

Combined Ultrasonic-Pneumatic Lithotripsy Reduces Operation Time, Hospital Stay in Staghorn Calculi, without Affecting Clearance

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Abstract

Objective: To compared ultrasonic and pneumatic lithotripsy for staghorn renal calculi, focusing on operation time, hospital stay, stone clearance rates, and patient-specific factors like age, gender, BMI, and disease characteristics.

Material and Methods: We retrospectively analyzed staghorn renal calculi patients treated at our institution from 15 March to 15 August 2023. Patients were separated into two groups: Group I (33 patients) received ultrasonic and pneumatic lithotripsy, and Group II (33 patients) received pneumatic alone. Operation time, hospital stay, and stone clearance were key outcomes. Secondary outcomes explored how patient demographics and illness variables affected primary outcomes. Statistical analysis used independent t-tests and chi-square tests, with a significance threshold of $P < 0.05$.

Results: The study included 66 patients 33 in Group I and 33 in Group II. Compared to Group II, Group I had considerably shorter mean surgery times and hospital stays across all patient demographics and stone types ($P < 0.001$ and $P \leq 0.02$, respectively). Stone clearance rates were similar between groups ($P > 0.05$), indicating similar stone-free effectiveness. Despite differences in operation timeframes and hospital stays, patient-specific factors did not affect stone clearance rates between groups.

Conclusion: Patients with staghorn renal calculi benefit from ultrasonic and pneumatic lithotripsy, which reduces operation duration and hospital stay without affecting stone clearing performance. These findings imply that the combination method may improve patient recovery and procedure efficiency. To optimize treatment outcomes, lithotripsy technique selection should also include patient and disease characteristics. Long-term results and cost-effectiveness of various lithotripsy methods need more study.

Keywords: Staghorn renal calculi, Lithotripsy, Ultrasonic lithotripsy, Pneumatic lithotripsy, Operation time, Stone clearance rate

How to cite: Khan F, Soomro N, Sarwar MA, Aslam MM, Qureshi HA, Murtaza HB. Combined Ultrasonic-Pneumatic Lithotripsy Reduces Operation Time, Hospital Stay in Staghorn Calculi, without Affecting Clearance. *Esculapio - JSIMS* 2024;20(02):277-282

DOI: <https://doi.org/10.51273/esc24.251320226>

Introduction

Urology faces a major problem in managing staghorn

renal calculi, enormous, complicated branching stones that occupy a big amount of the kidney's collecting system. Due to its mechanical approach of fragmenting stones for extraction or natural evacuation, pneumatic lithotripsy has become a prominent therapeutic option. In search of more efficient and effective treatments, ultrasonic energy and pneumatic lithotripsy have been combined. This combination may reduce treatment duration and improve patient outcomes by improving stone fragmentation. The efficacy of ultrasonic and pneumatic lithotripsy in treating staghorn renal calculi

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Submission Date: 28-03-2024

1st Revision Date: 18-04-2024

Acceptance Date: 12-06-2024

has been studied. This comparison aims to determine which technique improves stone-free rates, treatment sessions, patient safety, and recovery. This evaluation is crucial for clinical practise, treatment optimization, and patient quality of life for this onerous condition.

Urology still struggles to treat staghorn renal calculi, huge, branching stones that fill the renal collecting system. These calculi are notorious for their size, complexity, and ability to induce recurrent infections, chronic kidney disease, and renal failure if left untreated.¹ Over time, open surgery has given way to less invasive methods, with pneumatic lithotripsy becoming popular since it physically fragments stones to make them easier to remove.² Due to pneumatic lithotripsy's limitations, such as the necessity for several sessions and the risk of remaining fragments, there is growing interest in more effective treatment methods.

Combining ultrasonic energy with pneumatic lithotripsy is a major achievement in this field, combining the benefits of both modalities. Ultrasonic lithotripsy uses high-frequency sound waves to break down stones into tiny bits that can be removed or passed naturally, while pneumatic lithotripsy uses mechanical force to break down larger and harder stones.³ Research into their comparative efficacy has been spurred by the premise that combining these two techniques could increase stone-free rates, shorten treatment sessions, and reduce complications.

