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Research Article

Influence of stone burden and stone configuration on outcomes of percutaneous nephrolithotomy

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ABSTRACT

Background: Literature says that the stone burden, the location and the anatomy of collecting systems play a major role in the management of renal stones. To this purpose, the effect of stone burden and stone configuration on stone-free rate, mean operative time, complication rate, and the requirement of the secondary procedures following percutaneous nephrolithotomy (PCNL) procedure were studied.
Methods: Twenty-nine patients undergoing percutaneous nephrolithotomy (PCNL) for renal calculi such as calyceal calculi, pelvic calculi, staghorn calculi (both partial and complete staghorn) or any of the combination of above which are radio-opaque were studied. From each patient, intra-operative information concerning access, punctured calyx, operative time, complications if any and their management were recorded. Operative time is calculated from fluoroscopic puncture of target calyx to nephrostomy tube fixation. Complications if any were recorded throughout the follow-ups. Secondary procedures were usually performed at least one month after the initial procedure. The stone surface area (mm^2) was calculated by graph-paper tracing and a stone were called a pelvic component-dominant complex stone if the pelvic component was 50% to 100% and the calyceal component between 0 and 50%. Similarly, a stone was called a calyceal component dominant complex stone if calyceal component exceeded 50%.
Results: There were 17 males and 12 females. One patient underwent bilateral PCNL. The mean age of the patient was 37.2 years (9-62 years). The mean size of the stone was of 616.6 mm^2 (205- 1370 mm^2) There was a statistically significant decrease in stone-free rate as the surface area increased ($P < 0.05$). The mean operative time is 98.8 minutes (60-180 minutes). For the entire study, the stone-free rate of PCNL was 46.7%. The stone-free rate rose to 83.3% with the additional secondary procedure. The complication rate for the entire group was 36.7%. No colon injuries were seen in this study. Patients were discharged home after a median hospital stay of 7 days (5 to 12 days).
Conclusions: There is a decrease in the overall stone-free rate, as well as an increase in both the complication rate and the secondary procedure rate, with increasing stone surface area for PCNL. Concerning stone configuration, there is a decrease in the stone free rate, as well as an increase in the operative time with increasing caliceal components in complex renal stones.

Keywords: Renal stones, Radio-opaque stones, Stone burden, Percutaneous nephrolithotomy

INTRODUCTION

Percutaneous nephrolithotomy is an established procedure used primarily to treat patients with complex renal calculi and various other endourological indications and has lower morbidity, shorter operative time, shorter hospital stays and earlier return to work.[1-3]

In most patients, an upper pole nephrostomy tract allows direct access to most of the intrarenal collecting system.

Upper pole percutaneous access can be obtained via supra coastal or sub-coastal approach, but the preferred route depends on location and size of stone or lesion.[4] The success of percutaneous nephrolithotomy is critically dependent on achieving suitable percutaneous access. Familiarity with basic renal anatomy is essential to obtain access safely. Certain clinical situations may require special access techniques.[5]

The rationale for this study is to stratify and characterize stone-free rates of percutaneous nephrolithotomy procedure concerning stone size and stone distribution to provide realistic expectations to patients and better preparation for the outcome of the treatment by endourology teams. In proposing a system using the stone surface area to assess the stone burden of staghorn calculi, several criteria should be met. The system should rely on standard films of kidney, ureter, bladder so that the patients are not subjected to the costs and risks of additional diagnostic tests. Also, the technique for determining stone surface area should be accurate, reproducible, easy to perform, readily available and affordable.[6,7]

Techniques for determining stone surface area include the use of a graph paper, planimeter, CT, computer image analysis. Routine use of CT is a cumbersome and expensive, but results are accurate, rapid. In graph paper, total no. of squares (mm) contained within an irregular contour was counted. Although the necessary material is inexpensive, it is time-consuming. Accuracy was well within 5% of computed derived results for different shapes measured. Reproducibility was also within 5%.[6,7]

In the modern management of renal stones, three factors are important in selecting the optimal treatment, the total stone burden, the location of stone burden, and the anatomy of collecting systems. To this purpose, effect of stone burden and stone configuration on stone-free rate, mean operative time, complication rate, and the requirement of the secondary procedures following percutaneous nephrolithotomy procedure were studied.

