

THESES OF DOCTORAL (PhD) DISSERTATION

**MODERN SURGICAL TREATMENT
OF URETERAL CALCULI**

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DEBRECEN, 2007

INTRODUCTION

Due to the birth and development of ESWL, appearance of endoscopes – small calibre, flexible endoscopes and effective lithotriptors – and the perfection of surgical techniques, the treatment of upper and lower urinary tract calculi and the approach to treatment have changed a lot over the past 25 years.

As much as 98 % of ureteral calculi less than 5 mm in size may pass out of the body spontaneously. In the case of clinical symptoms (pain and fever) or even asymptomatic urinary tract obstruction, however, waiting cannot be the solution. Even small ureteral calculi may get trapped in a juxtavesical position. In order to remove such stones in a simple, fast and minimally invasive way, we have elaborated ostiolitholapaxy (OLL), a special technique used for the removal of minor stones stuck in or near the orifice of the ureter. An advantage of the technique is that, especially in women, it can be applied without anaesthesia. We have not found data of a similar method in the national or international literature at our disposal. One of the sections of the current theses has been devoted to this technique.

If the technique is ineffective or cannot be applied, ureteroscopy should be performed. In the possession of today's most effective lithotriptor energy source (Holmium:Yttrium-Aluminium-Garnet = Ho:YAG) laser and gracile (6-7 Ch) flexible endoscopes, the success rate can be as high as 100 %. We were the first to report the treatment of ureteral stones using a Ho:YAG laser in a scientific paper in Hungary. The description of the technique, a review of the results and a listing of advantages and disadvantages are outlined in another section of the theses.

Despite the aforementioned modern endoscopes and highly effective lithotriptors, occasionally we may fail to eliminate ureteral stones using ESWL, antegrade or retrograde ureteroscopies, which are regarded to be “classical”

techniques in urology today. In cases like that the increasingly widespread application of laparoscopic ureterolithotomy (LUL) or the undeservedly less popular technique of percutaneous ureterolithotomy (PCUL) can be the option.

In our department, we performed the first laparoscopic ureterolithotomy from retroperitoneal penetration on 14th November 2002. The operational technique, indications, results and complications are listed in a separate section of the theses.

Percutaneous ureterolithotomy (PCUL) was first performed by Csaba Tóth in 1985. In the literature available for us, we could not find articles, publications or even case reports by other departments concerning the application of PCUL, a surgical technique requiring excellent skills and a lot of experience in endoscopy.

PCUL is a technique which allows for the removal of stones trapped in the proximal and, in certain cases, middle portion of the ureter and “refusing” to pass out spontaneously.

In the Discussion section of the theses we describe the algorithm elaborated by us and applied in the case of impacted stones, specifying the role of laparoscopic and direct percutaneous ureterolithotomy.

GOALS

1. I wish to outline our experience obtained during the use of one of the newest and most effective lithotriptors, Ho:YAG solid body laser – the first publication on the topic in this country – calling attention to the advantages and drawbacks of the technique. Publishing our results we wish to support data on the cost-effective use of this energy source, even under circumstances present in our country.
2. In the process of crushing ureteral stones using Ho:YAG laser, I aim at demonstrating that the source of energy used by us ensures fast and easy

fragmentation even in the case of hard stones containing uric acid, cystine and calcium-oxalate-monohydrate, which often present a difficulty for other energy sources of lithotripsy.

