Am J Clin Exp Urol 2022;10(4):271-276
www.ajceu.us /ISSN:2330-1910/AJCEU0143453

Original Article

Open surgery versus percutaneous nephrolithotomy for management of staghorn calculi

Sayed Mohammad Amin Nourian[1], Mahshid Bahrami[2]

[1]College of Medicine, Florida International University-FIU/AUA, Miami FL 33199, USA; [2]Assistant Professor, Department of Radiology, Isfahan University of Medical Sciences, Isfahan, Iran

Received April 11, 2022; Accepted July 24, 2022; Epub August 15, 2022; Published August 30, 2022

Abstract: Background: For urologists, treating staghorn stones remains a difficult challenge. Various studies have evaluated the results of percutaneous nephrolithotomy (PCNL) and open surgery in different populations but these results were controversial. Here, we aimed to compare and evaluate the results of open surgery and PCNL in the treatment of staghorn stones. Methods: This retrospective descriptive study was performed to compare the results of open surgery and PCNL in the treatment of staghorn stones in 2013-2021. A total of 360 participants were studied among the population. Demographic data of patients including age, gender, and comorbidities were obtained. We assessed variables including type of stone, serum creatinine, degree of hydronephrosis, and urine culture before the operation. All participants in our study were informed of the two surgical alternatives. Results: The mean length of hospital stay in PCNL patients was 3.88 ± 1.76 and in open surgery patients was 5.858 ± 2.12 (P = 0.003). In 30 patients (13.9%) in the PCNL group and 27 patients (18.8%) in the open surgery group, bleeding necessitating blood transfusion was the only intraoperative complication. 309 patients (85%) had no residual stones at the time of discharge from the hospital, which was 81.9% (177 cases) in patients treated with PCNL and 91.6% (132 patients) in the open surgery group (P > 0.05). Conclusion: Staghorn calculi can be managed effectively with open surgery or PCNL. Given the reduced postoperative complication rate and higher stone-free rate, we believe open surgery is better technique for complicated staghorn stones with a high burden.

Keywords: Renal stone, staghorn, PCNL, surgery

Introduction

In urology, kidney stone development is one of the three most common diseases, making up 80-90% of all urinary calculi globally [1]. For urologists, treating staghorn stones remains a difficult challenge. Staghorn stones are large branch stones that obstruct the pelvicalyceal system entirely or in part [2]. According to the American Urological Association (AUA), a partial staghorn calculus is a branching stone that occupies part but not all of the collecting syste [3, 4].

Although men are more likely to develop kidney stones, staghorn stones are less frequently reported in men than in women, and they are typically unilateral [5]. In 49-68% of cases, staghorn stones are infection stones, and thus the term staghorn originally referred to struvite stones [6]. Staghorn calculi are made of struvite, which is chemically known as magnesium ammonium phosphate or MAP. They are typically present when a person has recurrent urinary tract infections caused by urease-producing bacteria. Treatment of these stones are performed by surgical procedures including percutaneous nephrolithotomy (PCNL). Untreated staghorn calculi have a high risk of destroying the kidney and/or causing life-threatening sepsis. To completely remove any causative organisms, relieve blockage, stop further stone formation and infection, and maintain renal function, complete stone removal is essential [7].

Nowadays, developed countries have reduced the incidence of staghorn stones to 4% of all urinary stones, owing to effective and early management of renal stones. However, staghorn stones remain a difficult challenge for urologists [2, 8]. Open surgery was once considered the gold standard for treating staghorn calculi

surgically [9, 10]. Percutaneous nephrolithotomy (PCNL) is recommended as the modality of choice and standard of treatment in the AUA guidelines for the management of staghorn calculi [11].

Although this operation has a high stone-free rate (SFR), it is more likely to cause postoperative problems like postoperative bleeding, discomfort, and fever [12, 13]. The additional problems brought on by greater tract access are the primary drawback of PCNL [14]. Also, the morphology of stones, as well as their stone burden, can have a considerable impact on the outcomes of PCNL in the treatment of staghorn calculi [15]. In contrast, the morphometric index of staghorn calculi has little effect on open surgery [16]. Many urologists still prefer open surgery for patients with difficult staghorn calculi for a variety of reasons, including the lack of surgical instruments, a higher SFR, and shorter operative times.

