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Original Research Article

Minimally Invasive Percutaneous Nephrolithotomy Combined with Holmium: YAG Laser for Treatment of Large Renal Stones

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Abstract

Kidney stone disease is a common problem in primary care practice. Bulgaria is endemic region and the number of people in need of treatment is growing. Patients may present with the classic symptoms of renal colic and hematuria. Some patients may be asymptomatic or have atypical symptoms such as vague abdominal pain, while others will have more typical symptoms, such as acute flank pain, nausea, urinary urgency or frequency, fever, or testicular pain. Drug treatment of urolithiasis is directly dependent on the chemical composition of the stone and very rarely the desired release of the stone is achieved. Approximately 20 to 30 percent of all kidney stones require surgical removal, which is determined based upon the presence of symptoms and the size and location of the stones. This article presents the effectiveness of the treatment of large kidney stones with minimally invasive percutaneous nephrolithotomy combined with disposable aspiration access shaft.

Keywords: Kidney stone disease, Minimally invasive percutaneous nephrolithotomy, Modified access aspiration Shaft, Holmium: Yag laser, Stone free rate

INTRODUCTION

Mini-percutaneous nephrolithotomy (mini-PNL) was first introduced by Jackman et al. (1998) in children. This treatment method has been developed as an alternative technique to conventional percutaneous nephrolithotomy using a large access shaft size (24-34 Fr).The team of physicians has treated seven patients with a mean stone size of 12 mm using a miniaturized nephroscope and an 11 Fr access shaft. In the following years, the technique was gradually adopted for use in adults, and was initially used mainly for smaller stones and those positioned in the calyx diverticulum (Lahme et al., 2001). This method complements the therapeutic gap between extracorporeal shockwave lithotripsy (ESWL), flexible ureterorenoscopy, and conventional percutaneous nephrolithotomy. Meanwhile, the technique was modified to use a 12 Fr nephroscope and a 16 Fr modified aspiration access shaft. The innovation allows for rapid and complete elimination of stones from the collector system of the kidney, without insertion of a nephrostomy tube at the end of the operation.

The efficacy and safety of minimally invasive percutaneous nephrolithotomy in the treatment of patients with large stones and complex staghorn stones have been questioned, mainly due to the limited diameter of the miniaturized access, presumably leading to reduced visibility, prolonged operative time, and reduced fragmentation elimination (Li et al., 2010). The success of treatment depends not only on the size of the stone, but also on its chemical composition, location, renal function, present renal abnormalities, and related urinary tract infections (Rassweiler et al., 2000). In the present study, the stones are classified as in the stydy of Tefekli et al. (2008) namely, simple (isolated in the renal pelvis or isolated calyx stones) or complex (partial or complete staghorn stones; stones in the renal pelvis, accompanied by calyx stones), regardless of their size.

The purpose of this retrospective analysis is to share our experience in the treatment of patients with complex large kidney stones (up to 40 mm in size) using the technique of minimally invasive percutaneous nephrolithotomy combined with disposable aspiration access shaft and a source of energy for lithotripsy - Holmium:Yag laser, focusingonthe stone complexity, the duration of surgery, the degree of complete

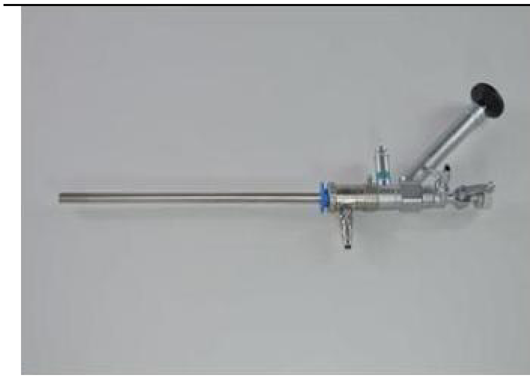

Figure 1. 12 Fr mininephroscope

Figure 2. 16 Fr modified access aspiration shaft

Figure 3. Position of the patient and operating theater preparation

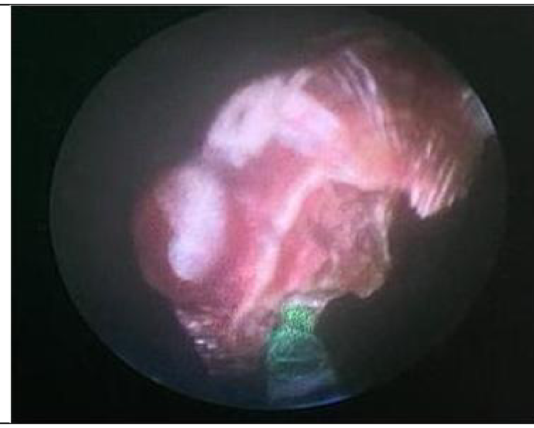

Figure 4. Laser tithotription

elimination of stones (Stone Free Rate), the frequency of need for re-treatment, the average level of decrease in hemoglobin after surgery and complications.

