SCIENTIFIC ARTICLE

Supine mini percutaneous nephrolithotomy: a method worth considering as the gold standard for treating renal stones – an experience from a tertiary referral centre

L. N. Seneviratne, C. Wickramsekera, Y. Mannikage, C. Hingalagoda,
J. Rajasinghe, S. Udurawana, W.C.M. Samaraweera, N.J Jahan, C. Pilimatalawwe
Sri Jayawardenapura General Hospital, Sri Lanka

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Abstract

Introduction

Mini PCNL was developed with the use of 15 - 18 F sheaths (instead of the conventional 24 - 30 F) to reduce morbidity that is seen in standard PCNL. Performing mPCNL in the supine position further adds to its many advantages including shorter operative time. This largest series evaluates the overall benefits observed in patients undergoing supine mPCNL for the treatment of renal stones in Sri Lanka.

Material and methods

Five hundred and five patients with renal and/or upper ureteric stones (in 509 kidneys) who underwent mPCNL between January 2016 - December 2020 were studied. Radiological evaluation was performed by CT scan. Holmium: YAG laser was used for stone fragmentation using a 12F nephroscope through 15 Amplatz sheath under fluoroscopic guidance. Patients clinical and treatment outcomes were evaluated in terms of stone-free rate, operative time, hospital stay and complications.

Results

Mean age was 48.85 years (14-80). There was a male preponderance. The majority (92.3%) being ASA I and II. The mean BMI was 25.32kgm-2 of whom 42.2% were overweight and 16.8% were obese. The mean stone diameter was 24.5 mm(9-45mm) and density1064Hu. The majority of stones (57.3%) had a GUYS score I while 13.4% were complete staghorn. The predominant approach was a single tract, subcostal lower pole puncture. However, multitrack PCNL was performed in 38(7.5%) patients. The complete stone-free rate achieved was 84.1%. Mean operative time was 87 min while the median hospital stay was 4 days. The overall complication rate was 21.5%(n=109), the majority of which being Clavien Dindo class I. No deaths, renal loss or conversion to open surgery were observed.

Discussion

Mini-PCNL in supine position should be considered more often for renal stone management in Sri Lanka not only due to its wide safety margin and effectiveness but also because of its rapid turnover time.

Correspondence: Lasantha N Seneviratne
E-mail: neerosene@yahoo.com
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Introduction

The management of renal stones has changed dramatically over the past four decades with the need for open surgery being reserved mainly for complex stones in abnormal kidneys. In the past extracorporeal shock wave lithotripsy, percutaneous nephrolithotomy and retrograde intrarenal surgery using ureterorenoscopy were the novel minimally invasive options available for renal stone treatment. However, the debate continues as to which modality is more superior all-around in treating renal stones.

When selecting a method for treating renal stones, especially in a low middle-income country such as Sri Lanka there should be a clear balance between its efficacy (in terms of stone-free rate), operative time, safety, cost-effectiveness and complications associated with the particular technique. PCNL is an effective technique that achieves a high stone-free rate in a single setting with a relatively shorter overall treatment time [1].

Standard PCNL is usually performed through 24-30-Fr percutaneous tracts. However, there is a reported increase in morbidity due to complications such as bleeding, postoperative pain, and potential renal parenchymal damage [2] due to the larger tracts made in standard PCNL. This led to modifications in the technique as well as diminishing the size of instruments used. The technique of using a smaller calibre working sheath (or mini-PCNL) was explored where a 15-18 Fr Amplatz sheath was developed accommodating a 12-14 Fr nephroscope. It was originally developed for the management of larger renal stones in 2-year-old pediatric patients [3]. Subsequently Jackman et al. revolutionized mini-PCNL in adults using an 11-Fr access sheath [4]. Since then mini PCNL has spread globally and has now become a popular technique in many centres where the working sheaths ranging from 11 to 20 Fr have been used [5]. Lately, Desai and colleagues introduced the smallest access tract used so far (4.8 Fr), naming it "micro perc". Unfortunately, this method has a few

Figure 1. Patient positioned for mPCNL

Figure 2. Multi tract supine mini PCNL

limitations as the stone fragmentation takes longer resulting in a high instrument failure rate. Even in the most experienced hands, the case number is limited to about 20 per single nephroscope [6]. Therefore its feasibility in a developing country such as Sri Lanka is debatable.

