Scientific Research Publishing

Open Journal of Urology, 2024, 14, 104-114
https://www.scirp.org/journal/oju
ISSN Online: 2160-5629
ISSN Print: 2160-5440

Treatment of Kidney Stones by Percutaneous Nephrolithotomy: Evaluation of the Results of the First Series of Our Experience in the Urology Department of the Idrissa Pouye General Hospital in Dakar

Mouhamadou Moustapha Mbodji, Mohamed Jalloh, Medina Ndoye, Abdourahmane Diallo, Issa Labou, Lamine Niang, Serigne Magueye Gueye

Department of Urology and Andrology, Hospital General Idrissa Pouye, Dakar, Senegal
Email: mbodjitaph11@gmail.com

How to cite this paper: Mbodji, M.M., Jalloh, M., Ndoye, M., Diallo, A., Labou, I., Niang, L. and Gueye, S.M. (2024) Treatment of Kidney Stones by Percutaneous Nephrolithotomy: Evaluation of the Results of the First Series of Our Experience in the Urology Department of the Idrissa Pouye General Hospital in Dakar. *Open Journal of Urology*, **14**, 104-114.
https://doi.org/10.4236/oju.2024.142011

Received: January 8, 2024
Accepted: February 26, 2024
Published: February 29, 2024

Abstract

The principle of PCNL is the extraction through a nephrostomy channel of kidney stones which are defined as the presence of crystalline concretions in the kidneys. **Objectives:** The objective of this work was to study the epidemiological, clinical and paraclinical aspects of patients with renal lithiasis treated by PCNL and on the other hand the different technical aspects of PCNL. **Materials and Methods:** This was a retrospective descriptive study, conducted in the urology department of HOGIP, covering the period from January 2015 to January 2019. We studied the demographic and clinical aspects of patients presenting renal lithiasis; we also studied the technical aspects and treatment outcomes. Statistical significance was set for $\alpha = 0.05$. **Results:** Our series covered 82 PCNLs performed during the study period. The average age was 45.95 years, the age group [40 - 49 years] was more affected. Our study involved 44 men and 38 women, a sex ratio of 1.15. At the clinic, atypical lumbar pain was more frequent in 45.83% of cases. On URO-CT, the calculations were located more at the pyelic level (31.2%) and lower caliceal (27.2%). The size of stones measured between 15 and 20 mm in 30.52%. The stone density was between 500 and 1000 HU in 47.54% of cases. Intraoperatively, the patients were placed in lateral decubitus in 41.46% of cases. Only one access to the kidney was necessary in 87.8% of cases. The lithoclast was used in 65.85% of cases. The overall success rate (stone free) in our series was 96%. The majority of cases, 41.44%, drainage were done by natural means (totally tubeless). The average duration was 92 minutes. The

complications encountered in our experience concerned 10 cases, a rate of 12.19%. **Conclusion:** Urinary lithiasis is more and more frequent in our regions. The development of Endo-urology offers several therapeutic options. Thus, PCNL occupies an important place in the management of kidney stones.

Keywords

HOGIP, Kidney Stones, PCNL, Stone Free, Uro CT Scan

1. Introduction

Urinary lithiasis is defined as the presence of crystal concretions or stones in the urinary tract. This pathology is increasingly frequent in our regions due to changes in dietary and professional habits and affects the younger population [1]. Its major symptomatology is nephritic colic-like lumbar pain. This pathology, considered benign, can be serious in certain cases because it is most often the cause of renal destruction (pyonephrosis), which is still frequent in our regions [2].

The treatment of urinary lithiasis and endo-urology underwent a revolution worldwide with the advent of modern, minimally invasive techniques: percutaneous nephrolithotomy (PCNL), ureterorenoscopy (URS) and extracorporeal shock waves lithotripsy (ESWL). Percutaneous nephrolithotomy is, in most comparative studies and meta-analyses in the literature, the most effective technique with 90% - 97% efficacy, while that of Flexible URS varies from 70% - 95% for stones larger than 10 mm [3] [4]. Compared to ESWL, the overall success rate at three months for kidney stones is 70% - 80% [5].

