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COMPARISON OF PNEUMATIC AND EMS SWISS TRILOGY LITHOTRIPSY IN CONVENTIONAL PERCUTANEOUS NEPHROLITHOTOMY

Original Research

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ABSTRACT

Background: Renal calculi are a significant urological burden globally, with percutaneous nephrolithotomy (PCNL) being the treatment of choice for large stones. Intracorporeal lithotripsy is a critical step during PCNL, where pneumatic and EMS Swiss LithoClast Trilogy are commonly used. Although several studies have compared these modalities internationally, data on their efficacy and safety within local clinical settings remain limited. This study was undertaken to address this gap and provide evidence-based guidance for urologists in resource-constrained regions.

Objective: To compare the stone-free rate and complication profile of pneumatic lithotripsy and EMS Swiss LithoClast Trilogy in patients undergoing conventional PCNL.

Methods: This descriptive comparative study was conducted at the Department of Urology, Lady Reading Hospital, Peshawar, from January 16 to July 15, 2021. A total of 122 patients aged 18–45 years with renal stones were enrolled. Participants underwent conventional PCNL with stone fragmentation using either pneumatic lithotripsy (n = 70) or EMS Trilogy (n = 52), based on clinical parameters. Outcomes were assessed in terms of stone-free rate on CT KUB at 2 weeks and complications graded by Clavien-Dindo classification. Data were analyzed using SPSS version 26, and a p-value ≤0.05 was considered significant.

Results: The mean age in the pneumatic and EMS groups was 32.78 ± 10.34 and 33.84 ± 12.05 years, respectively. Mean stone size was 16.21 ± 5.58 mm in the pneumatic group and 17.68 ± 6.29 mm in the EMS group. Stone-free rate was 84.7% with pneumatic lithotripsy and 74.0% with EMS Trilogy (p = 0.143). Grade IV complications were seen in 19.4% (n = 14) of the pneumatic group and 30.0% (n = 15) of the EMS group (p = 0.530).

Conclusion: Both pneumatic lithotripsy and EMS Swiss Trilogy are effective and viable intracorporeal modalities for stone fragmentation in conventional PCNL, showing comparable outcomes in terms of efficacy and safety.

Keywords: Lithotripsy, Nephrolithiasis, PCNL, Pneumatic Lithotripsy, Renal Calculi, Swiss LithoClast Trilogy, Urolithiasis.

INTRODUCTION

Renal calculus disease, commonly known as nephrolithiasis, is a prevalent global health concern, with a markedly higher incidence among males compared to females, exhibiting a male-to-female ratio of approximately 4:1. Peak occurrence is typically observed between the ages of 50 and 57 years (1). The disease burden varies across regions, with prevalence estimates ranging from 5% to 19.1% in West, Southeast, and South Asia, while lower rates of 1% to 8% are reported in East and North Asia (2). A regional study from Peshawar, Pakistan, revealed that 37.5% of patients presenting to Khyber Teaching Hospital were diagnosed with renal stones, with males aged 12 to 65 years predominantly affected (3). Moreover, nephrolithiasis significantly contributes to long-term complications, with 48.57% of affected individuals progressing to chronic renal failure (4). These figures underscore the urgent need for effective management strategies to combat the increasing burden of this disease, particularly in resource-limited settings. Several treatment modalities are available for the management of nephrolithiasis, ranging from conservative medical approaches to surgical interventions. Among these, percutaneous nephrolithotomy (PCNL) remains the standard of care for large renal calculi exceeding 2 cm in size (5). Stone fragmentation during PCNL is facilitated using various intracorporeal lithotripters, including ultrasonic, ballistic, laser-based, and combination devices. Pneumatic lithotripsy, which employs high-pressure air pulses to fragment stones, is widely used due to its cost-effectiveness, durability, and reusability, though it necessitates manual retrieval of stone fragments (6). In contrast, the EMS Swiss LithoClast Trilogy represents a more recent advancement in lithotripsy technology. It incorporates a single hollow probe that simultaneously delivers ballistic and ultrasonic energy, coupled with an inbuilt suction mechanism, thereby creating a trifecta effect that enhances stone clearance and procedural efficiency (7). Despite its clinical advantages, the Trilogy system is considerably more expensive, potentially limiting its widespread use in low-income regions.