Indication for the use of the mini-PCNL technique has not been clearly defined as yet. However, mini-PCNL should be explored more avidly as the treatment of choice for renal stones of diameter around 2 cm in children, renal stones less than 2.5 cm in adults, cysteine stones, anatomical abnormalities inhibiting retrograde access and in patients with a narrow or a long infundibulum [7]. It is noteworthy in the present day that mini-PCNL has also gained popularity in treating larger impacted upper ureteric stones as well as staghorn calculi, having to employ a multi-track approach [8,9].

Traditionally, PCNL was performed in the prone position, and it was a well-established technique. Valdivia Uría first described the supine position in 1998 as an alternative technique highlighting the many advantages for the patients, anesthesiologists as well as the surgeon. Following large series of studies and meta-analyses of standard PCNL for patients in the supine versus prone position, found that both positions appeared to be equivalent concerning efficacy and safety despite a significantly short operative time when the procedure was done in the supine position [10,11]. This was attributed to the longer time than it took to prone a patient under anaesthesia. This advantage should be taken well into consideration in the Sri Lankan setting, where shortening the operative time is crucial to ensuring a high turnover time thus ensuring shorter waitlists for patients suffering from renal stone disease.

Material and method

Five hundred and five patients with renal and/or upper ureteric calculi who were admitted from January 2016 to December 2020 to the urological unit at Sri Jayawardenapura Teaching hospital were included. During the sixty months, a total of 509 kidneys were studied. The patients with prior pigtail catheter insertions (DJ stenting) and/or percutaneous nephrostomy insertions due to obstruction associated with urosepsis who underwent PCNL later were excluded from the study. The local institutional review board had approved the data collection procedures.

All patients in the study underwent urine analysis and culture, renal function testing, clotting profile and pre-anaesthetic assessment. CT- KUB or when relevant a CT urogram was performed, especially in patients with previous open renal surgery as a definitive investigation for analysis of the stone burden, location, density and pelvicalyceal anatomy.

All patients were positioned supine in a modified Galdakao-Valdivia position following general anaesthesia. Here, the patient is slightly tilted from the supine position with a cushion under the flank, with the ipsilateral upper limb crossing over the body, lower limb extended and contralateral leg flexed to achieve a modified lithotomy position (Fig 1).

Under fluoroscopic guidance, a 5 Fr ureteric catheter was inserted allowing injection of contrast dye to obtain a pyelogram. Using an 18G coaxial needle the desired calyx was punctured. When multi tracts were necessary, further needle punctures were made strategically especially when dealing with larger stones. (Fig 2) Then a 0.035mm hydrophilic guidewire was passed percutaneously through the needle into the pelvis. Using metal dilators, [9,12,15] FR fascial dilatation was carried out utilizing the seldinger technique. 15/16 Fr Amplatz sheath was inserted as a single or multi-tract to allow a 15Fr nephroscope to enter the collecting system. Holmium: YAG laser was used for fragmentation of the stones.

Once the burden of the stone was removed, a 14Fr Foley catheter/ nephrostomy tube was placed when appropriate.

