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Impact of Miniaturization on Early Outcome of Percutaneous Nephrolithotomy

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ABSTRACT

Background: Percutaneous nephrolithotomy has become the standard procedure for large renal stones but still remains highly challenging due to complications such as bleeding and sepsis, even though it has high stone free rate (SFR). We report the early outcomes of more than 1000 percutaneous nephrolithotomys done in our center.

Methods: A retrospective study of all patients undergoing percutaneous nephrolithotomy from January 2010 to December 2017 in single institution was conducted. All cases were stratified into three groups based on tract size; standard percutaneous nephrolithotomy with tract size ≥ 22 F, mini percutaneous nephrolithotomy with tract size 15 – 20 F and ultramini percutaneous nephrolithotomy with tract size ≤ 14 F. Age, gender, stone complexity using Guy's stone score, stone size, operative time, hemoglobin drop, hospital stay, early major and minor complications were reviewed.

Results: A total of 1074 patients had undergone percutaneous nephrolithotomy among which, 578 patients were standard percutaneous nephrolithotomy, 433 mini percutaneous nephrolithotomy and 63 had undergone ultramini percutaneous nephrolithotomy. There was even distribution of patients with Guy's stone score 1 and 2 in all three groups. However, majority of patients with Guy's stone score 3 underwent standard percutaneous nephrolithotomy or mini percutaneous nephrolithotomy and no patients with Guy's stone score 4 underwent ultramini percutaneous nephrolithotomy. Age group, gender and operative time were comparable between the groups; however, significant difference was noted in terms of less hemoglobin drop and shorter hospital stay (p-value < 0.05) in the miniaturized percutaneous nephrolithotomy group. Complications were found to be fewer in mini percutaneous nephrolithotomy and ultramini percutaneous nephrolithotomy group in comparison to standard percutaneous nephrolithotomy.

Conclusions: Miniaturization of tract size significantly decreases post-operative complication rates, blood loss and hospital stay while maintaining high stone free rates in well selected patients undergoing Percutaneous nephrolithotomy.

Keywords: Endourology; percutaneous nephrolithotomy; PNL; urolithiasis.

INTRODUCTION

Since Fernstrom et al. first reported the introduction of percutaneous nephrolithotomy (PNL) in 1976,[1] it has become the standard procedure for large renal stones.[2] Over 4 decades have passed, but PNL still remains highly challenging due to complications such as bleeding and sepsis, even though it has high stone free rate (SFR).[3]

Many studies have showed that tract size is associated with bleeding risk.[4] In order to reduce the risk of bleeding, parenchymal injury and pain; minimally invasive PNL including mini PNL (mPNL), ultra-mini PNL (umPNL) and micro PNL are widely being used. This also has been possible due to development of new miniaturized and less invasive instruments. We report through this study, the early outcomes of more than 1000 PNLs done in our center.

METHODS

A retrospective study was done including all patients that underwent PNL in our center from January 2010 to December 2017. All cases were categorized into three groups based on tract size; standard PNL (S-PNL) with tract size ≥ 22F, mini PNL (mPNL) with tract size 15 - 20F and ultraminiPNL (umPNL) with tract size ≤ 14F. Data were collected for age, gender, stone

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complexity using Guy's stone score[5] (GSS), pre-operative stone size as calculated by ultrasound or computed tomography kidney ureter bladder (CT KUB), operative time, hospital stay, pre-operative and post-operative hemoglobin. Hemoglobin drop was calculated by the difference between pre-operative and post-operative hemoglobin level taken after 24 hours of procedure. Complications were tabulated for each group according to Clavien-Dindo classification[6] and grouped into minor and major complications having score ≤ II or score ≥ III respectively. Statistical Package for the Social Sciences (SPSS©) version 20 was used for comparing variables between three groups of PNL and p value< 0.05 taken as significant.

