TECHNIQUES TO IMPROVE OUTCOMES OF PERCUTANEOUS NEPHROLITHOTOMY: SINGLE CENTER EXPERIENCE

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ABSTRACT

Background

Percutaneous nephrolithotomy (PCNL) has become a well established procedure for the management of renal calculi, and there success relies on appropriate preoperative planning and optimal percutaneous access.

Objectives

To evaluate the technique of percutaneous nephrolithotomy, at our center since 2009, and assess the results and outcomes. We compare our initial and late experience.

Materials and Methods

We retrospectively analyzed the medical records of patients who had undergone percutaneous nephrolithotomy at our center since 2009. We divided the patients into two groups depending on the changes and developments in instrumentation and strategies. To improve the results, we incorporated newer ancillary procedures such as flexible nephroscopy and minipercs for clearance. The first group comprised of (125) cases, from April 2009 to April 2010; and the second group comprised of (142) cases, from June 2015 to January 2016.

Results

Demographic data and stone characteristics such as stone burden, the number of stones, and stone laterality were not different between the two groups. The mean operative time, decrease in hemoglobin level, blood transfusion rate, and hospital stay continued to decline and the stone-free rate increased as our experience improved. Bleeding requiring a transfusion during the operation time that occurred in group one and two was 10(8%), 2 (1.40%) patients respectively, (p = 0.0067). The mean (range) hospital stay for group one and two were 1.48 (1-8) days, and 1.15 (1-4) days respectively, (p = 0.0087). Stone clearances rate in group one and two were 88.0%, and 95.08%, respectively (p= 0.001).

Conclusion

The success of PCNL in patients with renal calculi is highly dependent on the optimal access into the targeted kidney. Higher success rate and decrease morbidity can be markedly improved with increasing experience, decrease the size of the access tract, preoperative access plan, and liberal use of flexible nephroscopy.

Keywords: *Flexible nephroscope, Percutaneous nephrolithotomy (PCNL), Renal calculus.*

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INTRODUCTION

Percutaneous nephrolithotomy (PCNL) currently remains the gold-standard approach for difficult-to-treat renal stones of all ages and body habitus [1-3]. With more than three decades of worldwide practice, PCNL remains a milestone technique with a very low major complication rate and a very high success rate [4,5].

Successful percutaneous nephrolithotomy (PCNL) relies on appropriate preoperative planning and optimal percutaneous access. In this respect, the quality of the radiologic information displayed to the surgeon is crucial [6].

Currently, the routine 3D computed tomography, performed before most PCNL procedures, provide excellent representations of renal anatomy and allows a preplanning step, and more accurate than ultrasonography or contrast radiography in this regards [7, 8].

To reduce the disadvantages of conventional PCNL, a 'mini-perc' technique was developed [9], and to improve the stone-free rate and decrease auxiliary procedures post PCNL in the American Urological Association guideline Preminger et al suggested more aggressive and liberal use of the flexible endoscopes as an adjunct to rigid instruments during primary PCNL [10].

To improve our results, we incorporated newer ancillary procedures such as flexible nephroscopy and 'minipercs' for clearance. The aim of this study was to review the developments in the technique of PCNL for renal stones at our center since 2009 and to assess the results and outcomes.

METHODS

We retrospectively analyzed the medical records of 2000 patients who had undergone PCNL at our center since 2009. We divided the patients into two groups depending on the changes and developments in instrumentation and strategies, which represent our early [11] versus late experience. The first group (125) cases, from April 2009 to April 2010; and the second group (142) cases, from June 2015 to January 2016.

Preoperative evaluations include history, examination, ultrasonography, intravenous urography. Urine analysis and complete blood count, urea, creatinine, urine culture, and coagulation profiles were done for all patients. Urinary tract infection preoperatively was treated with appropriate antibiotics.

Non-contrast CT and contrast urography with three-dimensional (3D) reconstruction proved to be very useful in planning the percutaneous access and were used in the management of patients in group two (Figure 1 a, b, c, d). Which helps us to assess the pelvicalyceal system, as well as the stone bulk and location.