Table 1. Patient characteristics

Male: Female	349:156	69.1%:30.9%
Age (mean/range)	48.85	14-80
ASA status		
I	210	41.5%
II	257	50.8%
III	34	6.7%
IV	4	0.7%
Comorbidity		
DM	142	28.1%
HT	168	33.2%
IHD	29	5.7%
DL	99	19.6%
CKD	36	7.1%
BMI kgm-2 (mean/range)	25.69	13.42-44.23
<18.5	10	1.9%
18.5- 24.9	196	38.9%
25-29.9	213	42.2%
30-39.9	56	11.1%
>40	30	5.7%

Next, the patient was stented using a 6/26 double pigtail stent in an antegrade manner. The clamped nephrostomy tube was removed 24-48 hrs. postoperatively depending on the stone burden treated. The urinary catheter was removed 24 hrs. after nephrostomy removal and the patient was discharged on that day.

All patients were followed up at two weeks following surgery with a urine culture report and one month later with an X-ray KUB (or CT-KUB in the case of radiolucent stones) to determine the presence of residual stones along with the stone analysis report. Stone free status was defined as the absence of any residual stones a or stones less than 4 mm in size. Patients with multiple or much bigger residual stones were managed with medical expulsive therapy, ureterorenoscopy at the time of stent removal. The double pigtail stent was removed at 4-6 weeks postoperatively using flexible cystoscopy under local anaesthesia as a day-case procedure. All patients were followed up for a minimum of three months. Postoperative complications were classified according to the modified Clavien Dindo classification system 2004.

Data collection was done based on the demography, comorbidity profile and stone characteristics. The complexity of stones was recorded according to the GUYS stone score.

It comprises 4 grades:

I. Solitary stone in mid/lower pole or solitary stone in the renal pelvis with normal anatomy

II. Solitary stone in the upper pole or solitary stone with abnormal anatomy or multiple stones with normal anatomy

III. Multiple stones in abnormal anatomy or partial staghorn

IV. Complete staghorn or stone with a patient with spinal deformity/injury

Table 2. Stone characteristics

Laterality of stones		
Right: Left	242:256	47.9%: 50.7%
Bilateral	4	0.7%
Solitary kidney	3	0.5%
GUYS score		
I-solitary stone mid/lower pole	133	26.3%
I-solitary stone pelvic	157	31%
11- solitary stone upper pole	7	1.3%
11- multiple stones in normal anatomy	57	11.2%
111- partial staghorn	22	4.3%
111- multiple stone in abnormal anatomy	4	0.7%
IV – complete staghorn	68	13.4%
Upper ureteric stone/impacted PUJ stone	57	11.2%
Stone density	1064 Hu	180-1800 Hu
Index stone size (range) mm	24.5	9-45.6
<20mm	330	65.3%
20-40	147	29.1%
>40	28	5.5%
Stone composition		
Calcium oxalate	210	62.8%
Uric acid	64	19.1%
Calcium oxalate + Uric acid	42	12.5%
Cysteine	1	0.2%
Magnesium + oxalate	8	1.6%
Ammonium + oxalate	4	0.8%
Carbon appetite	4	0.8%
Other combinations	6	1.2%

The stone analysis was done using the chemical method and infrared spectroscopy depending on the availability of the method in the private sector. The outcome of mPCNL was interpreted in terms of stone-free rate, operative time, hospital stay and complications.

Results

There was a total of 505 patients.

There was a male preponderance with a male to female ratio just above 2:1. The median age was 48.85 years with the youngest being 14 years while the oldest operated was 80 years. However, the majority of patients 360 (71.28%) were from the active working group between the ages of 30 to 60 years.

A considerable number of patients were suffering from diabetes 142(35.5%), hypertension 168(33.2%) and dyslipidemia99(19.6%) were identified in this study indicating that stone disease had an association with metabolic syndrome. Chronic kidney disease was seen in 36(7.1%) patients.

