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Comparison of outcomes of Percutaneous Nephrolithotomy Using Pneumatic Lithotripsy and in Combination with Ultrasonic Lithotripsy for Renal stones in Stanley Medical College Hospital,Chennai

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Abstract:*Fernstrom and Johansson first removed a renal calculus through a nephrostomy tract in 1976, and percutaneous nephrolithotomy (PCNL) is now accepted as the procedure of choice .15 (group A) and 14 (group B) patients underwent Lithoclast PCNL and combination therapy, respectively, from March 2017 to July 2017, and the two groups were compared in terms of stone size, location, and composition, operative time; average number of treatments; hospital days; hemoglobin loss; ancillary procedures; rate of device failure; and initial and total stone-free rates.The two groups did not differ significantly in preoperative stone size, location, or composition; the average number of treatments; or the initial and overall stone-free rates. However, combination therapy was associated with a significantly lower operative time number of hospital days and average hemoglobin loss . Transfusions were required in 6 patients (4 and 2 in each group, respectively), but there were no significant complications related to percutaneous access.*

The combination of ultrasonic lithotripter and pneumatcLithoclast is more effective than pneumatic Lithoclast alone because it significantly decreases operative time, hemoglobin loss, and the hospital stay

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I. Introduction

Fernstrom and Johansson first removed a renal calculus through a nephrostomy tract in 1976, and percutaneous nephrolithotomy (PCNL) is now accepted as the procedure of choice for those patients who have large renal stones (＞2 cm in diameter), infected stones, or lower calyceal stones with obstruction or anatomical variations in the renal collecting systems as well as for those patients in whom prior extracorporeal shock wave lithotripsy (ESWL) has failed [1].In recent decades, endoscopic technology and operative techniques have consistently advanced, which has increased the success rate (＞90%) of PCNL and decreased the associated complications and morbidity [2]. Consequently, a wide range of lithotripsy techniques are currently available. One of these is ultrasonic lithotripsy, in which the stones are fragmented while suction is applied simultaneously [3].Little has been published about the use of ultrasonic lithotripters for PCNL. The objective of this study was therefore to compare the effectiveness of pneumatic lithotripsy combined with ultrasonic lithotripsy with the effectiveness of pneumatic lithotripsy alone.

II. Material And Methods

A review of medical records between Feb2017 and July2017 identified 40 patients who had undergone PCNL by the experienced surgeon. Details of the patients and the procedures and the postoperative clinical results and complications were recorded. Of the 40 patients, 21 (group A) underwent PCNL with pneumatic Lithoclastand 19 (group B) underwent simultaneous combination therapy withpneumaticLithoclastand an ultrasonic lithotripter. The patients were randomly assigned to receive PCNL performed by pneumatic lithotripsy or a combination of ultrasonic and pneumatic lithotripsy.

Study Design: Retrospective observational study

Study Location: This was a tertiary care teaching hospital based study done in the Department of Urology and Renal Transplantation,Stanley Medical College, Chennai , India

Study Duration: February 2017 to July 2017.

Sample size: 40 patients.

Inclusion criteria:

1. Presence of large (＞2 cm) renal stones,

2. low-pole stones,
3. partial and complete staghorn calculi.

Exclusion criteria:
1. Patient age below 18 years,
2. Presence of coagulopathy,
3. Pregnant women.

Procedure methodology:

The stone size and type were documented preoperatively. Before the operation, all the patients were subjected to intravenous urography (IVU) or computed tomography (CT), and if needed, an assessment of renal function was done by dimercaptosuccinic acid scanning. The urine culture had to be sterile and antibiotics were given 1hour before the operation.

For the group A patients, lithotripsy was performed by using a pneumatic lithoclast'andlithotripsy was continued until the stone had fragmented into pieces small enough to be removed directly by a two or three-pronged grasper. For the group B patients, lithotripsy was usually first initiated with a few bursts of the pneumatic lithoclast, after which the ultrasonic lithotripter was used. At the end of the operation, a nephrostomy tube was placed..

A number of parameters were recorded. The success of PCNL treatment was evaluated by two categories: 1) the initial stone-free rate, which was defined as no visible residual calcification or remanant calcification smaller than 4 mm in diameter (clinically insignificant residual fragment) on a plain KUB or CT image after the first session, and 2) the overall stone-free rate, which was defined as no residual fragment or $<$4 mm on the KUB film or CT image 4 weeks after the last treatment. The number of sessions referred to the number of PCNL procedures each patient underwent.

