Safety and efficacy of ambulatory tubeless mini-percutaneous nephrolithotomy in the management of 10–25 mm renal calculi

A retrospective study

Parsa Nikoufar[1], Amr Hodhod[2], Ruba Abdul Hadi[1], Loay Abbas[1], Sai K. Vangala[1], Ahmed S. Zakaria[1], Maher Gawish[3], Amer Alaref[4], Radu Rozenberg[4], Hazem Elmansy[1]

[1]Department of Urology, Thunder Bay Regional Health Sciences Centre, Northern Ontario School of Medicine, Thunder Bay, ON, Canada; [2]Department of Urology, King Abdulaziz Medical City, National Guard Hospitals Affairs, Riyadh, Saudi Arabia; [3]Department of Urology, Alazhar University, Assiut Branch, Assiut, Egypt; [4]Department of Radiology, Thunder Bay Regional Health Sciences Centre, Northern Ontario School of Medicine, Thunder Bay, ON, Canada

Cite as: Nikoufar P, Hodhod A, Abdul Hadi R, et al. Safety and efficacy of ambulatory tubeless mini-percutaneous nephrolithotomy in the management of 10–25 mm renal calculi: A retrospective study. *Can Urol Assoc J* 2024;18(10):341-7. http://dx.doi.org/10.5489/cuaj.8764

Published online June 10, 2024

See related commentary on page 348

ABSTRACT

INTRODUCTION: This study aimed to assess the safety and efficacy of ambulatory mini-percutaneous nephrolithotomy (mini-PCNL) in a totally tubeless exit (without a nephrostomy tube or an internal stent) and tubeless exit (without a nephrostomy tube but with an internal stent) for the treatment of renal calculi 10–25 mm in size.

METHODS: We conducted a retrospective analysis of patients who underwent mini-PCNL at our institution between September 2018 and September 2022. The study included a cohort of 95 patients diagnosed with renal calculi measuring 10–25 mm. All patients underwent a computed tomography (CT) renal colic scan preoperatively, on postoperative day one (POD 1), and at three-month followup. Patient demographics and outcome parameters were recorded, including stone characteristics, operative time, hospital stay, stone-free rate (SFR), complication rates, and subsequent emergency room (ER) visits. Patients were considered stone-free if they had no fragments or residual fragments measuring <4 mm.

RESULTS: The median maximum stone diameter was 16 mm (10–25 mm). Twenty-nine patients (30.5%) had multiple renal calculi. The median operative time was 64 (38–135) minutes. Eighty-six patients (90.5%) underwent a totally tubeless procedure, without a nephrostomy tube or an internal stent. All patients were discharged home on the same operative day with a median hospitalization time of six hours. Seven (7.4%) postoperative ER visits were recorded, and two (2.1%) led to hospital readmission. The frequency of grade I, II, and III Clavien-Dindo complications were 18 (18.9%), one (1.1%), and one (1.1%), respectively. The SFR on POD 1 and three-month followup was 73.7% and 92.6%, respectively. Two patients in the study required retreatment.

CONCLUSIONS: Ambulatory tubeless mini-PCNL is a safe and effective treatment option for 10–25 mm renal stones. Experienced institutions can safely adopt ambulatory mini-PCNL as a treatment option without an increased risk of postoperative complications, ER visits, or hospital readmissions.

INTRODUCTION

Percutaneous nephrolithotomy (PCNL) remains the preferred treatment option for renal stones >20 mm due to its higher success rate; however, it is associated with increased complication rates.[1,2] Traditionally, patients were admitted for observation following PCNL to monitor for signs and symptoms of complications.[2] The concept of miniaturized PCNL was introduced in 1998 and has evolved in recent years due to advancements in technology and the use of smaller instruments.[3-6]

The most widely adopted and extensively studied miniaturized PCNL technique is mini-PCNL. It provides a stone-free rate (SFR) comparable to standard PCNL while reducing the intraoperative and postoperative complications.[6-17] Mini-PCNL also increases the likelihood of achieving a totally tubeless exit (without a nephrostomy tube or an internal stent) compared to standard PCNL.[14-17]