The mean BMI was 25.32 kg m-2 (13.42- 44.23) with the majority of patients being overweight 213(42.2%) or obese 86(16.8%). The majority of patients were ASA I and II accounting for 92.5% of the study group. ASA III patients

Table 3. Surgical procedure related characteristics

No of tracts		
Single: multiple	467:38	92.5%:7.5%
Calyx puncture (main puncture)		
upper pole	7	1.5%
mid pole	167	33%
lower pole	331	65.5%
Rib puncture (main puncture)		
supracostal	5	1%
subcostal	500	99%
Operative time(min)	87	32- 211
Median Hospital stay	4	3-17
Stone free rate	84.1%	
Auxiliary procedures		
Second stage PCNL	3	0.6%
Simultaneous URS	21	4.1%
Interval URS	20	3.9%

who were morbidly obese and symptomatic patients who underwent recent cardiac stenting underwent the procedure safely. However, four ASA 1V patients with poor cardiac function underwent mPCNL under spinal anaesthesia. All the rest underwent general anaesthesia for the surgery.

Stone laterality was more or less equal. However, four patients underwent bilateral mPCNL in the same setting while three patients with solitary kidneys underwent the procedure safely. The majority had renal stones while 57(11.2%) patients had impacted upper ureteric stones associated with hydronephrosis. According to the GUYS score the majority of stones were Grade 1 290(57.3%). However, there were 22(4.3%) partial staghorn and 68(13.4%) complete staghorn in the series. The mean stone size of the index stone was 24.5 mm with the largest being 45 mm. Mean stone density was over 1064 HU indicating that the stones were very hard. However, the stone density ranged from 180 HU to 1800 HU. Stone analysis later found that the majority of stones were hard calcium oxalate monohydrate and/or dihydrate 210(62.8%). The second commonest stone type was a uric acid stone which was reported in 64 (19.1%). However, there were 42(12.5%) stones were mixed with having a combination of uric acid and calcium oxalate. There were other metabolic components also reported.

The single puncture was done in the majority while multi-tracts were created in 38(7.5%) patients. The lower calyceal puncture was achieved as the access in the majority 331 (65.5%)which was the most frequent site of the targeted puncture. The subcostal approach was selected in the majority to avoid a potential pleural injury. However, the supracostal puncture was necessary only in five patients. The overall stone-free rate was above 84.1%. The mean operative time was 87 min while the median hospital stay was 4 days. Mean hospital stay was 4 days. All procedures were

Table 4. Complications according to Clavien Dindo classification

Total complications		109	21.5%
I	Fever >38 C treated without antibiotics	17	9.8%
	Prolong nephrostomy leak managed conservatively	13	
	Deranged renal functions managed conservatively	7	
	Nephrostomy site bleeding/hematoma	2	
II	Blood transfusion	6	6.9%
	Pneumonia/ atelectasis	2	
	Colon perforation managed conservatively	1	
	Symptomatic UTI treated with antibiotics	24	
	Nephrostomy site infection	2	
III	Clot retention + clot evacuation	5	3.9%
	Angio embolization	3	
	Displaced DJ stent requiring repositioning	3	
	Collecting system perforation	8	
	Infundibular/PUJ stricture	1	
IV	Pulmonary oedema needing ICU care	2	0.9%
	Heart failure requiring ICU care	1	
	Arrhythmia requiring ICU care	2	
	Nephrectomy	0	
	MODS	0	
V	Death	0	0

successful and none of the patients were converted to open surgery. However, three surgeries were done as two-stage PCNL for staghorn calculi since there was considerable difficulty in visualizing stones due to bleeding where the complete fragmentation of the stone was deferred to a later date. Twenty-one patients underwent simultaneous ureteroscopy at the same setting to achieve complete stone clearance while a similar patient number underwent interval ureteroscopy during the stent removal to deal with significant residual stones.

Post-operative complications reported were classified according to the modified Clavien Dindo 2004. Overall complications were 21.5%. The commonest complication was culture-positive UTI developed postoperatively which needed prolong the course of antibiotics. These patients were mainly diabetics with large stone burdens who underwent surgery. Of the grade II complications, blood transfusion was required in 6 patients. Two patients each developed pneumonia and surgical site infection which were managed with IV antibiotics and supportive therapy. There was one patient with a colonic injury. It was incidentally detected in a patient who underwent multi-tract PCNL for a staghorn calculus where CT was done before the second stage. It was managed conservatively with prolonging antibiotics. He recovered completely.