Early comparative studies suggest that combined ultrasonic and pneumatic lithotripsy may improve treatment outcomes for staghorn renal calculi.⁴ These studies emphasise the necessity of assessing these treatments' immediate success rates, patient safety, recovery duration, and quality of life.⁵ As such, continuing research and clinical studies are vital to finding the most effective and patient-friendly ways to manage this complex ailment, with the objective of improving staghorn renal calculi patients' care. Technological breakthroughs and improved patient outcomes have changed the literature on lithotripsy-managed staghorn renal calculi. Its direct mechanical force in fragmenting big kidney stones has made pneumatic lithotripsy a standard treatment. It has been shown to be effective, however it may require many treatment sessions and leave stone pieces.⁶ Ultrasonic lithotripsy uses high-frequency sound waves to shatter stones, giving finer control and perhaps minimising leftover fragments.⁷

Managing staghorn calculi with ultrasonic and pneu-

matic lithotripsy is recommended. The ultrasonic component disintegrates stone efficiently, while the pneumatic component handles harder, bigger stone particles.⁸ Early clinical trials and comparative research suggest that this combination technique may improve stone-free rates, complications, and treatment sessions compared to pneumatic lithotripsy alone.⁹

The literature also stresses the necessity of addressing patient-specific aspects such stone composition, anatomy, and comorbidities when choosing a treatment approach. Some stones work better with ultrasonic energy, whereas others work better with pneumatic force.¹⁰ Optimal outcomes depend on the treating urologist's ability and experience, as well as postoperative care techniques to reduce problems and speed recovery.¹¹ Finally, ultrasonic and pneumatic lithotripsy may improve staghorn renal calculi therapy, according to the research. It highlights a trend toward individualised treatment that combines technology and clinical knowledge to improve patient outcomes. Further research, particularly bigger randomised controlled trials and long-term follow-up studies, is needed to compare different therapy methods and inform clinical practise.¹²

Material and Method

The methodology section of this study was designed to rigorously evaluate the efficacy of two lithotripsy techniques in managing staghorn renal calculi, assessing various factors such as operation time, hospital stay, stone clearance rate, and the impact of patient demographics (age, gender, BMI) and disease characteristics (duration, type of renal stone) on treatment outcomes. This section outlines the patient selection criteria, treatment modalities, outcome measures, and statistical analyses employed in the study. The study analyzed staghorn renal calculi patients aged 18+ treated at a hospital between March and August 2023. Patients were divided into two groups: those treated with combined ultrasonic and pneumatic lithotripsy techniques and those treated with pneumatic lithotripsy alone.

Group I (Combined Ultrasonic and Pneumatic Lithotripsy): This group underwent a lithotripsy procedure that integrated ultrasonic and pneumatic energies to fragment and remove staghorn calculi. Group II (Pneumatic Lithotripsy Alone): Patients in this group received lithotripsy using solely pneumatic energy for stone fragmentation. Primary outcomes included operation time, hospital stay, and stone clearance rate, while secondary outcomes examined patient demographics and disease

characteristics' impact on primary outcomes. Data from electronic medical records was analyzed to assess post-treatment outcomes, including demographics, disease characteristics, and stone clearance through follow-up imaging studies. The study used descriptive statistics to summarize continuous and categorical variables, with independent t-tests and chi-square tests for comparison. Statistical significance was determined at a p-value of less than 0.05. The study protocol was approved by the institutional review board (IRB) of [Institution Name], ensuring compliance with ethical standards and patient confidentiality. As a retrospective study, patient consent was waived by the IRB, but all patient data were anonymized before analysis.

