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Original Article

Comparison of Outcomes of Pneumatic Ballistic Lithotripsy, Holmium Laser Lithotripsy, and Combined Electromagnetic with Ultrasonic Lithotripsy during Percutaneous Nephrolithotomy

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ABSTRACT

Objective: To compare outcomes of combined electromagnetic with ultrasonic lithotripter, pneumatic ballistic lithotripter, and holmium laser lithotripter among patients at a Tertiary Care Hospital.

Study Design: Prospective comparartieve study.

Place and Duration of Study: Department of Urology at Tabba Kidney Institute, Karachi Pakistan, from May 2020 to Jun 2021.

Methodology: Ninety patients were divided into three groups of lithotripsy energies. Group-A (n=30) patients got pneumatic lithotripsy, Group-B (n=30) patients got laser lithotripsy, while Group-C (n=30) patients got trilogy lithotripsy technique. Outcomes such as post-operative pain, post-operative complications, and stone clearance were evaluated in all groups.

Results: The overall mean age of the patients was 50.23±9.24 years, ranging from 33-74 years. The majority of the participants were males (n=52,57.8%), and 38(35.6%) of the participants were females. The intra-operative time, severity of post-operative pain, fever and UTI were the same between the three groups. However, the proportion of hematuria (p=0.001) and stone clearance (p=0.025) significantly differed between the three groups.

Conclusion: Laser and pneumatic lithotripter were more effective in complete stone clearance than trilogy lithotripter. While laser lithotripter significantly decreases the occurrence of hematuria.

Keywords: Complications, Hematuria, Laser lithotripsy, Pneumatic lithotripsy, Stone clearance, Trilogy lithotripsy, urolithiasis.

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INTRODUCTION

Urolithiasis is a frequent disorder that causes stones to form in the urinary tract or kidneys.[1] It is estimated that 5-9% of people in Europe, 1% to 5% in Asia, 20% in Saudi Arabia, and 13% in North America have it.[2] In 1979, Fernstorm *et al*. first utilised percutaneous nephrolithotomy (PCNL) to remove renal calculi.[3] Afterwards, PCNL was recommended as a standard treatment for patients with stone size >2.0 cm, unfavourable anatomy, and hard stones with house field unit > 800.[4] This procedure has the benefits of cost-effectiveness, higher success rates, and early convalescence than other treatments like Extracorporeal shock wave lithotripsy (ESWL) and open surgery.[5]

In recent years, advancements in endoscopic and operative techniques have also increased the success rate of PCNL up to 90% and decreased the related complications and morbidity.[6] Consequently, various intracorporeal lithotripsy devices are available to fragment the residual stones and help in their clearance. The pneumatic ballistic lithoclast lithotripter is the most extensively utilised method of stone breaking. The ultrasonic lithotripsy device, which breaks the stone by producing shock waves, is the second most regularly used device.[7,8] The latest technology, which combines electromagnetic and ultrasonic energies to more quickly break the hardest of stones, has been unveiled. It can spontaneously break the stone and aspirate the little pieces through multiple channels in the same instrument.[9] Hence, in this study, we have compared the efficacy of combined electromagnetic with ultrasonic lithotripter, pneumatic ballistic lithotripter, and holmium laser in terms of stone clearance, operative time, per operative complications, post-operative pain, post-operative hb loss, and hospital stay among patients presenting at a tertiary care hospital.

METHODOLOGY

The prospective comparartieve study was conducted at the Department of Urology at Tabba Kidney Institute, Karachi Pakistan, from May 2020 to June 2021 after approval from the Ethical Review Committee (ERC# TKI HEC 003). The sample size was estimated using statistics of the duration of operation

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in holmium laser lithotripter as 74.5±26.6 mins and in pneumatic ballistic lithotripter as 51.5±17.2 mins.[10] The non-probability consecutive sampling technique was applied.

Inclusion Criteria: Patients aged>18 years, of either gender, having renal stones greater than 2 cm and undergoing PCNL were included after informed consent.

Exclsuion Criteria: Pregnant females and patients having severe cardiopulmonary intolerance to surgery, urinary tract abnormalities, coagulopathy, organ infections or previous history of ureteroscopy were excluded.

After getting demographic data, a detailed history was taken, and pain status and lower urinary tract symptom status were evaluated. Presenting complaints and imaging systems were used, such as Ultrasound KUB, X-ray KUB, IVU, and CT, according to the instructions of the senior consultant. A total of 90 patients were divided into three groups of lithotripsy energies after randomization by lottery method. Group-A (n=30) patients got Pneumatic lithotripsy, Group-B (n=30) patients got Laser lithotripsy, while, Group-C (n=30) patients got Trilogy lithotripsy technique (Figure).

