The experience of the Târgu Mureş Clinic of Urology in multimodal treatment of staghorn stones

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Abstract

Introduction: Percutaneous surgery is a safe and effective method in the treatment of staghorn stones.
Objectives: the analysis of our experience in percutaneous treatment of staghorn stones. Over a period of 24 years (1987-2010), the percutaneous nephrolithotomy (PCNL), extracorporeal lithotripsy (ESWL), retrograde rigid ureteroscopy and antegrade rigid ureteroscopy have almost completely replaced open surgery.
Materials and Methods: From a series of 7215 patients with urolithiasis, 1070 (14.83%) had staghorn stones (7 were children), and of these 17/ 1070 patients presented bilateral staghorn stones.
Results: Average operating time was 115 minutes. The average duration of hospitalisation was 18.1 days. Stone free rate at the end of the intervention was 900/ 1070 (82.79%). We had postoperative complications in 142/1070 patients (13.06%), with 3/ 1070 (0.27%) deathscaused by haemorrhage (1) and toxico-septical shock (2).
Conclusions: In order to a successful resolution of staghorn stones by minimally invasive methods it is necessary to have a good knowledge of three-dimensional anatomy of the kidney, well chosen and fairly tracks of the percutaneous nephrostomy (PN), training, experience and good techniques in endoscopy of the kidney and the ureter.

Key words: staghorn stones, PCNL, ESWL, URS

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Introduction

It is widely accepted today that staghorn stones, especially when associated with urinary tract infection (UTI) has a more aggressive potential than considered (1, 2, 3).

Modern therapeutic methods such as PCNL and ESWL, used alone or in combination were favoured for the open surgery because of efficiency, safety, and especially by reducing parenchymal loss, followed by a rapid socio-professional rehabilitation of the patient (2, 3, 4, 5).

Renal function studies, arteriography and computed tomography after PCNL, compared to the post anatrophic nephrolithotomy confirm the minimum quality of minimally aggressive endoscopic renal surgery (4, 6).

Percutaneous surgery became an established method in the treatment of lithiasis of the upper urinary system in the early 1980s, after Fernström first extracted instrumentally in 1976, a kidney stone through percutaneous nephrostomy track(7). In 1981 Marberger used for the first time a nephroscope in order to disintegrate a kidney stone by ultrasound (8). The first successful attempt to solve a percutaneous staghorn stone belongs to R. V. Clayman (9) and dates from 1983. In the Clinic of Urology, Tîrgu Mureş, the first successful attempt to extract a percutaneous staghorn stones was performed in 1987, percutaneous surgery for staghorn stones soon became a widely accepted method (8).

Materials and methods

Between 1987-2010, the personal experience of percutaneous renal procedures includes 8048 operation in 7215 patients (percutaneous nephrolithotomies and associated with antegrade or retrograde ureteroscopy for kidney stones and antegrade endopyelotomies. The statistics is homogeneous, all patients were operated by the same surgeon.

Over a period of 24 years (1987-2010) we operated percutaneously 1070 patients with percutaneous staghorn stones, of whom 7 were children. 17/ 1070 patients had bilateral staghorn stones. Another 25 patients had bilateral stones with staghorn stones in one side and renal lithiasis (pyelic, calix) or ureteral on the other side, they were solved by PCNL, ESWL, antegrade or retrograde ureteroscopy. On the series of 1070 patients with staghorn stones no significant difference between the two sexes was recorded. Ratio F/ M was 547/532. It is generally known that lithiasis in women, as well as the staghorn stones is met more frequently due to increased incidence of UTIs than in men. We had 2/4 children with bilateral staghorn stones of the 17 patients with bilateral staghorn stones.

The distribution of the patients with staghorn stones per age decade (Table 1) shows that the most affected was the 4th decade, followed by decades 5 and 6.

Age group	Number of patients
0-10	4
11-20	25 (3+22)
21-30	93
31-40	187
41-50	290
51-60	232
61-70	201
71-80	38
TOTAL	1070

Because the staghorn stones is the most intrackable of all urinary stones, this form of lithiasis should be approached only after the technique of solving all percutaneous kidney stones is very well mastered.

