PROFILE OF NEPHROLITHIASIS PATIENTS TREATED WITH MINI-PERCUTANEOUS NEPHROLITHOTOMY (MINI-PCNL): A SINGLE CENTER EXPERIENCE IN JAMBI, INDONESIA

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ABSTRACT

Objective: *This study aims to describe the characteristics of patients undergoing mini-PCNL at our center in Jambi, Indonesia.* ***Material & Methods:*** *This is a descriptive study involving patients with kidney stones treated with mini-PCNL during 2017 – 2021 in Jambi. The selection of the study subjects was using total sampling method. All patients had a medical history taken and a physical examination performed prior to surgery. The procedure was performed by three operators in one referral district hospital.* ***Results:*** *From 2017 to 2021, a total of 188 mini-PCNL procedures were performed at our center for the removal of kidney stones. However, only 186 cases were included in this study after excluding 2 due to incomplete data. The mean age of patients in this study was 49.3 years old (ranging from 12–87 years old) with the majority being male (101/165 [61.21%]). Of 186 cases, a total of 175 cases had no residual stone and only 11 had residual stone (stone-free rate [SFR] 94.08%). Most patients presented with hydronephrosis, and DJ stent placement was performed in 44 out of 186 cases. The SFR decreased as the stone size increased.* ***Conclusion:*** *Mini-PCNL proves to be a valuable choice for managing kidney stones, especially for medium-sized and hard stones, leading to enhanced patient results and reduced post-operative complications.*

Keywords: *Kidney stone, mini-PCNL, stone free rate.*

ABSTRAK

Tujuan: *Penelitian ini bertujuan untuk mendeskripsikan karakteristik pasien yang menjalani mini-PCNL di pusat kami di Jambi, Indonesia.* ***Bahan & Cara:*** *Ini adalah studi deskriptif yang melibatkan pasien batu ginjal yang diobati dengan mini-PCNL selama 2017 – 2021 di Jambi. Pemilihan subjek penelitian menggunakan metode total sampling. Semua pasien memiliki riwayat medis yang diambil dan pemeriksaan fisik dilakukan sebelum operasi. Prosedur dilakukan oleh tiga operator di satu rumah sakit kabupaten rujukan.* ***Hasil:*** *Selama periode 2017 hingga 2021, pusat kami telah melakukan 188 prosedur mini-PCNL untuk pengangkatan batu ginjal. Namun, hanya 186 kasus yang dimasukkan dalam studi ini setelah mengesampingkan 2 kasus karena data yang tidak lengkap. Dari 186 kasus tersebut, sebanyak 165 pasien menjalani prosedur mini-PCNL. Usia rerata pasien dalam penelitian ini adalah 49.3 tahun (berkisar antara 12-87 tahun) dengan mayoritas laki-laki (101/165). [61.21%]). Waktu operasi rerata adalah 113.5 ± 50.5 menit, dan rerata lama tinggal di rumah sakit adalah 2.8 ± 1.3 hari. Dari 186 kasus, sebanyak 175 kasus tidak memiliki sisa batu dan hanya 11 yang memiliki sisa batu (stone-free rate [SFR] 94.08%). Sebagian besar pasien mengalami hidronefrosis, dan penempatan DJ stent dilakukan pada 44 dari 186 kasus. SFR menurun seiring dengan peningkatan ukuran batu.* ***Simpulan:*** *Mini-PCNL terbukti menjadi pilihan yang baik untuk mengelola batu ginjal, terutama untuk batu berukuran sedang dan keras, memberikan hasil yang lebih baik dan mengurangi komplikasi pasca-operasi.*

Kata kunci: *Batu ginjal, mini-PCNL, stone free rate.*

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INTRODUCTION

Globally, there has been an increase in the incidence and prevalence of nephrolithiasis, which is unique to climate and socioeconomic status.[1-2] With the development of the minimally invasive endourological procedure, there has been a paradigm shift in the management of nephrolithiasis.