However, in this series there was no damage to adjacent other viscera including liver injury, splenic injury inferior vena cava or diaphragmatic injury resulting in pneumothorax, all of which have been reported in the literature.

Of the grade III complications, five patients developed secondary haemorrhage and clot retention which were managed with clot evacuation. Of them, three out of four patients underwent angioembolization while the fourth failed to demonstrate a significant bleeder on angiography. Three patients developed persistent urine leak from the nephrostomy site due to double J stent dislodgment to the ureter which was repositioned back under fluoroscopy guidance. Collecting system perforation was noted in eight patients at the time of and all were managed with a slightly longer indwelling time of the double J stents and the open nephrostomy tubes. One patient underwent laser infundibulotomy and phlebotomy to deal with infundibular and a PUJ stricture. Four ASA III and one ASA IV patient needed intensive care support postoperatively which were not directly related to the surgery. All patients recovered completely. More importantly, there were no renal losses or death reported.

Discussion

Renal calculi are a major health hazard and a burden to the health care system in Sri Lanka. Its prevalence as in the rest of the world is increasing. In an era of minimally invasive surgery, the gold standard in surgical procedure for renal stones must ensure a high stone-free rate, increased manoeuvrability, minimal risk of haemorrhage, lower postoperative pain, shorter operative time and an overall shorter hospital stay.

Many studies have reported similar stone-free rates and comparable overall complication rates between mini-PCNL and standard PCNL when renal stones are less than 2.5 cm. When the stone size was around 1 cm or less mini-PCNL mini PCNL had a better stone-free rate compared to shock wave lithotripsy. On the other hand, mini-PCNL has shown better stone-free rates for the management of larger renal stones (>2 cm) and large impacted upper ureteral stones when compared with retrograde intrarenal lasertripsy [12,13].

After analyzing 15 randomized controlled trials involving 1474 patients were found comparable results in overall complications rate and blood transfusion when supine PCNL was compared with prone PCNL [14,15].

Supine PCNL apart from having a shorter operative time due to the single-stage positioning has many other added advantages over prone PCNL. These include a needle puncture that is directed laterally away from the fluoroscopy tube; therefore, reducing accidental radiation exposure to the surgeon's hand. PCNL tract is placed in a downward direction in a more dependent position; therefore, the irrigation fluid causing intrarenal pressure rise is minimal. Therefore, pyelorenal reflux is also minimized. With the jet of saline-injected, gravity is used to ease out stone fragments with the whirlpool effect that is created. Another advantage is that simultaneous access to the upper ureter, renal pelvis and the calyceal systems can be performed using ureteroscopy by a second surgeon to facilitate greater stone clearance since the patient is in the lithotomy position rather than in the prone position. This approach by a second surgeon was advantageous in 4% of patients in our series to achieve complete stone clearance. In addition, the procedure may be performed while the surgeon is seated making it more ergonomically friendly. The nephrostomy tube was placed on the lateral aspect rather than on the back of the patient making it far more comfortable for the patient to lie on their back during the postoperative recovery period [16].