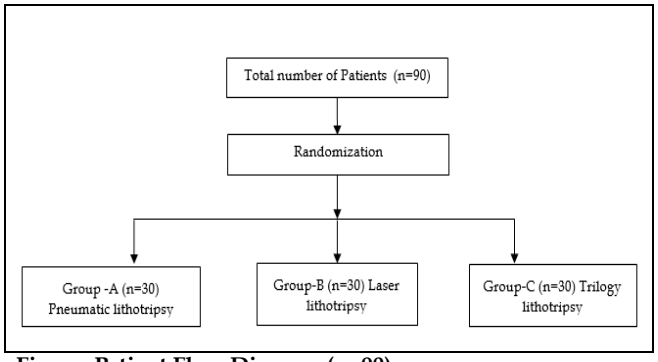

Figure: Patient Flow Diagram (n=90)

Under general anaesthesia, patients were positioned in dorsal lithotomy position; a cystoscope was introduced, a Ureteral catheter was passed over the guidewire onto the respective side under fluoroscopic guidance, the contrast was injected to highlight the pelvicalyceal system, findings noted under fluoroscopy, Foley's catheter inserted. The patients' position then changed to prone. The contrast was injected again to highlight the pelvicalyceal system, and then puncture was performed in the appropriate calyx using an 18 gauge needle; guidewire was then passed into the pelvicalyceal system. Then tract dilatation was performed with Alken Metallic Telescopic Dilators up to the appropriate size. After dilatation, Amplatz Sheath was inserted, a nephroscope was introduced, and the stone fragmented with the help of a pneumatic lithoclast or holmium YAG laser. At the end of the procedure, a fluoroscopic image was taken to confirm the stone-free status. The Amplatz sheath was removed, and hemostasis was secured by applying gentle pressure over the wound, which was then closed with the help of Vicryl rapid 4/0 or glue stitch. Foley's catheter and the ureteral catheter were left in place for 48 hours. No nephrostomy tube was placed. Time consumed during placement of the ureteral catheter in dorsal lithotomy position followed by the change of position to prone was also included in total operative time. Outcomes such as intra-operative time, post-operative pain and complications, and stone clearance were evaluated in all groups.

Statistical package of Social Science version 20 was used to analyse the data. Numeric variables were presented as Mean±SD/, median, and interquartile range. Categorical variables were presented as frequency and percentage. Categorical outcome variables were compared using the Chi-square, whereas numeric outcome variables were compared using the Kruskal-Walis test. The *p*-value of ≤0.05 was considered statistically significant.

RESULTS

Of 90 patients, the mean age was 50.23±9.24 years, ranging from 33-74 years. The majority of the participants were males (n=52,57.8%), and 38(35.6%) of the participants were females. The most frequent comorbidity was hypertension (n=32,35.6%), followed by diabetes (n=16,17.8%) (Table-I). In all groups, the pelvis was the most frequent location of the stone. The frequency of multiple stones was higher in Group-C than Groups A and B. A stone size of 10-20 mm was frequent in Groups B and C, and a stone size of 20-30 mm was frequent in Group A, respectively.

The median operative time was highest in Group A, followed by Groups B and C, but the difference was statistically insignificant (*p*=0.529)(Table-II).

The severity of post-operative pain and the proportion of fever and UTI were the same between the three groups. However, the proportion of hematuria was significantly higher in Group-A than in Groups B and C (*p*=0.001). In Group-A, 27(90%) patients had complete stone clearance, whereas in Group-B, 26(86.7%) patients and in Group-C, 18(60%) patients had complete stone clearance (*p*=0.025) (Table-III).

Table-I: Demographic and Clinical Characteristics of Participants in Study Groups (n=90)

Characteristics	Group-A	Group-B	Group-C
Age (years)	51.06±9.97	49.73±9.17	49.90±8.80
Gender			
Male	17(56.7)	23(76.7)	12(40)
Female	13(43.3)	7(23.3)	18(60)
Comorbidities			
Hypertension	12(40)	5(16.7)	15(50)
Diabetes Mellitus	12(40)	0	4(13.3)
Hypothyroidism	0	0	5(16.7)
Hepatitis	1(3.3)	0	0
Ischemic heart disease	3(10)	0	0
Stone location			
Pelvis	12(40)	17(56.7)	17(56.7)
Upper calyx	3(10)	0	1(3.3)
Mid calyx	1(3.3)	5(16.7)	2(6.7)
Lower calyx	4(13.3)	8(26.7)	2(6.7)
Multiple location	10(33.3)	0	8(26.7)
Number of stones			
Single	15(50)	15(50)	10(33.3)
Multiple	15(50)	15(50)	20(66.7)
Stone size			
10-20 mm	9(30)	16(53.3)	12(40)
20-30 mm	11(36.7)	14(46.7)	6 (20)
30-40 mm	6(20)	0	5(16.7)
>40 mm	4(13.3)	0	7(23.3)