The total operation time was calculated by adding the time taken to perform the percutaneous nephrostomy to the time taken for the lithotripsy. Hospital days referred to the total number of days the patients stayed in the hospital after the first PCNL, during which time some patients also underwent a second or third PCNL procedure. After the last PCNL procedure, ESWL was used as an accessory treatment in the patients with residual stones ≥4 mm. The characteristics of the stones were evaluated. The complications associated with the PCNL session were recorded, including postoperative fever, total hemoglobin loss, need for transfusion, perforation of the renal pelvis, and the development of pneumothorax or pleural effusion. The total rates of technical lithotripter related problems that occurred during the PCNL were also recorded.

All data were statistically analyzed .The results were expressed as Means±SDs. Student's t-test was used to compare the mean values of the continuous variables, whereas the chi-square test was used to compare the discrete variables. A p-value less than 0.05 was considered significant.

Statistical analysis

All data were statistically analyzed .The results were expressed as Means±SDs. Student's t-test was used to compare the mean values of the continuous variables, whereas the chi-square test was used to compare the discrete variables. A p-value less than 0.05 was considered significant

III. Result

Table 1. Patients' characteristics

Pneumatic Lithoclast		Ultrasonic lithotriptor + Pneumatic lithoclast	p-value
No. of patients	21	19	
Mean age (yr)	55.9±14.5	54.5±13.3	0.660
Male:female	19:16	23:16	
Mean stone size	29.0±17.6	33.3±18.4	0.318
Type of stone			0.510[a]
Complete staghorn stone		2	
Partial staghorn stone	6	4	
Pelvis stone	10	10	
Calyceal stone	3		3

[a]: chi-square comparison with linear by linear

As shown in Table 1, groups A (Pneumatic lithoclast alone) and B (Pneumatic lithoclastin combination with ultrasonic lithotripsy) were similar in terms of stone size (29.0±17.6 and 33.3±18.4 mm, respectively, p=0.318). The two groups also did not differ significantly in the distribution of stone type (p=0.510): 9 group A patients and 6 group B patients had staghorn calculi, and the remaining stones were renal calyx stones or renal pelvis stones.

Table 2. Treatment outcomes after PCNL

	Pneumatic lithoclast	Ultrasonic lithotriptor + Pneumatic lithoclast	p-value
Success rate (%)			
Initial stone free rate	45.7	61.5	0.177
Overall stone free rate	85.7	92.3	0.369
No. of sessions	1.71±0.93	1.44±0.64	0.134
Operative time (min)	120±55	100±40.0	0.004
Hospital days	10±4.4	8±3.8	0.009
No. of patients with residual fragment	6	1	
Stone composition (%)			0.935[a]
Calcium oxalate	15	14	
Calcium phosphate	1	1	
Struvite	5	4	

PCNL: percutaneous nephrolithotomy, [a]: chi-square comparison with linear by linear

After the first PCNL session, 6 (28.5%) of the group A patients and 1 (5.26%) of the group B patients continued to have clinically significant residual stone fragments, and they had to undergo a second PCNL.Thus, as shown in Table 2, the initial stone-free rates for groups A and B were 45.7% and 61.5%, respectively (p=0.177). The average number of treatment sessions for groups A and B was 1.71±0.93 and 1.44±0.64, respectively; this difference did not achieve statistical significance (p=0.134). Whereas groups A and B did not differ significantly in their overall stone-free rates or stone composition (p=0.369, p=0.935), combination therapy significantly reduced the total operative time (120±55 vs. 100±40 min, respectively, p=0.004) and the duration of the postoperative hospital stay (10±4.4vs. 8±3.8, respectively, p=0.009). After the last PCNL session, 6 group A patients (28.5%) and 1 group B patients (5.2%) continued to have clinically significant residual stone fragments and therefore underwent ESWL treatment.
The rates of various complications associated with the first PCNL are shown in Table 3.

