results highlight the rationale for excluding radiographic navigation without compromising the quality of care. In our study, in 88.2% of cases, it was possible to completely remove the stone without additional procedures and without stopping the operation, which is consistent with world data. However, the question of determining the factors that reliably determine the success of the intervention remains open. Among the parameters included in the study, the density, maximum size and localization of the stone, as well as the indication, independently affected the TUULT result, which allowed us to further formulate a prognostic nomogram to identify the most suitable cohort of patients. It is necessary to separately highlight the shortcomings of our study. First, the retrospective nature does not allow us to take into account all the factors and possible nuances of each specific case. Second, a control group was not formed to compare the results obtained with X-ray-controlled analogues. Third, the influence of the urologist's experience was not determined, which could lead to a deviation of the results in their subsequent stratification. These shortcomings will be taken into account in further studies, but they did not cause difficulties in conducting a multivariate analysis to identify prognostically significant factors.

Conclusion: Transurethral ureterolithotripsy is a highly effective method for the treatment of ureteral stones. Transurethral ureterolithotripsy, performed without X-rays, is an alternative method that reduces the radiation risk for patients and medical personnel while maintaining effectiveness and safety.

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