Table II: Comparison of Operative Time between Study Groups (n=90)

Groups	Operative time (minutes)	*p*-value
Group-A	100 (80-130)	0.529
Group-B	90 (70-120)	
Group-C	75 (65-100)	

Table-III: Comparison of Outcomes between Study Groups (n=90)

Outcomes	Group-A	Group-B	Group-C	*p*-value
Post-operative pain				
Mild	23(76.7)	22(73.3)	24(80)	0.081
Moderate	4(13.3)	8(26.7)	2(6.7)	
Severe	3(10)	0	4(13.3)	
Complications				
Fever	2(6.7)	3(10)	2(6.7)	0.529
UTI	1 (3.3)	0	0	0.999
Hematuria	23(76.7)	4(13.3)	16(53.3)	0.001*
Stone clearence				
Complete	27(90)	26(86.7)	18(60)	0.025*
Partial	3(10)	4(13.3)	12(40)	

DISCUSSION

Urolithiasis is a common urological problem, and treatment options for it have evolved dramatically in the last 20 years as technology and equipment have advanced.[11,12] The development of many energy sources, such as pneumatics, holmium lasers, and combined electromagnetic and ultrasonic lithotripsy, has improved PCNL success rates and reduced the risk of complications.[13] Some lab-based studies have revealed that the Holmium: YAG lithotripsy has the capability of producing smaller fragments of kidney stones as compared to other techniques of lithotripsy like electrohydraulic, mechanical (pneumatic or ultrasound), and pulsed-dye laser.[13,14] A retrospective analysis of lithotripsy techniques for bladder stones recommended that the pneumatic and ultrasound lithotripsies, using rigid, larger probes, may be more effective for fragmenting larger and harder stones than other intracorporeal device.[15,16] Hence, in the present study we have compared the outcomes of pneumatic, holmium laser and combined electromagnetic with ultrasonic lithotripsy.

Maghsoudi *et al*. also revealed that laser lithotripsy had more benefits than pneumatic lithotripsy in terms of success, i.e., stone clearance rate and lower rate of upward displacement of kidney stones. However, complication rates were rare and similar in both groups.[17] Some other studies showed that combined (ultrasonic and pneumatic) lithotripsy had a lower complication rate than ultrasonic lithotripsy.18 In our study, common post-operative complications were hematuria, fever and UTI. We found insignificant differences in the frequency of fever and UTI between groups. At the same time, hematuria was significantly lower in patients treated with laser lithotripsy, followed by trilogy and pneumatic lithotripsy. Timm *et al*. found no statistically significant difference in complications between trilogy and laser groups (p=0.994).[19] Abedi *et al*. also revealed that complications were statistically similar in pneumatic lithotripsy and laser lithotripsy groups.[20]

In the present study, we observed significant differences in the proportion of complete stone clearance between the three groups (p=0.025). The rate of complete stone clearance was higher in patients treated with pneumatic lithotripsy, followed by laser and trilogy lithotripsy. Rabani *et al*. found that the stone clearance success rate was similar in the pneumatic and laser groups (79.3% and 77.9%, p= 0.52).[16] Abedi *et al*. concluded that laser and pneumatic lithotripsy techniques were safe and effective for kidney stones. However, the laser group had a slightly higher stone-free rate than the pneumatic group.[20] In another study by Joshi *et al*. the stone clearance rate was higher in the laser group (98%) than in the pneumatic group (84%). However, the difference

between both groups was statistically insignificant, with *p*-value=0.507.[21] Jhanwar *et al*. found a statistically insignificant difference in stone-free rate between laser and pneumatic lithotripsy groups (94% and 100%).[22] We also found that the complete stone-free clearance rate was almost similar in pneumatic and laser lithotripsy (90% and 87%).

CONCLUSION

Laser and pneumatic lithotripters were more effective in complete stone clearance than trilogy lithotripters. While laser lithotripter significantly decreases the occurrence of hematuria.

Conflict of Interest: None.

Authors Contribution:

Following authors have made substantial contributions to the manuscript as under:

ME & SS: Data acquisition, data analysis, critical review, approval of the final version to be published.

SSUQ & AA: Conception, study design, data interpretation, drafting the manuscript, critical review, approval of the final version to be published.

Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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