We used Moores and O'Boyle classification, easy to remember, more expressive, allowing an easier mental representation and more accurate from the point of view of the stones. According to this classification our patients were grouped as shown in Table 2.

Table 2. The distribution of staghorn stones in patient, according to the Moores and O'Boyle classification

Type of staghorn stones	kidney/patients Nr.	stones %
A	172/169	15.80
B	264/ 259	24.20
C	370/370	34.57
D	129/123	11.50
E	111/108	10.10
F	41/41	3.83
TOTAL kidney/patients	1087/1070	100.00

4/1070 patients with staghorn stones had these stones in horseshoe kidney types B, C and E. In these patients in addition to the difficulties posed by staghorn stones; the difficulties of approaching a horseshoe kidney are added due to: abnormal rotation, vascularity and structure specific to these congenital anomalies.

149/1070 patients (13.92%) had recurrent staghorn stones. We met in one patient (female) a rapid recurrence (3 months) also of the staghorn stones type A calcium oxalate dihydrate on the opposite side ALSO.

After the investigation of the patient in Iaţi, parathyroid adenoma was discovered and resolved. After the surgical intervention the Ca and P values returned to normal, as well as hypercalciuria. In this female patient we performed bilateral PCNL for staghorn stones type A (calcium oxalate dihydrate). Follow-up at 3, 6 months, 1 year, 2 years showed no recurrence of lithiasis.

178/1070 (16.63%) patients had associated diseases (diabetes, hypertension, varicose veins, etc.) Table 3.

Table 3. Associated diseases

Disease	Number of patients	%
Diabetes	78	7.28
Arterial hyertension	30	2.80
Varicose veins	12	1.12
Obesity	25	2.33
Stroke	9	0.85
Fibrilo-flutter	8	0.75
Other conditions	16	1. 50
TOTAL	178/1070	16.63

Urinary infection was met in 439/1070 (41%) patients. The staghorn stones were often associated with urinary infection, especially the recurrent one (1, 3, 5, 10). Germs which were isolated are presented in Table 4.

Table 4. Postoperative microbial germs (UTI)

Microbial germs	Number of patients	%
Proteus	115	10.74
E. coli	96	8.97
Enterobacter	61	5.70
Klebsiella	72	6.72
Pseudomonas	50	4.67
Staphylococcus aureus	9	0.84
Mixed culture	36	3.36
TOTAL	439/1070	41.00

Techniques and strategy

Preoperative preparation was the regular one, all patients with infected preoperative urine culture i.v. or i.m. were administered preoperative antibiotic as were the patients with recurrent staghorn stones after open or endoscopic surgery.

Most patients with staghorn stones were operated after peridural or spinal anaesthesia. The seven children were operated under general anaesthesia.

Percutaneous nephrostomy (PN) in most of the patients was performed by fluoroscopically guided puncture on the level of the lower calyx. Exceptions were patients with type C staghorn stones with extension into the middle or upper calyx, staghorn stones type D (middle or upper calyx) and patients with staghorn stones type B, which hadn't extensions in the lower calyx.

In patients with large pyelic stones or staghorn stones type A or B we always choosed nefrostomy tracks that allowed easy removal of the largest part of the stones, after the first session we left a Foley catheter in order to keep the track for future interventions. This track was usually performed through the lower calyx, the kidney gateway of the great majority of patients with stones operated with percutaneous method.

Renal access

The PN technique used consisted in fluoroscopically guided percutaneous puncture. In 14/1070 (1.28%) kidneys in whom we couldn't insert the ureteral probe for various reasons, or we couldn't effectively opacifay the target calyx, we used echoguided puncture of the pielocaliceal system followed by the opacifiation of this and then we fluoroscopically punctured the chosen calyx. The calyceal puncture is done perpendicular to the convexity of the kidney always through a posterior, transpapillary and perfectly straight track (11).