Historically, the rationale for overnight observation was to monitor the risk of hemorrhage and sepsis. Nevertheless, systematic reviews and large case series have demonstrated low complication rates following PCNL, particularly in high-volume centers.[18,19] Numerous studies from high-volume institutions have explored the feasibility of ambulatory PCNL, reporting safe and successful implementation; however, widespread adoption has not followed, likely due to regional differences in practice patterns and surgical techniques, which make it harder to generalize their findings.[20-25]

Recent findings indicate a satisfactory safety record, high overall patient satisfaction, and a significant reduction of the total cost, enhancing the hospital's operating margin when opting for the ambulatory approach.[26,27] This study's primary objective was to evaluate the safety and efficacy of ambulatory tubeless mini-PCNL in managing 10–25 mm renal stones. The secondary objective was to determine the factors affecting SFR in our study population.

METHODS

After obtaining Research Ethics Board approval, we conducted a retrospective study of computed tomography (CT) scan-confirmed 10–25 mm renal stones managed with mini-PCNL from September 2018 to September 2022. Upon reviewing the medical records of enrolled patients, we verified the completeness of perioperative data and the presence of postoperative CT scans for evaluating residual stones on postoperative day one (POD 1) and three-month followup, along with information regarding stone composition.

Preoperative CT scans were reviewed, and stone characteristics, including stone number, stone site (upper pole, middle pole, lower pole, and renal pelvis), three-dimensional stone size (width [w], length [l], and height [h]), and stone density were recorded. Stone volume was calculated using the formula (π*l*w*d*0.167).[28] The presence of hydronephrosis and use of preoperative ureteral stents were also documented.

All procedures were conducted by a single surgeon (H.E.). At our institution, mini-PCNL cases are typically scheduled as outpatient procedures, with the primary goal of achieving a totally tubeless procedure (no nephrostomy tube or internal stent) unless there is an intraoperative indication for stent insertion (tubeless) or nephrostomy tube placement. The maximum stone size for mini-PCNL at our center is restricted to 30 mm. Patients with preoperative factors such as unfit medical conditions (e.g., cognitive disorders and uncontrolled cardiovascular disease) were excluded from early discharge. Individuals residing beyond city limits and those without a caregiver were also excluded. All patients had negative urine cultures before the procedure.

Operative time was recorded as the duration from the insertion of the cystoscope to skin closure. A prophylactic preoperative intravenous (IV) cefazoline was given to all patients. The procedure was performed under general anesthesia, starting in the lithotomy position with the insertion of a ureteric catheter under fluoroscopy. Subsequently, the patient's position was transitioned to the prone position. Access to the kidney was achieved using the triangulation technique or, occasionally, the bull's eye technique.

Mini-PCNL was performed using 16.5/17.5 Fr dilators and sheath with a 12 Fr nephroscope (Storz, Germany). Laser lithotripsy was carried out with a 100W Holmium:yttrium-aluminum-garnet (Ho:YAG) laser and a PowerFlex 200-micron laser fiber until December 2020. Subsequently, we adopted the MOSES™ technology P120 H laser system (Lumenis®Pulse) and a 200-micron laser fiber until September 2022.

Laser techniques (fragmentation, dusting, or both) were also recorded. Stone extraction was accomplished through a vacuum cleaner effect and/or a 1.5 Fr retrieval basket. Using flexible ureteroscopy in an antegrade fashion, all calyces were visually inspected for sizable residual stones.

The surgeon recovered the obtainable calculus fragments, sending some for chemical analysis. The attending urologist's decision for a totally tubeless exit or a tubeless exit (without a nephrostomy tube but with antegrade insertion of a ureteral stent) and the reason for stent insertion were recorded at the end of the procedure. Additionally, a gelatin matrix hemostatic sealant was injected into the tract followed by an intraoperative IV dose of Ketorolac.