The stone burden was calculated by multiplying the two largest dimensions, measured on preoperative radiographs and /or CT scan.

The same well-experienced urologist performed all the operations under general or spinal anesthesia, using antibiotic prophylaxis. After retrograde catheterization with a 5F/7F ureteric catheter in the lithotomy position, patients were turned to prone and percutaneous access was established under fluoroscopic guidance.

After tract dilatation using coaxial serial Teflon coated dilators, a 26–30F Amplatz sheath with adult rigid nephroscope 24 Fr (Karl Storz) were used in group one, while in group two,18-24Fr Amplatz sheath with adult slender nephroscope 17 Fr, and 12 Fr mini nephroscope (Karl Storz, Germany) were used for the procedure. Pneumatic lithotripsy was used to disintegrate the stones in all cases. Mean operative time was defined as the time from starting an incision on the skin puncture site till suturing of the skin.

For complete clearance of the stones, intraoperative percutaneous calyceal irrigation was performed to remove small fragments avoiding additional punctures, multi-perc (Multi-Tract) were done when required. In group two patients additional puncture was mini-perc, and flexible nephroscopy is performed routinely after debulking the stone with rigid nephroscope in group two patients to avoid the second puncture and/or to clear stone fragments (Figure e, f, g, h).

Stone clearance was confirmed by fluoroscopy before termination of the procedure. A double J stent was placed at the end of the procedure, except for patients having a simple uncomplicated procedure where a ureteric catheter was left in situ. The procedure was concluded by placing a nephrostomy tube. A 12-16 Fr Foley catheter was placed as a nephrostomy tube at the end of the procedure.

Postoperative evaluation included a hemogram, renal variables and a plain kidney, ureter, and bladder X-ray on the next postoperative day to confirm stone clearance. Urethral catheters and nephrostomy tube were removed the next morning in uneventful cases, and the patient was discharged on the same day or the day after.

Patients were followed at 2-week intervals, when ultrasonography, plain-X-ray KUB were performed, double J stent was removed when auxiliary treatment is not needed.

The PCNL procedure was considered successful if the patient was either free of stones or had any clinically insignificant residual fragments (CIRFs), defined as ≤ 4 mm, nonobstructive, noninfectious, and asymptomatic residual fragments, on the kidney, ureter, and bladder radiography and/or ultrasonography on postoperative follow-up.

Statistical analysis was performed using the x^2-test and Student's t-test. The level of significance was defined as $p<0.05$.