The principle of PCNL is the extraction of renal or ureteral calculi through a nephrostomy tunnel created by a transcutaneous route allowing the passage of endoscopic instruments to crush, pulverize or extract the calculi. This technique represents a very important advance that has significantly reduced the number of lumbotomies performed in young patients for benign lithiasis, especially given the technical progress and miniaturization of the instrumentation. Its complications are essentially hemorrhagic, infectious, and lesions of the neighboring organs [6] [7] [8].

PCNL was performed for the first time in Senegal at the Urology Department of the Hospital General Idrissa Pouye (HOGIP) in 2015. While this technique is well codified in Western countries and Asia with a lot of data available in the literature, PCNL is still in its infancy in Sub-Saharan Africa. Thus, we have not found any related publications in West Africa. It is therefore important to describe the first experiences with this technique to use the interest recognized elsewhere for its effectiveness and its minimally invasive character.

The objective of this work, which is the first series in West Africa, was to evaluate the feasibility and study the results of PCNL a new therapeutic option in the management of kidney stones.

2. Patients and Methods

We conducted a cross-sectional descriptive study from January 2015 to January 2019, at the urology department of HOGIP. All patients who underwent PCNL treatment at HOGIP during the study period, and who had an available and duly completed medical record, operative report and anesthesia form, were included in our work.

The different variables studied were: marital status, medical and surgical history, circumstances of diagnosis, physical exam findings, imaging exams, location, size and density of the stones, preoperative laboratory assessment, operative modalities and postoperative data. Our data sources were the patients' medical records, the operative report book and the hospitalization register.

We performed analyses of means, standard deviations and medians for quantitative variables; qualitative variables were studied in terms of frequencies. Statistical significance was accepted for $\propto < 0.05$. Descriptive analyses were performed using Epi Info 7 software.

The surgical procedures were performed under general anesthesia with antibiotic prophylaxis. Patients were positioned either prone, modified supine or modified lateral decubitus. A ureteral catheterization with the injection of contrast reagent mixed with methylene blue was performed at the first stage of the operation. Then a calyceal puncture was performed under fluoroscopic or ultrasound control in the calyx defined preoperatively according to the position of the stone and its complexity. Once the puncture was successful (methylene blue was released through the puncture mandrel), a guide was put in place. A dilatation of the pathway was performed until the amplatz sheath was placed, which allowed access to the calyceal cavities through the nephroscope. The endo-renal lithotripsy used was laser, lithoclast or ultrasound. The drainage used was the double J(JJ) stent, ureteral stent, nephrostomy or drainage through the natural channels (Totally tubeless). The patient was evaluated postoperatively according to the stone free percentage rate, the control of biology and bacteriology and the rate of complications.

3. Results

Among 90 cases operated, the inclusion criteria allowed us to consider 82 cases or 91.11% for our study, and to exclude 8 cases or 8.89%. The average age of our patients was 45.95 years (Range: 16; 80 years). The age group [40 - 49] represented 28.05% of the patients (**Table 1**). Sex ratio was 1.15.

Regarding patients' history, 4 patients (4.88%) had hyperparathyroidism while 7 had obstructive uropathy corresponding to 4 cases of pyeloureteral junction syndrome and 3 cases of ureteral stenosis.

Twelve patients had a history of open renal surgery (11 cases of nephrolithotomy and one case of pyelolithotomy).

Atypical back pain was present in 55 cases (45.83%) and renal colic in 32 cases (26.66%).

In our study, lumbar fossa tenderness was observed in 43 cases while 2 cases of large kidneys were outlined on physical examination.

Uro-CT-Scan was performed in all our patients to assess the different characteristics of the stones. Table 2 shows the distribution according to the location of the stones. The predominant sites were renal pelvis in 39 cases (31.2%) and inferior calyx in 34 cases (27.2%). Forty-three patients had two different stone locations in the kidney.