MATERIAL AND METHODS

The study includes 127 patients (71 males and 56 females)treated in the Urology Clinic at University Hospital "Kaspela"from January 2019 to July 2021 for large kidney stones (diameter 20 - 40 mm, measured by computed tomography scanor ultrasound), with the use of a mini-PNL technique combined with disposable aspiration access shaftand a Holmium: YAG laser. A 12 Fr miniature nephroscopic system (Karl Storz, Germany) (Figure 1) and a modified 16 Fr access aspiration shaft (Clear Petra, Wellead) (Figure 2) were used in all patients (Nagele et al., 2007; Schilling et al., 2008). After retrograde insertion of a 6 Fr-sized ureteral catheter to contrast the renal collector system, patients were placed in a supine position over an inflatable cushion located caudally to the xiphoid process of the sternum (Figure 3). Percutaneous access was achieved under combined (ultrasound and X-ray) control. A single dilatation with a 10Fr nitinol dilator was applied and then a 16 Fr access aspiration shaft was introduced. The stones were defragmented using a holmium: yag laser (Litho-Evo 35W, Quanta Systems) with a laser fiber size of 550µm (Figure 4). The manipulation took place under constant visibility, and the stone fragments were evacuated by aspiration through the modified access shaft. At the end of the procedure, the retrograde contrast catheter of the kidney was removed and an anterograde double J (JJ) stent was placed. The access shaft was slowly withdrawn from the patient and the nephrostomy tract was closed. In cases where residual fragments were suspected, we left a 14 Fr nephrostomy tube to serve as an inlet for re-manipulation.

Patients were examined with an X-ray (CT scan was performed on X-ray-negative stones) and abdominal ultrasound on the first postoperative day. Hemoglobin, serum creatinine and urea levels were examined before and after surgery. Clinical records were reviewed retrospectively for the following parameters: stone complexity, duration of surgery (defined as the time from puncture to closure of the access tract), degree of complete elimination of fragments (Stone Free Rate), postoperative hemoglobin level and complications. Patients were considered completely free of stones in the absence of any noticeable fragment on nephroscopy at the end of the procedure and on postoperative X-ray and ultrasound diagnosis. A "complication" was defined as any adverse event

Table 1. Number and age of the patients

Total number of patients	Male	Female	Mean age of patients
127	71	56	52,8

Table 2. Type and size of the stones

Number of patients with stones	Complex	Simple	Mean size of stones
127	81	46	31.5 mm

Table 3. Operation duration according to stone type

Mean duration of operation	Average duration in complex stones	Average duration in simple stones
41.9 min	48.2 min	35.7 min

Table 4. Stone free rate

Total number of patients	Stone free	Second procedure	ESWL
127	112	6	9

Table 5. Table of complications based on the Clavien-Dindo classification

	Clavien grade	Simple Stone, n	Complex Stone, n	Total, n
Transfusion	II	0	1	1
Gross hematuria	II	1	0	1
Fever>38 C	I	8	3	11
Bladder haematoma requiring cystoscopic evacuation	IIIb	1	1	2
Urinoma requiring JJ stent	IIIb	0	1	1
Extravasation treated conservatively	II	2	1	3
Obstruction requiring JJ stenting	IIIb	0	2	2
Perinephric haematoma	II	0	1	1
Total		12	10	22

intraoperatively or <30 days after the procedure. The grade of complication was determined on the basis of the Clavien classification and its modification for percutaneous procedures (Tefekli et al., 2008).

RESULTS

The total number of patients were 127 with mean age of 52.8 years. (Table.1)

In general, in 81 of the patients the stones (63.78%) were classified as complex, and in the remaining 46 (36.22%) as simple stones. The average size of the stones was 31.5 mm (Table 2).

In all 127 patients, access to the kidney was via the lower group of calyces. All punctures were subcostal - none of the punctures were above the 11 intercostal space.

The mean operating time was 41.9 minutes, and operative duration for complex stones was not significantly longer than for simple stones - 48.2 versus 35.7 minutes ($P = 0.2$) (Table 3).

The median average decrease in hemoglobin was 4.2 g/dl, with no significant difference between the two groups ($p = 0.5$), which we did not consider to be a significant difference from baseline levels.

In total, 112 out of 127 cases (88.19%) were cleared of stones after the first procedure. Six patients (4.72%) underwent a second procedure, and nine (7.09%) underwent extracorporeal lithotripsy (ESWL) (Table 4).

A total of 22 complications occurred during 127(17.32%) procedures (Table 5). In 17 cases (13.39%) complications were Clavien grade I or II and were managed conservatively, five complications (3.94%) necessitated endoscopic intervention (Clavien grade IIIb). There were no grade IV or V complications. As it is shown in Table 5, grade I complications were more likely to occur on simple stones and grade IIIb in complex stones.