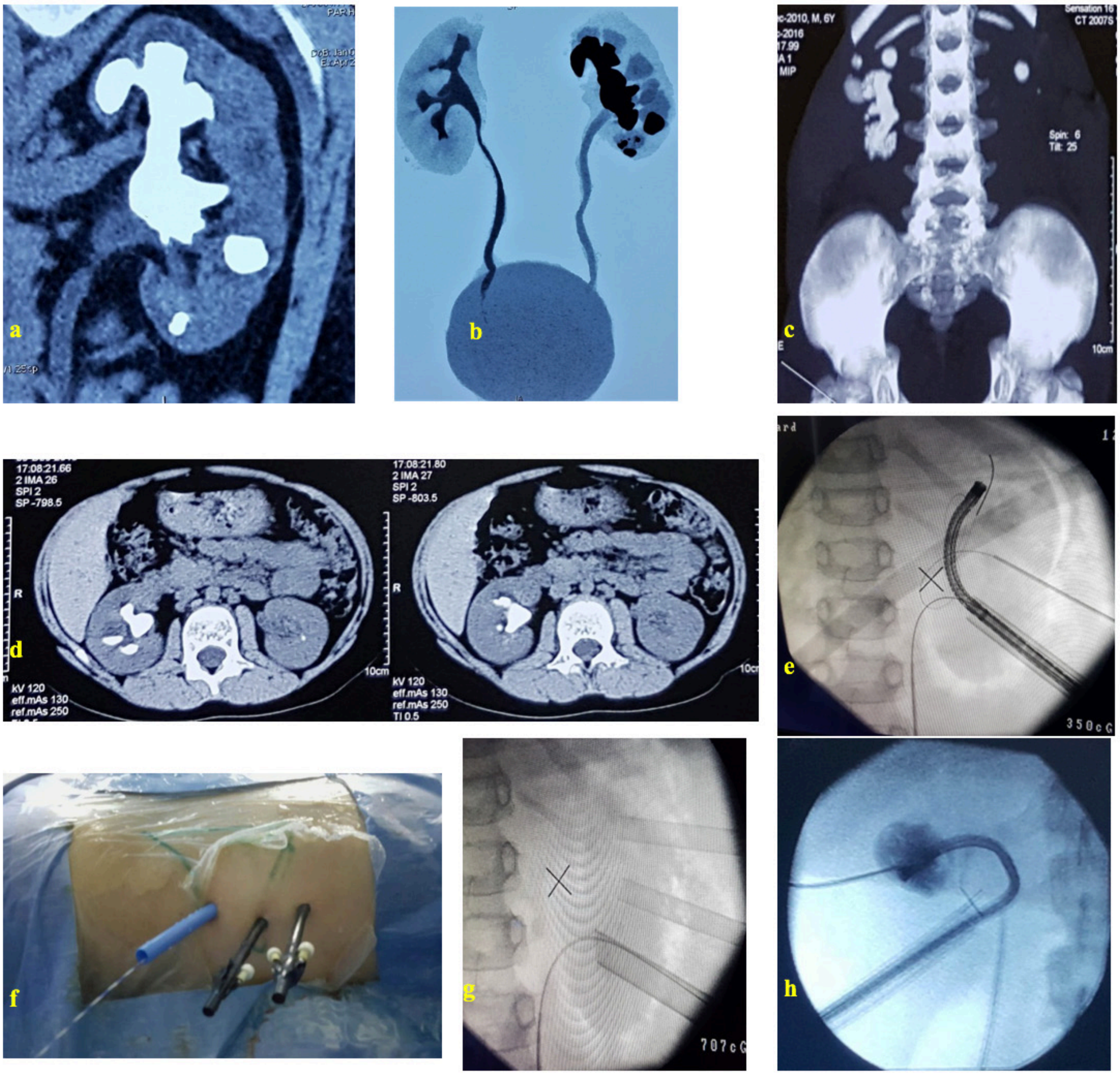

Figure 1: Technique of PCNL.a, b, c , d native and CTU of patients with staghorn calculus for preplanned puncture ;e, flexible nephroscopy clearing the upper calyx stone and aid in the second puncture; f, standard PCNL and Miniperc 2nd and 3rd puncture; g, clearance of right staghorn calculi; h, flexible nephroscope helping doing 2nd puncture in difficult access calyx.

RESULTS

Demographic data and stone characteristics such as stone burden, the number of stones, and stone laterality were not different between the two groups (Table 1). In group one mean age was 34.65 (3-83) years and in group two was (11-69) 41.83. The mean stone burden was 39.06 (10-80) mm and 30.29 mm, (10-62) mm in groups one and two respectively (p: 1.05).

Pre-and postoperative data of the two groups are shown in Table 1 and 2.

The mean operative time, decrease in hemoglobin level, blood transfusion rate, hospital stay continued to decline and the stone-free rate increased as our experience increased.

Fifteen (12.0%) patients had more than one access in group One, & 24 (16.9%) patients had more than one access in group Two (p =0.32). Mean operative time in group one and two was 95.14 and 55 minutes respectively, *(p* = 0.001)**.**

The most common complication after surgery was fever (temperature above 38.5 C) detected in 14 (11.2%) patients in group one and in 15 (10.5%) patients in group two (p value =0.42). All patients were treated with suitable antipyretic and antibiotics. Bleeding requiring transfusion during the operation time that occurred in group one and two was 10(8%) & 2 (1.40%) patients respectively, (*p*= 0.0067). while mean, SD, (range) hemoglobin drops in group one was and two were 3.38,1.6, (1.6-8) &1.91,1.44, (0.3-6) respectively, (*p* = 0.0002). The mean, SD(range) hospital stay for group one and two were 1.48 ,1.47(1-8) &1.15,0.45 (1-4) respectively, (*p* = 0.0087).