After transferring the patient to the recovery room, they were asked to provide a pain score on a scale of 1–10. In cases where opioids were administered, we recorded the number and quantity administered. All patients were discharged from the hospital on the same operative day, and their length of hospital stay was recorded in hours. A complete blood count (CBC) was performed both before and after the procedure, and the difference between the two counts was documented. Predetermined discharge criteria included: whether the patient was deemed medically fit, had a caregiver; and met post-anesthesia care unit (PACU) discharge criteria.[29] Before discharge, patients were also required to have acceptable laboratory results, tolerate a diet, and be ambulating independently. Discharge instructions were explained to patients, including light activities for one week, avoiding lifting heavy objects for two weeks, and seeking medical advice in case of increasing pain or developed fever.

A postoperative low-dose CT scan was performed on POD 1 as an outpatient and at the three-month followup. A next-day CT scan was done to assess SFR and detect postoperative complications during our initial experience. The results were reviewed by both a radiologist and a urologist to assess for any residual stones, with the size and locations of any remaining stones recorded. The SFR was determined using two criteria:[30,31] no visual remnants (zero fragments) and fragments <4 mm (3 mm or less).

In addition, postoperative complications were closely monitored over 90 days and recorded, including emergency room (ER) visits, complaints during followup visits, and imaging results that indicated a complication. The complications were categorized and reported according to the Clavien-Dindo scale. Study participants were provided with the option to use Seamless MD (*www.seamless.md*), a comprehensive digital care platform. This platform enables remote monitoring and personalized guidance. Patient progress was systematically tracked, and our team performed postoperative followup phone calls. During these calls, we discussed postoperative CT scan results on POD 1 and diligently monitored patients for any complaints, including hematuria or renal colic.

Continuous variables were represented by their median values and ranges, while categorical variables were characterized through frequencies and percentages. Statistical analysis was performed using the Statistical Package for the Social Sciences (SPSS®) version 23.0 (IBM® Corporation, Chicago, IL, U.S.). Multivariate logistic regression models were employed to explore potential independent factors that may predict the stone-free status.

RESULTS

After exclusion of three patients, a total of 95 patients who underwent scheduled mini-PCNL day-surgery were included in the study. Two patients were excluded due to residing beyond city limits, and one patient because of an uncontrolled cardiovascular condition. Patient demographic data, stone characteristics, and preoperative variables are listed in Table 1. The median stone size was 16 mm (10–25 mm). Sixty-six cases (69.5%) involved a solitary stone, while 29 patients (30.5%) presented with multiple stones.

Intraoperative and perioperative data are included in Table 2. The median operative time was 64 minutes (38–135 minutes), and the median hemoglobin drop (intraoperative blood loss) was 14 g/L (4–45 g/L). One patient had a hemoglobin drop of 45 g/L. He was monitored for an additional four hours and was vitally stable. CBC was repeated twice, once before discharge and another one when he came for the next-day CT scan, and both showed stable hemoglobin. He didn't receive a blood transfusion because his hemoglobin level was 121 g/L, and blood transfusion is not indicated according to our institution's protocol for blood transfusion. The median hospital stay was six hours (4–7 hours), and none of the patients required an overnight hospital admission.

Table 1. Patient demographics

Parameter		Values
Total number of participants (n)		95
Gender, n (%)	Male	60 (63.2)
	Female	35 (36.8)
Age, years, median (range)		61 (27–79)
BMI, kg/m², median (range)		22 (18–41)
ASA score, n (%) (functional status)	I	53 (55.8)
	II	37 (38.9)
	III	5 (5.3)
Comorbidities, n (%)	Hypertension	19 (20)
	Diabetes mellitus	15 (15.8)
Stone size, mm, median (range)		16 (10–25)
Stone density, HU, median (range)		914 (350–1417)
Laterality, n (%)	Left	42 (44.2)
	Right	53 (55.8)
Stone number, n (%)	Single	66 (69.5)
	Multiple	29 (30.5)
Stone site, n (%)	Upper pole	5 (5.3)
	Middle pole	3 (3.2)
	Lower pole	50 (52.6)
	Pelvis	37 (38.9)
Hydronephrosis, n (%)	None	64 (67.4)
	Grade I and II	22 (23.2)
	Grade III and IV	9 (9.5)
Presence of preoperative stent, n (%)		9 (9.5)

ASA: American Society of Anaesthesiologists; BMI: body mass index; HU: Hounsfield units.

