Original Article

Evaluation of stone volume and its relationship with surgical outcomes in patients with staghorn calculi

Abhirudra Mulay, Vikram Satav, Ashwani Kandari, Sonu Sharma, Deepak Mane, Vilas Sabale

Department of Urology, Dr. D. Y. Patil Medical College, Pune, Maharashtra, India

Abstract

Introduction: Urolithiasis is one of the most common renal diseases with a significant burden on health-care system worldwide. Here, we evaluated the stone volume and its relationship with duration of operation, blood loss, and total stone clearance in patients with staghorn calculi.

Materials and Methods: This was a prospective, single-center study conducted from October 2015 to September 2017. Patients of either sex aged more than 18 years of age with a confirmed diagnosis of staghorn calculus were eligible to participate in the study. Eligible patients were divided into three groups based on stone volume (assessed by three-dimensional computed tomography): Group 1 ($\leq$5000 mm^3), Group 2 ($>$5000 to $\leq$20,000 mm^3), and Group 3 ($>$20,000 mm^3).

Results: A total of 85 patients were enrolled in the study (Group 1, n = 9; Group 2, n = 66; and Group 3, n = 10). The mean age was 43.68 years, and 62.4% of patients were male. The mean operative time increased significantly from Groups 1–3, (31.67, 60.14, and 92.30 min, respectively). The mean pre- and postoperative hematocrit was highest in Group 3 (2.82%) ($P < 0.0001$). Overall, the correlation between stone volume and operative time and difference in hematocrit showed a positive relationship. A total of five patients had residual calculus, and only four patients reported complications.

Conclusions: The results showed that patients with larger stone volume need more operative time and may have more blood loss.

Keywords: Complications, morphometry, renal stones, staghorn calculi

Address for correspondence: Dr. Vikram Satav, Department of Urology, Dr. D. Y. Patil Medical College, Pune, Maharashtra, India.
E-mail: vikramsatav@yahoo.com
Received: 18.05.2018, **Accepted:** 13.09.2018

INTRODUCTION

Urolithiasis is one of the most common renal diseases with a significant burden on health-care system worldwide. It may seriously affect health and quality of life. The prevalence of urolithiasis varies in different countries across the world. The lifetime prevalence of urolithiasis in the United States was around 5%–12%, which may again vary based on the patients' age, gender, race, and geographic location.[1-3] The treatment for stone disease forms the bulk of urosurgical work in almost all the hospitals in the country. Staghorn calculi are large renal stones which generally occupy most of the renal system and are commonly classified as partial or complete. With the use of computed tomography (CT) scan, the stone volume can be calculated by stone morphometry software and staghorn calculi can be classified according to their volume.[4]

Access this article online	
Quick Response Code:	Website: www.urologyannals.com
	DOI: 10.4103/UA.UA_65_18

How to cite this article: Mulay A, Satav V, Kandari A, Sharma S, Mane D, Sabale V. Evaluation of stone volume and its relationship with surgical outcomes in patients with staghorn calculi. Urol Ann 2019;11:53-7.

In this study, we evaluated the association between stone volume (using three-dimensional [3D] CT scan technique) and duration of operation, blood loss, total stone clearance, and complications in patients with staghorn calculi.

MATERIALS AND METHODS

Study design and population

This was a prospective, single-center study conducted from October 2015 to September 2017 at a tertiary care center in India. Patients of either sex aged more than 18 years of age with a confirmed diagnosis of staghorn calculus were eligible to participate in the study. Patients with anatomical abnormalities, previous renal surgery, coexisting comorbid conditions, concomitant stones at other sites (e.g., bladder and ureter), and coagulation disorders were excluded from the study. Patients with nonfunctioning systems and renal insufficiency were also excluded from the study.

Eligible patients were admitted and underwent 3D CT scan to assess the stone volume[5] [Figure 1], and patients were divided into three groups based on the stone volumes: Group 1 (≤5000 mm^3), Group 2 (>5000 to ≤20,000 mm^3), and Group 3 (>20,000 mm^3).

The study protocol was reviewed and approved by the institutional ethical committee before initiation of the study. The study was conducted in accordance with the principles that have their origin in the Declaration of Helsinki. Patients and their relatives were informed and explained about the surgical management. Each study participant provided written informed consent before participation in the study.