The size was specified in 76% of the stones. A size of 15 - 20 mm was observed in 29 cases (30.52%) and a size of over 20 mm was noted in 24 cases (25.26%) (Table 3).

The density was specified in 48.8% of the calculi (Table 4). A density of 500 - 1000 Hounsfield Unit (HU) was noted in 47.54% of the stones, while a density of 1000 - 1500 HU was noted in 42.62% of the stones.

Table 1. Age distribution of 82 patients treated with PCNL for urinary lithiasis at HOGIP.

Age (years)	Number	Percentage (%)
<20	02	02.44
20 - 29	15	18.29
30 - 39	11	13.41
40 - 49	23	28.05
50 - 59	12	14.63
60 - 69	09	10.98
≥70	10	12.20
Total	**82**	**100**

Table 2. Distribution of stone location on CT-Scan in 82 patients treated with PCNL for urinary lithiasis at HOGIP.

Stone location on CT-Scan	Number	Percentage (%)
Renal pelvis	39	31.2
Inferior calyx	34	27.2
Medium calyx	20	16.0
Superior calyx	14	11.2
Staghorn calculi	18	14.4

Table 3. Size distribution of stones in 82 patients treated with PCNL for urinary lithiasis at HOGIP.

Size on CT-Scan	Number	Percentage (%)
Less than 5	4	04.21
5 and 10	16	16.84
10 and 15	22	23.15
15 and 20	29	30.52
More than 20	24	25.26

Preoperative laboratory workup showed a mean creatinine level of 9.8 mg/l (SD: 2.46; Range: 6.1; 17.4); a mean hemoglobin level of 13.15 g/dl (SD: 1.8; Range: 9.3; 18.3). All patients had sterile urine at urine culture.

General anesthesia with orotracheal intubation was performed in all our patients.

Patients were placed in modified lateral decubitus in 34 cases (41.46%), prone position in 26 cases (31.70%) and supine position in 22 cases (26.84%) (Figure 1).

In 87.8% of the cases, only one access was needed for the entire PNLC procedure and in 10.97% of the cases, two accesses were performed.

Regarding energy source of lithotripsy, lithoclast was used in 54 cases (65.85%), Holmium laser in 24 cases (29.27%) and ultrasound in 4 cases (4.88%).

The overall success rate (stone free) in our series was 96%.

Nephrostomy was performed in 20 cases (32.92%) and the JJ stent in 17 cases (20.73%). It should be noted that in 34 cases (41.44%) no drainage was performed (Figure 2).

Post-operatively, the mean creatinine level was 9.62 mg/l (Range: 5; 8.7). The mean hemoglobin level was 11.32 g/dl (Range: 6.4; 16.9). The median hemoglobin level was 12.2 g/dl.

Table 4. Distribution of stones according to density (HU) in 82 patients treated with PCNL for urinary lithiasis at HOGIP.

Density (HU)	Number	Percentage (%)
Less than 500	4	06.55
500 and 1000	29	47.54
1000 and 1500	26	42.62
More than 1500	2	03.27

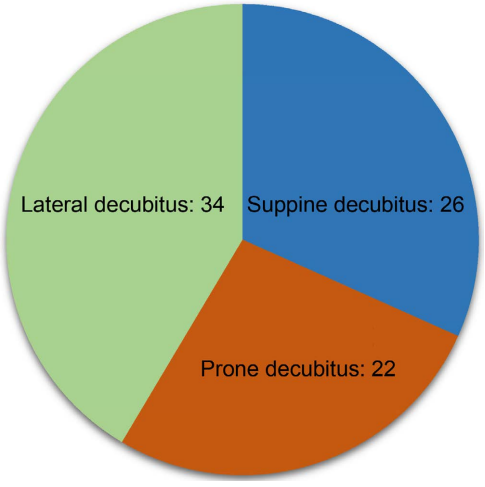

Figure 1. Distribution of type of patient's position in 82 patients treated with PCNL for urolithiasis at HOGIP.