Eighty-six patients (90.5%) were discharged home totally tubeless, without the need for a nephrostomy tube or intraoperative stent insertion. In contrast, nine cases (9.5%) required intraoperative stent insertion at the conclusion of the procedure. The reasons for intraoperative stent insertion are outlined in Table 2. All stents were removed at 2–4 weeks postoperatively.

A total of seven ER visits were documented, with three related to hematuria, two to renal colic, and two

Table 2. Perioperative findings		
Parameter		Values (N=95)
Operative time, min		64 (38–135)
Number of working tracts, n (%)	Single	92 (96.8)
	Multiple	3 (3.2)
Puncture technique, n (%)	Triangulation	70 (73.7)
	Bull's eye	25 (26.3)
Postoperative ureteral stent insertion (by indication), n (%)	Total	9 (9.5)
	Ureteral injury	2 (2.1)
	Ureteropelvic edema	3 (3.2)
	Migrated stone	4 (4.2)
Totally tubeless, n (%)		86 (90.5)
Intraoperative blood loss (Hg drop), g/L, median (range)		14 (4–45)
Blood transfusion, n (%)		0 (0)
Pain score in the recovery room, median (range)		1 (0–7)
Use of opioids in the recovery room, n (%)		8 (8.4)
Length of hospital stay, hours, median (range)		6 (4–7)
Postoperative ER visit, n (%)		7 (7.4)
Readmission, n (%)		2 (2.1)
Retreatment, n (%)		2 (2.1)
Perioperative complications, n (%)	Clavien–Dindo Grade I	18 (18.9)
	Clavien–Dindo Grade II	1 (1.1)
	Clavien–Dindo Grade III	1 (1.1)

ER: emergency room; Hg: hemoglobin.

to postoperative fever. The 90-day complication rates were recorded according to the Clavien-Dindo classification system of surgical complications.

Clavien I complications were observed in 18 cases, accounting for 18.9% of the total cases. These complications included one instance of hematuria with clot passage, 13 cases of prolonged hematuria without clot passage, and four cases of renal colic, with one of them requiring the insertion of an intraoperative stent. Thirteen of the 20 patients who experienced postoperative complications opted not to visit the ER; instead, they were provided reassurance via a phone call from a member of the urology team.

All cases were managed expectantly. A Clavien II complication included one patient who presented with a low-grade fever with mild hydronephrosis (without detected stone fragments) and was treated with oral antibiotics. Clavien III complications included a case of moderate-grade fever postoperatively due to urosepsis that was treated with stent insertion under general anesthesia (Clavien IIIa). The readmission rate was 2.1% due to postoperative fever.

Postoperative outcomes are presented in Table 3. On POD 1, the SFR, defined as the absence of residual fragments measuring 0 mm, was 56.8%. In contrast, an SFR of 73.7% was achieved when a cutoff of <4 mm was used. At the three-month postoperative CT assessment, the SFR remained favorable at 87.4% with a cutoff of 0 mm, and it increased to 92.6% when a cutoff of <4 mm was applied. Notably, only two patients (2.1%) required flexible ureteroscopy (F-URS) for the management of residual stones. Multivariate logistic regression analysis indicated that no factors significantly impacted the presence of residual stones on POD 1.

DISCUSSION

Due to the constraints on hospital resources and healthcare accessibility brought about by the COVID-19 pandemic, we initiated measures to enhance the quality of care. The unprecedented experience underscored the significance of efficiently using healthcare resources, improving patient care and satisfaction, while simultaneously decreasing medical expenditures.