After induction of general anesthesia, patient was kept in lithotomy position. Rigid cystoscopy was done and ureteric catheter of 4F/6F was placed (depending upon the patient age and built) under fluoroscopic guidance after negotiating guidewire into the desired ureter. We used Terumo guidewire of 0.038 inch for 6F and 0.025 inch for 4F ureteric catheter respectively. Foleys catheter of appropriate size was placed to drain bladder and tied with the ureteric catheter. Patient was then changed to prone position with adequate padding of pressure points.

Entry calyx was chosen based upon the location and accessibility of the stone after visualization of pyelogram by injecting diluted contrast through the ureteric catheter placed earlier. Ultrasound guided puncture was done with the help of radiologist only when ureteric catheter could not be negotiated or in cases of retrorenal colon as visualized in plain CT KUB film taken preoperatively in prone position. Patients with prior history of open renal surgery all have CT KUB done routinely in prone position to rule out retrorenal colon.

We prefer triangulation technique for puncturing and guidewire was negotiated into the ureter after successful puncture evidenced by free flow of urine through the needle. Operating time was calculated starting from the initial cystoscopy for ureteral catheter placement to fixation of the nephrostomy tube or closure of the tract. Serial dilatation was done over guidewire using Alken dilators and amplatz sheath was placed. Stones were fragmented using pneumatic lithotripter or in case of umPNL, holmium laser was used. After completion of the procedure, placement of nephrostomy tube and/or double J stent was based on surgeon's discretion taking into account of various factors such as residual stone, hemorrhage, pelvicalyceal system injury, duration of surgery and degree of preoperative obstruction.

Nephrostomy tube was removed on 2nd post-operative day after confirming absence of residual stone by plain X-ray kidney ureter bladder (KUB). Stone free status was defined as absence of significant stone (≥ 4mm in size) by plain X-ray KUB or ultrasonography. If double J stent was not placed during surgery, we left the ureteric catheter in-situ to be removed during Foley removal on 3rd post-operative day. Post-operative hemoglobin and renal function tests were sent after 24 hours of surgery. Patients were discharged on 4th postoperative day provided there was no significant hematuria and follow-up was done after 2 weeks with X-ray KUB or ultrasonography as deemed appropriate.

RESULTS

Among 1074 patients that underwent PNL, 578 patients underwent S-PNL, 433 underwent mPNL and 63 had underwent umPNL. The trend towards miniaturization over the years can be seen in Figure 1. In this series, the initial years of PNL were mostly S-PNL, with gradual inclination to mPNL after 2012 and umPNL starting since 2015. The summary of patient characteristics is tabulated in Table 1 and their distribution according to GSS can be seen in Figure 2. There were 53 cases of bilateral simultaneous PNL which were done in single setting. Multi-session PNL were done in 18 cases during same hospital stay out of which 6 cases were pre-planned and 12 cases were done for residual stone. There were 20 cases of failed PNL due to various causes illustrated in Table 2.

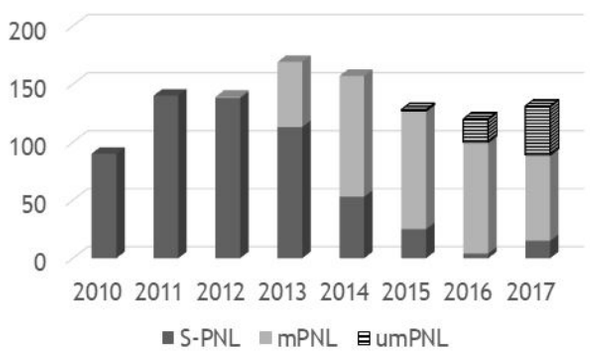

Figure 1. Trend of PNL over the years from 2010 - 2017 AD.

Table 1. Summary of patient characteristics.