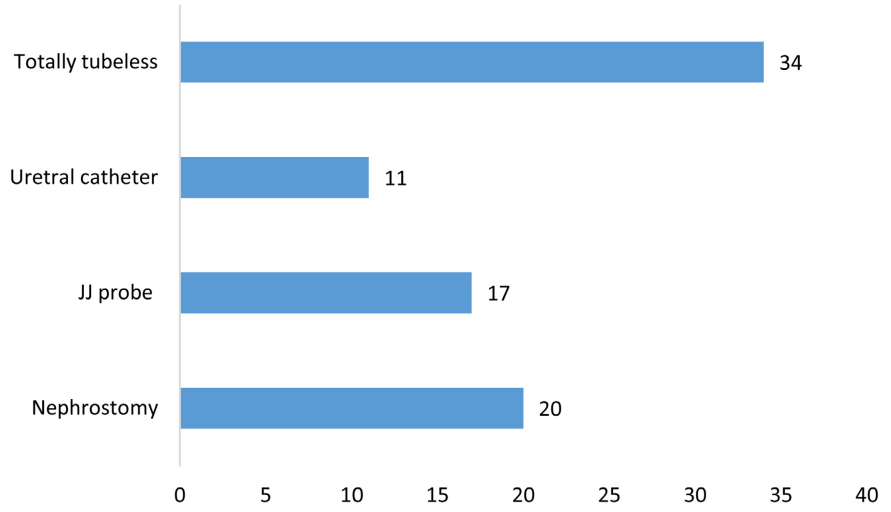

Figure 2. Distribution of type of drainage in 82 patients treated by PCNL for urinary lithiasis at HOGIP.

The urine culture control was positive in 10% of cases in our series.

Ten patients (12.19%) had complications, including 2 cases of intraoperative bleeding, 5 cases of acute pyelonephritis and 1 case of renal colic. Bleeding was noted at the puncture site, sometimes requiring a change in the drainage method into a nephrostomy. No transfusions were performed.

4. Discussion

Endourological treatment of kidney stones, regardless of the technique used, is currently recommended due to its excellent results and acceptable morbidity [9]. Thus, PCNL has a significant place in kidney stone management. It is currently performed routinely in the urology department of HOGIP.

The average age of our patients was 45.95 years (Range: 16; 80 years). The age group [40 - 49] was the most affected (28.05%). Li Jianxing *et al.* [10] reported a mean age of 43 years (Range: 6 months; 85 years) and Niang *et al.* [11] noted a mean age of 44.7 ± 13.9 years while Hosseini K *et al.* [12] reported a relatively younger mean age of 30.3 ± 6.5 years. In contrast, Palmero X *et al.* [9] reported a higher mean age of 50.7 ± 16.9 years.

Male predominance was noted in our series with a sex ratio of 1.15. In the series by Benchkroun A *et al.* [8], the sex ratio was four men to three women (113 men and 85 women).

In our series, we noted the history of 11 cases of open nephrolithotomy and 1 case of pyelolithotomy in the surgical history.

According to the second international consultation on urolithiasis held in Paris in September 2007 [13], the following recommendation was made: a history of open surgery does not contraindicate PCNL (Level of evidence III). Patients with a history of open nephrolithotomy who are treated with PCNL will, according to Margel *et al.* [14], undergo longer operative times (203 ± 92 minutes versus 177 ± 52 minutes) with greater need for an additional procedure

(29% versus 12%), but with no loss of efficacy or additional morbidity. However, these differences were not shown by Lojanapiwat *et al*. [15].

Uro-CT-Scan was performed in all our patients. It allowed us to determine the different characteristics of the stones. In our series, the renal pelvis and the inferior calyx were the most represented sites with respectively 31.2% and 27.2% of cases. This order of frequency was noted by many authors in the literature. Benchkroun A. *et al*. [8], in their study, showed 79.15% of renal pelvic lithiasis and 7.58% of inferior caliceal lithiasis. In our study, the most common stone size was between 15 and 20 mm, in 30.52% of cases. Calculi larger than 20 mm were found in 25.26% of cases. The results of Palmero X. *et al*. [9] were similar to our findings with 47.8% of stones between 10 and 20 mm and 45.3% larger than 20 mm. This reflects the preferred indication for PCNL for large stones over 20 mm.