One of the essential aspects of cost reduction in PCNL is lowering the average length of hospital stay. With recent technological advancements in PCNL, there has been a notable increase in the adoption of ambulatory PCNL, allowing patients to be discharged within 24 hours.[23,24,27,32,33]

The adoption of an ambulatory PCNL program may not be feasible for all institutions, urologists, or patients. It is crucial that the attending surgeon possesses the necessary skills and receives training in managing a high volume of cases. Moreover, an experienced healthcare team ensures that the perioperative process aligns with the complexity and unique aspects of PCNL. Establishing precise inclusion and exclusion criteria is imperative to guarantee the highest level of patient safety.

In this study, we present our findings from a cohort of 95 patients who underwent planned ambulatory mini-PCNL. Wu and colleagues reported the results of a retrospective data of planned day-surgery PCNL with a mean stone diameter of 33 mm. The average operative time was 64 minutes, which is similar to our data. A total of 95.4% of patients in their study were either discharged on the same day or placed under overnight observation before discharge, while four patients (4.6%) necessitated a full admission exceeding

24 hours.[23] Contrary to our findings, it is worth noting that all patients in Wu et al's study received either a ureteral double-J stent or an external catheter. Tubeless procedures without a nephrostomy tube were performed in 60.5% of cases.[23]

In their randomized controlled trial (RCT), Dutta et al assessed the outcomes of ureteroscopy vs. prone mini-PCNL for the management of 1–2 cm renal stones. Renal drainage was favored using a 14 Fr Foley catheter as a nephrostomy tube, a ureteral stent, or, in specific cases, a totally tubeless approach. A notable distinction between their trial and our retrospective data lies in the duration of hospitalization, as patients in their mini-PCNL group stayed overnight, whereas our study typically resulted in a six-hour hospital stay. Additionally, their trial included postoperative CT scans conducted between POD 1 and 30.[32]

In our cohort, 3.2% of patients required more than one tract access with a totally tubeless discharge. In Zhao et al's retrospective review, which used propensity score matching, 86 patients who underwent planned day-PCNL were matched to another 86 patients who required a minimum two-day postoperative hospital stay following the same procedure. The hospital stay for day-PCNL patients averaged 13.6 hours, and double-J stents were routinely inserted. The frequency of multiple tract usage was slightly lower in the planned day-PCNL group (9.3%) compared to the admitted group (12.8%).[24]

The primary obstacle preventing PCNL from being conducted as outpatient surgery is the management and treatment of postoperative complications. Patients in our hospital typically receive a phone call the following day from a member of the urology team and are monitored for postoperative complications with the Seamless MD digital care platform. In our cohort, the overall complications rate was 21.1% including Clavien I (18.9%), Clavien II (1.1%), and Clavien III (1.1%). Among the 20 patients who experienced postoperative complications, 13 (65%) chose not to visit the ER and received reassurance via phone calls from the urology team. The readmission rate, attributed to postoperative fever, was 2.1%.

Jones and colleagues' systematic review evaluating the safety and efficacy of day-case PCNL surgery with a mean stone size of 20.5 mm documented an average hospital stay of 17.5 hours. The results showed an overall complication rate of 13.5%, primarily comprising Clavien I or II complications, with an associated 3% hospital readmission rate.[33]

Zhao et al reported an overall complication rate of 11.6% in the day-care mini-PCNL group, consisting of 7% Clavien I, 2.3% Clavien II, and 2.3% Clavien III complications. Notably, among the eight (9.3%) patients who underwent multiple tracts, there was no significant increase in the complication rate. Additionally, the readmission rate for day-care mini-PCNL patients was at 2.3%.[24]

Table 3. Postoperative outcomes

Parameter			Values (N=95)
Day 1 postoperative CT	Stone-free rate, n (%)	Cutoff 0 mm	54 (56.8)
		Cutoff <4 mm	70 (73.7)
	Presence of residual stone ≥4 mm, n (%)		25 (26.3)
	Residual stone size, mm, median (range)		0 (0–10)
3-month postoperative CT	Stone-free rate, n (%)	Cutoff 0 mm	83 (87.4)
		Cutoff <4 mm	88 (92.6)
	Presence of residual stone ≥4 mm, n (%)		7 (7.4)
	Residual stone size, mm, median (range)		0 (0–9)
Stone composition	Calcium oxalate monohydrate, n (%)		43 (45.3)
	Calcium oxalate dihydrate, n (%)		32 (33.7)
	Uric acid, n (%)		12 (12.6)
	Calcium phosphate, n (%)		8 (8.4)

CT: computed tomography.