So far, various studies have evaluated the results of PCNL and open surgery in different populations but only limited studies have compared these results. However, all of this research used small sample sizes and produced contentious and inconclusive findings. The appropriate course of treatment for staghorn calculi is still debatable. The aim of the current study is to compare and evaluate the results of open surgery and PCNL in the treatment of staghorn stones.

Methods and material

Study design

This is a retrospective descriptive study that was performed to compare the results of open surgery and PCNL in the treatment of staghorn stones referred to Shahid-Beheshti Hospital in Abadan in 2013-2021. The current study was approved ethically by Abadan University of Medical Sciences (approval number: IR.ABADANUMS.REC.1392.200).

Inclusion and exclusion criteria

The inclusion criteria were age more than 18 years, diagnosis of staghorn renal stone based on imaging modalities, occupying more than 80% of the renal collecting system and having informed consent. Exclusion criteria were prior abdominal (or ipsilateral flank) surgery or shock wave lithotripsy (SWL), previous PCNL, renal abnormalities or a solitary kidney, active urinary tract infection, and uncorrectable coagulopathies, lack of patient's cooperation and lack of consent.

Study population

There were a total of 382 patients in attendance. A total of 360 participants who met all of the inclusion criteria were studied among the population. Demographic data of patients including age, gender, and comorbidities were obtained. We assessed variables including type of stone, serum creatinine, degree of hydronephrosis, and urine culture before the operation. All participants in our study were informed of the two surgical alternatives. As a result, the patient groups were neither equal nor randomized. The grouping of the study was performed by the request of the patients after fully understanding the exact procedures, their advantages and complications. In the current study, 144 patients chose open surgery and 216 patients preferred the PCNL procedure.

Surgical technique

Percutaneous nephrolithotomy: PCNL was performed under general anesthesia under fluoroscopic guidance, but depending on the stone morphology, the surgeons obtained midpole and upper percutaneous accesses. The tract was dilated up to 28 Fr and a 30-Fr Amplatz sheath was placed. For stone fragmentation, a pneumatic lithotripter was used, and an 18-Fr nephrostomy tube was placed in each tract after the procedure was completed. In the pelvis, a Malecot tube was left. A 6-0 Vicryl suture was used for the calicoplasty, while a 3-0 Vicryl suture was used for the parenchymal suture.

Open surgery: The kidney was exposed under general anesthesia via a flank incision on the 11th intercostal space. Gerota's fascia was incised longitudinally, and the perinephric fat was carefully dissected off the entire renal capsule. Satinsky clamps were used to cross clamp the renal pedicle after identifying the renal vein and artery. The kidney was then split apart at the convex edge, exposing and removing the stones from the body. Hemostasis was obtained visibly by partially removing the clamp and applying 3-0 Vicryl to the running bleeders.

Table 1. Preoperative characteristics of patients

Variables		Open surgery group (n = 132)		PCNL group (n = 216)	
		Mean	SD	Mean	SD
Age (years)		44.18	12.04	43.12	11.47
Creatinine (mg/dL)		1.2	1.1	0.95	0.46
		Frequency	Percent	Frequency	Percent
Gender	Male	57	39.6	105	48.6
	Female	87	6.04	111	51.4
Stone type	Complete	36	25	27	12.5
	Partial	108	75	189	87.5
Hydronephrosis	Mild	36	25	60	27.8
	Moderate	72	50	117	54.2
	Severe	36	25	39	18.1
Urine culture	Positive	15	10.4	15	6.9
	Negative	129	89.6	201	93.1

For both procedures, operative time, stone-free rates (SFR), length of hospital stay, and intraoperative and postoperative complications were calculated, plotted in a database, and statistically analyzed.

Postoperative intervention and follow-up

On the first postoperative day, a kidney, ureter, bladder (KUB) and/or ultrasound (US) were performed to determine the position of the tubes and the presence of any residual stones. After discharge, all patients were monitored for at least three months. Antibiotics were given to all patients based on their culture and sensitivity.

Statistical analysis

Data were entered to SPSS software (version 25, IBM Corporation, Armonk, NY). We used Chi-square and T-test to analyze the data. *P*-value < 0.05 was considered as a significant level.