	S-PNL	mPNL	umPNL
Mean Age (years)	40.0±13.8	39.1±14.1	39.4±16.4
Female/Male (%)	36.5/63.5	36.9/63.1	39.6/60.4
PNL (Left/Right)	270/274	217/202	31/27
Bilateral PNL	34	14	5
Stone size (mm)	20.87±12.24	17.94±8.37	18.51±7.08

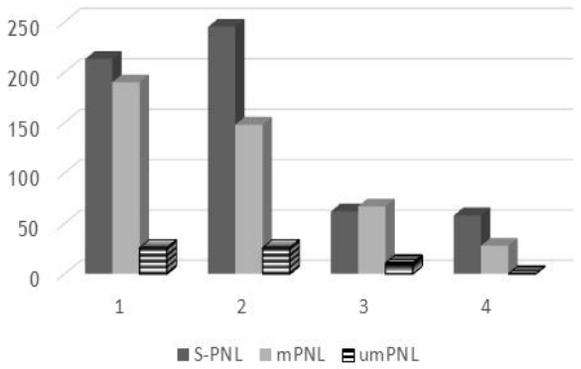

Figure 2. Type of PNL according to Guy's stone score[5] (GSS).

Table 2. Causes of failed/aborted PNL.

Cause	Cases
Failed puncture	5
Failure to negotiate guidewire into the system	3
Pus/dirty urine on puncture	2
Intraoperative hemorrhage	3
Intraoperative hypotension/hypertension after anesthesia	5
Non-visualization of stone under fluoroscope	2
Total	20

Table 3. Comparison of results among three PNL types.

	S-PNL	mPNL	umPNL	p value
Age (years)	40.0 ± 13.8	39.1 ± 14.1	39.4 ± 16.4	0.557
OT time (min)	78.6 ± 38.0	77.1 ± 36.5	69.5 ± 35.2	0.242
Hemoglobin drop (gm%)	1.55 ± 0.96	1.34 ± 0.86	1.18 ± 0.82	0.036
Hospital Stay (days)	5.5 ± 2.1	5.7 ± 2.4	4.7 ± 1.9	0.003
SFR (%)	93.5	94.7	98.5	-

Analys is ofresults among the three PNL types are illustrated in Table 3. All 3 groups were nearly comparable in terms of age groups. Longer operative time was noted in the S-PNL group (78.6 ± 38.0 vs 77.1 ± 36.5 vs 69.5 ± 35.2) but it was not statistically significant. However, the drop in hemoglobin was significantly different amongst the 3 groups where the least amount of hemoglobin drop was observed in umPNL followed by mPNL as compared to S-PNL. The SFR in all the groups were similar.

Overall complications were higher in the S-PNL group as illustrated in the Table 4. Rate of minor complication was 17.9% vs 14.7% vs 7.9% in S-PNL, mPNL and umPNL

Table 4. Complications of PNL according to Clavien-Dindo grading[6] (CD).

	CD	S-PNL (n=578)	mPNL (n=433)	umPNL (n=63)	Total (N=1074)
Minor Complications					
Hematuria managed conservatively	I	3.9% (23)	3.6% (16)	4.7% (3)	3.9% (42)
Residual Stones	I	6.5% (38)	5.3% (23)	1.5% (1)	5.7% (62)
Failure to complete the procedure	I d	1.9% (11)	1.8% (8)	1.5% (1)	1.8% (20)
Prolonged leakage from nephrostomy site	II	0.5% (3)	0.4% (2)	0	0.4% (5)
Incontinence due to DJ stent migration	II	0.1% (1)	0.2% (1)	0	0.1% (2)
Postop UTI / urosepsis	II	3.1% (18)	2.5% (11)	0	2.7% (29)
Minor cardiac events managed conservatively	II	1.7% (10)	0.6% (3)	0	1.2% (13)
Minor complication rate		17.9% (104)	14.7% (64)	7.9% (5)	16.1% (173)
Major Complications					
Extravasation of irrigating fluid (Hydrothorax/Hydroperitoneum)	III a	1.2% (7)	0.9% (4)	1.5% (1)	1.1% (12)
Hematuria requiring secondary procedure (DJ stenting, bladder wash, embolisation)	III a	0.8% (5)	0.2% (1)	0	0.5% (6)
Residual stones requiring auxillary procedures	III b	3.4% (20)	3.6% (16)	3.1% (2)	3.5% (38)
Colon injury	III b	0.17% (1)	0	0	0.09% (1)
Major complication rate		5.7% (33)	4.8% (21)	4.7% (3)	5.3% (57)
Total complication rate		23.7% (137)	19.6% (85)	12.6% (8)	21.4% (230)