Pelvic and calyceal injury(perforation) with insignificant clinically and radiologically extravasation occurred in 5 (4%) patients in group one and in 6 (4.22%) patients in group two (p value=0.43). Other major complications, including pleural effusion, and visceral organ trauma, neither patient death nor kidney loss, were seen in any group.

The stone clearance rate in groups one and two were 81.06%, and 91.5 %, respectively, after completing the procedure; the overall clearance rate with observation (Fragments≤ 4 mm) was 88.0%, & 95.08%, respectively (p-value: 0.001).

Table 1. Demographic Data and Stone Characteristics of the Two Groups.

	Group one Period from 2009-2010	Group two Period from 2015-2016	p value
No. of patients	125	142	
Mean age year, (range)	34.65 (3-83)	41.83 (11-69)	
Gender, No,(%)	Male 85 (68%) Female 40 (32%)	Male 102 (74.54%) Female 40 (27.6%)	0.47
Side, No, (%)	Right 63 (50.4%) Left 62 (49.6%)	Right 67 (47.18%) Left 75 (52.82%)	0.59
Size of stone, mean, mm	39.06 (10-80) mm	30.29 (10-62) mm	1.050
Site of the stone, No, (%)	Pelvic 17 (13.6%) Caliceal 16 (12.8%) Pelvic and calyceal 79(63.2%) Upper ureteric 3 (2.4%) Upper ureteric and calyceal 10(8%)	Pelvis 37 (19.68%) Caliceal 23 (12.23%) Pelvis and caliceal 102 (54.25%) Upper ureter 8 (4.25%) Upper ureter and calyx 18 (9.57%)	0.46
Previous stone related surgery , No, (%)	Yes 38(30.4%) No 87(69.6%)	Yes 36 (25.35%) No 106 (74.64%)	0.35

Table 2. Intra- and Postoperative Data of the Two Groups.

	Group one Period from 2009-2010	Group two Period from 2015-2016	p value
No. of patient	125	142	
Access tract	125 (100%)	142 (100%)	
No. of tract	One tract, 110(88%) Two tract, 11(8.8%) Three tract, 4(3.2%)	One tract 118 (83.09%) Two tract 17 (11.97%) Three tract 4 (02.81%) Four tract 3 (02.11%)	0.32
operation time (minutes) Mean, SD, (range)	95.14, 26.57, (35-125)	45, 30, (20-95)	0.001
Hospital stay (day) mean, SD (range)	1.48,1.47, (1-8)	1.15,0.45 (1-4)	0.0087
Decrease in hemoglobin g/dL, mean SD, (range)	3.38 ,1.65, (1.8-8)	1.91, 1.44, (0.3-6)	0.00022
Complications No, (%)	29 (23.2%)	23 (16.19%)	0.107
Blood transfusion, No, (%)	10 (8%)	2 (1.40%)	0.0067
Fever, No, (%)	14 (11.2%)	15 (10.5%)	0.43
Pelvic and calyceal perforation No, (%)	5(4%)	6 (4.22%)	0.35
Pneumothorax and hydrothorax No, (%)	0(0%)	0 (0%)	
Adjacent organ injury No, (%)	0(0%)	0 (0%)	
Extravasation No, (%)	0(0%)	0 (0%)	
Hyponatremia No, (%)	0(0%)	0 (0%)	
Mortality No, (%)	0(0%)	0 (0%)	
Stone free rate, No, (%)	Stone free, 102(81.6%) Fragments≤ 4 mm, 8 (6.4%) Fragments >4mm, 15(12%)	135 (95.07%) 7 (4.92%)	0.001
Auxiliary treatment, No, (%)	4(3.2%) ESWL 4(3.2%) URS, 0(0%) PCNL, 0(0%)	2 (1.4%) 2 (1.4%) 0 (0%) 0 (0%)	1

DISCUSSION

Renal stone treatment has significantly evolved from open surgery to minimally invasive surgical procedures. There have been significant improvements in techniques, instruments, and experience [12]. Open stone surgery has been replaced by PCNL because of its cost effectiveness, lower morbidity, shorter operative time, and lower postoperative complications [13, 14].

