

Comparison Of Percutaneous Nephrolithotomy By The Use Of Pneumatic Lithotripsy Alone Or In Conjunction With Ultrasonic Lithotripsy

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Abstract

Background: Percutaneous nephrolithotomy (PCNL) refers to an invasive process for removing large-size stones from the kidney. Pneumatic lithotripsy on the other hand is also an effective procedure in spite of the composition of stones. Lithotripsy through ultrasound helps in aspirating small particles of debris during the procedure of lithotripsy.

Objective: This study will investigate the comparative analysis of the percutaneous nephrolithotomy procedure through pneumatic lithotripsy alone or in combination with the ultrasonic lithotripsy approach.

Study design: A retrospective case-control study

Place and Duration: This study was done at Dr Ziauddin Hospital Karachi from October 2021 to October 2022

Methodology: A total of 128 participants were recruited for the study and divided into two groups with 69 participants each. Both the groups had undergone pneumatic lithotripsy either alone through percutaneous nephrolithotomy or in combination with ultrasonic lithotripsy. Data has been compared for the variables of the location, size, composition, the average range of treatments, time of operation, loss of blood, hospital stay, chances of device failure and rates of free stones.

Results: The study has depicted no difference in the variables at the baseline in terms of size, composition and location of the stone, number of treatment sessions provided and the number of stones found within the region. Results of the study show that the treatment provided through the combined approach of pneumatic along with ultrasonic lithotripsy has a lower stay within the hospital with a statistically significant p-value of 0.002 and lower time for operation with a p-value of < 0.005. These patients were also observed to have a low loss of blood with a p-value of 0.005. Some patients however required transfusions without any significant complications associated with it.

Conclusion: The study concluded that the combined approach has more beneficial effects as compared to a single approach with a lesser stay in the hospital, time of operation and decrease the loss of blood.

Keywords: Percutaneous nephrolithotomy, lithotripsy, ultrasonic lithotripsy, pneumatic lithotripsy, renal stones, kidney stones.

Introduction:

Percutaneous nephrolithotomy is the procedure of choice for the removal of calyceal and infected renal stones having a diameter of $> 2\text{cm}^1$. Patients may also have stones that reflect an anatomical variation in the collecting renal system or they may have priorly received an unsuccessful treatment through extracorporeal shock wave lithotripsy (ESWL)². Treatment through shock wave lithotripsy of the large-sized stones usually results in the dispersion of stones into small pieces which obstructs the passage of the ureter causing severe infections³.

Advanced research has been available which represents PCNL to be an effective treatment approach for the management of renal calculi⁴. However, there are variety of lithotripsy techniques that are available so far for destroying renal stones². Among them, one of the approaches is ultrasonic lithotripsy which helps in fragmenting the stones into pieces followed by the suction of the fragmented parts and thereby suggests minimal invasion of the surrounding tissues. In some cases, suction may irritate due to a large size of the fragments⁵. Pneumatic lithotripsy on the other hand is more successful and powerful as compared to other types of lithotripsies owing to having a minimum tissue injury when used with full caution⁶. Although, its disadvantages suggest that it is a time-consuming process and graspers are used for extracting the stones⁷. Literature suggests that the type of treatment technique is dependent upon the size, location and composition of the renal stone⁸. However, some studies suggest that ultrasonic lithotripsy along with percutaneous nephrolithotomy is essential for the removal of renal stones³. This study aims to compare the efficacy of pneumatic lithotripsy in combination with ultrasonic lithotripsy to isolated pneumatic lithotripsy.

Clinical implications: This study is important clinically as it will provide the basis for deciding the best approach for managing kidney stones. It will provide an evidence-based approach towards the process of management.