respectively. Most of the hematuria was managed conservatively (3.9% vs 3.6% vs 4.7%) in all three groups but few cases of hematuria requiring auxillary procedures (1.2% in S-PNL, 0.9% in mPNL and 1.5% in umPNL) were managed either by DJ stenting or bladder wash or embolization. 20 patients in whom the procedure could not be completed, were dealt during follow-up on individual basis by either observation or other modality of intervention like extracorporeal shockwave lithotripsy (SWL) or retrograde intrarenal surgery (RIRS).

Additionally, major complication rate amongst three groups appeared comparable with slightly higher rate in S-PNL (5.7%) vs mPNL (4.8%) and umPNL (4.7%). There was one case of colon injury and 7 cases of extravasation of irrigating fluid. Secondary interventions for residual stones were required in 3.4 % of S-PNL, 3.6% of mPNL and 3.1% of umPNL. Cases which were considered successful were all free of any significant residual stones.

DISCUSSION

There has been a paradigm shift in the management of renal stones in the past decade, from the conventional PNL to tract size as small as 4.8F.[7] First mPNL was reported by Helal et al. in 1997, using a 15 F peel-away sheath and 10 F pediatric cystoscope for a 2 year old girl.[8] It is usually performed using a tract size of <22F.[9] In 2013, Desai et al. initially reported a case series using umPNLwith a 13 F tract sheath and 3.5 F telescope.[10]

The aim of our study was to compare the early outcomes of S-PNL vs mPNL vs umPNL. UmPNL was limited to cases with less complex stones (GSS 1 and 2) because of the obvious reason of longer operating time required. While complications were comparably less in all three groups, mPNL and umPNL demonstrated less drop in hemoglobin (Hb) level and lesser days of hospital stay as compared to S-PNL with similar efficacy in regards to stone free rate (SFR). Similar findings were noted in Clinical Research Office of Endourological Society (CROES) data which showed transfusion rates of 1.1%, 4.8% and 5.9% in tract sizes of <18 F, 24 - 26 F and 27 - 30 F respectively.[11]

The trend of decreasing hemoglobin drop in our series is comparable to a comparative study done by Lange et al. However, they demonstrated that there was no significant difference in residual stone, total operative time or postoperative pain among S-PNL and mPNL.[4] Similarly, Yasir et al., in a systemic review conducted in 2017, found that mPNL is atleast as efficacious and safe as S-PNL but the quality of evidence was poor.[12]

Major complications like major hematuria requiring auxillary procedures or adjacent visceral injury were virtually absent in umPNL. We had single case of colonic perforation and three cases of pseudoaneurysm after S-PNL which were managed by diversion loop colostomy and angio-embolization respectively. There were fewer cases of inadvertent extravasation of irrigation fluid into the thorax or peritoneum in umPNL compared to S-PNL. Also post-operative urosepsis, stent migration or cardiac events was not seen in umPNL which might be due to less number of umPNLcases in our study. Leakage from nephrostomy site was not seen because most of the umPNLswere tubeless and tracts were closed at the end of procedure.

There are however, limitations to our study. Since it is a retrospective study, all the drawbacks of which are inherited. Multivariate subgroup analysis considering tubeless, total tubeless, fluoroscopic time could have been more informative but could not be done due to lack of detailed records. Stone free status would have been better evaluated by plain CT KUB rather than X ray KUB or ultrasonography.

CONCLUSIONS

Miniaturization of tract size significantly decreases post-operative complication rates, blood loss and hospital stay while maintaining high stone free rates in well selected patients undergoing PNL.

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