In the standard PCNL technique, the patient was installed in the prone position as described by Theocharis K *et al*. [16]. In our study, the prone position was used in 31.7% of cases. It should be noted that this installation has some disadvantages, namely the change of position after the placement of the ureteral catheter and the respiratory and circulatory anesthetic difficulties, especially in obese patients. However, it reduces the risk of injuries such as perforations of the abdominal viscera, as reported in the studies by Tea-Kon *et al*. [17] and Theocharis *et al*. [16]. Although rare, colonic perforation has been reported in 0.2% - 0.3% by Sitki U *et al*. [18].

Many types of precautions have been developed subsequently. Modified supine and modified lateral decubitus positions were reported in 26.82% and 41.46% of cases respectively in our study. These positions allow simultaneous anterograde and retrograde access to the calyces, allowing placement of the ureteral catheter and the PCNL itself. Youness El Harrech *et al*. [19] reported 159 modified supine PCNL in their study.

Yanbo W *et al*. [20] compared the efficacy and safety of prone and modified supine positions in a study in China. They showed that both positions were effective and safe for PCNL but the operative time was longer in the prone position (78 vs 88 min, $P < 0.05$). A randomized controlled study by Marco de Seo *et al*. [21] reported a significant time difference between the two positions (43 min in lateral decubitus versus 68 min in ventral decubitus).

In our study, 87.8% of patients had only one access. The puncture was performed in the lumbar region limited by the posterior axillary line, the 12th rib and the iliac crest. Neto *et al*. [22] reported that a puncture on the posterior axillary line is safe, even for a supra-costal puncture, whereas in the prone position, a puncture is performed 1 to 2 cm below this line, which increases the risk of perforation of neighboring organs. Fan *et al*. [23] demonstrated the advantages of the subcostal route compared to the supra-costal route in terms of time-saving for the placement of the puncture trocar, stone extraction and mobility of the Amplatz sheath. It should be noted that guided punctures can be performed by a urologist

or a radiologist. In our study, all punctures were performed by a urologist. Watterson *et al*. [24] showed that if the puncture was performed by a urologist, there were fewer complications and a better fragment-free result. On the other hand, El-Assmy *et al*. [25], in a comparative study of 661 punctures performed by a urologist and 612 by a radiologist, found no difference in either complications or outcome.

The treatment of calculi is carried out by endo-corporeal lithotripsy as described by Osman *et al*. [26] using ultrasound, pneumatic energy or laser fiber. In our study, lithoclast was used in 65.85% of cases and holmium laser in 29.27% of cases. Jou *et al*. [27] used the same laser fiber in 349 PCNL performed in 334 patients with a fragment-free result of 83.7%. In 3.7% of PCNL, and particularly in cases of very large stones, a pneumatic lithotripter was used in conjunction with the laser fiber to limit the operating time. In a more recent study, Jou *et al*. [28] showed that the laser could be used successfully for stones larger than 3 cm with an energy of 3.0 J for a fragment-free rate after PCNL of 61.4%. Recently, Lee *et al*. [29] compared the holmium laser with the Thulium laser with the latter providing more efficient fragmentation and deeper craters.

In our series, the overall success rate (stone free) was 96%. Three hundred and fifteen patients (156 males, 159 females, aged 13 to 85 years) were treated by PCNL between 1987 and 2002 by the team of Osman *et al*. [26]. At one month, the fragment-free rate was 96.5%, of which 45.7% were stone free immediately postoperatively, 21.3% became stone free secondarily by spontaneous migration of residual fragments and 23% became stone free by secondary treatment with another PCNL, ESWL or ureterorenoscopy. Benchkroun A. *et al*. [8] reported a success rate (stone free) of 92%. In contrast, Wickham *et al*. [30] reported a low success rate of 60%.