3. I also want to prove that, compared to ureteroscopy, ostiolitholapaxy (OLL), introduced and discussed by us, is less invasive and more effective in the removal of impacted, small juxtavesical ureteral stones which resist fragmentation and refuse to pass out after ESWL treatment. The success rate of OLL is higher (85.41%) than that of the other methods of stone extraction (using different kinds of loops and baskets), which are applied “blindfold”, i.e. without visual/optical control.
4. I demonstrate that ureteroliths impacted in the more cranial portion of the ureter and inaccessible by retrograde or antegrade ureteroscopy should not necessarily be removed by open surgery or laparoscopic ureterotomy: a faster and less invasive technique known as percutaneous ureterolithotomy (PCUL) can be applied instead, which is safe and free of complications.
5. I want to prove that in rare cases, when two stones are impacted proximally and simultaneously in the same ureter and inaccessible via uretersocopy, the surgeon should not necessarily rely on open or even laparoscopic ureterolithotomy. Instead, he can remove the stones fast and safely via one or – depending on the distance between the stones – two percutaneous tracks of penetration in one session, using the technique known as percutaneous ureterolithotomy.
6. I use our results to support the viability and worth of our strategy (protocol) in the treatment of impacted ureteroliths which are inaccessible by ureteroscopy but can be removed using the techniques listed below. If the ureteral stones are located in the upper region, percutaneous ureterolithotomy (PCUL) is recommended, but if it is impacted in the middle portion of the ureter, laparoscopic removal of the stone is

indicated. In the case of small juxtavesical stones, ostiolitholapaxy (OLL) is recommended prior to ureteroscopy. Minimum invasiveness was the main guideline of our strategy.

PATIENTS AND METHODS

Holmium:Yttrium-Aluminium-Garnet laser ureterolith fragmentation

In the period between 1st January 1999 and 31st December 2003, 137 laser lithotripsies were performed in 131 patients (six of the patients suffered from bilateral ureteral stones). There were 77 males and 54 females among them, aged between 13 and 91 years (mean: 54 years). According to location, 60 of the stones were on the left, while 77 were detected on the right side. By size they ranged between 4x5 and 20x30 mm (mean: 8.5 mm). 78.5 % of the patients were given ESWL treatment prior to surgery.

The patients were positioned on the operating table in a modified lithotomy position, with their legs stretched on the affected side (Perez-Castro position). We applied an endovideo camera and an X-ray viewing screen. The device was introduced through the ureteral orifice using the manoeuvre developed by Thüroff. In each case, we made an attempt to grab the ureterolith using a Dormia basket. Once we managed to hold the stone, the edges were “cut” by laser fragmentation to an extent that it could be pulled down without difficulty.

On the first postoperative day and after 4 weeks, plain X-rays of the kidney and bladder were made to assess early and late success rate, respectively. In the follow-up period, ultrasonography (US) and intravenous urography (IVU) were performed after the 3rd and 6th postoperative months to detect possible stenosis or reflux in the ureters.

Laparoscopic ureterolithotomy

At the Department of Urology, Medical and Health Science Center of the University of Debrecen, laparoscopic removal of a ureteral stone was performed for the first time on 14th November 2002. In the subsequent four-year period, ten retroperitoneoscopic surgeries were performed in ten patients, which resulted in the removal of eleven ureteral stones. The patients' mean age was 61.6 years (52-76 years). We operated on six males and four females in whom the stone was located in the left and right ureter in seven and three cases, respectively. In seven cases the stones were located in the middle portion of the ureter – at the level of the superior edge of the iliac bone – while in three cases they were trapped in the ureter in the true pelvis. By size, the removed stones were 16 mm on average, ranging between 6-30 mm.

The patient was laid in a lithotomy position and a ureteral catheter was introduced up to the stone. Next, the patient was laid on the unaffected side at a 90-degree angle, his/her waist was elevated and he/she was fixed in this position. Peritoneal dissection was performed using the modified Gaur-technique. In order to save time in the last cases, the trocars were introduced blindly, along the guidance of the surgeon's middle finger.

After the preparation of the ureter, a one-centimetre-long opening was made in the ureter, above the stone. Having enucleated the stone we removed it using forceps. The ureteral catheter was pushed up as far as the renal pelvis, under optical control. A drain was left in the retroperitoneum, above the ureterotomy opening in each case.

On the 2nd or 3rd postoperative days, plain X-rays of the kidney and the urinary bladder were made. In the follow-up period, ultrasonography was made in three and six months after the operation and, if it was necessary, IVU was

performed when dilated cavital system and narrower than usual renal parenchyma were suspected.