When there is a significant success rate in the standard PCNL in prone position surgeons are reluctant to explore a new

Table 5. Cases series more than 100 mPCNL

Author	Resorlu et al[17]	Zeng et al[18]	Abdehafez et al[19]	Long et al[20]	Present study
Year	2012	2013	2013	2013	2021
N(patients)	106	12482	172	163	505
Stone burden(cm^2)	2.37	14.56	2.5	1.84	2.45*
Operative time(min)	76.3	83	82.9	83.8	87
Stone free rate (%)	85.8	78.6	83.8	95.7	84.1
Auxiliary procedure					
total (%)	14.4	23.1	13.1		8.6
PCNL	3.8	17	3.7	NR	0.6
SWL	5.6	3.2	0.5	NR	-
URS	-	2.9	8.9	NR	8
Clavien Dindo total					
Complications (%)	17	25.9	23	23.1	21.5
I		16.8	12	14.6	9.8
II	17	5	5.8	8.5	6.9
III	0	3.9	5.2	0	3.9
IV	0	0.05	0	0	0.9
V	0	0	0	0	0

* mean index stone maximum diameter in cm

method such as supine mini PCNL. But mini PCNL technique has now shown more favourable outcomes in terms of high stone-free rates and fewer complications due to the smaller tract [17, 18, 19, 20]. Even the few minor complications that we encountered in this study completely resolved with time. None of the patients in our study experienced any major complications such as death, renal loss or major haemorrhage.

In our opinion, when weighing the pros and cons, supine mPCNL by far outweighs the benefits of carrying out standard PCNL for renal stone disease. Experience gained over the years has allowed us to identify some tips and tricks in supine mPCNL to optimize its outcomes while minimizing complications. In our experience changing our practice to the novel, supine mini PCNL technique for the treatment of renal calculi hasn't been overly complicated. Our learning curve has been short in mastering the technique while showing a favourable outcome. Supine mPCNL can revolutionize the management of renal stones especially at the hands of a well-experienced endourologist.

All authors disclose no conflict of interest. The study was conducted in accordance with the ethical standards of the relevant institutional or national ethics committee and the Helsinki Declaration of 1975, as revised in 2000.