Methodology:

It was a retrospective case-control study in which 128 participants were recruited. All the patients were traced retrospectively to throw light on the surgical procedures of the patients that they had undergone for stone removal along with the outcome variables such as the timing of operations, and loss of blood during the procedure⁵. All the details were documented in the files including the patient's surgical procedures, post-operative summarization and complications associated with the patients. Patients were randomly assorted into two groups and there was no difference between both the groups in terms of age, inclusion or exclusion criteria, size, combination, type and location of the stone. The mean age for both the groups were recorded as (Group A = 50.5 ± 13.2 , Group B = 51.2 ± 12.2) and the mean size of the stone was recorded as (Group A = 25.0 ± 16.1 , Group B = 27.1 ± 17.4). Inclusion criteria included patients having a renal calculi size of $> 2\text{ cm}$. Exclusion criteria included patients less than 18 years of age having any associated comorbidity, complications or pregnancy³. All details of the patients were documented prior to surgery including history, physical examination, assessments, investigations and urine analysis.

Patients in group A had undergone a lithotripsy procedure through the use of a lithoclast which continued the process until the fragmentation of the renal stones into such small pieces that they can be removed easily with the help of a grasper. Patients in group B had undergone a lithotripsy procedure followed by ultrasonic lithotripsy. After the successful completion of the procedure, the **ureteric stent** was inserted in order to remove the hematuria. Several parameters were assessed after the successful completion of the procedure including the diameter of the stone, investigations after the first sessions (CT scan, KUB film and ultrasonography), the total time for the operation, time duration for the stay in the hospital, evaluation of the stone characteristics, any associated complications like chills, fever, loss of blood, pleural effusion or pneumothorax.

Statistical analysis:

All the recorded data of the patients were statistically analyzed by using the SPSS version 25 and results were recorded along with mean \pm S.D. T-test was used for comparing the means of different variables whereas the chi-square test was used for comparing the means of discrete variables by considering a value of < 0.05 as significant⁹

Results:

The study shows that all the values of the patients in terms of age, size, composition or location of stone were similar at the baseline (as shown in table 1). It has been observed that after the performance of the first session through percutaneous nephrolithotomy 25 of the group 1 patient whereas 19 of the group 2 patients were not **completely stone free** so further sessions were required for the removal of the residual renal calculi. Table no 2 has presented the comparative analysis of both groups in terms of the rate of stone removal initially ($p = 0.21$) and finally ($p = 0.35$), operation time ($p = 0.001$), hospital stay ($p = 0.004$), residual fragments and stone composition ($p = 0.008$). Residual fragments were still observed in some patients (Group A = 2, Group B = 3) even after the last session therefore ESWL was applied in order to get rid of the remaining residues.

In addition, some complications were also observed post-treatment and were presented in a tabulated form (table no 3). The study depicted that the combined treatment approach is very effective in the eradication of renal calculi from the kidneys with less loss of blood from the body (1.0 ± 0.2) with a p-value of 0.001. No complication of pleural effusion or renal perforations were observed in any of the two groups however, probe fracture has been the significant complication observed in about 4 patients in Group A. In addition, complications of obstruction (4 cases) and malformation (3 cases) were also observed in patients but most frequently in Group B patients. Severe bleeding requiring embolization has not been observed in any case of the two groups, and neither any patient required ureteroscopy for the removal of remaining fragmental stones in the kidney.

Table no 1: Characteristics of patients.

Characteristics	Group A patients	Group B patient	P-value
Number of patients.	69	69	-
Mean age.	50.5 ± 13.2	51.2 ± 12.2	0.71
Mean size of the stone.	25.0 ± 16.1	27.1 ± 17.4	0.25

Table no 2: Treatment outcome variables associated with the procedure (Chi-square analysis)

Outcome variables	Group A	Group B	p-value
Rate of success			
Initial rate.	40.6	60.9	0.21
Final rate.	80.2	91.5	0.35
No of sessions.	1.50 ± 0.5	1.21 ± 0.4	0.22
Time of operation.	112 ± 59	165 ± 45	0.001
Stay in hospital.	12.9 ± 3.8	9.5 ± 3.5	0.004
Patients with residual fragments	2	3	
Composition of stone			0.008
Uric acid	6 (7.4)	4 (6.1)	
Cysteine	10 (6.9)	10 (6.5)	
Calcium phosphate	14(12.9)	17(14.6)	
Calcium oxalate.	39 (51.3)	38 (49.2)	

Table no 3: Complications associated with the procedure.