Drainage of the upper urinary tract was performed by nephrostomy in 32.92% of cases and by JJ stent in 20.73% of cases. It should be noted that in the majority of cases (41.44%), drainage was done by the natural route, also known as totally tubeless. Tubeless PCNL is a PCNL without nephrostomy but with a ureteral stent or a JJ stent. Tubeless PCNL developed by Bellman *et al*. [31] in 1997 is a valid alternative. A few years after Bellman, Goh and Wolf [32] and Lojanapiwat *et al*. [15] adopted the principle of not draining the kidney with a nephrostomy tube and proposed replacing the double J stent with a single ureteral tube, which has the advantage of being easily removed.

The overall complication rate in our series was 12.19%, which is comparable to the literature data.

Ballager *et al*. [33] reported a complication rate of 17.5% for a population of 750 patients.

Complication rate depends essentially on the experience of the operator, the technical platform, anatomical variations (for example retro-renal colon), and the presence of comorbid conditions.

The mortality rate in the literature is 0 to 0.7%, but no deaths were noted in

our study. The major complications are hemorrhagic and septic.

Our experience shows that PCNL is an effective technique adapted to our developing country context. Our stone-free rate at the beginning of our practice is already good and could improve further with the increase in the number of cases which will further improve the experience of our team.

However, we noted certain limitations when carrying out this study. We try to list them: the problem of archiving files in our structures; lack of urine analysis before surgical procedures; the lack of means for patients to be able to carry out post-operative control scans.

5. Conclusion

Urinary lithiasis is becoming more and more frequent in our regions. The development of endo-urology offers several therapeutic options. Thus, PCNL occupies an important place in the management of kidney stones. It is being tested in our regions with excellent results and acceptable morbidity and complication rates.

Ethics Approval and Consent to Participate

This study was approved by the ethics committee of Hospital General Idrissa Pouye de Grand Yoff.

Competing Interests

The authors declare that they have no conflict of interest.

References

[1] Türk, C., Knoll, T., Petrik, A., Sarica, K., Skolarikos, A., Straub, M. and Seitz, C. (2015) Guidelines on Urolithiasis (EAU). *European Urology*, **69**, 475-482. https://doi.org/10.1016/j.eururo.2015.07.041

[2] Sow, Y., Fall, B., Sarr, A., Thiam, A., Diao, B., Fall, P.A., Ndoye, A.K., Ba, M. and Diagne, B.A. (2011) Pyonéphrose: 44 Observations Au Sénégal. *Médecine Tropicale*, **71**, 495-498.

[3] Bozkurt, O.F., Resorlu, B., Yildiz, Y., Can, C.E. and Unsal, A. (2011) Retrograde Intrarenal Surgery versus Percutaneous Nephrolithotomy in the Management of Lower-Pole Renal Stones with a Diameter of 15 to 20 mm. *Journal of Endourology*, **25**, 1131-1135. https://doi.org/10.1089/end.2010.0737

[4] De, S., Autorino, R., Kim, F.J., Zargar, H., Laydner, H., Balsamo, R., *et al.* (2015) Percutaneous Nephrolithotomy versus Retrograde Intra-Renal Surgery: A Systematic Review and Meta-Analysis. *European Urology*, **67**, 125-137. https://doi.org/10.1016/j.eururo.2014.07.003

[5] Lechevallier, E., Traxer, O. and Saussine, C. (2008) Lithotritie Extracorporelle du Haut Appareil Urinaire. *Progrès en Urologie*, **18**, 878-885. https://doi.org/10.1016/j.purol.2008.09.017

[6] Ligeman, J.E., Coury, T., Newman, D. and Khanoski, R. (1987) Comparison of Results and Morbidity of Percutaneous Nephrostolithotomy and Extracorporeal Shock Wave Lithotripsy. *Journal of Urology*, **138**, 485-490.

https://doi.org/10.1016/S0022-5347(17)43236-8

[7] Le Duc, A. (1991) Immediate Complications of Percutaneous Surgery of the Kidney. *Progrès en Urologie*, **1**, 31-35.