Result

Study population

360 patients entered this study. Our study population consisted of 162 (45%) males and 198 females (55%). Out of 360 patients, 216 (60%) were treated with PCNL and 144 (40%) were treated with open surgery. The mean age in the PCNL group was 43.12 ± 11.47 (minimum 18 and maximum 72), and in the open surgery group the mean age was 44.18 ± 12.04 (minimum 18 and maximum 77). In the PCNL group, 105 were male and 111 were female, and in the open surgery group, 57 patients were male and 87 were female. **Table 1** shows the preoperative information of our patients.

Patient's outcomes

Table 2 contains operative time, length of hospital stay, SFR, and intraoperative and postoperative complications. In our study, the mean length of hospital stay in PCNL patients was 3.88 ± 1.76 and in open surgery patients was 5.858 ± 2.12. The T-test revealed a significant difference in the length of hospital stay between the two groups (P = 0.003).

Postoperative complications

In 30 patients (13.9%) in the PCNL group and 27 patients (18.8%) in the open surgery group, bleeding necessitating blood transfusion was the only intraoperative complication (P > 0.05). Postoperative complications including urinary leakage, massive hematuria, obstructive uropathy, and wound infection were observed in 27 patients (12.5%) of the PCNL group and in 6 patients (4.2%) of the open surgery group, with no statistically significant difference (P > 0.05).

Further evaluations

Additionally, 309 patients (85%) had no residual stones at the time of discharge from the hospital, which was 81.9% (177 cases) in patients treated with PCNL and 91.6% (132 patients) in the open surgery group (P > 0.05).

Discussion

Untreated staghorn stones are related with recurrent infection, stone growth, significant morbidity and progressive loss of renal function [17]. The surgical management of renal stones has changed dramatically over the last three decades as a result of tremendous advancements in endourologic procedures [7, 16, 18]. At centers of excellence, open surgery is now only used in less than 5% of patients. The natu-

Table 2. Length of Hospitalization, Intraoperative and postoperative complications and stone-free rate

Variables		Open surgery group		PCNL group		*P*-value
		Mean	SD	Mean	SD	
Length of hospitalization		5.85	2.12	3.88	1.76	0.003
		Frequency	Percent	Frequency	Percent	
Intraoperative complications	Bleeding	27	18.8	30	13.9	0.611
	Renal pelvis injury	-	-	-	-	
	Pleural injuries	-	-	-	-	
Postoperative complications	Urinary leakage	3	2.1	18	8.3	0.05
	Massive hematuria	-	-	3	1.4	
	Wound infection	3	2.1	3	1.4	
	Obstructive uropathy	-	-	3	1.4	
Stone-free rate at 3 months		132	91.6	174	81.9	0.135

ral path and distinctive form of big staghorn renal stones make treatment challenging even with current advancements (i.e., infection-related complications and a high rate of recurrence) [19, 20].

Our study was performed on 360 cases that receiving open surgery or PCNL for management the staghorn stones. For both groups, operative time, stone-free rates (SFR), length of hospital stay, and intraoperative and postoperative complications were calculated. In current study, the mean operative time for PCNL was shorter than patients that underwent open surgery. However, there was no statistically significant difference. Bleeding necessitating blood transfusion was the only intraoperative complication observed in both groups. Also, postoperative complications observed in the PCNL group was higher than the open surgery group. Urinary leakage was the most complication that observed in patients following PCNL. In contrast with PCNL group, massive hematuria and obstructive uropathy were not observed in the open surgery group. Our study also calculated the SFR after three month of follow-up. The results demonstrate that the SFR was 81.9% and 91.6% following PCNL and open surgery, respectively. The main point of our study was the large study population, in contrast with other studies.

In 2019, Chen and colleagues [21] conducted a meta-analysis study to compare the open surgery versus PCNL for surgical treatment. No significant differences were found in major complications and minor complications between the two groups. Finally, as compared to open surgery or mini-PCNL, this study found that standard PCNL is a safe and viable alternative for patients with staghorn stones. In addition, in our study, hospitalization periods and operative times were shorter in the PCNL group. However, in contrast to this study, the postoperative complication and bleeding necessitating blood transfusion was higher in the PCNL group versus the open surgery group.