Percutaneous nephrolithotomy (PCNL) is recommended as the first line of treatment for renal stones larger than 20 mm in size, according to international guidelines. For stones ranging in size from 10 to 20 mm, treatment options include shock wave lithotripsy (SWL), PCNL, or retrograde intrarenal surgery (RIRS).[3-4] Since 1976, the PCNL procedure has evolved and many modifications and refinements in the techniques and instruments have been made to achieve maximum stone clearance with minimal complications. One of them is miniaturizing the access sheath. Standard PCNL is done with sheath sizes ranging from 24 to 30 F, whereas mini-PCNL is done with sheath sizes ranging from 14 to 20 F.[5] According to a meta-analysis[6] published in 2015, the size of the PCNL access sheath is important. Mini PCNL is less dangerous and has the same efficacy rate for the treatment of renal stones.[7]

OBJECTIVE

In this study, we aim to describe the characteristics of patients undergoing mini-PCNL at our center in Jambi, Indonesia.

MATERIAL & METHODS

This is a descriptive study involving patients with kidney stones treated with mini-PCNL during 2017 - 2021 in Jambi, Indonesia. The selection of the study subjects was using total sampling method. All patients had a medical history taken and a physical examination performed prior to surgery. All patients had urine analysis, complete count, renal function test, serum electrolytes, bleeding tendency profile, and fasting blood sugar performed. Preoperative ECG, echocardiography, and chest X-rays are performed on selected patients. Ultrasonography, intravenous pyelography, including (KUB), or CT-urography are used to determine the location, size, and laterality of the stone, as well as the anatomy of the pelvicalyceal system.

Following the induction of spinal anesthesia, patients were placed in the dorsal lithotomy position, a urethral cystoscope was performed with a 20 Fr rigid cystoscope, and a hydrophilic guide wire was inserted into the relevant ureter. Then a 5 Fr open-ended ureter catheter was advanced and a 16 Fr Foleys catheter was fixed. The patient was in supine position, and 50% diluted nonionic contrast material was pushed through the ureteric catheter under fluoroscopy, and all calyces were allowed to fill with radio-opaque material. Under C-arm fluoroscopy, an 18-gauge needle (Shiba) was inserted into the targeted calyx (usually the lower calix), a guide wire was passed through to the pelvicalyceal system, and Alken metal dilatators were inserted into the kidney over the guide wire.

Then a 22 Fr operating sheath was inserted above the dilators, and the lower calyx was entered with an 18 Fr nephroscope, and the pelvicalyceal system and stones were evaluated. Stones were either taken without fragmentation or fragmented with a pneumatic lithotripter if necessary. Large stones, on the other hand, were fragmented and removed. Fluoroscopy and a nephroscope were used at the end of surgery to confirm complete stone clearance inside the kidney. A20 Fr nelaton tube was used as a nephrostomy tube in some patients. Furthermore, depending on local tissue trauma and the amount of gravel left behind, DJ stent insertion was optional. In this study, the stone-free rate is defined as residual stone less than 4 mm based on ultrasound (US), X-ray, or CT post-surgery.

RESULTS

During the period of 2017-2021, our center had been performed 188 mini-PCNL procedure for the removal of kidney stones. However there were only 186 cases included in this study (2 were excluded due to incomplete data). Of 186 cases, the number of patients was only 165 patients (some patients having more than one mini-PCNL performed). The mean age of patients in this study was 49.3 years old (ranging from 12-87 years old) with the majority being male (101/165 [61.21%]).

The mean operation time was 113.5 ± 50.5 minutes and the mean hospital stays were 2.8±1.3 days (Table 2). Of 186 cases, a total of 175 cases had no residual stone and only 11 had residual stone; thus, it can be calculated that the stone-free rate (SFR) was 94.08%. The majority of patients in this study also present with hydronephrosis and DJ stent placement was done in 44/186 cases. The stone-free rate decreased as the stone size increased. The significant relationship between the stone-free rate and stone size was found, with a p-value of 0.0001. (Table 3). The patient's profile is summarized in Table 1.