In Pakistan, particularly in the conflict-affected and socioeconomically challenged province of Khyber Pakhtunkhwa, healthcare infrastructure and resources remain constrained. The region continues to experience a high incidence of primary and recurrent nephrolithiasis, intensifying the need for cost-effective and efficient treatment solutions. While multiple international studies have compared the clinical efficacy of pneumatic and Trilogy lithotripsy systems, there remains a paucity of data evaluating their comparative performance in conventional PCNL within this local demographic context (8,9). Addressing this gap is crucial for informing evidence-based decision-making and optimizing resource utilization in such settings. Therefore, the present study was designed to compare the efficacy of pneumatic and EMS Swiss Trilogy lithotripsy in conventional percutaneous nephrolithotomy, with particular focus on achieving stone-free rates and evaluating associated complications, thereby guiding future clinical practice in under-resourced healthcare systems.

METHODS

This descriptive comparative study was conducted in the Department of Urology at Lady Reading Hospital, Peshawar, over a six-month duration from January 16, 2021, to July 15, 2021. The study population included male and female patients aged 18 to 45 years, diagnosed with renal calculi confirmed by non-contrast computed tomography of the kidneys, ureters, and bladder (CT KUB), which showed a radio-opaque renal shadow. Exclusion criteria included any prior history of renal interventions, solitary functioning kidney, impaired renal function, and immunocompromised status, to eliminate potential confounding variables and ensure homogeneity of the study cohort. Institutional ethical approval was secured from the hospital's research review board, and informed written consent was obtained from all enrolled participants prior to the procedure. A total of 122 patients were recruited based on a calculated sample size using the WHO sample size calculator, assuming a 19.1% prevalence of renal stones, a 7% margin of error, and a 95% confidence level. Non-probability consecutive sampling technique was employed for recruitment (10,11). Preoperative data including demographic characteristics (age, gender, BMI), stone parameters (size, location, laterality), presence of comorbidities, and area of residence were documented using a structured proforma. All surgical procedures were performed under general anesthesia in the prone position by consultant urologists. After aseptic preparation and urethral catheterization, renal access was established using fluoroscopic guidance. Once the desired calyx was punctured, a guidewire was inserted followed by progressive tract dilation and placement of an Amplatz sheath. The nephroscope was introduced through the sheath for direct visualization of the calculus. Intracorporeal lithotripsy was performed using either a pneumatic lithotripter or the EMS Swiss LithoClast Trilogy system, with patients assigned to respective groups

based on the lithotripsy technique employed during surgery. The decision regarding lithotripsy modality was made according to standardized clinical criteria related to stone characteristics and patient profile.

Following fragmentation, a ureteric stent was inserted to maintain urinary drainage and prevent obstruction. Patients were observed for a minimum of 48 hours postoperatively and discharged upon achieving clinical stability. Postoperative care included analgesia, hydration, and monitoring for complications. Follow-up imaging using CT KUB was performed after two weeks to evaluate stone-free status, which was defined as complete absence of calculi or presence of clinically insignificant residual fragments <4 mm. Postoperative complications were recorded and classified using the Clavien-Dindo grading system, with grades III and IV considered clinically significant. Data analysis was carried out using SPSS version 26. Continuous variables such as age and stone size were presented as mean ± standard deviation, whereas categorical variables were expressed in frequencies and percentages. Chi-square test or Fisher's exact test, as applicable, was used to compare stone-free rates and complication rates between the two groups. Effect modifiers including age, gender, comorbidities, stone laterality, and size were controlled through stratification. A p-value ≤0.05 was considered statistically significant.

RESULTS

The study included a total of 122 patients, with an overall mean age of 33.21 ± 11.04 years. The mean age in the pneumatic lithotripsy group was 32.78 ± 10.34 years, while it was 33.84 ± 12.05 years in the EMS group. The average stone size among all participants was 16.81 ± 5.90 mm, with the pneumatic group exhibiting a mean stone size of 16.21 ± 5.58 mm compared to 17.68 ± 6.29 mm in the EMS group. The mean BMI across all patients was 24.62 ± 2.43 kg/m², with relatively similar distributions between the two groups. Hospital stay duration was also comparable, averaging 3.76 ± 1.35 days overall, with 3.74 ± 1.15 days in the pneumatic group and 3.80 ± 1.61 days in the EMS group. In terms of gender distribution, 67.2% of patients were male. The majority of participants belonged to the 18–30-year age group, comprising 57.4% of the total population, and distributed as 55.6% in the pneumatic group and 60.0% in the EMS group. Most patients had a BMI ≤25 kg/m² (63.9%) and presented with right-sided stones (52.4% overall). Single tract access was used in 77.9% of cases, with 79.2% in the pneumatic group and 76.0% in the EMS group. Hydronephrosis was more common in the pneumatic group (81.9%) compared to the EMS group (76.0%). Regarding stone number and morphology, 42.6% had a single stone, 35.2% had multiple stones, and 22.1% presented with staghorn calculi. Multiple stones were seen in 31.9% of patients in the pneumatic group and 40.0% in the EMS group.