In 2020, El-nasr and colleagues [17] conducted a prospective randomized study on 50 patients with staghorn calculi to evaluate the outcome of open surgery and PCNL. Stone-clearance was higher in open surgery group versus in PCNL group with no significant difference (92 vs. 84). There is statistically significant operative creatinine rise in open surgery group. Mean operative hemoglobin loss in PCNL group was higher than the open surgery group. However, the difference was not statistically significant. Intraoperative complications in the open surgery group were 28% and included significant bleeding (16%) and pleural injury (12%), and in the PCNL group they were 24% and included renal pelvis injury (12%) and bleeding (12%) with no significant difference. Postoperative complications in the open surgery group and the PCNL group were 36% and 24%, respectively. In contrast with our study, operative time was significantly shorter for open surgery group than for PCNL. However, postoperative hospital stay and recovery time were significantly shorter in PCNL group versus open surgery group. In addition, in contrast with our study, the incidence of significant bleeding and postoperative complications were higher in the open surgery group than in the PCNL group. Overall, this research demonstrates that PCNL

is an effective therapeutic option for staghorn stones with an SFR similar to open surgery. It also has a lower morbidity rate, as well as a shorter hospitalization time and earlier return to work.

Also, Zhang and colleagues [5] published a study comparing the treatment of staghorn calculi with open surgery and PCNL. In this study, similar to our study, patients were not equally divided between the two groups. Therefore, 11 patients underwent open surgery and 61 patients underwent PCNL. No differences in patient demographics, estimated blood loss, stone size or mean change in renal function level were observed between the two groups. However, mean operative time, mean hospital stay, and postoperative SFR were higher in the open surgery group versus the PCNL group. This study found that both PCNL and open surgery are viable options for the treatment of staghorn calculi. They suggested that open surgery is better for stones with large burdens because it requires less auxiliary treatment and has a lower postoperative complication rate. This study is line with our study. However, the main point of our study was the large study population, in contrast with other studies.

In another study, on the day of discharge, the PCNL group had the lowest SFR (43.75%) compared to the open anatrophic nephrolithotomy (92.85%) and the laparoscopic group (80%). After 12 months, the open anatrophic nephrolithotomy group experienced the highest decrease in kidney function, followed by the laparoscopic anatrophic nephrolithotomy and PCNL groups. The need for ancillary treatments to manage residual stones was lowest in the PCNL group and highest in the open anatrophic nephrolithotomy group. Ancillary procedures are a significant influence in determining the overall cost of treatment, which was greatest in the PCNL group [16]. Although, this study used three procedure, the SFR in the PCNL group was similar to our study.

The shortcomings of this survey were restricted study population and not randomizing the study population. Another limitation was that we evaluated simple variables and this study lacks advanced statistical analysis to draw a unique conclusion. However, the results of this study were significant and could be used in clinical practice. We recommend that future studies should consider randomization of patients and larger study populations.

Conclusion

Both open surgery and PCNL are viable options. Patients that underwent PCNL had lower duration of hospitalization but the postoperative complications were significantly lower in open surgery group. We recommend that further data on larger populations should be evaluated.

Disclosure of conflict of interest

None.

Address correspondence to: Mahshid Bahrami, Department of Radiology, School of Medicine, Isfahan University of Medical Science, Hezar Jarib St., Isfahan City, Isfahan, Iran. Tel: +9891093-64982; Fax: +983134165007; E-mail: hadi-imalek769@gmail.com

References

[1] Enikeev D, Taratkin M, Klimov R, Alyaev Y, Rapoport L, Gazimiev M, Korolev D, Ali S, Akopyan G, Tsarichenko D, Markovina I, Ventimiglia E, Goryacheva E, Okhunov Z, Jefferson FA, Glybochko P and Traxer O. Thulium-fiber laser for lithotripsy: first clinical experience in percutaneous nephrolithotomy. World J Urol 2020; 38: 3069-3074.

[2] Sharbaugh A, Morgan Nikonow T, Kunkel G and Semins MJ. Contemporary best practice in the management of staghorn calculi. Ther Adv Urol 2019; 11: 1756287219847099.

[3] Winoker JS, Chandhoke RA, Atallah W and Gupta M. Morphometry scores: clinical implications in the management of staghorn calculi. Asian J Urol 2020; 7: 78-86.

[4] Gadzhiev N, Malkhasyan V, Akopyan G, Petrov S, Jefferson F and Okhunov Z. Percutaneous nephrolithotomy for staghorn calculi: troubleshooting and managing complications. Asian J Urol 2020; 7: 139-148.