Table 1. Patients Profile.

Characteristics	Frequency (N = 186)	No of patients (N = 165)
Age (years)		
Mean (Range)	49.3 (12–87)	
≤20	3 (1.61%)	2 (1.21%)
21–30	5 (2.69%)	5 (3.03%)
31–40	34 (18.28%)	29 (17.57%)
41–50	51 (27.42%)	46 (27.88%)
51–60	61 (32.80%)	54 (32.73%)
≥60	32 (17.20%)	29 (17.58%)
Sex		
Male	118 (63.44%)	101 (61.21%)
Female	68 (36.56%)	64 (38.78%)
Stone Size		
10–15 mm	92 (49.46%)	-
>15–20 mm	42 (22.58%)	-
>20–25 mm	26 (13.97%)	-
>25 mm	26 (13.97%)	-
Residual stone		
Yes	11 (5.91%)	-
No	175 (94.08%)	-
Hydronephrosis		-
Yes	83 (44.62%)	
No	103 (55.37%)	

Table 2 . Intraoperative & post operative data.

Intraoperative & Post-operative Data	N = 186 (%)
Hospital stay (days)	2.8±1.3
Hemoglobin drop (mg/dl)	0.93 ± 1
Mean operation time (minutes)	113.5 ± 50.5
Stone-free rate	94.08%
DJ Stent	44 (23.66%)
Nephrostomy	21 (11.29%)
Tubeless	121 (65.05%)

Table 3. Stone-free rate based on stone size.

Stone Size	Stone-free rate		Total	P value
	Success (%)	Fail (%)		
10-15 mm	90 (83.59)	2 (8.41)	92	
>15-20 mm	79 (85.41)	15 (8.59)	94	0,001
Total	169	17	186	

DISCUSSION

Throughout the literature, the term "mini-perc" refers to access sheath sizes ranging from 11 to 20 Fr. Given the new terminology, we believe the term 'mini' should be used more specifically to describe access sheaths sized 14-20Fr.[5] The concept of miniaturizing the PCNL cross-section was first reported by Jackman, who described the use of a miniaturized nephroscope in children. The outcomes were satisfactory, and the complication rate was low. Jackman did not use a mini-nephroscope that had been specially designed. The question was whether miniaturized PCNL could be used to treat upper urinary tract stones in adults, who make up the majority of stone patients.[8-9]

Because of its higher safety profiles, mini-PCNL has become an increasingly popular alternative for the management of renal stones since its first use in 1997.[7] Mini-PCNL was recommended by Lahme to treat all types of upper urinary tract calculi larger than 10 mm in diameter, and it is regarded as a treatment alternative to flexible ureterorenoscopic lithotripsy (URSL), shock wave lithotripsy (SWL), and conventional PCNL.[9] The indications for miniaturized PCNL have not yet been standardized. Mini-PCNL, which was initially used in a pediatric population, has gradually become the procedure of choice in this subset of patients as a safe and effective alternative to standard PCNL. Traditionally, medium-sized (1.5-3 cm) and hard stones (>1000 Hounsfield units [HU]) are the best indicators for mini-PCNL.[10]

Anesthesia is required for percutaneous nephrolithotomy. To check for stones, a small skin incision is made and a nephroscope is advanced into the renal pelvicalyceal system.[11] The nephroscope has a cross-section of 12F and is used in conjunction with a reusable stainless steel Amplatz sheath with an inner diameter of 15F and an outer diameter of 18F. The kidney is punctured using ultrasound guidance. The dilation is accomplished with the aid of a special stainless steel dilator that is custom-made to fit the Amplatz sheath. This means that the dilation is done in "single-step dilation." The guidewire is inserted after successfully puncturing the calyceal system. The stainless steel dilator is then placed over the guidewire, followed by the stainless steel Amplatz sheath.[9]