[8] Benchkroun, A., Iken, A., Karmouni, T.K., Jira, H., Belahnech, Z., Marzouk, M. and Faik, M. (2001) La Néphrolithotomie Percutanée: À Propos de 211 Cas. *Annales d'Urologie*, **35**, 315-318. https://doi.org/10.1016/S0003-4401(01)00051-1

[9] Palmero, X., Balssaa, L., Bernardinia, S., Chabannesa, E., Guicharda, G., Bittard, H. and Kleinclaussa, F. (2016) Étude Rétrospective Comparant la Néphrolithotomie Percutanée et L'Uréterorénoscopie Souple Pour le Traitement des Calculs Intrarénaux. *Progrès en Urologie*, **26**, 500-506. https://doi.org/10.1016/j.purol.2016.07.299

[10] Li, J.X., Xiao, B., Hu, W., *et al*. (2014) Complications of Ultrasound Guided Percutaneous Néphrolithotomie in 8025 Cases in China. *Chinese Medical Journal*, **127**, 4184-4189. https://doi.org/10.3760/cma.j.issn.0366-6999.20141447

[11] Niang, L., Pare., A.K., Ndoye, M., *et al*. (2016) Urétéroscopie Rétrograde: Expérience de L'Hôpital Général de Grand-Yoff. *African Journal of Urology*, **22**, 110-114. https://doi.org/10.1016/j.afju.2016.01.002

[12] Hosseini, K., Mohammad, M.M., Aida, M., *et al*. (2014) Blind versus Fluoroscopy-Guided Percutaneous Nephrolithotomy: A Randomized Clinical Trial. *Urology Journal*, **11**, 1386-1391.

[13] Saussine, C., Lechevallier, E. and Traxer, O. (2008) PCNL: Special Indications. *Progrès en Urologie*, **18**, 908-911. https://doi.org/10.1016/j.purol.2008.09.031

[14] Margel, D., Lifshitz, D.A., Kugel, V., Dorfmann, D., Lask, D. and Livne, P.M. (2005) Percutaneous Nephrolithotomy in Patients Who Previously Underwent Open Nephrolithotomy. *Journal of Endourology*, **19**, 1161-1164. https://doi.org/10.1089/end.2005.19.1161

[15] Lojanapiwat, B., Soonthornphan, S. and Wudhikarn, S. (2001) Tubeless Percutaneous Nephrolithotomy in Selected Patients. *Journal of Endourology*, **15**, 711-713. https://doi.org/10.1089/089277901525962299

[16] Theocharis, K., Konstantinos, M. and Christian, B. (2012) Positions for Percutaneous Nephrolithotomy: Thirty-Five Years of Evolution. *Arab Journal of Urology*, **10**, 307-316. https://doi.org/10.1016/j.aju.2012.06.005

[17] Tea-Kon, H. (2010) Percutaneous Nephroscopic Surgery. *Korean Journal of Urology*, **51**, 298-3073. https://doi.org/10.4111/kju.2010.51.5.298

[18] Sitki, U., Volkan, C., Osman, K., *et al*. (2015) Colon Perforation during Percutaneous Nephrolithotomy and Fistula Closure with Spongostan Following Conservative Therapy. *Canadian Urological Association Journal*, **9**, e313-e315. https://doi.org/10.5489/cuaj.2442

[19] El Harrech, Y., Ghoun-Dale, O., Zaini, R., Moufid, K. and Touiti, D. (2011) La Nlpc en Décubitus Dorsal Modifié: Notre Expérience. *Canadian Urological Association Journal*, **5**, 261-265. https://doi.org/10.5489/cuaj.10168

[20] Yanbo, W., Yan, W., Yunming, Y., *et al*. (2013) Prone versus Modified Supine Position in Percutaneous Nephrolithotomy: A Prospective Randomized Study. *International Journal of Medical Sciences*, **10**, 1518-1523. https://doi.org/10.7150/ijms.6305