In their RCT, Dutta and colleagues observed that the SFR on POD 1, determined using CT criteria, was greater in the mini-PCNL group when using a 2 mm cutoff (76%) compared to our cohort's use of a <4 mm cutoff (73.7%). Similarly, when applying a strict 0 mm cutoff, the SFR was also higher in their mini-PCNL group (67%) as opposed to our cohort (56.8%).[32] Furthermore, the retreatment rate for residual stones was 4% in their study, whereas it was 2.1% in our cohort. Serra et al's retrospective study, found that the SFR, defined as the absence of residual stones confirmed by ultrasound or CT scan three months after the intervention, was 83%. Only one patient (3%) required retreatment with ureteroscopy.[27]

Despite the presence of advanced laser technologies (i.e., TFL and MOSES™) at our institution, many patients opt for mini-PCNL to avoid stent-related symptoms. In addition, we use a ureteral access sheath with stent insertion in nearly all cases of F-URS managing kidney stones >1 cm. Additionally, we believe that renal anatomy, including factors such as the infundibular-pelvic angle, infundibulum width, and length, can influence the success rate, particularly in the lower pole calyx when F-URS is used, which represents over 50% of cases in our cohort.

Limitations

This study has certain limitations. Firstly, it is a retrospective study conducted at a single center, involving a relatively small group of patients. Secondly, it lacks a control group that underwent conventional inpatient mini-PCNL, which prevents us from making comparisons regarding complications or readmission rates to the ER or hospital. Additionally, our results were achieved by a single surgeon with extensive experience with mini-PCNL and may be difficult to replicate by someone earlier in their learning curve. A definitive clinical protocol for safely assessing unplanned readmissions during the initial postoperative phase following ambulatory mini-PCNL has not been established. Moreover, it is essential to exercise meticulous perioperative management, and larger well-structured research studies are needed in this area.

CONCLUSIONS

Mini-PCNL is a safe and efficient technique for treating 10–25 mm kidney stones. Experienced institutions can safely adopt ambulatory mini-PCNL as a treatment option without an increased risk of postoperative complications, ER visits, or hospital readmissions. Most complications can be managed conservatively, with only a minimal number necessitating interventions.

COMPETING INTERESTS: Dr. Elmansy is an investigator for Urotronic Inc. (Laborie) and Zenflow Inc; and previously received honoraria and a research grant from Boston Scientific. The remaining authors do not report any competing personal or financial interests related to this work.

ACKNOWLEDGMENT: The authors would like to thank Dr. Walid Shahrour and Dr. Waleed Shabana for their valuable advice.

This paper has been peer reviewed.