Figure 1: Three-dimensional reconstructed stone (stone volume 11,873 mm^3)

Preparation and surgical procedure

Patients with hemoglobin level <10 g/dL were given blood transfusion before the surgery. All patients had at least a minimum of 10 g/dL of hemoglobin before posting for surgery. All patients were treated with percutaneous nephrolithotomy (PCNL) by the same team of urologists under spinal or general anesthesia and fluoroscopic control. Patients were placed in lithotomy position. A 6 Fr ureteral catheter was introduced via cystoscopy into the pelvicalyceal system, and the ureteral catheter was fixed to 14 Fr/urethral Foley catheter. The patient was then turned into the prone position. Under fluoroscopic guidance, selective calyceal puncture, usually the most favorable calyx, was carried out with an 18-gauge diamond tip initial puncture needle. A flexible 0.035" terumo guidewire was then inserted into the renal collecting system, preferably in the ureter or else in the upper pole calyx/second favorable calyx. The access needle was removed, and the skin and fascia were incised. In the staghorn calculi with multiple calyces having calculus, an extra guidewire was placed in the desired calyx before dilatation of the pelvicalyceal system.

Tract dilatation was done using a sheath ranging from 18 Fr to 26 Fr according to the infundibulum size. Miniature Nephroscope 17.5 Fr Karl Storz was used in all the cases. Stone fragmentation was done by a pneumatic (EMS) Lithoclast. Grasping forceps 5 Fr was used for fragment removal. The collecting system was examined by direct nephroscopy and fluoroscopy to confirm complete stone clearance. In all the cases, a 5F 24-cm double-J stent was placed, and a nephrostomy tube was placed for 24 h. Hematocrit/hemoglobin was checked 1 day after the surgery. All patients underwent X-ray (kidney, ureter, and bladder [KUB]) on postoperative day 1 and ultrasonography on day 2. All patients received broad-spectrum antibiotics (ceftriaxone 1 g twice daily and amikacin 750 mg once daily) for 3 days. Nephrostomy was opened on postoperative day 1 and removed on day 2 if urine was clear. If postoperative period remained uneventful, patients were discharged on postoperative day 3 with oral antibiotics. The stent was removed after 21 days. Follow-up visits were scheduled at 1 month after the procedure and then at 3-month interval. At each visit, thorough clinical examination, urine analysis, in case of pyuria (urine culture and sensitivity), X-ray KUB, and ultrasonography were performed.

Definitions

Operative time was defined as the time from the initiation of puncture up to the insertion of the nephrostomy tube for PCNL. Complete clearance of the calculi was considered if the postoperative X-ray showed no residual or insignificant residual stone material <4 mm on ultrasonography. The decrease in hemoglobin was the difference in hematocrit levels in preoperative and immediate-postoperative period and was considered as an indicator of intraoperative blood loss. Blood transfusion was done in patients with postoperative hemoglobin <9 g/dL. Ancillary procedures were performed in patients with significant residual stone after the procedure or stone fragmentation could not be done due to unfavorable location. Immediate urine culture and sensitivity tests were performed in patients who developed fever or signs of urosepsis during the postoperative period. Hospital stay was defined as days from day 1 of admission before surgery till discharged after proper individual management. The success rate was defined as the number of cases achieving complete clearance after procedure who do not require any further procedures, and the failure rate was defined as cases requiring the second or ancillary procedure.

RESULTS

A total of 85 patients were enrolled in the study. The mean (standard deviation) age was 43.68 years, and the range was 18–80 years. Most of patients ($n = 24$; 28.2%) were from 31 to 40 years of age group. A total of 53 (62.4%) patients were male and 32 (37.6%) were female; 35 (41.2%) patients had renal stones on the left side while 50 (58.8%) had stones on the right side. Based on the 3D CT, patients were classified into three groups: Group 1 ($n = 9$, 10.6%), Group 2 ($n = 66$, 77.6%), and Group 3 ($n = 10$, 11.8%).

The mean operative time increased significantly from Group 1, Group 2, and Group 3 (31.67 min, 60.14 min, and 92.30 min, respectively) [Table 1]. The maximum difference between mean preoperative and postoperative hematocrit was in Group 3 (2.82%), and the difference between three groups was statistically significant ($P < 0.0001$) [Table 1]. The least difference was in Group 1 (0.21%) followed by Group 2 (1.25%). The maximum individual difference in pre- and postoperative hematocrit loss was 5.8%.

Table 1: Comparison of time taken and difference in hematocrit according to stone volume

	Group 1 (n=9)	Group 2 (n=66)	Group 3 (n=10)	F	P
Duration of operation (min), mean (SD)	31.67 (5.57)	60.14 (12.75)	92.30 (13.82)	57.57	<0.0001
Difference in hematocrit (%), mean (SD)	0.21 (0.15)	1.25 (0.96)	2.82 (1.04)	19.80	<0.0001
Residual stone, n (%)	0	2 (3.03)	3 (30.0)	12.04*	0.002

*Chi-square test. SD: Standard deviation

A total of five patients had residual calculus: three patients from Group 3 and two patients from Group 2 [Table 1]. There was no residue in Group 1. After the ancillary procedures, three out of five patients had residue. Four (4.7%) out of 85 patients had complications: 2 (2.4%) patients had intraoperative bleeding, 1 (1.2%) patient had drain site leak, and 1 (1.2%) patient had urinary tract infection. There was no complication in 95.3% of the patients.