Complications	Group A	Group B	p-value
Pyrexia	0	0	
Loss of blood	1.25 ± 0.9	1.0 ± 0.2	0.015
Pleural effusion	0	0	

Renal pelvis perforations	0	0	
Fracture of probe.	4	0	
Obstructions	0	4	
Malfunctions	0	3	

Discussion:

Extracorporeal shock wave lithotripsy (ESWL) has been considered the advanced therapeutic approach for the removal of kidney stones however, PCNL is also an essential procedure in the eradication of large-sized renal calculi¹⁰. Its implications are divided into three categories including access to the patient percutaneously, dilation of the tract and fragmentation of the stones¹¹. It has a high success rate for tackling the stones that are staghorn and lie in the superior part of the calyx⁵. The current study suggests that for targeting the stones, incisions were made at the level of lower or mid calyx for the prevention of complications¹². This procedure also requires tract dilation which creates access for nephrostomy. Amplatz facial dilators were used for the purpose of carrying out the procedure¹³. A study carried out by Song et al (2012) showed that this technique has a high perforation rate as compared to pneumatic lithotomy¹⁴. Several procedures of lithotripsy associated with the fragmentation of stones were developed starting with electrohydraulic lithotripsy on the basis of spark gap technology developed by Yutkin¹⁰.

The LITHOCLAST technique has utilized the pneumatic ballast for crushing the stone short of thermal effects production¹⁴. The energy produced by the technique connects the stone to the wire and thereby helps in acting as a chisel for the surface of the stone¹⁵. It is advantageous as it destroys the stone into minute fragments at an extremely cost-effective rate. Ultrasonic lithotripsy on the other hand uses the same mechanical energy for the creation of piezo-electric components¹⁶. It transmits vibration through a probe for the action of drilling in order to remove the particles of stone, especially of calcium oxalate, calcium phosphate, uric acid and cysteine⁷. When the probe comes in contact with the surface, it dissipates continuous vibration for fragmenting the stones, this continuous vibration is necessary for preventing the overheating of the probe. The device must operate between the power of 1-2 although the maximum point it can reach is 3¹⁰.

The combined approach of pneumatic lithotomy with ultrasonic lithotripsy is clinically advantageous and effective in the management of large-sized renal calculi¹⁷. Even in the presence of hard kidney stones that have difficult removal from the kidneys, ultrasonic lithotripsy has good and advantageous effects¹⁰. Power is utilized in this approach in order to make the stones into an appropriate size and shape for easy removal. The complications risk associated with this device is very low so it can be used very easily and safely¹². However, some complications with this technique suggest that the malfunctions of the device may occur in terms of fracture of the probe, and obstruction of the suctioning tube during the procedure. In some cases, hemorrhage may also occur as a serious complication¹⁴. Owing to the dilation of the tracts access has been given for the surgical options through the use of the suctioning device so that it doesn't require the use of forceps or any other device for grasping the fragmented stones¹⁵.

Limitations:

In spite of its effectiveness in clinical practice, this study has some limitations such as the study design. It was a single-centered retrospective study that covered the targeted population of the last ten years. Further, the patients were not divided on the basis of age as several parameters can disrupt the accuracy of the results. Therefore a highly evidence-based study such as an RCT should be adopted in this respect.

Conclusion:

The study concluded that the removal of renal calculi through the combined approach of ultrasonic lithotripsy with pneumatic lithotripsy or with isolated pneumatic lithotripsy are both efficient **energy modalities in PCNL**. However, certain variations exist in both the treatment approaches like the loss of blood, stay in hospital and time of operation

which were associated to be less with the combined approach as compared to the isolated treatment approach. Thus, the study suggests the application of a combined treatment approach to be an efficient and effective procedure and has some advantages over others.

Conflicts of interest:

There are no conflicts of interest in the study.

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