Percutaneous ureterolithotomy

Forty PCULs were performed because of impacted stones between 1st January 2000 and 31st December 2006. All of the patients had received ESWL treatment. Among the 40 cases, in 12 patients (33,3 %) “primary” PCUL was performed after the ESWL treatment.

The patients’ mean age was 54.8 years (33-83 years), there were 16 females and 24 males among them. Forty-four stones were removed from forty patients, the mean stone size being 12 mm (6-28 mm). In four patients percutaneous ureterolithotomies “yielded” two stones in one session each.

The majority of the operations were performed in spinal or local anaesthesia (the latter involving three patients).

After the insertion of a ureteral catheter, the patient was placed in the prone position. The kidney, more precisely speaking the affected segment of the ureter, was exposed by angulating the operating table. A 18 G needle was introduced percutaneously and directly at the ureteral stone at the level of the posterior axillary line. A rigid wire was introduced into the needle and its end was also made to reach the stone. A button-probe was guided to the wire and a 26 Ch nephroscope was introduced into the retroperitoneum via the dilated puncture track. The relevant part of the ureter was prepared using fenestrated stone forceps. When the ureter and protruding stone were clearly visible, we used a straight cold knife to open the wall of the ureter longitudinally, long enough to allow for the easy enucleation of the stone. After the removal of the stone the ureteral catheter was introduced into the pelvis under optical and X-ray control. A drain was left in the already existing puncture track in the retroperitoneum.

After PCUL we followed up the patients according to the protocol outlined in the section discussing laparoscopic ureterolithotomy.

Ostiolitholapaxy

Between 1st January 1995 and 31st December 2006, ostiolitholapaxy (OLL) was performed in 41 patients due to stones impacted in the ureteral orifice or intramurally, causing complaints and/or obstructed urine draining. The patients' mean age was 54.25 years (16-76 years). Stones affecting the right and left sides were operated on in 25 and 16 cases, respectively. The largest diameter of the stones ranged from 3 to 12 mm, the mean being 5.2 mm. The male to female ratio turned out to be 23/18.

In eleven cases (22.91 %), OLL was performed as an acute emergency intervention. Basically, the intervention – as its name, OLL, suggests – involves the removal of stones - without fragmentation - from the ureteral orifice and its vicinity after the dilation of the orifice.

The patients were placed on the operating table in the lithotomy position. A nephroscope was introduced into the bladder. In order to extract the stones, we applied fenestrated stone forceps, which were inserted into the ureteral orifice closed. Then we tried to open them with fine movements in order to dilate the intramural portion of the ureter. After dilation, we introduced the forceps upward to the stone, with jaws closed, and applying fine rotating movements. Having moved the stone grabbed in the forceps we tried to make sure the wall of the ureter was not caught. In the next step, we removed the stone. We tried to avoid any rough movement or forced extraction.

The patients had to present at control examinations every three months, when ultrasonography, urine test and, if necessary, IVU were performed.

RESULTS

Holmium:Yttrium-Aluminium-Garnet laser ureterolith fragmentation

The ultimate success rate of transurethral lasertripsy (TUL) – four weeks after the intervention and without a second operation – was as follows:

- proximal portion of the ureter : 84 % (11 successfully removed stones)
- middle portion of the ureter: 96.7 % (30 successfully removed stones)
- distal portion of the ureter: 96.7 % (90 successfully removed stones)

The interventions took 35 minutes on average (13-130 min). Mean hospitalisation was 3.7 days (1-12 days). Regarding a stone of 20x30mm in size, the energy requirement of fragmentation ranged between 0.15-6.0 kJ. The mean energy consumption was 1.6 kJ.

Intra and postoperative complications were as follows:

- fever in 17 cases (12.4 %);
- damage to the ureteral wall during endoscopic manipulation in 12 cases (8.7 %);
- perforation of the ureteral wall by Ho:YAG laser beam in five cases (3.6 %);
- accidental burning of the guiding ureteral catheter in six cases (4.3 %), cutting the metal spiral of the Dormia basket in one case;
- burning of the optics of the endoscope due to the use of a damaged fibre.

