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Endoscopic Treatment of Complex Ureteral Calculi Using Ultrasound and Laser Contact Ureteral Lithotripsy

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Keywords: ureteral calculi; ultrasound contact lithotripsy; laser contact lithotripsy

Abstract.

Nowadays contact ureteral lithotripsy with the use of semi-rigid ureteroscope is the method of choice for the urologist in the treatment of ureteral calculi. It is possible to use both the ultrasonic and laser lithotripter.

Materials and methods. Comparative analysis of the duration of lithotripsy various stages was conducted with the use of ultrasound and laser lithotripters based on video recording analysis. Thus, we compared the chronometry results in 23 patients with the calculi up to 1 cm in size and density of no more than 1000 Hounsfield units (conventionally we named them "standard" calculi) and in 18 patients with complex calculi localized in the lower third of the ureter during the treatment with the use of ultrasound contact lithotripsy.

Results of the research. Total duration of the surgery was the lowest in patients with complex calculi up to 1 cm in size with the use of laser ureteral lithotripsy and constituted 11.31 ± 0.85 minutes. Duration of the surgery in patients with "standard" calculi amounted 14.20 ± 1.15 minutes on average being significantly greater ($p<0.5$) than in the previous group. Duration of the surgery in patients in the group with complex calculi larger than 1.5 cm in size with the use of laser lithotripsy constituted 17.31 ± 2.11 minutes being unreliably higher than in case of endoscopic treatment of "standard" calculi using ultrasound probe ($p>0.5$). Duration of the surgery was the largest in patients of the group with complex calculi using laser lithotripsy, regardless of the size of stone up to 1.5 cm and constituted 27.84 ± 2.41 minutes (differences were significant in comparison with other groups, $p<0.01$).

Conclusions. Comparative analysis of the surgery course, namely contact ureteral lithotripsy using ultrasound lithotripters in patients with "standard" and complex ureteral calculi and laser ureteral lithotripsy in patients with the calculi up to 1 cm in size and over 1.5 cm in size showed undeniable advantages of the latter in the treatment of complex ureteral calculi.

Problem statement and analysis of the recent research

Urolithiasis has been following the mankind for many centuries [2, 3]. Fortunately, the rapid development of medical technology has improved the treatment of urolithiasis while minimizing complications [1, 4]. Majority of urinary calculi go beyond renal calices and pelvis falling eventually into the ureter causing severe symptoms. Most often these are pain syndrome, hematuria, hydronephrosis, purulent-septic complications, hyperasotemia [2, 7].

Nowadays contact ureteral lithotripsy with the use of semi-rigid ureteroscope is the method of choice for the urologist in the treatment of ureteral calculi. It is possible to use both the ultrasonic and laser lithotripter [6].

Undoubtedly, laser ureteral lithotripsy is significantly more expensive option than contact ultrasonic disintegration of calculi. Using the latter, problems during the crushing of calculi up to 1 cm in size and with relatively low density up to 1200 Hounsfield units located in the lower third of the ureter do not occur [4, 6].

In this paper we presented the treatment results of complex ureteral calculi to which we referred calculi of any size and density located in the upper and middle third of the ureter, calculi of any size and localization with the density of more than 1000 Hounsfield units, calculi of any density and localization with more than 1 cm in size using both ultrasound and laser ureteral lithotripsy.

The objective of the research involved comparative analysis of endoscopic surgery characteristics in patients with complex ureteral calculi using ultrasound and laser ureteral lithotripsy.

Materials and methods of the research

Semi-rigid ureteroscope 8F/9.8F manufactured by RICHARD WOLF GmbH (Germany) and video system with endoscopic cameras manufactured by R. Wolf (Germany) and Olympus (Japan) were used during ureteroscopy. R. Wolf ultrasound lithotripter (Germany) was used for calculi disintegration. Laser lithotripsy was performed with the use of Richard Wolf Tower 30+ laser lithotripter. 0.9% sodium chloride solution was used as irrigation solution.

The surgery was conducted under spinal or epidural anesthesia. Routine antibiotic prophylaxis with the use of fluoroquinolones and cephalosporins was performed in all cases. Ureteroscope advancement through the ureter was performed using wire guide. Ureter catheter 4 Fr as the latter was used being introduced under direct visual control.

"Shoe horn" technique was applied for less traumatic insertion of ureteroscope through intramural part of ureter. After the introduction of the guide into the opening to the depth of 1.5 cm, ureteroscope was turned to 1800. Concurrently, the opening dilatation occurred due to the tensioning of the anterior wall of the intramural part with the string. Ureteroscope was introduced "under the string". After the introduction of the device through the intramural part, it was turned to its original position.