Table 3. Complications of percutaneous nephrolithotomy

	Pneumatic lithoclast	Ultrasonic lithotriptor + Pneumatic lithoclast	p-value
Postoperative fever (≥38.5°C)	0	0	
Hb loss	1.39±1.02	1.12±0.61	0.013
Transfusion	5	1	
Perforation of renal pelvis	0	0	
Pneumothorax or pleural effusion	0	0	
Total technical problems			
Lithoclast probe fracturing 2		0	
No. of suction tubing obstructions	n/a	1	
No. of lithotrite malfunctions	n/a.	01	

n/a: not applicable

None of the patients experienced severe bleeding that required embolization. There were also no cases of pleural or lung injury due to the puncture. None of the patients required ureteral catheterization or ureteroscopy to remove residual stones. Pneumatic lithoclastalone was associated with mechanical failures in 2 group A patients (9.52%), and this was due to fracturing of the lithoclast probe (Table 3). Combination therapy was associated with mechanical malfunction in 2 group B patients (10.52%) due to suction tube obstruction (1 patients) and device failure that required resetting of the machine every 30 minutes (1patient).

IV. Discussion

The PCNL procedures are divided in to three steps, percutaneous access, tract dilatation and stone fragmentation.The success of PCNL is related to the ability to achieve an optimal access tract.[4]

A number of lithotripsy approaches have been developed. The first is electrohydraulic lithotripsy (EHL), which is based on sparkgap technology and was first introduced by Yutkin (1955). Raney and Handler have reported the use of EHL for open nephrolithotomy [5]. EHL is cheaper than the other lithotripsy devices. However, despite the technical improvements and extensive clinical experience with EHL, it remains the least safe of all lithotripsy devices [6].

The pneumatic lithoclastlithotripter uses pneumatic ballast, which crushes the stone without producing any thermal effects [7]. Because this mechanical energy passes along the metal wire to the stone, the probe works like a chisel on the stone surface [8]. This modality destroys all stones, regardless of their composition. Another advantage of the pneumatic lithoclast is that its cost is low.

Ultrasonic lithotripsy uses mechanical energy that is created by pizoceramic elements. The vibrations (23-27 Hz) are transmitted through rigid probes, which results in a drilling action [9,10]. This lithotripter allows stone fragments to be simultaneously aspirated through the hollow probe, which helps to remove the stone particles. In particular, soft matrix stones such as phosphate containing calculi can be readily suctioned out. Ultrasonic lithotripsy is very safe, because activating the probe when it is in contact with the urothelium results in only superficial erosion. However, ultrasound lithotripsy is somewhat less effective for very hard renal stones or for hard stones with a smooth surface [11].

The ultrasound and pneumatic lithotripsy technologies have recently been combined to produce a single device. Compared with an ultrasonic device, the combined pneumatic and ultrasonic device is associated with significantly increased lithotripsy efficacy (stone disintegration) and efficiency (stone fragmentation and clearance) [12,13]. The main advantage of using an ultrasonic lithotripter in combination with a pneumatic lithotripter is that the fragmented stones can be cleared by active negative pressure suction. Because negative pressure suction maintains the renal collection system at a low pressure, this also reduces the risk of bacterial infection. When considering the stone fragmentation efficacy of combined pneumatic lithoclastand ultrasonic lithotripsy, pneumatic lithoclast is more powerful for treating hard stones, whereas small fragments, granulation tissue-wrapped stones, impacted stones, and stones with a soft matrix (e.g., phosphate containing calculi) are particularly suitable for aspiration through the ultrasound probe.

The present study was limited by the fact that it was a retrospective, single-center study with a relatively small sample size (40 patients). In addition, the stones were not divided according to their composition into hard and soft stones. Although a device that combines ultrasonic lithotripsy with pneumatic lithoclast has recently been invented, little was known about the benefits of combining these two lithotripsy technologies, which makes this study useful for actual practice.

V. Conclusion

Disintegration of renal stones by use of pneumatic lithotripsy alone or together with ultrasonic lithotripsy was found to be effective. The combination was associated with significant reductions in the operation time, hemoglobin loss, and hospital stay as compared with the use of pneumatic lithoclastalone, and this was true regardless of the stones' composition. Thus, combining a pneumatic lithotripter with an ultrasonic lithotripter, which permits using the superior power of the pneumatic lithoclast and enables the aspiration of debris during ultrasonic lithotripsy, is highly advantageous for treating renal calculi.

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