REFERENCES

1. Ur Rehman O, Imran M, Rafaqat M, et al. Outcomes in lower pole kidney stone management using mini-percutaneous nephrolithotomy compared with retrograde intra renal surgery: A randomized controlled trial. *Cureus* 2023;15:e35343. https://doi.org/10.7759/cureus.35343
2. Assimos D, Krambeck A, Miller NL, et al. Surgical management of stones: American Urological Association/Endourological Society guideline, PART I. *J Urol* 2016;196:1153-60. https://doi.org/10.1016/j.juro.2016.05.090
3. 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;7:141-8. https://doi.org/10.4103/0974-7796.152927
4. Mishra S, Sharma R, Garg C, et al. Prospective comparative study of mini-perc and standard PNL for treatment of 1 to 2 cm size renal stone. *BJU Int* 2011;108:896-9; discussion 9-900. https://doi.org/10.1111/j.1464-410X.2010.09936
5. Ruhayel Y, Tepeler A, Dabestani S, et al. Tract sizes in miniaturized percutaneous nephrolithotomy: A systematic review from the European Association of Urology Urolithiasis Guidelines Panel. *Eur Urol* 2017; 72:220-35. https://doi.org/10.1016/j.eururo.2017.01.046
6. Wright A, Rukin N, Smith D, et al. 'Mini, ultra, micro' - nomenclature and cost of these new minimally invasive percutaneous nephrolithotomy (PCNL) techniques. *Ther Adv Urol* 2016;8:142-6. https://doi.org/10.1177/1756287215617674
7. Jiao B, Luo Z, Huang T, et al. A systematic review and meta-analysis of minimally invasive vs. standard percutaneous nephrolithotomy in the surgical management of renal stones. *Exp Ther Med* 2021;21:213. https://doi.org/10.3892/etm.2021.9645
8. Kandemir E, Savun M, Sezer A, et al. Comparison of miniaturized percutaneous nephrolithotomy and standard percutaneous nephrolithotomy in secondary Patients: A randomized prospective study. *J Endourol* 2020;34:26-32. https://doi.org/10.1089/end.2019.0538
9. Qin P, Zhang D, Huang T, et al. Comparison of mini percutaneous nephrolithotomy and standard percutaneous nephrolithotomy for renal stones >2 cm: A systematic review and meta-analysis. *Int Braz J Urol* 2022;48:637-48. https://doi.org/10.1590/s1677-5538.ibju.2021.0347
10. Wan C, Wang D, Xiang J, et al. Comparison of postoperative outcomes of mini percutaneous nephrolithotomy and standard percutaneous nephrolithotomy: A meta-analysis. *Urolithiasis* 2022;50:523-33. https://doi.org/10.1007/s00240-022-01349-8
11. Zeng G, Cai C, Duan X, et al. Mini percutaneous nephrolithotomy is a noninferior modality to standard percutaneous nephrolithotomy for the management of 20-40 mm renal calculi: A multicenter, randomized, controlled trial. *Eur Urol* 2021;79:114-21. https://doi.org/10.1016/j.eururo.2020.09.026
12. Cheng F, Yu W, Zhang X, et al. Minimally invasive tract in percutaneous nephrolithotomy for renal stones. *J Endourol* 2010;24:1579-82. https://doi.org/10.1089/end.2009.0581
13. Guler A, Erbin A, Ucpinar B, et al. Comparison of miniaturized percutaneous nephrolithotomy and standard percutaneous nephrolithotomy for the treatment of large kidney stones: A randomized prospective study. *Urolithiasis* 2019;47:289-95. https://doi.org/10.1007/s00240-018-1061-y
14. Desai MR, Kukreja RA, Desai MM, et al. A prospective randomized comparison of type of nephrostomy drainage following percutaneous nephrostolithotomy: Large bore vs. small bore vs. tubeless. *J Urol* 2004;172:565-7. https://doi.org/10.1097/01.ju.0000130752.97414.c8
15. Borges CF, Fregonesi A, Silva DC, et al. Systematic review and meta-analysis of nephrostomy placement vs. tubeless percutaneous nephrolithotomy. *J Endourol* 2010; Epub ahead of print. https://doi.org/10.1089/end.2010.0231
16. Wang J, Zhao C, Zhang C, et al. Tubeless vs. standard percutaneous nephrolithotomy: A meta-analysis. *BJU Int* 2012;109:918-24. https://doi.org/10.1111/j.1464-410X.2011.10463.x
17. Veser J, Fajkovic H, Seitz C. Tubeless percutaneous nephrolithotomy: Evaluation of minimal invasive exit strategies after percutaneous stone treatment. *Curr Opin Urol* 2020;30:679-83. https://doi.org/10.1097/MOU.0000000000000802
18. Seitz C, Desai M, Hacker A, et al. Incidence, prevention, and management of complications following percutaneous nephrolitholapaxy. *Eur Urol* 2012;61:146-58. https://doi.org/10.1016/j.eururo.2011.09.016
19. Emmott AS, Brotherhood HL, Paterson RF, et al. Complications, re-intervention rates, and natural history of residual stone fragments after percutaneous nephrolithotomy. *J Endourol* 2018;32:28-32. https://doi.org/10.1089/end.2017.0618
20. Beiko D, Lee L. Outpatient tubeless percutaneous nephrolithotomy: the initial case series. *Can Urol Assoc J* 2010;4:E86-90. https://doi.org/10.5489/cuaj.886
21. Aldoukhi AH, Black KM, Shields J, et al. Ambulatory tubeless mini-percutaneous nephrolithotomy using moses technology and dusting technique. *Urology* 2019;124:306. https://doi.org/10.1016/j.urology.2018.11.007
22. Tian Y, Yang X, Luo G, et al. Initial prospective study of ambulatory mPCNL on upper urinary tract calculi. *Urol J* 2020;17:14-8.
23. Wu X, Zhao Z, Sun H, et al. Day-surgery percutaneous nephrolithotomy: A high-volume center retrospective experience. *World J Urol* 2020;38:1323-8. https://doi.org/10.1007/s00345-019-02942-0
24. Zhao Z, Sun H, Wu X, et al. Evaluation of day-care versus inpatient mini-percutaneous nephrolithotomy: A propensity score-matching study. *Urolithiasis* 2020;48:209-15. https://doi.org/10.1007/s00240-019-01160-y
25. Zhao Z, Yin S, Zhu H, et al. The feasibility of multiple-tract mini-percutaneous nephrolithotomy as an overnight surgery for the treatment of complex kidney stones. *Urolithiasis* 2021;49:167-72. https://doi.org/10.1007/s00240-020-01208-4
26. Thakker PU, Mithal P, Dutta R, et al. Comparative outcomes and cost of ambulatory PCNL in select kidney stone patients. *Urolithiasis* 2022;51:22. https://doi.org/10.1007/s00240-022-01392-5