Results

The study compares two lithotripsy techniques for managing staghorn renal calculi, focusing on operation time, hospital stay, and stone clearance rates. Results show significant differences between the two groups, with combined ultrasonic and pneumatic lithotripsy reducing operation time and hospital stay. However, stone clearance rates showed no significant difference. The study emphasizes the importance of considering individual patient and disease factors when selecting the most effective lithotripsy technique.²⁰

The data shows that patients with staghorn renal calculi had an average disease duration of 8.33 months before intervention, with a range of 1 to 23 months. The lithotripsy procedures took an average of 207.90 minutes, reflecting the complexity of managing the condition. The average hospital stay post-operation was 3.96 days, indicating the benefits of lithotripsy as a less invasive approach compared to traditional open surgery. The table 1 presents the outcomes of a study evaluating the efficacy of combined ultrasonic and pneumatic lithotripsy versus pneumatic lithotripsy alone in managing staghorn renal calculi, segmented by age groups (15-49 and 50-70 years). It shows significantly shorter mean operation times for both age groups in Group I (combined therapy) compared to Group II (pneumatic alone), with P-values <0.001 for both age ranges. Similarly, mean hospital stays were significantly shorter in Group I across both age categories, with P-values of 0.02 and 0.04, respectively. However, the stone clearance rates between the groups did not significantly differ within the age groups, indicating similar efficacy in achieving a stone-free state (P-values of 0.81 and 0.08). Overall stone clearance rates showed no significant difference between the

groups, with 87.9% in Group I and 81.8% in Group II achieving stone clearance (P=0.49). This indicates that while the combined lithotripsy technique significantly reduces operation time and hospital stay, it does not compromise the efficacy of stone clearance when compared to pneumatic lithotripsy alone.

Table 2 outlines the effects of gender and BMI on the outcomes of lithotripsy for staghorn renal calculi, comparing combined ultrasonic and pneumatic lithotripsy (Group I) with pneumatic lithotripsy alone (Group II). For both males and females, Group I experienced significantly shorter mean operation times (P<0.001 for males, P=0.003 for females) and hospital stays (P<0.001 for males, P=0.01 for females) compared to Group II, indicating a clear advantage of the combined approach in reducing these parameters. However, stone clearance rates were not significantly different between groups for both genders, suggesting similar efficacy in achieving stone-free outcomes regardless of the lithotripsy technique used. Similarly, when categorized by BMI (normal weight versus overweight to obese), Group I showed significantly reduced operation times and hospital stays across both BMI categories (P<0.001), yet stone clearance rates showed no significant difference, indicating comparable effectiveness in stone removal across BMI classifications. These findings highlight the benefits of combined lithotripsy in redu-

Table 1: Impact of Age on Outcomes of Lithotripsy Techniques for Staghorn Renal Calculi Management.

	Category	Group I	Group II	P-value
Effect of age on mean Operation Time	Age Group 15-49 Years	187.26± 18.95	224.0± 19.2	<0.001
	Age Group 50-70 Years	193.6± 15.44	226.00± 18.42	
Effect of age on mean Hospital Stay	Age Group 15-49 Years	3.40±0.98	4.46±1.30	0.02
	Age Group 50-70 Years	3.55±1.04	4.44±1.46	0.04
Effect of age on Stone clearance Rate	Age Group 15-49 Years	12±0.853	11±0.633	0.81
	Age Group 50-70 Years	17±0.583	16±0.873	0.08
Stone Clearance	Yes	29 (87.9%)	27 (81.8%)	0.49
	No	4 (12.1%)	6 (18.2%)	

cing operation times and hospital stays without compromising stone clearance efficiency, across different patient demographics.

Table 2: Gender and BMI: Their Influence on Lithotripsy Outcomes for Staghorn Renal Calculi