No stenosis or reflux were detected during the follow-up period.

Laparoscopic ureterolithotomy

Retroperitoneoscopic removal of impacted ureteral stones was performed in ten cases in the period between 14th November 2002 and 31st December 2006.

In nine of the ten cases (90 % success rate), we were able to achieve complete removal of the stones.

Our first patient had to be converted, while in two cases ureteroscopes introduced via a trocar, and a Dormia basket had to be used to identify and remove the ureteral stone. In another two cases we needed an X-ray viewing screen to find the stone.

The mean operating time was 90.4 minutes (20-230 min). The last few operations took 30, 25 and 20 minutes. There was no need for transfusions. In one case, however, the patient had fever postoperatively. In the majority of cases, postoperative pain was negligible. The patients complained only of being bedridden for 48 hours and having to rely on a bladder and ureteral catheter. There were no inflamed wounds, purulence or retroperitoneal abscess even in cases when the urine was infected. Mean postoperative hospitalisation took 6.33 days, ranging between 3 and 11 days.

The patients' mean follow-up was 25 months (3-50 months). There were no passage disturbances or renal morphofunctional deterioration detected among them.

Percutaneous ureterolithotomy

The percutaneous lithotomies performed by us were all effective; the stones could be completely removed.

Owing to the mobile ureteral wall sliding away when we tried to incise it using a straight knife, we had to rely on a hooked endopyelotomy knife to make a longitudinal incision into the ureteral wall in five cases. In two cases the patients had radiolucent ureteroliths. In those cases, contrast material injected via the ureteral catheter helped us with locating the stone. In seven cases, the ureter was "splinted" using ureteral catheters introduced antegradely. In five cases double J catheters had to be introduced percutaneously and in two cases

the ureteral catheters had to be replaced by double J ones later, owing to urine soaking along the drain. Because of the size of the stone, Amplatz tubes had to be applied in two patients.

On average, surgery lasted for 23 minutes (12-55 min), while postoperative hospitalisation took 4.3 days (2-12 days). There were no intraoperative or early or late postoperative complications. A haemophiliac had to be given conservative treatment due to the development of a relatively large retroperitoneal haematoma (10x5 cm).

The follow-up period ranged from 1 to 78 months, the mean being 45.73 months. Secondary ureteral stenosis causing complications or resulting in the worsening of the morphofunctional condition of the kidney was not detected.

Ostiolitholapaxy

Ostiolitholapaxy was performed on 48 occasions in the aforementioned 12-year period. In 41 cases we were effective in removing the stones, achieving a success rate of 85.41%. In the remaining seven unsuccessful cases the size of the stones was 10 mm or larger, and in three cases they had been stationary for more than three months. Despite our efforts to remove them using stone forceps, they could not be extracted through the orifice. The long-stationary stones could not be grabbed; further trials would have carried the risk of injury, therefore, in those cases, surgery was continued applying ureterscopy.

Operations lasted 8.5 minutes on average (3.5-35 min). There were no complications following ostiolithotomy. Postoperative hospitalisation was 1.4 day on average (0-4 days). In the first postoperative year, the patients were checked up three-monthly (ultrasonography, urine test, IVU). The mean follow-up period was 95.3 months (2-143 months). Neither ureteral stenosis causing passage disturbance nor vesicoureteral reflux were detected.

DISCUSSION

There has been a dramatic change in the treatment of ureteral stones since the 1980s when extracorporeal shock wave lithotripsy (ESWL), percutaneous lithotomy and ureteroscopy were introduced into the arsenal of urology. As a result of the appearance of miniature flexible and rigid ureteroscopes, highly effective intracorporeal stone crushing energies and urological laparoscopy, open lithotomies were almost completely eliminated from the palette of treatment. The above are especially true in the developed countries of the world.

PCUL, a technique developed by us, requires less expensive and less complicated equipment. It has kept its position among the techniques of treatment even in the age of laparoscopy. In the knowledge of the techniques outlined earlier in the theses, we elaborated a protocol for the treatment of impacted ureteral stones, giving priority to minimum invasiveness. Under the conditions prevailing in this country today (lack of holmium laser and gracile flexible endoscopes), the technique can be efficiently used by an experienced expert.