METHODS

Twenty-nine patients with renal calculi at urology clinics of SVIMS, Tirupati, India from January 2008 to December 2009 were included in the study. Included patients were both male and female, undergoing percutaneous nephrolithotomy (PCNL) for renal calculi such calyceal calculi, pelvic calculi, staghorn calculi (both partial and complete staghorn) or any of the combination of above. Only radiopaque calculi visualised on X-ray KUB film were taken into the study. Patients were excluded if they were not willing to undergo the procedure, having radiolucent calculi which are not visualised on X-ray KUB film, and patients in whom percutaneous nephrolithotomy is done without taking X-ray KUB Film.

Clinical and demographic details of the patients such as age sex, weight, presenting complaints, significant medical and surgical history, comorbidity were recorded. Preoperative data included laboratory studies like urine analysis, urine culture and sensitivity, complete blood count, renal function test, coagulation profile, serum electrolytes, radiographic evaluation like plain KUB film, IVU, ultrasonography of stone size, renal anatomy and function. Appropriate antibiotic coverage in the presence of infection is given. The PCNL was performed as a one-stage procedure with the patient in the prone position. Each patient, intraoperative information concerning access, punctured calyx, operative time, complications if anyone their management is recorded. Operative time is calculated from fluoroscopic puncture of target calyx to nephrostomy tube fixation. Complications if any were recorded throughout the follow-ups. Secondary procedures were usually performed within one month after the initial procedure.

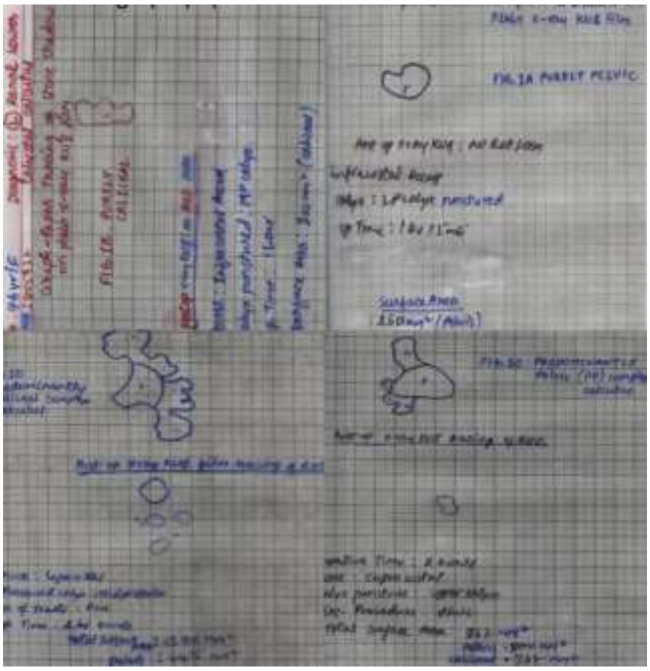

Figure 1: Stone surface area (mm^2) was calculated by graph tracing.

The stone surface area (mm^2) was calculated by graph paper tracing of the two-dimensional projection of the stone on X-Ray KUB film, by two investigators. (Figure 1) Patients were stratified with respect to their stone burdens into 3 groups, group-1 < $500mm^2$, group-2: 501-1000 mm^2, group-3: > 1000 mm^2. Patients were classified into relation to their store configuration into four groups. Pure calyceal stones, purely pelvic stones, pelvis (P) component-dominant complex stone sand calyceal (C) component-dominant complex stones. Surface-area technique was used to measure a given stone and provide the percentage of stone burden present in the slices vs. the renal pelvis. For instance, a given stone was called a pelvic component-dominant complex stone if the pelvic component was 50% to 100% and the calyceal component between 0 and 50%. Similarly, a stone was called a calyceal component dominant complex stone if calyceal component exceeded 50%.

Statistical analysis

Data obtained was entered into the statistical analysis in SPSS software. Differences and correlations were tested for the statistical difference was computed with Chi-square analysis. A two-tailed P < 0.05 was considered as statistically significant.

RESULTS

Among the 29 patients, there were 17 males and 12 females. One patient underwent bilateral PCNL. The mean age of the patient was 37.2 years (9-62 years). Stones were located in the right kidney in 15 and the left in 15 patients. There were five pelvic, three calyceal, eight partial staghorn, six complete staghorn stones; rest was pelvic with secondary calyceal calculus. None of the patients had a renal anomaly. The mean size of the stone was of 616.6 mm^2 (205- 1370 mm^2) There was a statistically significant decrease in stone-free rate as the surface area increased (P <0.05). For the entire study, the stone-free rate of PCNL was 46.7%.