DISCUSSION

Percutaneous access to the collecting system of the kidney allows a high rate of complete elimination of stones. This is the main reason why this technique is recommended as a method of choice for the treatment of medium and large sizedkidney stones (Tuerk et al., 2011). Percutaneous nephrolithotomy is generally considered a complex procedure, although it is safe and effective in experienced hands (Michel et al., 2007; Schilling et al., 2011). Conventional PNL technique is usually performed by renal access with a shaft diameter of 24-34 Fr and a semi-closed irrigation system. Reducing the size of the kidney access shaft has led to the possibility of applying Mini-PNL (Jackman et al., 1998). Knoll et al. considered that this method can reduce blood loss and blood transfusion levels compared to conventional techniques (Knoll et al., 2010). In an attempt to further reduce the likelihood of complications, the mini-PNL technique is in use, combined with a modified aspiration access shaft. This in turn allows for the rapid elimination of the stone without need of additional endoscopic extraction instruments.Although the concept of this procedure results in complete elimination of fragments in 92.9% of cases with kidney stones (Nagele et al., 2008), application of the procedure in patients with significantly large stones depends mainly on the experience of the operator. Great importance is attached to lesser access and presumably reduced irrigation flow, which in turn leads to poor visibility (Feng et al., 2001; Li et al., 2010). The purpose of this retrospective analysis is to determine the safety and efficacy of mini-PNL combined with a modified access aspiration shaft for the treatment of kidney stones up to 40 mm in diameter.

The complete elimination of stones for all procedures in our patients is 88.19%. These results are similarto a multi-institutional international prospective study conducted by the Clinical Research Office of the Endourological Society (CROES).In 5803 patients undergoing conventional PNL, the rate of complete elimination of stones was 75.7%, and re-intervention was performed in 15.5% of cases (de la Rosette et al., 2011). It should be noted that the group of patients is very diverse, different surgical techniques are involved (supine or prone position), and in some patients there were small stones with a diameter of less than 20 mm, and in others - staghorn stones.

Given that the average stone size in the present study (31.5 mm) is larger than mentionedin other studies, it can be assumed that the complete elimination of stones is not affected by the smaller diameter of the access shaft.Their extraction by means of active aspiration in continuous low-pressure irrigation without the need for additional endoscopic extraction tools can in fact contribute to the effective clearance of stones and significantly speed up the procedure (Nagele et al., 2008).

There is conflicting evidence as to whether miniaturization of access tools necessarily leads to longer operating times for larger stones. A comparative study of 180 patients undergoing conventional or mini-PNL found a significantly longer operative time for mini-PNL in simple (89.4 vs. 77.0 min), staghorn (134.3 vs. 118.9 min), and complex stones (113.9 vs. 101.2 min) (Schilling et al., 2008). In another prospective comparative study of conventional and mini-PNL in 50 consecutive patients, Knoll et al., (2010) noted that there is no significant difference in operative time in patients operated with an access shaft 18 Fr compared to those with an access shaft 26 Fr (mini-PNL - 48 minutes compared to conventional 57 min). However, the authors suggestedthat this fact may be due to differences in the chemical composition of the stones in the two groups. The mean duration of surgery in the present study was significantly lower, proving once again the advantage of the modified disposable aspiration shaft for kidney access.

One of the main problems with the conventional PNL technique is the significant intraoperative blood loss, as well as the need for blood transfusion after the procedure.In the present study, the mean decrease in hemoglobin level was 4.2 g/dL.Recent studies indicate similar levels of mean decrease in hemoglobin (Desai et al., 2011). In general, the reason for the lower level of hemoglobin decrease in this technique may be the minor trauma to the parenchyma and large segmental renal vessels, due to the small-caliber aspiration shaft used to access the kidney. Other studies have rep orted a reduced rate of transfusions after surgery (Cheng et al., 2010). Although blood loss appears to depend on many different factors such as: the size and type of access shaft, the size, complexity, and chemical composition of the stone, and the duration of surgery, we did not find a significant increase in blood loss with increasing size of the stone ($P = 0.4$). There is no significant difference in operating time between simple and complex stones ($P = 0.5$).

During 127 procedures, 22 complications occurred. Most of them were classified Clavien grade I or II and could be managed conservatively. Grade I complications were significantly more frequent in simple stones. However, there was a tendency to higher grade complications in complex stones. The grade III could be managed endoscopically. Severe complications did not occur throughout the procedures. The complication rate reported here is in absolute accordance with already published rates (Abdelhafez et al., 2012). Although the overall complication rate in different PCNL procedures is high, generally higher grade complications (>grade II) are rare (Li et al., 2010).

CONCLUSION

This retrospective analysis of 127 patients treated with minimally invasive percutaneous nephrolithotomy combined with a modified disposable access aspiration shaft and Ho: YAG laser shows that this technique is effective not only for small stones, but also in patients with large and complex stones. The method has a stone free rate comparable to that of conventional PNL and is equally effective even in complex kidney stones. Minimally invasive access to the kidney and low blood loss and complication rate are huge advantages that give a significant superiority to the choice of this technique by the urologist and the patient.This method has clearly shown that it can be as effective in managing renal lithiasis as is conventional PNL, regardless of the size, chemical composition and location of the stone.

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