In 651/1070 (60.84%) patients with C, D, E, F staghorn stones and 135/1070 (12.61%) with type B staghorn stones we extracTed the stones through a single PN track, in contrast to 301/ 1070 (28.13%) in whom we used two or more PN tracks. For complete extraction of the stones in patients with type A staghorn stones we used even 3 or 4 PN tracks, some in the shape of "Y", in the case of secondary calyces inaccessible to the rigid side nephroscope. We punctured all the three main caliceal groups both subcostally XII, as well as supracostally XII or XI and transthoracically. To avoid the transpleural track we used angulated PN tracks under the twelfth rib, which allowed the insertion into the target calyx under 1 or even 2 intercostal spaces located above (10, 12, 13). For the stones in the secondary calyx which were unapproachable because of the high position of the middle or upper calyx (intercostal space X) we used an approach associated with ESWL (14, 15, 16) in 74/ 1070 (6.70%) of the patients. 14/1070 (1.30%) patients had fragments or caliceal stones which had migrated to the lumbal ureter. In such cases we used retrograde rigid ureteroscopy or antegrade rigid ureteroscopy. We encountered such incidents in the first 5-6 years of the percutaneous

approach of staghorn stones, incidentes presented later.

Removal of the stones

We used three methods of fragmentation, but for the fragmentation of hard stones (We, uric acid, cystine) we combined these methods (Table 5).

Table 5. Methods of lithotripsy

Lithotripsy	Number of patients	%
Ultrasound lithotripsy (USL)	862	79.30
Mechanical lithotripsy	9	0.83
Pneumatic lithotripsy (PL)	52	4.78
USL + PL	164	15.08
TOTAL	1070	100

We preferred ultrasonic lithotripsy (USL) for its quality (fragmentation and aspiration of small fragments) compared to other methods of lithotripsy that we have. We used a combination of pneumatic lithotripsy and USL for hard staghorn stones (monohydrate, uric acid, cystine) in the last 11 years, with good results.

The extraction of stones fragments after lithotripsy was achieved mainly by Amplatz sheaths 28 and 30 Ch, or even directly by the maturated PN track, in the 2nd or 3rd session after at least minimum 7 days of its creation. Smaller stones were extracked through the sheath of the nephroscope (Table 6). NP track can be successfully used for the direct extraction of hard stones (oxalate monohydrate, uric acid, cystine). We extracted stones through the PN track even in patients with infected urine, followed by healing without inflammation or suppuration of the PN track.

Table 6. Methods of extraction of the stones

Stones extraction	Number of patients	%
Nephroscope sheath (NS)	562	51.70
NS + Amplatz sheaths 28-30 Ch	403	37.07
Straight through the PN track	122	11.22
TOTAL	1070	99.99

RESULTS

Immediate results

We analysed the experience of 22 years (1988-2010) in the percutaneous treatment of staghorn stones in a number of 1070 patients, among whom, 17 had bilateral staghorn stones, all being treated endoscopically. On the whole, we performed 1104 PCNL sessions.

In 803/1087 (73.87%) renal unites the entire calculus, was successfuly extracted dure one surgical session, while in 284/ 1087 renal unites (26.13%) the calculus was extracted in 2-3 or 4 surgical sessions, using other associated treatments (there were patients with complex and / or bulky calculi).

The number of tracks was 1 to 4 for complex stones (staghorn stones type A or B), as shown in Table 7.

Table 7. PN tracks

Number of PN tracks	Renal units	%
1	794	73.04
2	99	9.10
3	176	16.20
4	18	1.65
TOTAL	1087	99.99

The stones was completely extracted in 900/ 1070 renal unites (82.79%), no remaining fragments were identified on the operating table on fluoroscopic and/or postoperative ultrasound examination. The remaining fragments in the kidney and / or in lumbal ureter was 187/1070 (17,20%) renal unites. Ureteric stents were inserted in 81/ 1070 (7.33%) of the operated kidneys, which favoured the complete elimination of the remaining fragments in the ureter and/or kidneys. The stents were maintained for 4-6 weeks. In 71/ 1070 (6.53%) of the operated kidneys for the resolution of the remaining fragment/s ESWL was carried out with or without stenting. In 35/ 1870 (3,21%) of the operated kidneys stones or fragments migrated in the ureter were identified intraoperatively and were extracked: with the aid of Dormia retrograde probe in 14/ 1870 (1.28%) kidneys by antegrade ureteroscopy in 8/ 1070 (0.73%) kidneys, or by retrograde ureteroscopy during another surgery in 13/ 1070 (1.19%) of the operated kidneys. After ureteral approach ureteric stents were left for 7-10 days.