[5] Dar MA, Malik SA, Dar YA, Wani PM, Wani MS, Hamid A, Khawaja AR and Sofi KP. Comparison of percutaneous nephrolithotomy under epidural anesthesia versus general anesthesia: a randomized prospective study. Urol Ann 2021; 13: 210-214.

[6] Large T, Assmus MA, Valadon C, Emmott A, Forbes CM, Agarwal D, Nottingham C, Scotland K, Rivera M, Chew B and Krambeck A. A multi-institutional review of single-access percuta-

neous nephrolithotomy for complex staghorn stones. Eur Urol Focus 2021; 7: 1170-1175.
[7] Rizvi SAH, Hussain M, Askari SH, Hashmi A, Lal M and Zafar MN. Surgical outcomes of percutaneous nephrolithotomy in 3402 patients and results of stone analysis in 1559 patients. BJU Int 2017; 120: 702-709.
[8] Shi B, Hong X and Yu J. Management of unilateral staghorn renal stones with concurrent urinary tract infections by retroperitoneal laparoscopic pyelolithotomy with prolonged renal posterior lower segment incision. Exp Ther Med 2019; 18: 366-372.
[9] Xiao Y, Li Q, Huang C, Wang P, Zhang J and Fu W. Perioperative and long-term results of retroperitoneal laparoscopic pyelolithotomy versus percutaneous nephrolithotomy for staghorn calculi: a single-center randomized controlled trial. World J Urol 2019; 37: 1441-1447.
[10] Diri A and Diri B. Management of staghorn renal stones. Ren Fail 2018; 40: 357-362.
[11] Sabler IM, Katafigiotis I, Gofrit ON and Duvdevani M. Present indications and techniques of percutaneous nephrolithotomy: what the future holds? Asian J Urol 2018; 5: 287-294.
[12] Yang T, Liu S, Hu J, Wang L and Jiang H. The evaluation of risk factors for postoperative infectious complications after percutaneous nephrolithotomy. Biomed Res Int 2017; 2017: 4832051.
[13] Torricelli FCM and Monga M. Staghorn renal stones: what the urologist needs to know. Int Braz J Urol 2020; 46: 927-933.
[14] Inanloo SH, Yahyazadeh SR, Rashidi S, Amini E, Nowroozi MR, Ayayti M, Jamshidian H, Nikoobakht MR, Aghamir SMK, Hemmatian O and Momeni SA. Feasibility and safety of ultrasonography guidance and flank position during percutaneous nephrolithotomy. J Urol 2018; 200: 195-201.
[15] Keyu G, Shuaishuai L, Raj A, Shuofeng L, Shuai L, Yuan Z, Haitao Z and Junqi W. A 3D printing personalized percutaneous puncture guide access plate for percutaneous nephrolithotomy: a pilot study. BMC Urol 2021; 21: 184.
[16] Aminsharifi A, Irani D, Masoumi M, Goshtasbi B, Aminsharifi A and Mohamadian R. The management of large staghorn renal stones by percutaneous versus laparoscopic versus open nephrolithotomy: a comparative analysis of clinical efficacy and functional outcome. Urolithiasis 2016; 44: 551-557.
[17] El-Nahas AR, Shokeir AA, Shoma AM, Eraky I, Sarhan OM, Hafez AT, Dawaba MS, Elshal AM, Ghali AM and El-Kenawy MR. Percutaneous nephrolithotomy versus open surgery for treatment of staghorn stones in pediatric patients. Can Urol Assoc J 2014; 8: E906-9.
[18] Bai Y, Tang Y, Deng L, Wang X, Yang Y, Wang J and Han P. Management of large renal stones: laparoscopic pyelolithotomy versus percutaneous nephrolithotomy. BMC Urol 2017; 17: 75.
[19] Singh P, Harris PC, Sas DJ and Lieske JC. The genetics of kidney stone disease and nephrocalcinosis. Nat Rev Nephrol 2022; 18: 224-240.
[20] Deng J, Li J, Wang L, Hong Y, Zheng L, Hu J and Kuang R. Standard versus mini-percutaneous nephrolithotomy for renal stones: a meta-analysis. Scand J Surg 2021; 110: 301-311.
[21] Chen Y, Feng J, Duan H, Yue Y, Zhang C, Deng T and Zeng G. Percutaneous nephrolithotomy versus open surgery for surgical treatment of patients with staghorn stones: a systematic review and meta-analysis. PLoS One 2019; 14: e0206810.