The correlation between stone volume and operative time had a positive relationship, indicating that with the increase in stone volume, the time taken for surgery also increased significantly ($P < 0.0001$) [Figure 2a]. Similarly, the correlation between stone volume and difference in hematocrit was also showed a significantly ($P < 0.0001$) positive relationship [Figure 2b].

DISCUSSION

This was a prospective, single-center study conducted to evaluate the association between stone volume and duration of operation, blood loss, and total stone clearance in patients with staghorn calculus. The results showed that

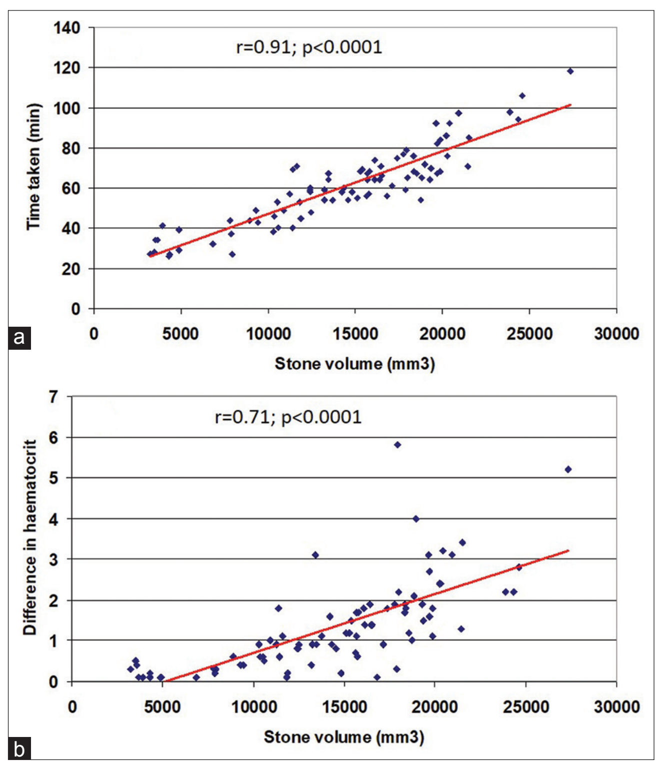

Figure 2: Correlation between stone volume with (a) operative time and (b) pre- and postoperative difference in hematocrit

majority of patients had a stone volume between 5000 mm^3 and 20,000 mm^3. The stone volume had a significant impact on the duration of operation, blood loss, and total stone clearance.

A previous retrospective case–control study by Mishra *et al*. reported that maximum number (57.57%) of cases ranged from 5000 mm^3 to 20,000 mm^3.[5] The classification based on the stone volume used in our study (≤5000 mm^3; >5000 to ≤20,000 mm^3; and >20,000 mm^3) was consistent with previous reports.[6]

In the present study, the mean duration of operation in patients with stone volume >20,000 mm^3 (Group 3) was more as compared to stones in Group 1 and Group 2. The mean time to operate the staghorn calculi in Group 3 patients was 92.3 min as compared to 31.67 min and 60.14 min in Group 1 and Group 2, respectively ($P < 0.0001$), indicating that higher stone volume may have a significant impact on the operative time. A previous report by Sorokin *et al*., who evaluated the operative time required in retrograde intrarenal surgery (RIRS) in 118 patients with renal calculi in a multivariate analysis, concluded that stone volume had the strongest impact on operative time.[7] The authors predicted that operative time may increase roughly by 2 min/100 mm^3 of stone volume. In another study, Reddy and Shaik retrospectively reviewed the medical records of 367 patients who underwent PCNL (primary or secondary) and reported that stone with more area had higher operative time as compared to stone with lesser area.[8]

In the present study, the mean difference in pre- and postoperative hematocrit was 2.82% in Group 3, which was higher than Group 1 (0.21%) and Group 2 (1.25%). Zeng *et al*. in their long-term study interestingly found that the drop in hemoglobin was more in large complex stones as compared to simple stones.[9]

We had 5 (5.88%, $P = 0.002$) out of 85 patients who had residue after the PCNL. Of these five patients, two patients were from Group 2 and three from Group 3. These results were consistent with the previous report by Reddy and Shaik, who had 93%–94% success rate in all the study groups.[8] In a study, Mishra *et al*.[5] who classified their results according to stone volume had similar results with residual calculus in 5 (5.31%) of 94 cases and mentioned that the larger stone volume needed more number of staged operations and all the smaller stones were cleared in single-stage PCNL, which was comparable to our results.