Table 1: Clinical parameters and outcomes.

Parameter	N	Parameter	Mean
Female	12	Age (year)	37.2 (9 -62)
Male	17	Size (mm^2)	616 (205-1370)
Right	15	Postoperative time (minutes)	98.8 (60-180)
Left	15	Hospital stay (days)	7 (5-12)

The stone-free rate rose to 83.3% with the additional secondary procedure. The complication rate for the entire group was 36.7%. No colon injuries were seen in this study. Patients were discharged home after a median hospital stay of 7 days (5 to 12 days) (Tables 1).

There was statistically significant relation between stone surface area and secondary procedure rate. It was also found that there was a significant relation between secondary procedure rate and stone configuration. The mean operative time is 98.8 minutes (60-180 minutes). The operative time increases as stone burden increased. There was a significant correlation between the operative time and the stone burden (P <0.05)..

Table 2: Correlation of stone area and stone configuration with clinical outcome.

Stone configuration	Number	Stone free Rates (%)	Secondary Procedure rates (%)	Mean Operative time (min)	Complications (%)
Pure Pelvic stones	5	4/5 (80)	1/5 (20)	70	1/5(20)
Pure Calyceal stones	3	2/3(66.7)	1/3(33.3)	70	0
Pelvic dominant complex stones	8	4/8 (50)	4/8 (50)	90	2/8 (25)
Calyceal dominant complex stones	14	4/14 (28.6)	10/14 (71.4)	130	8/14 (57.1)
P value		P=0.036	P=0.036	P = 0.0001	P=0.059
Stone surface area					
<500mm^2	15	10/15 (66.7)	5/15(33.3)	75	3/15(20)
501-1000 mm^2	8	3/8 (37.5)	5/8(62.5)	110	3/8(37.5)
>1000 mm^2	7	1/7 (14.3)	6/7(85.7)	150	5/7(71.4)
P value		P<0.05	P=0.020	P = 0.0001	P=0.024

Similarly, there was a positive correlation between the operative time and the stone configuration. Bleeding necessitating transfusion or abandoning of procedure was considered a complication. But incidence was high in patients (5/7 cases, 71.4%) with the large stone burden (>1000mm^2). Bleeding necessitating blood transfusion was the most common complication, occurring in 30% of 30 PCNL procedures. Urine leakage from PCNL site occurred in 2 patients, beyond 24 hours, was managed conservatively. In 8 patients with supra-costal access, one pneumothorax occurred managed by right chest tube. 3 cases of mild hydrothorax were managed conservatively. The number of complications rose with increasing stone surface area being 20% in group 1, 37.5% in group 2, 71.4% in group 3, which is significant.

Table 3: Complications based on stone surface.

Surface area	500 mm^2	501-100 mm^2	>1000 mm^2
Fever	0	1	0
Obstruction	0	0	1
Collecting system perforation	1	2	0
Bleeding requiring transfusion	2	2	5
Pulmonary complication (hydrothorax/Pneumothorax)	1	1	2

However, when the relation between the complication rate and stone configuration was analyzed, there was no statistically significant difference between groups) (Table 2, 3).

DISCUSSION

Percutaneous nephrolithotomy is a well-accepted technique for the removal of large or complex renal calculi. Extracorporeal shock wave lithotripsy should be recommended for select cases with small stone burdens (<500mm^2) and non-dilated collecting system.[2] In present study, cases with stone surface area <500mm^2, PCNL was advised primarily as these stones were densely opaque on X-ray KUB film, anticipating ESWL resistance.

Today the most common indications for open stone surgery are a complex stone burden, failure of SWL or endourologic treatment and anatomic abnormalities.[2] However disappointing results of PCNL alone or ESWL monotherapy have led to a planned combination of these two techniques that has minimised the residual stone rate and reduced the disadvantages of each technique used alone.[8] The combined approach is based on a simple de-bulking of the stone by PCNL followed by multipleSWL sessions.[9] Also, percutaneous techniques are not always successful ESWL should be considered complimentary for large stones when several slices are involved.[9]

There is no absolute threshold value for stone size on PCNL. Very few studies have analysed the effects of stone burden and stone configuration on PCNL, outcome.[2] Hence the present study was undertaken. This study shows that overall stone-free rate and complication rate for large renal calculi is 46.7% and 36.7% respectively. Stone free rates obtained with PCNL in published reports range from 40 to 90%.[14] The practice of single tract PCNL and not using flexible nephroscope routinely might be causes of relatively low overall stone-free rate. Further, as stone surface area increased, the stone free rates decreased.