[21] De Seo, M., Autorino, R., Quarto, G., *et al*. (2008) Modified Supine versus Prone Position in Percutaneous Nephrolithotomy for Renal Stones Treatable with a Single Percutaneous Access: A Prospective Randomized Trial. *European Urology*, **54**, 196-202. https://doi.org/10.1016/j.eururo.2008.01.067

[22] Neto, E.A., Mitre, A.I., Gomes, C.M., *et al*. (2007) Percutaneous Nephrolithotripsy

with the Patient in a Modified Supine Position. *Journal of Urology*, **178**, 165-168. https://doi.org/10.1016/j.juro.2007.03.056

[23] Fan, D., Song, L., Xie, D., *et al*. (2015) A Comparison of Supracostal and Infracostal Access Approaches in Treating Renal and Upper Ureteral Stones Using MPCNL with the Aid of a Patented System. *BMC Urology*, **15**, Article No. 102. https://doi.org/10.1186/s12894-015-0097-3

[24] Watterson, J.D., Soon, S. and Janak, K. (2006) Access Related Complications during Percutaneous Nephrolithotomy: Urology versus Radiology at a Single Academic Institution. *Journal of Urology*, **176**, 142-145. https://doi.org/10.1016/S0022-5347(06)00489-7

[25] El-Assmy, A.M., Shokeir, A.A., Mohsen, T., El-Tabey, N., El-Nahas, A.R., Shoma, A.M., *et al*. (2007) Renal Access by Urologist or Radiologist for Percutaneous Nephrolithotomy: Is Still an Issue? *Journal of Urology*, **178**, 916-920. https://doi.org/10.1016/j.juro.2007.05.015

[26] Osman, M., Wendt-Nordhal, G., Heger, K., Michel, M.S., Alken, P. and Knoll, T. (2005) Percutaneous Nephrolithotomy with Ultrasonography Guided Renal Access: Experience from over 300 Cases. *BJU International*, **96**, 875-878. https://doi.org/10.1111/j.1464-410X.2005.05749.x

[27] Jou, Y.C., Shen, J.H., Cheng, M.C., Lin, C.T. and Chen, P.C. (2005) Percutaneous Nephrolithotomy with Holmium: Yttrium-Aluminium-Garnet Laser and Fiber Guider: Report of 349 Cases. *Journal of Urology*, **65**, 454-458. https://doi.org/10.1016/j.urology.2004.09.069

[28] Jou, Y.C., Shen, J.H., Cheng, M.C., Lin, C.T. and Chen, P.C. (2007) High-Power Holmium: Yttrium-Aluminium-Garnet Laser for Percutaneous Treatment of Large Renal Stones. *Journal of Urology*, **69**, 22-25. https://doi.org/10.1016/j.urology.2006.08.1114

[29] Lee, H., Kang, H.W., Teichman, J.M. and Welch, A.J. (2006) Urinary Calculus Fragmentation during Ho:YAG and Er:YAG Lithotripsy. *Lasers in Surgery and Medicine*, **38**, 39-51. https://doi.org/10.1002/lsm.20258

[30] Wickham, J.E., Kellett, M.J. and Miller, R.A. (1983) Elective Percutaneous Nephrolithotomy in 50 Patients: An Analysis of the Technique, Results and Complications. *Journal of Urology*, **129**, 904-906. https://doi.org/10.1016/S0022-5347(17)52450-7

[31] Bellman, G.C., Davidoff, R., Candela, J., Gerspach, J., Kurtz, S. and Stout, L. (1997) Tubeless Percutaneous Renal Surgery. *Journal of Urology*, **157**, 1578-1582. https://doi.org/10.1016/S0022-5347(01)64799-2

[32] Goh, M. and Wolf Jr., J.S. (1999) Almost Totally Tubeless Percutaneous Nephrolithotomy: Further Evolution of the Technique. *Journal of Endourology*, **13**, 177-180. https://doi.org/10.1089/end.1999.13.177

[33] Ballanger, P. (2002) Results of the Percutaneous Extraction of Calculi of the Kidney and Ureter. A Propos of 750 Cases. *Journal of Urology*, **92**, 11-16.