27. Abella Serra A, Colom Feixas S, Torrecilla Ortiz C, et al. Initial results of the implementation of an ambulatory mini percutaneous nephrolithotomy program. *Actas Urol Esp* (Engl Ed) 2023;47:450-6. https://doi.org/10.1016/j.acuro.2023.03.010
28. Geraghty RM, Davis NF, Tzelves L, et al. Best practice in interventional management of urolithiasis: An update from the European Association of Urology Guidelines Panel for Urolithiasis 2022. *Eur Urol Focus* 2023;9:199-208. https://doi.org/10.1016/j.euf.2022.06.014
29. Palumbo P, Tellan G, Perotti B, et al. Modified PADSS (Post Anaesthetic Discharge Scoring System) for monitoring outpatients discharge. *Ann Ital Chir* 2013;84:661-5.
30. Ulvik O, Harneshaug JR, Gjengsto P. What do we mean by "stone free," and how accurate are urologists in predicting stone-free status following ureteroscopy? *J Endourol* 2021;35:961-6. https://doi.org/10.1089/end.2020.0933
31. Ghani KR, Wolf JS Jr. What is the stone-free rate following flexible ureteroscopy for kidney stones? *Nat Rev Urol* 2015;12:281-8. https://doi.org/10.1038/nrurol.2015.74
32. Dutta R, Mithal P, Klein I, et al. Outcomes and costs following mini-percutaneous nephrolithotomy or flexible ureteroscopic lithotripsy for 1-2 cm renal stones: Data from a prospective, randomized clinical trial. *J Urol* 2023;209: 151-8. https://doi.org/10.1097/JU.0000000000003397
33. Jones P, Bennett G, Dosis A, et al. Safety and efficacy of day-case percutaneous nephrolithotomy: A systematic review from European Society of Uro-technology. *Eur Urol Focus* 2019;5:1127-34. https://doi.org/10.1016/j.euf.2018.04.002

CORRESPONDENCE: Dr. Hazem Elmansy, Thunder Bay Regional Health Sciences Centre, Northern Ontario School of Medicine, Thunder Bay, ON, Canada; hazem.mansy@rocketmail.com