When stone-free rates were analysed about stone configuration, the best rates were achieved in patients with purely pelvic stones whereas worst results were obtained in patients with caliceal component dominant complex stones. In a study by Burak TQ et al. Similar findings were seen.[2] The advent of percutaneous procedures has significantly reduced the morbidity by attending previous surgical procedures.[10] However, PCNL is not without minor and major complications.[11] Reported complications rates for PCNL range from 0 to 38% and our overall complications rate 36.7% is in agreement with the literature.[11] Collecting system perforation has seen, in patients.[3] In one case significant perforation occurred, the procedure was abandoned.

No colonic perforations were observed in this study. The transfusion rate was 30%, the reason being, flexible nephroscopes was not routinely use, torqueing the rigid nephroscope against the pelvi-calyceal system might be a factor in the higher bleeding rate in patients with large stone burdens. In another similar study transfusion rate was 23.1%.[2]

Complications of PCNL can be minimised with proper patient selection and preparation.[2] In this study, there was a tendency toward higher complication rates with increasing stone size. From the results of this study, one can predict stone-free rates and complication rates on the stone burden and stone configuration. Thus, necessary precautions such as adequate cross-matched blood can be provided beforehand.[2]

Lam et al have elegantly shown that stone surface area measurements with computers are feasible, economical, highly accurate and reproducible.[6,7] Though three-dimensional CT is ideal for measuring stone surface area, it is an expensive and additional cost for the patient. Hence, it was not used in present study. In the present study, graph paper was used tracing of a two-dimensional projection of stone on a KUB film in the antero-posterior view to measure surface area. The important difference in the data is that study by Lam et al included only staghorn calculi, where as we report results on all renal calculi, of which 46.7% were staghorn stones.[6,7]

The classification of staghorn stones as partial or complete is subjective and variable. The use of stone surface area eliminates differences among urologists regarding the definition of what constitutes a staghorn stone.[12] Although patients were classified regarding stone types, and the results were analyzed with respect to stone burden as well as the stone configuration to present the results in an objective way.

Helical CT is the most accurate method to determine residual calculi. Management of residual stones after primary PCNL continues to be controversial. Many authors advocate the use of repeated PCNL to obtain a stone free renal unit. For residual calculi, relook PCNL not done routinely because it needs anaesthesia additional hospital stay is expensive. The approach of the study relies on secondary ESWL as on outpatient treatment for retained fragments, which minimizes the number of tracks required by PCNL and hence reduces the operative time and risk of perforation, as well as extravasations and bleeding that are usually associated with multiple tracts. Finally, this combined approach has the advantage of lower residual stone rate; reduced disadvantages of each technique used alone, shorter hospital stay, lower cost, as ESWL is performed on outpatient basis. This approach was published by several series like to quote some.[8,13,6,7]

The stone free rates rose by 36.6% to 83.3% with secondary procedures (secondary procedure rate 53.3%). Reported secondary procedure rates range from 0 to 81% in the literature.[10] The high reliance on secondary ESWL may be explained by exclusive utilisation of a rigid nephroscope and single tract PCNL. Constant use of flexible nephroscopes to catch the distant and difficult stone fragments without increasing the number of tracts may reduce the need for secondary ESWL and improve the stone-free rate.[8] These rates are affected by stone number, size, nature (staghorn/simple), operator skills.

In the present study, the goal was to provide an analysis of treatment outcome for PCNL on the stone surface area and configuration. According to knowledge, there are only a few studies in the literature that analyse PCNL treatment outcomes about stone burden.[14] The limitations of the study was that the number of patients was not equally distributed among the groups, so one must be careful when analysing the data.

CONCLUSION

There is a decrease in the overall stone-free rate, as well as an increase in both the complication rate and the secondary procedure rate, with increasing stone surface area for PCNL.

Also, when stone burden grows, the mean operative time also rises. The stone-free rate decreases, while complication rate increases when the stone burden exceeds 1000 mm^2, suggesting critical stone burden. However, with a combined approach of PCNL and ESWL, the stone-free rate rises significantly without a concomitant increase in morbidity or complications as seen in multitrack PCNL. Concerning stone configuration, there is a decrease in the stone free rate, as well as an increase in the operative time with increasing caliceal components in complex renal stones. However, the stone configuration does not seem to influence complication rates or blood loss

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