Based on the protocol, if the impacted ureteral stone is located in the proximal-middle portion of the ureter and is accessible to percutaneous ureterolithotomy, PCUL is the recommended solution. In the case of stones impacted in the middle and distal portion of the ureter, in which the above criterion does not hold true, laparoscopic retroperitoneal ureterolithotomy is recommended. Juxtavesical stones should be approached through the peritoneum, unless the patient has had abdominal surgery. In theory, even this protocol allows for open surgery, especially in the case of large ureteral stones located in the minor pelvis, when laparoscopy is contraindicated due to the patient's cardiorespiratory condition or previous open surgery.

Based on the studies at our department, only 1.2 % of the stones impacted according to the definition by Deliveliotis are expected to resist "removal" using

ESWL, and antegrade or retrograde URS, which are regarded to be classical techniques today. The calculation has been made on the basis of the data processed about 3601 surgical interventions due to ureteral stones (ESWL: 3278, URS: 278, OLL, Zeiss- and Dormia-basket extraction: 36, *open surgery*: 3, *PCUL*: 34, *LUL*: 6).

Using holmium laser, crushing is based on the *photothermic* principle, which results in the vaporisation of the stone. That is what its great advantage is attributed to: using this technique, the fragmented ureteral stone is not pushed proximally, thus there is no need to catch it in a basket or use any manoeuvre to prevent propulsion (e.g. introduction of a ureteral balloon-catheter over the stone) in the process of fragmentation. The fact that Ho:YAG laser rays are 100 % absorbable by water further contributes to the safety of the procedure. Actually, it is impossible to damage the ureteral wall from a distance greater than 1 mm.

In our practice, the most valuable properties of the holmium laser energy source has been as follows:

1. The 360-micrometre fibre applied by us in the ureter leaves plenty of free space in the working channel of the endoscope for the flow of fluid, which ensures optimal visual field and cooling for the fibre (the relevant properties in the case of a 200-micrometre fibre are supposedly even more expressed, but we did not have the opportunity to test them).
2. The device can easily fragment any type of stone, independently of the stone's surface, colour or hardness.
3. In the process of crushing, the stone is not pushed towards the pelvis.
4. The resulting fragments, if smaller than 1 mm in size, and the gravel can pass out without difficulty.
5. The fibres are flexible, designed for multiple use, can be calibrated and their ends can be polished and renewed.

6. The device is functional shortly after it is turned on (in less than 1 minute).

The disadvantages in our experience are as follows:

1. Price.
2. In the process of learning, damage to both the ureteral wall and the devices is easy to make (thermal damage to the optics, cutting through the Dormia basket and ureteral catheter).
3. If we try to push the ureteroscope even higher up in the ureter, the laser fibre may crack easily, if it is not withdrawn.
4. The crushing of larger stones takes longer, because after each series we have to wait for the “dusty” visual field to clear up, which can be sped up or even prevented by using various tricks.

According to our experience so far we think the advantages of holmium laser lithotripsy greatly surpass its disadvantages.

Our 1.2 % impaction ratio should be considered in view of the absence of holmium laser energy source. In such cases we used a 9.8 Ch semiflexible ureteroscope, and ballistic (electrokinetic) and ultrasonographic intracorporeal lithotripsy energy sources.

Since the first **laparoscopic ureterolithotomy** performed at our department in November 2002, no more open ureterolithotomies have been performed.

Ureteral stenosis is regarded to be the major complication of LUL, at a rate of 15-20 %. No ureteral stenosis developed among our patients in the mean period of follow-up for 25 months. It was possibly due to the fact that the ureter was not completely bared during the preparation; in order to spare its neurovascular system, we used a cold knife and tried to make sharp incision margins. The ureteral wall was sewn up using superficial stitches, tight knots were avoided and an appropriate drain was applied for an appropriate time.