According to Lahme, the Amplatz sheath is used to insert the 12F Mini-nephroscope. Stones are fragmented through the nephroscope using either laser or pneumatic lithotripsy.[11] The use of a holmium laser is advised because it facilitates disintegration by dusting. It is critical to understand that there is a space between the Amplatz sheath's inner part and the Mini-Nephroscope. This area is required in order to wash away the stone fragments. Only irrigation allows stone fragments to exit the calyceal system through the Amplatz sheath. Active stone removal, such as with forceps or a basket, is not advised or required in Mini-PCNL. The unique effect in Mini-PCNL of small stone fragments automatically exiting the calyceal system via the irrigation backflow was discovered by chance. This effect is determined by the specific proportion of the Amplatz sheath length and diameter. This effect was not anticipated during the development of Mini-PCNL. However, in today's world, this effect is the main advantage of Mini-PCNL because it eliminates the time required for active stone removal in conventional PCNL. As a result, Mini-PCNL and conventional PCNL have comparable operating times.[9]

In various studies, the average age of participants was reported differently. Thakur et al. found that the mean age was 36.4 years, with a range of 19 to 62 years. Agrawal et al. reported a similar mean age of 36.7 years, ranging from 12 to 74 years. In contrast, Mahmood reported a slightly higher average age of 42.75 years, with a standard deviation of 16.15.

In similar studies, the gender distribution varies. In the research by Hosseini MM, the male-to-female ratio was 61.60% to 38.39%. Mahmood SN found a ratio of 71.7% males to 28.3% females. Meanwhile, Agrawal SM observed a distribution of 64.16% males and 36.84% females. In Thakur APS et al.'s study, the gender ratio was 70% males and 30% females. These findings highlight the diversity in gender distribution in similar studies that should be taken into consideration.

Differences in sex steroids leading to distinct conditions in males and females could explain gender disparities. As individuals age, testosterone levels tend to decline progressively, and androgen signaling is known to be a risk factor for nephrolithiasis. Notably, the presence of androgen receptors in the kidneys of patients with renal calculi was significantly increased. Exogenous testosterone can raise the risk of stone formation, whereas androgen deprivation therapy and finasteride can lower the risk of kidney stones.

Mini-PCNL had a significant advantage over standard PCNL in terms of reduced bleeding, which led to a higher chance of tubeless surgery and a shorter hospital stay. In a study by Long et al., the average hospital stay for patients was 3.6 days (ranging from 2 to 6 days). Another study by Wishahi et al. found that the hospital stays for mini-PCNL patients were (2.05±0.9) days, in contrast to (3.4±1.1) days for standard-PCNL patients. Moreover, a systematic review and meta-analysis conducted by Zhu et al. demonstrated that the mini-PCNL group had shorter hospitalizations, implying a significant advantage of mini-PCNL in reducing both the duration of the patient's hospital stays and the overall procedure costsIt is also can be done in narrow infundibulum. The mean hemoglobin drop was 0,93±1. Long et al. reported a mean hemoglobin drop of 1.52 g/dl, with a range of 0.6 to 3.9. In line with this, Wishahi's study demonstrates that mini PCNL offers the advantage of reduced hemoglobin drop (0.8±0.9 vs. 1.3±0.4). The longer operative time was attributed to the weight of the stone and the type of energy used for lithotripsy.[7,12,13]

Wishahi et al. reported an operation time of 95 minutes, while Sultan Naveed et al. had an operation time of 80 minutes. In contrast, Ferakis Nikolas had a considerably longer operation time of 155.5 minutes, exceeding the other two studies by 45 minutes. Operation times can vary for several reasons, including differences in surgical techniques, patient characteristics, complexity of the procedure, surgeon's experience, and equipment used. The comparison between mini-PCNL and conventional PCNL was presented in Table 4.