Of the five cases who have residue, the first case had to undergo a lithotripsy for a small residual calculus in the middle calyx and the second case was posted for RIRS to clear the lower pole residual calculi. For the rest three cases, ancillary procedure had failed. Among patients with stone volume <5000 mm^3 (Group 1), the stone clearance was 100%. Group 2 had two cases which had residue. One of them got treated with lithotripsy. A retrospective study by Ganpule and Desai mentioned that of 2469 patients, 187 had residue calculus after PCNL.[10] Of these 187 patients, 84 patients spontaneously passed the stones. Our results were consistent with these results.

There are a number of complications mentioned in the literature. In the present study, only four complications were reported. Two patients had intraoperative bleed and two patients had postoperative complications (drain site leak and urinary tract infection, $n = 1$, each). Of the two patients with intraoperative bleeding, one required blood transfusion and other was managed conservatively.

The patient with urinary tract infection had fever with no signs of sepsis and was treated with intravenous antibiotics. This was comparable with a previous study by Mousavi-Bahar *et al*., who mentioned that only 1% of their patients had urinary tract infection postoperatively after PCNL.[11] In another study by Gudeman *et al*. ($n = 107$), 1 (0.9%) patient had drain site leak.[12] A report by Reddy and Shaik reported that the rate of postoperative fever was about 10.8% in one of the study groups. However, most of the studies available have a lower rate (0% to 3%) of complications.[13] Intraoperative bleeding is a known complication and may occur anytime throughout the procedure. The main cause of bleeding is due to injury to the major vessels. Wang *et al*. reported severe hemorrhage in 4 (1%) cases which was comparable to our study.[14]

CONCLUSIONS

The results from our study contribute to the literature that evaluation of stone using CT scan may contribute to plan the procedure. The results also confirm that patients with larger stone volume need more operative time and may have more blood loss.

Financial support and sponsorship
Nil.

Conflicts of interest
There are no conflicts of interest.

REFERENCES

1. Scales CD Jr., Smith AC, Hanley JM, Saigal CS, Urologic Diseases in America Project. Prevalence of kidney stones in the United States. Eur Urol 2012;62:160-5.

2. Norlin A, Lindell B, Granberg PO, Lindvall N. Urolithiasis. A study of its frequency. Scand J Urol Nephrol 1976;10:150-3.
3. Sierakowski R, Finlayson B, Landes RR, Finlayson CD, Sierakowski N. The frequency of urolithiasis in hospital discharge diagnoses in the United States. Invest Urol 1978;15:438-41.
4. Mishra S, Bhattu AS, Sabnis RB, Desai MR. Staghorn classification: Platform for morphometry assessment. Indian J Urol 2014;30:80-3.
5. Mishra S, Sabnis RB, Desai M. Staghorn morphometry: A new tool for clinical classification and prediction model for percutaneous nephrolithotomy monotherapy. J Endourol 2012;26:6-14.
6. Paul S. Staghorn morphometry for percutaneous nephrolithotomy. Indian J Urol 2012;28:473-4.
7. Sorokin I, Cardona-Grau DK, Rehfuss A, Birney A, Stavrakis C, Leinwand G, *et al.* Stone volume is best predictor of operative time required in retrograde intrarenal surgery for renal calculi: Implications for surgical planning and quality improvement. Urolithiasis 2016;44:545-50.
8. Reddy SV, Shaik AB. Outcome and complications of percutaneous nephrolithotomy as primary versus secondary procedure for renal calculi. Int Braz J Urol 2016;42:262-9.
9. 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;27:1203-8.
10. Ganpule A, Desai M. Fate of residual stones after percutaneous nephrolithotomy: A critical analysis. J Endourol 2009;23:399-403.
11. Mousavi-Bahar SH, Mehrabi S, Moslemi MK. Percutaneous nephrolithotomy complications in 671 consecutive patients: A single-center experience. Urol J 2011;8:271-6.
12. Gudeman SR, Stroup SP, Durbin JM, Patino G, L'Esperance JO, Auge BK, *et al.* Percutaneous stone surgery using a tubeless technique with fibrin sealant: Report of our first 107 cases. BJU Int 2012;110:E1048-52.
13. Taylor E, Miller J, Chi T, Stoller ML. Complications associated with percutaneous nephrolithotomy. Transl Androl Urol 2012;1:223-8.
14. Wang Y, Jiang F, Wang Y, Hou Y, Zhang H, Chen Q, *et al.* Post-percutaneous nephrolithotomy septic shock and severe hemorrhage: A study of risk factors. Urol Int 2012;88:307-10.