	Category	Group I	Group II	P-value
Effect of Gender on Mean Operation Time	Male	186.26±12.783	222.63±11.843	<0.001
	Female	201±3.393	228.42±9.892	0.003
Effect of Gender on Mean Hospital Stay	Male	3.56±0.482	4.31±1.042	<0.001
	Female	3.3±0.872	4.64±1.954	0.01
Effect of Gender on Stone Clearance Rate	Male	21±0.042	16±0.742	0.48
	Female	8±0.984	11±1.045	0.93
Effect of BMI on Mean Operation Time	Normal Weight (BMI: <24.9 kg/m ²)	188.78±11.053	228.14±12.322	<0.001
	Overweight to Obese (BMI: >25.0 kg/m ²)	192.15±10.492	222.84±9.743	<0.001
Effect of BMI on Mean Hospital Stay	Normal Weight (BMI: <24.9 kg/m ²)	3.52±0.743	4±0.492	<0.001
	Overweight to Obese (BMI: >25.0 kg/m ²)	3.15±0.742	4.78±0.843	<0.001
Effect of BMI on Stone Clearance Rate	Normal Weight (BMI: <24.9 kg/m ²)	12±0.853	10±0.733	0.35
	Overweight to Obese (BMI: >25.0 kg/m ²)	17±0.643	2±1.322	1.0

Table 3:

	Category	Group I	Group II	P-value
Effect of Duration of Disease on Mean Operation Time	Duration of disease <1 years	190±21.854	227.14±15.522	<0.001
	Duration of Disease > 1 years	194.8±9.593	213.6±7.583	<0.001
Effect of Duration of Disease on Mean Hospital Stay	Duration of disease <1 years	3.53±1.422	4.5±1.422	<0.001
	Duration of Disease > 1 years	3.2±0.733	4.2±0.583	<0.001
the Effect of Duration of Disease on Stone Clearance Rate	Duration of disease <1 years	24±0.432	24±0.633	0.95
	Duration of Disease > 1 years	5±0.482	3±0.873	0.13
Effect of Type of Renal Stone on Mean Operation Time	Partial Staghorn Stones	190.07±14.783	225.12±13.583	<0.001
	Complete Staghorn Stones	193.14±9.722	225±11.422	0.006
Effect of Type of Renal Stone on Mean Hospital Stay	Partial Staghorn Stones	3.5±1.001	4.33±0.733	0.02
	Complete Staghorn Stones	3.42±0.073	4.77±0.754	0.02

Table-3 delves into the impact of disease duration and renal stone type on lithotripsy outcomes, comparing combined ultrasonic and pneumatic lithotripsy (Group I) with pneumatic lithotripsy alone (Group II). It demonstrates that irrespective of the disease's duration (<1 year or >1 year), Group I consistently showed significantly shorter mean operation times ($P<0.001$ for both durations) and hospital stays ($P<0.001$ for both durations) than Group II, highlighting the efficiency of the combined approach in accelerating recovery. Interestingly, the stone clearance rate was not significantly influenced by the duration of the disease, indicating that both lithotripsy methods are comparably effective in removing stones regardless of how long the patient has had the disease. Additionally, when analyzing outcomes based on the type of renal stone (partial versus complete staghorn stones), Group I again benefited from shorter operation times ($P<0.001$ for partial staghorn stones, $P=0.006$ for complete staghorn stones) and hospital stays ($P=0.02$ for both stone types) compared to Group

II. These findings suggest that the advantages of combined ultrasonic and pneumatic lithotripsy in reducing operation times and hospital stays extend across different disease durations and stone types, without compromising the efficacy of stone clearance.

Discussion

The management of staghorn renal calculi through lithotripsy is a complex process due to the variability in stone composition, patient demographics, and the physical characteristics of the stones. A study found that a combined ultrasonic and pneumatic lithotripsy approach was associated with significant improvements in operation time and hospital stay across various patient subgroups. The study also found that both male and female patients in Group I benefited from shorter operation times and hospital stays, regardless of age. However, the stone clearance rate did not show significant differences between treatment groups when stratified by age or gender. BMI's role in influencing lithotripsy out-

comes was also examined, revealing that both normal weight and overweight to obese patients experienced better outcomes in Group I. The study also found that the duration of the disease prior to treatment did not significantly impact the likelihood of achieving stone clearance. The type of renal stone (partial versus complete staghorn stones) also influenced treatment outcomes, emphasizing the need for a tailored approach based on the extent of stone formation within the kidney.

Conflict of interest *None*

Funding Source *None*

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Authors Contribution

FK: Conceptualization of Project

NS: Data Collection

MAS: Literature Search

HBM: Statistical Analysis

HAQ: Drafting, Revision