Table 4. Comparison between mini-PCNL and conventional or standard PCNL[9]

	Mini-PCNL	PCNL
Dilation	Single-step	Multiple-steps
Amplatz sheath	15F	30 F
Disintegration	Holmium laser	Holmium laser ballistic lithotripsy ultrasound
Stone removal	by irrigation	forceps baskets
Stone-free rate	+++	+++
Nephrostomy	12F or tubeless	22F
Transfusion rate	1%	10–15%

The overall complication is the same for mini-PCNL and standard PCNL. Complications are caused by untreated preoperative urinary tract infection, high perfusion pressure, longer operative time, toxin absorption and pelvicalyceal system perforation, and poor drainage of the pelvicalyceal system after surgery.[9] The nephrostomy tube, which is placed at the end of the procedure, has several benefits. It allows for continuous urine drainage from the kidney, a tamponade effect on the renal access tract, and a "second look" surgery if necessary. Less postoperative pain and earlier discharge were advantages of tubeless PCNL.[7,14]

Stone-free is defined as the absence of residual stones after undergoing percutaneous nephrolithotomy for the first time. SFR in this study is 94.08% and is similar with the results obtained by Lahme.[9] Atmoko et al. evaluate the associated factors of SFR after primary percutaneous nephrolithotomy on staghorn calculi and the results showed that history of ipsilateral open renal stone surgery (p = 0.01), stone burden (p = < 0.001), and type of anesthesia (p = 0.04) had a significant impact on the stone-free. From multivariate analysis, the history of ipsilateral open renal stone surgery [OR 0.48; 95% CI 0.28-0.81; p 0.01] and the stone burden [OR 0.28; 95% CI 0.18-0.45; p 0.00] were significant independent risk factors for stone-free.[15] According to Chen et al., larger stone size, staghorn stone, and multiple calyxes were significantly associated with lower SFR based on univariate logistic analysis. Multivariate analysis revealed that larger stone size (P = 0.001) and staghorn stone (P = 0.001) were associated with lower SFR, whereas higher ASA score (P = 0.002), multiple tract (P = 0.004), and staghorn stone (P = 0.028) were independently associated with complications development.[16]

Kokov et al. showed that the only independent predictor of stone-free status was stone size (OR 0.9; p = 0.02). Patients with stones larger than 20 mm were less likely to be stone-free than those with stones 10-20 mm (OR 0.3; p = 0.009). SFRs were 33.3%, 50.5%, and 25% for stone sizes 10, 10-20, and > 20 mm, respectively.[17] Between 1992 and 2011, Zeng et al. conducted 10,000 mini-PCNL procedures, and they found that SFR (stone-free rate) was lower in cases with multiple stones (p = 0.018) and when the stone burden exceeded 20 mm (p = 0.026). Similar results were also obtained in our study (Table 2). As the stone size increased, the stone-free rate decreased.

Although the association of the degree of hydronephrosis with SFR in mini-PCNL has not been reported, an association of hydronephrosis with SFR in flexible ureterorenoscopy (FURS) has been reported. The SFR decreases as the grade of hydronephrosis increase. The SFR for hydronephrosis grade 1 is 28%, 16% for grade 2, 12% for grade 3, and 2% for grade 4. In other words, it is expected that the success rate of FURS operations in patients with hydronephrosis grade 2 and above will decrease.[18]

CONCLUSION

In the research carried out from 2017 to 2021, the study highlighted the effectiveness of mini-PCNL in achieving a stone-free rate of 94.08% for the removal of kidney stones. Mini-PCNL presented several advantages, including decreased bleeding, shorter hospitalization periods, and a lesser drop in hemoglobin levels when compared to traditional PCNL. Various factors, such as stone size, the presence of hydronephrosis, and the surgical approach, influenced the study's outcomes. Overall, mini-PCNL proves to be a valuable choice for managing kidney stones, especially for medium-sized and hard stones, leading to enhanced patient results and reduced post-operative complications.

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