The opening dilatation was conducted with the use of bougies in case of impossibility to introduce the ureteroscope through the intramural part of the ureter due to disparity in the opening diameter and ureteroscope as a result of natural causes or stricture. For this purpose a standard set of urethral bougies from 6 to 9 Fr was used. The latter were introduced through core wire controlled by cystoscope into the intramural part of the ureter to a depth of 1.5 cm. No complications were observed when using this method of ureteral opening expansion.

Comparative analysis of the duration of ureteral lithotripsy various stages was conducted with the use of ultrasound and laser lithotripters based on video recording analysis in order to determine the effectiveness of laser ureteral lithotripsy. Thus, we compared the chronometry results in 23 patients with the calculi up to 1 cm in size and density of no more than 1000 Hounsfield units (conventionally we named them "standard" calculi) and in 18 patients with complex calculi localized

in the lower third of the ureter during the treatment with the use of ultrasound contact lithotripsy. In addition, the course of the surgical endoscopic intervention in 22 patients with complex calculi in the upper third of the ureter up to 1 cm in size and density over 1500 Hounsfield units and in patients with complex calculi in the lower parts of the ureter with 1.5 cm to 2.4 cm in size and density over 1500 Hounsfield units was analyzed.

Results of the research and their discussion

Video recording of the surgery was analyzed. On its basis a number of ureteral lithotripsy stages were determined and their chronometry from the moment of ureteral opening discovery to ureteroscope removal was conducted. The average time of all the major points of the operation was taken into account, namely passing the intramural part of the ureter, calculus visualization and examination of the surgical area, calculus destruction with the use of ultrasound and laser lithotripter probe, extraction of calculus fragments with ureter forceps, ureteric stenting (Table 1).

Table 1

Comparative analysis of the various stages duration of contact ultrasound ureteral lithotripsy in patients with "standard" and complex calculi in the lower third of ureter

Different variability of ureteral calculi	"Standard" calculi, n=23	Complex calculi, n=18	Complex calculi up to 1 cm in case of laser lithotripsy, n=22	Complex calculi up to 1.5-2.4 cm case of laser lithotripsy, n=19
Surgery stages	Absolute index rate, M±m.	Absolute index rate, M±m.	Absolute index rate, M±m.	Absolute index rate, M±m.
Calculus size, cm	0.83±0.26	1.02±0.64	0.92±0.31	2.41±0.21
Calculus density, Hounsfield units	639.58 ±24.52	1784.05 ±67.03	1981.22 ±94.01	1695.73 ±81.09
Total duration of the surgery, minutes	14.20±1.15	27.84±2.41	11.31±0.85	17.31±2.11
Passing the intramural part of the ureter, minutes	1.25±0.32	1.11±0.34	1.31±0.54	1.45±0.73
Calculus visualization and examination, minutes.	1.01±0.44	0.91±0.23	3.21±0.47	1.24±0.56
Calculus destruction, minutes	8.44±0.52	17.58±0.90	4.21±0.72	10.67±0.79
The number of fragments	3.07±0.76	7.24±1.03	0.92±0.31	1.71±0.27
Calculus fragments extraction, minutes	1.05±0.35	5.06±0.51	0	0
Stenting	1.75±0.52	2.05±0.44	1.75±0.34	1.81±0.47
Surgery duration in case of impaired visualization of the surgical area	1.06±0.39	9.47±1.08	0	0

Note. The probability of differences is indicated in the text

According to the table, calculi sizes in patients in the first three groups were not significantly different constituting 0.83±0.06 cm in the patients with "standard" calculi, 1.02±0.64 and 0.92±0.31

cm in the patients with complex calculi (p>0.5). Only the last group of patients was characterized by significantly larger calculi which constituted 2.41±0.21 cm (p<0.5). Calculi density in all groups of patients with complex calculi was significantly higher than in the group of patients with standard calculi and constituted 639.58±24.52 Hounsfield units, 1784.05±67.03 Hounsfield units, 1981.22±94.01 Hounsfield units, 1695.73±81.09 Hounsfield units, respectively (differences with a group of patients with "standard" calculi were significant concerning the value of this index, the probability of difference in other groups was not observed, p>0.5).

The total duration of the surgery with the use of laser ureteral lithotripsy was the lowest in the group of patients with complex calculi up to 1 cm in size and constituted 11.31±0.85 minutes. The surgery duration constituted 14.20±1.15 minutes on average in the patients with "standard" calculi, which was significantly larger (p<0.5) than in the previous group. The surgery duration with the use of laser lithotripsy constituted 17.31±2.11 minutes in the group of patients with the complex calculi over 1.5 cm in size which was insignificantly larger than in case of endoscopic treatment of "standard" calculi using an ultrasound probe (p>0.5). The surgery duration with the use of laser lithotripsy was the largest in the group of patinets with the complex calculi despite the size of calculi up to 1.5 cm and constituted 27.84±2.41 minutes (the differences were significant in comparison with other groups, p<0.01).