The drawbacks of PCNL are increased hospital stay, duration of treatment and complications [15]. The main risk of PCNL is hemorrhage that requires a blood transfusion 11–14% of the time, and an increased risk of kidney loss [16, 17].

The goal of percutaneous nephrolithotomy (PCNL) is to ensure complete stone clearance with minimal morbidity. An accurate technique, and appropriate expertise and instrumentation necessary for complete clearance are needed. Development in imaging and instrumentation, with improvement and miniaturization of endourological equipment and optics, led to the development and refinement of percutaneous renal access techniques [18].

Various studies have confirmed that reducing the tract size and using smaller sheath, could result in minimal damage to the involved renal parenchyma. In that way it reduces the related morbidity in terms of reduced bleeding, leading to a tubeless procedure and reduced hospital stay, without diminishing its therapeutic efficacy [19-22].

As our experience increases, we realized that large tract and large nephroscope is not necessary to have a good PCNL outcome. In the second group, we used slender nephroscope (17 Fr Karl Storz) without an external sheath and hence the Amplatz sheath with intermittent high irrigation enables retrieval of large fragments, reducing the operating time, simultaneously keeping the intrapelvic pressure low.

Among the various strategies used for improving the efficacy of PCNL is the liberal use of the flexible endoscopes as an adjunct to rigid instruments during primary PCNL. This helps the surgeon to inspect the entire collecting system, which facilitates the removal of residual fragments. Subsequently it helps in reducing the number of tracts and provides complete or nearly complete clearance of stones, decreasing or eliminating the need for additional auxiliary procedures [23-27].

In our experience, flexible nephroscopy has been of use mainly for residual stones in the inaccessible calyces. Newer instruments, e.g. laser lithotripsy, stone retrieval baskets, graspers, high-pressure irrigants, help in perfecting the procedure.

The AUA Nephrolithiasis guidelines panel on staghorn calculi suggested that percutaneous monotherapy with multiple tracts is associated with a 79% stone clearance rate. Its acute complication rate is 15%, and transfusion rate of 18% [28]. It is evident from our analysis that the stone clearance rate improved, with a decrease in associated morbidity (fewer complications and blood loss) as our experience rose.

The main object of this article was to compare our early outcome after PCNL *vs* late PCNL procedures in terms of success, complication rates, in the early postoperative period.

Our retrospective comparison revealed that the mean operative time, blood transfusion rate, decrease in hemoglobin level, hospital stay continued to decline and the stone-free rate increased as our experience increased.

Bleeding requiring a transfusion during the operation time was significantly different in both groups that occurred in 10 (8%) patients in group One and in 2 (1.40%) patients in group Two (p=0.0067).

The mean, SD, (range) hemoglobin drops was significantly less in group two 1.91,1.44, (0.3-6) vs group one 3.38,1.6, (1.6-8) (p =0.0002).

As our experience increases hospitalization time decreases and our success rates significantly increase from 81.06% (group one), to 91.5 %(group two) respectively (*p* =0.001), with overall clearance rate with observation (Fragments≤ 4 mm) was 88.0%, and 95.08%, respectively (*p*= 0.001).

We feel that with increasing our experience, preoperative planning renal access using 3D reconstructed CT, reducing the size of Amplatz sheath and size of nephroscope, liberal use of flexible nephroscope, all helped to reduce the morbidity (complications) and simultaneously improved the clearance rate.

The success of PCNL in patients with renal calculi is highly dependent on the optimal access into the targeted kidney. Higher success rate and decrease morbidity can be markedly improved with increasing experience, decrease the size of the access tract, preoperative access plan and liberal use of flexible nephroscopy.

Compliance with Ethical Standards. No conflict of interest. Informed consent was obtained from all individual participants included in the study.

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