97/1070 (9.06%) patients had intra- or immediate postoperative complications. The most common intraoperative complication of PCNL was haemorrhage (3, 5, 13, 17, 18). In the series of 1070 patients with staghorn stones solved by PCNL the intraoperative bleeding was encountred in 25/1070 (2.33%) of the patients. In 10/1070 of them (0.93%) the haemorrhage was resolved by swabbing the renal track of transparenchymatous PN with balloon catheters, while in 4/1070 (0.37%) patients open surgery was performed. Of these in 1/1070 (0.09%) the bleeding was stopped by suturing the PN track with sutures resorbable in fat, while in 3/1070 (0.28%) we were forced to have a radical approach because of important bleeding and vital risk.

Significant immediate postoperative bleeding was found in 5/1070 (0.46%) patients in bed, before the suppression of the PN catheter by dislogement of the PN tube in transparenchymatous of PN (kidneys with high mobility, obese patients, sudden movements, vomiting). The bleeding was stopped by suppressing the PN tube and swabbing of the lumbal wall on the level of the PN track in 3 patients. In 1/1070 (0.09%) patient open surgery was carried out obtaining haemostasis by suturing the PN track with resorbable sutures for keeping of the kidney. Unfortunately one female patient was lost due to bleeding complications in poorly supervised and late-diagnosed haemorrhagic shock.

Postoperative bleeding which occurred also after 1-2 days, after the suppression of the PN catheter, by arteriovenous fistulas, during the patient's favorable evolution were present in 6/ 1070 (0.56%) patients in 2/ 1070 of whom we performed nephrectomy for haemostasis reason. The other 4/ 1070 patients were resolved by open surgery and parenchymal suture on the level of the PN track and blood and plasma transfusions isoRh, isogroup.

Consequently, intraoperatively and immediately postoperatively we had 25/ 1070 (2.33%) patients with haemorrhage and we performed surgery in 11/ 1070 (1.02%) patients for the purpose of haemostasis in the immediate postoperative period. In 5/ 1070 (0.46%) of them we had to perform nephrectomy for haemostasis and in 6/ 1070 (0.56%) the haemostasis was managed by the suture of the parenchymal PN track. In 13/1070 (1.21%) patients with immediate intra- and postoperative bleeding the haemostasis was managed by clipping the PN catheter, or by the compressive wadding of the PN track, conversion and suture, if bleeding occurred in suppressing the tube, or the PN catheter. We lost 1 female patient outcome for the above mentioned reasons.

38/1070 (3.55%) patients had small fragments. In such cases, intraoperative ureteric stents were inserted or such stents were postoperatively inserted after the first few days to facilitate the removal of stones fragments. In 2/ 38 patients 1 or 2 ESWL procedures were associated. In 7/ 38 patients with residual fragments, the urinary fistulas were resolved with the insertion of ureteric stents.

34/1070 (3.17%) patients had septic complications, with elevating 38-39°C temperatures and chills. These patients had positive blood cultures. They were largely identical to those found in preoperative with positive urine culture. 5/ 1070 (0.46%) developed toxico-septical shock of whom three recovered, we lost 2/ 1070 (0.18%) patients with septic complications.

The incidence of preoperative urinary tract infection (UTI) was 371/ 1070 (34.67%) patients, while postoperatively they ware 439/ 1070 (41.02%) patients with UTI. This is explained by the increased percentage of generally infected staghorn stones as opposed to the rest of kidney stones, by the greater number of surgical interventions needed for the removal of bulky and complex stones, by maintaining percutaneous nephrostomy for a longer period and because of the infected content of many staghorn stones, even in patients with sterile urine culture on admission.

The chemical composition of stones in the 1070 patients is shown in Table 8. The 17 patients who had bilateral staghorn stones had identical stones on both sides: uric acid, struvite, Ca apatite and cystine.