References

1. Feng MI, Tamaddon K, Mikhail A, Kaptein JS, Bellman GC. Prospective randomized study of various techniques of percutaneous nephrolithotomy. Urology. 2001 Sep;58(3):345-50. https://doi.org/10.1016/S0090-4295(01)01225-0
2. Yamaguchi A, Skolarikos A, Buchholz NP, Chomon GB, Grasso M, Saba P, et al. Operating times and bleeding complications in percutaneous nephrolithotomy: a comparison of tract dilation methods in 5,537 patients in the Clinical Research Office of the Endourological Society Percutaneous Nephrolithotomy Global Study. J Endourol. 2011 Jun;25(6):933-9. https://doi.org/10.1089/end.2010.0606
3. Helal M, Black T, Lockhart J, Figueroa TE. The Hickman peel-away sheath: alternative for pediatric percutaneous nephrolithotomy. J Endourol 1997;11:171-172. https://doi.org/10.1089/end.1997.11.171
4. Jackman SV, Docimo SG, Cadeddu JA, Bishoff JT, Kavoussi LR, Jarrett TW. The "mini-perc" technique: a less invasive alternative to percutaneous nephrolithotomy. World J Urol 1998;16:371-374. https://doi.org/10.1007/s003450050083
5. Nagele U, Schilling D, Sievert KD, Stenzl A, Kuczyk M. Management of lower-pole stones of 0.8 to 1.5 cm maximal diameter by the minimally invasive percutaneous approach. J Endourol 2008;22:1851-1853. https://doi.org/10.1089/end.2008.9791
6. Desai M R, Sharma R, Mishra S, Sabnis R B, Stief C, Bader M. Single-step percutaneous nephrolithotomy (microperc): the initial clinical report. J Urol 2011;186:140-145. https://doi.org/10.1016/j.juro.2011.03.029
7. Ferakis N, Stavropoulos M. Mini percutaneous nephrolithotomy in the treatment of renal and upper ureteral stones: Lessons learned from a review of the literature. Urol Ann 2015;7:141-148. https://doi.org/10.4103/0974-7796.152927
8. Yang Z, Song L, Xie D, Hu M, Peng Z, Liu T, et al. Comparative study of outcome in treating upper ureteral impacted stones using minimally invasive percutaneous nephrolithotomy with aid of patented system or transurethral ureteroscopy. Urology 2012;80:1192-1197. https://doi.org/10.1016/j.urology.2012.08.045
9. Zhong W, Zeng G, Wu W, Chen W, Wu K. Minimally invasive percutaneous nephrolithotomy with multiple mini tracts in a single session in treating staghorn calculi. Urol Res 2011;39:117-122. https://doi.org/10.1007/s00240-010-0308-z
10 Valdivia Uría JG, Valle Gerhold J, López López JA, Villarroya Rodriguez S, Ambroj Navarro C, Ramirez Fabián M, et al. Technique and complications of percutaneous nephroscopy: Experience with 557 patients in the supine position. J Urol. 1998;160:1975-8. https://doi.org/10.1016/S0022-5347(01)62217-1
11. Liu L, Zheng S, Xu Y, Wei Q. Systematic review and meta-analysis of percutaneous nephrolithotomy for patients in the supine versus prone position. J Endourol. 2010;24:1941-6. https://doi.org/10.1089/end.2010.0292
12. Kruck S, Anastasiadis AG, Herrmann TR, Walcher U, Abdelhafez MF, Nicklas AP, et al. Minimally invasive percutaneous nephrolithotomy: an alternative to retrograde intrarenal surgery and shockwave lithotripsy. World J Urol 2013;31:1555-1561. https://doi.org/10.1007/s00345-012-0962-6
13. Gu XJ, Lu JL, Xu Y. Treatment of large impacted proximal ureteral stones: randomized comparison of minimally invasive percutaneous antegrade ureterolithotripsy versus retrograde ureterolithotripsy. World J Urol 2013;31:1605-1610. https://doi.org/10.1007/s00345-013-1026-2
14. Falahatkar S, Moghaddam AA, Salehi M, et al.: Complete supine percutaneous nephrolithotripsy comparison with the prone standard technique. J Endourol. 2008;22(11):2513-7. https://doi.org/10.1089/end.2008.0463
15. Liangren L, Shou Z, Yong Xu, Qiang W Systematic Review and Meta-Analysis of Percutaneous Nephrolithotomy for Patients in the Supine Versus Prone Position. J Endourol. 2010 Dec;24(12):1941-6.https://doi.org/10.1089/end.2010.0292
16. Seneviratne N, Percutaneous renal stone surgery: redefining the better technique and lessons learnt in a developing country. The Sri Lanka Journal of Surgery 2018; 36(4): C 11-1 doi: http://doi.org/10.4038/sljs.v36i4.8553
17. Resorlu B, Unsal A, Tepeler A, Atis G, Tokatli Z, Oztuna D, et al. Comparison of retrograde intrarenal surgery and mini-percutaneous nephrolithotomy in children with moderate-size kidney stones: Results of multi-institutional analysis. Urology. 2012;80:519-23. https://doi.org/10.1016/j.urology.2012.04.018
18. Zeng G, Zhao Z, Wan S, Mai Z, Wu W, Zhong W, et al. Minimally invasive percutaneous nephrolithotomy for simple and complex renal caliceal stones: A comparative analysis of more than 10,000 cases. J Endourol. 2013 Oct;27(10):1203-8. https://doi.org/10.1089/end.2013.0061

19 Abdelhafez MF, Amend B, Bedke J, Kruck S, Nagele U, Stenzl A, et al. Minimally invasive percutaneous nephrolithotomy: A comparative study of the management of small and large renal stones. Urology. 2013 Feb;81(2):241-5. https://doi.org/10.1016/j.urology.2012.09.030

20. Long Q, Guo J, Xu Z, Yang Y, Wang H, Zhu Y, et al. Experience of mini-percutaneous nephrolithotomy in the treatment of large impacted proximal ureteral stones. Urol Int. 2013;90(4):384-8. https://doi.org/10.1159/000343668