Analyzing different stages of the surgery, some features were distinguished. Such stage of the surgery as detection of ureteral opening, passing through the intramural part of ureter was about similar in all groups and lasted 1.25±0.32 minutes on average in the patients with standard calculi, 1.11±0.34 in patients with complex calculi treated with contact ultrasound ureteral lithotripsy, 1.31±0.54 in patients with complex calculi up to 1 cm in size and 1.45±0.73 minutes in case of complex calculi over 1.5 cm in size. Laser ureteral lithotripsy was applied in two latter groups (the differences were insignificant, p>0.5).

The next stage of the surgery, namely calculi visualization, examination of future ureteral lithotripsy area lasted 1.01±0.44 on average in patients with "standard" calculi, 0.91±0.23 on average in patients with complex calculi the destruction of which was performed by laser lithotripsy, 1.24±0.56 minutes on average in patients with complex calculi from 1.5 to 2.4 cm in size (differences are insignificant in the group where laser ureteral lithotripsy was applied, p>0.5). This stage of the surgery was the longest in the group with complex calculi up to 1 cm in size with the use of laser lithotripsy and lasted 3.21±0.47 minutes (the differences were significant in comparison with the indices of other groups, p<0.01). This feature was related to the localization of the calculi in the upper part of the ureter which certainly complicated achieving the calculi area in the ureter and elongated the total time of the whole intervention.

The duration of a key stage of the surgery, namely calculi disintegration by supplying lithotripter probe energy to it was the shortest and lasted 4.21±0.72 minutes in patients with complex calculi up to 1 cm in size. This was undoubtedly related to the high efficiency of laser lithotripsy. Average time of "standard" calculi disintegration with the use of ultrasound probe was significantly higher and constituted 8.44±0.52 minutes (p<0.1). That occurred despite the fact that these calculi density was the lowest in case of size up to 1 cm. Complex calculi ranging from 1.5 cm to 2.4 cm in size were crushed during 10.67 ± 0.79 minutes. Complex calculi were crushed for a longer time, namely during 17.58±0.90 minutes with the use of ultrasound lithotripsy, p<0.01, the differences were significant.

In case of calculi crushing with the use ultrasound lithotripsy, their average number constituted 3.07±0.76 in patients with "standard" calculi and 7.24±1.03 in patients with complex calculi. In case of laser lithotripsy application, the average number fragments constituted 0.92±0.31 in patients with complex calculi up to 1 cm in size and 1.71±0.27 in patients with complex calculi over 1.5.cm in size.

It should be noted that the maximum size of the fragments was not more than 2 mm. The fragments cleared independently with the ureteroscope removal. Additional traction with the use of forceps or basket forceps was not needed.

Fragments extraction with forceps lasted 1.05 ± 0.35 minutes on average in the group with "standard" calculi. The duration of fragments extraction lasted 2.05±0.44 minutes in the group with complex calculi after ultrasound lithotripsy. Moreover, there was no need to extract the fragments after laser lithotripsy in all cases, they all cleared independently from the ureter lumen after the ureteroscope removal.

The average duration of stenting did not differ significantly in all groups of patients and constituted 1.75±1.12 minutes, 2.05±0.44 minutes, 1.75±0.34 minutes, 1.81±0.47 minutes ($p>0.5$), respectively.

It should be noted that during laser ureteral lithotripsy the timing of the surgery in case of impaired visualization of the surgical area associated with hemorrhagic discharge from the mucous membrane of the ureter as a result of the injuries was equal to 0, regardless of calculus size.

Conclusions

Comparative analysis of the surgery course, namely contact ureteral lithotripsy using ultrasound lithotripters in patients with "standard" and complex ureteral calculi and laser ureteral lithotripsy in patients with the calculi up to 1 cm in size and over 1.5 cm in size showed undeniable advantages of the latter in the treatment of complex ureteral calculi.

The use of energy deposition of laser lithotripter on the calculus causes the effective disintegration of the calculus into smaller fragments not requiring extra traction to extract them from the ureter lumen. Surgery occurs in case of the perfect visualization of the surgical area. Laser lithotripsy performance is so high that it makes it possible to crush rather big calculi of high density in a minimum of time. Moreover, additional trauma of the ureter wall and its intramural part does not occur contributing to the surgery performance without complications of varying severity.

Prospects for further research

Study of contact laser lithotripsy possibilities has significant prospects in the treatment of urethrolithiasis. Further investigation of the influence of this treatment method on the dynamics of laboratory data, ultrastructural, morphological, histochemical and functional changes of the ureter wall is required to confirm this hypothesis.

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