Table 8. The chemical composition of stones

Chemical composition	Patients	%
Whewellit	61	5.70
Wheddellit	246	23.00
Uric acid	200	18.70
Cystine	23	2.14
Struvite	191	17.85
Brushit	86	8.03
Ca apatite	131	12.24
Ammonium urate	19	1.77
Soft stones	16	1.49
Mixed composition	97	9.06
TOTAL	1070 patients	99.98

The average operating time was 115 minutes and the postoperative hospitalisation was of 18.1 days (8-29 days).

Late results

We had 49/1070 (4.57%) late complications. Among these 8/ 49 patients had postoperative significant haematuria after 3-4 weeks, resolved after treatment with blood transfusions isogrup, isoRh, plasma isogrup and intravenous volemic support to support a large volume of diuresis. In one patient we administered Vitamin K intravenously twice a day. Blood count values (number of red blood cells, hematocrit and hemoglobin.) did not require haemostatic surgery under the treatment.

In 3/49 patients there were perirenal encysted purulent formations of sizes between 2-5cm. One patient was treated with open surgery (incision,

drainage), in the other the content was aspired and antibiotics were administered by needle puncture, obtaining a sustainable recovery.

31/49 patients presented residual hydronephrosis without stones. After the instrumental probation (ureteral probe) ureteric stenosis were found in 8/ 49 patients, resolved by endoureterotomy. In 23/ 49 patients with pieloureteral junction of normal calibre we used ureteric stents for six weeks, during which period the hydronephrosis did not disappear completely, or rather worsened. In one of such patient the endopielotomy was performed, but without notable results.

7/49 patients had persistent postoperative pain on the level of the scar of the PN track, which seems to be the result of prolonged compression of the PN catheter on the intercostal/ subcostal nerves. We performed local infiltration with xiline/ lidocaine and/ or physiotherapy. The results were inconclusive in 4 patients, but 3 had good results, along with the disappearance of these painful symptoms.

We had 45/1070 (4.20%) patients with recurrent lithiasis: pelvis, caliceal, staghorn or ureteral stones which were solved by PCNL, retrograde ureteroscopy and/ or more ESWL sessions.

16/1070 (1.49%) patients with relapsed stones in the pelvis and/ or one or more calyces were solved by ESWL with or without ureteral stenting, by one or more ESWL sessions.

Other 20/1070 (1.86%) patients had bulky stones of over 2 cm diameter, which were solved by PCNL. The same therapeutic method was used in other 5/1070 (0.46) patients with staghorn stones C, D or E in one or more PCNL sessions, using 1 or 2 PN tracks.

In 4/1070 (0.37%) patients with stone relapse 6-12 months after PCNL for staghorn stones, antegrade enopyelotomy was associated where JPU obtruction appearance was initially interpreted as the result of a staghorn stones, being actually the cause of it.

Discussions

Percutaneous kidney surgery can not be done successfully without a thorough knowledge of tridimensional anatomy of the kidney, especially the renal pyelocaliceal system and its vascular system.

Usually endoscopic treatment of a staghorn stone is done by firstly approaching the inferior posterior calyx which enables extraction of most of the stones during the operative session. This approach allows the extraction of caliceal extension (posterior secondary calyx, the main stem of the lower calyx), after which the pelvis is reached and the stone can be removed, and then, depending on the conformation of the kidney, the extension in the upper calyx can be approached through the same PN track (lower calyx) in the same session or in a subsequent session.

Sometimes an additional Y-shape path may be needed for the removal of the entire inferior caliceal stone from an anterior secondary calyx which is inaccessible through the initial PN track. Usually the resolution of the lower calyx and of the pelvis piece will be the main purpose of a first meeting, especially in the case of a type A staghorn stones.

After the removal of the piece from the inferior calyx and of the pelvis one, the PN track in the inferior calyx will sometimes allow the approach of the piece located in the upper calyx. If this is not possible, the removal of the piece located in the upper calyx can be done through an additional angulated PN track (4, 5, 13, 17) below the XII-th rib or in the XI-th intercostal space, avoiding the bottom of the pleura. Sometimes it is possible to remove the piece in the upper calyx through the PN track done on the level of the middle calyx, after the piece from this calyx has been removed (18). The number of PN tracks through the main calyx can be limited when the staghorn stones is accompanied by important hydronephrosis, the dilations of the pielocaliceal system allowing the insertion of the rigid nephroscope in the adjacent dilated calices. The removal of the pieces in calyces inaccessible to the rigid nephroscope is done nowadays with the flexible nephroscope which allows the approach of all the main calyces, thus reducing the number of PN tracks and preventing transthoracic and especially transpleural tracks.