After the spread of laparoscopic retroperitoneal ureterolithotomy, **PCUL** appeared to have become outdated, but it still has some grounds – proximally impacted ureteral stones – in which other, classical endoscopic methods fail, and laparoscopy is contraindicated for anaesthesiological (cardiovascular problems, poor respiratory function tests) or surgical (previous retroperitoneal surgeries) reasons. Moreover, after informing the patient, PCUL can be used as the primary treatment following ESWL – by an experienced physician.

Retroperitoneoscopy and PCUL are not opponents; on the contrary they complement each other on the therapeutic palette.

Of course, due to the further modernisation of the endoscopic urological armamentarium, the narrow field of ureteral stone treatment in which classical endourological techniques (antegrade and retrograde URS) fail (1.2 %) will keep on decreasing, but, apparently, it will not disappear.

Small ureteroliths, often thought to pass readily, may stop in the distal portion of the ureter, and, even if they do not get impacted, may cause problems in the passage of the urine to various degree. The technique known as **ostiolitholapaxy** has been elaborated for such cases, and can be used even if we cannot introduce the thinnest flexible wire beside the stone. It can be used to treat acute cases, especially females, without much anaesthesia; we can offer them not only transitory but also a final solution to the complaints. Another advantage of the technique is that it does not require complicated endoscopic devices, just a nephroscope and a pair of fenestrated stone forceps, available in any department of urology.

Like elsewhere, life and development do not stop in urology at the current level. Newer attempts are being published in which surgery through the natural openings of the body (N.O.T.E.S. = natural orifices transluminal endoscopic surgery) is predicted, which is foreseen as the third revolution in surgery. Scar-free surgery is soon expected to appear in our profession, too – transvesical

peritoneoscopy has already been reported. It may revolutionise not only the treatment of stones in the urinary tract but even the whole of urological surgery.

CONCLUSIONS

1. I am the first in Hungary to report in a clinical study the results of holmium laser lithotripsy – based on experience of my own – and compare them with results in the international literature. Worldwide, this is regarded to be the most effective source of energy for lithotripsy since it can readily fragment any type of stone. There was no stone in our sample which caused any difficulty at all. In our opinion, the advantages of the Ho:YAG laser energy source surpass its disadvantages. Its applicability is only limited by the devices at our disposal, should they be unsuitable to approach the ureteral stone, which causes the complaints. The use of more modern gracile endoscopes further increases success rate, especially in the case of proximal ureteroliths, which refuse to pass out of the body.
2. I am the first to describe the technique of ostiolitholapaxy (OLL) and review its efficiency. The technique can be used successfully, even without anaesthesia, to remove small ureteral stones impacted juxtavesically and “refusing” to pass out of the body. My experience is to justify that neither orificial stenosis nor vesicoureteral reflux have developed after the intervention. The advantages of the technique include immediate applicability, minimum invasiveness and no need for special instrumentation.

3. This is the first time in Hungary that a clinical study of laparoscopic ureterolithotripsy (LUL) has been reported on the basis of the results from a single centre. In addition, parallel to PCUL, the role of this technique in the strategy of treating impacted ureteral stones is also described.
4. I have summed up the details of percutaneous ureterolithotomy (PCUL) elaborated and published by us on the basis of experience in urological endoscopy for many years. Our results (100 % stone-free condition, negligible rate of complications) demonstrate that the technique is undisputably worthwhile and – in the possession of due experience – it could be used in several urological departments.
5. Applying PCUL, it is possible for us to remove unilateral double impacted ureteroliths via one or two puncture tracks, in just one session. Although such stones rarely occur, if they are detected, they make a challenge for urologists.
6. Elaborated and applied by us, techniques such as OLL and PCUL have led to the development of the strategy of treating impacted ureteral stones which, in the possession of experience and the tools available in Hungary today, allows for avoiding open surgery in all of the cases. The efficiency of the strategy is also justified in the theses. Owing to the above techniques, open surgery is required in extreme circumstances only.

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Impact factor: 1.957

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Impact factor: 1.343

Cumulative impact factor: 3.31

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