If for the resolution of a type A or B complicated staghorn stones several meetings are needed, in the existing PN track or tracks one or more Foley probes are left which will allow the maintaining of the tracks and its/ their maturation. This comes as an advantage since through a maturated track with the aid of instruments during future meetings bulkier fragments can be removed than those which are usually removed through Amplatz 28-30Ch sheaths. The maturated track allows for good orientation, it is easy and it offers safety because the PN track cannot be lost as a result of the dislocation of the rigid nephroscope from the calices, just as in the case of new PN tracks. Thus, additional safety guides are not necessary because the maturated track assures the safe removal of the frag-

ments or of some solitary stones (19, 20).

When the staghorn stone molds and entirely obstructs the minor and major calyx another intraoperative difficulty arises. The flexible part of the guide wire cannot exceed the stone to enter the renal pelvis, or the lumbal ureter. The flexible extremity stop in the parenchyma or extrarenally, making it impossible to introduce dilators, this leading to the eventual loss of the PN track. In such cases rigid guides are successfully used since they allow permanent contact with the stones, which should not be lost prior to the insertion of the axial dilator of the Alken's set.

Another difficulty the operator is faced with at the beginning of percutaneous lithotripsy, is the space because of the stones which fills the entire calyx system. In these cases ultrasound lithotripsy proves its superiority in comparison with other methods of lithotripsy, by the association of fragmentation with concomitant aspiration of the small fragments that result after lithotripsy. Thus, as the stones is fragmented some space is created that allows the insertion of the clamp and the extraction of fragments. Eventually the entire caliceal system is emptied which will allow access to the pelvis (4, 5, 12, 15). After extracting the pelvis piece other caliceal extensions can be deal with.

The percutaneous treatment of staghorn stones is superior to open surgery: parenchymal loss is much lower, it is less aggressive. On the other hand, in the treatment of staghorn stones ESWL has not been very successful, its major disadvantage being the formation of large fragments of stones whose migration into the ureter leads to the formation of Steinstrasse, requiring new ESWL procedures and/ or other methods to solve the obstructive mechanical complications (PCNL, retrograde rigid ureteroscopy and antegrade rigid ureteroscopy). This means the increase of the aggressiveness of the procedure, prolongation of hospitalisation, new costs and longer convalescence (14, 19, 21).

The global incidence of major complications after PCNL is between 3-5% (22, 23, 24) and between 30-70% of the minor ones (4, 5, 12,15, 22, 25). The incidence of complications after PCNL has not changed significantly over the past two decades because of improved equipment and better adapted surgical techniques, or because of the experience of operators. The "threshold" of these complications has been reached today, beyond which the influence of the learning curve with certain role in the value of global incidence of PCNL complications (22) occurs.

Mortality due to PCNL is described in the literature as being between 0.5-1%, statistically insignificant (17, 22, 23, 25).

The most common complication is intraoperative haemorrhage (2, 5, 12, 23, 24). It's reason may be inadequate puncture which does not obey the basic rules of percutaneous surgery (perfectly straight trajectory and transpapillary puncture in a posterior calyx) and of the other several patient-related causes: abnormal position or rotation of the kidney, its excessive mobility, skeletal abnormalities, the high position of the calyces in high lumbal ectopies, abnormal vascularity, etc. Another cause can be the use of Amplatz dilators and the respective sheaths, after an inadequate caliceal puncture (18, 22, 23, 24, 25, 26) and the association of the septic factor.

Conclusions

In the treatment of staghorn stones PCNL has established itself as an effective, less aggressive procedure compared to anatrophic nephrolithotomy.

For effective treatment of staghorn stones by PCNL properly done PN tracks are required, well-chosen ones along with good technicality.

Although convincing because of its efficiency and minimal aggressiveness, PCNL complications can be serious, even life-threatening.

In the treatment of staghorn stones ESWL seems to be a more complementary method rather than a single one.

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