The overall stone-free rate observed in the study was 80.3%. Pneumatic lithotripsy achieved a stone-free rate of 84.7%, while EMS achieved a rate of 74.0%, with no statistically significant difference between groups (p = 0.143). Postoperative complications were evaluated using the Clavien-Dindo classification. Grade 3 complications occurred in 21.3% of all patients, with similar distribution between pneumatic (20.8%) and EMS groups (22.0%). Grade 4 complications were reported in 23.8% of patients overall, with 19.4% in the pneumatic group and a higher rate of 30.0% in the EMS group, though this difference was also not statistically significant (p = 0.530). Subgroup analysis based on stone size, anatomical location, and stone type revealed notable variations between the pneumatic and EMS groups. The mean stone size was slightly smaller in the pneumatic group (16.21 ± 5.58 mm) compared to the EMS group (17.68 ± 6.29 mm), which may have influenced fragmentation outcomes. In terms of laterality, left-sided stones were slightly more common in the pneumatic group (51.4%), whereas right-sided stones predominated in the EMS group (58.0%). Analysis by stone type showed that single stones were more frequently treated in the pneumatic group (44.4%) compared to the EMS group (40.0%). Conversely, the EMS group had a higher proportion of patients with multiple stones (40.0% vs. 31.9%) and a slightly lower percentage of staghorn stones (20.0% vs. 23.6%). These subgroup differences suggest that patients in the EMS group may have had more complex stone presentations, which could have contributed to the observed differences in stone-free rates and complication profiles.

Table 1: Mean ± S.D of patient according to baseline parameters

Parameters	Overall (n = 122)	PL (n = 72)	EMS (n = 50)
Age (years)	33.21±11.04	32.78±10.34	33.84±12.05
BMI (kg/m2)	24.62±2.43	24.46±2.19	24.84±2.75
Stone Size (mm)	16.81±5.90	16.21±5.58	17.68±6.29
Hospital stays (days)	3.76±1.35	3.74±1.15	3.80±1.61

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Table 2: Frequencies and percentages of patients according to various clinical parameters

Parameters		Overall (n =122)	PL (n = 70)	EMS (n = 50)
		Frequency (%)	Frequency (%)	Frequency (%)
Gender	Male	82 (67.2%)	47(65.3%)	35(70.0%)
	Female	40 (32.8%)	25(34.7%)	15(30.0%)
Age (years)	18-30	70 (57.4%)	40(55.6%)	30(60.0%)
	31-45	52 (42.6%)	32(44.3%)	20(40.0%)
BMI (kg/m2)	≤25.0	78 (63.9%)	48(66.7%)	30(60.0%)
	>25.0	44 (36.1%)	24(33.3%)	20(40.0%)
Stone side	Right	64 (52.4%)	35(48.6%)	29(58.0%)
	Left	58 (47.5%)	37(51.4%)	21(42.0%)
Tracts number	Single	95 (77.9%)	57(79.2%)	38(76.0%)
	Multiple	27 (22.1%)	15(20.8%)	12(24.0%)
Hydro-nephrosis	Yes	70 (57.4%)	59(81.9%)	38(76.0%)
	No	52 (42.6%)	13(18.1%)	12(24.0%)
Stone number	Single	52 (42.6%)	32(44.4%)	20(40.0%)
	Multiple	43 (35.2%)	23(31.9%)	20(40.0%)
	Staghorn	27(22.1%)	17(23.6%)	10(20.0%)

Table 3: Frequencies and percentages according to outcome variables

Parameters		Overall (n = 122)	PL (n = 70)	EMS (n = 52)	P value
		Frequency (%)	Frequency (%)	Frequency (%)	
SFR	Achieved	98(80.3%)	61(84.7%)	37(74.0%)	0.143
	Not achieved	24(19.7%)	11(15.3%)	13(26.0%)	
Clavien Dindo Grades	3	26(21.3%)	15(20.8%)	11(22.0%)	0.530
	4	29(23.8%)	14(19.4%)	15(30.0%)	

Table 4: Subgroup Analysis: Stone Size, Location, and Type

Subgroup	Pneumatic Lithotripsy (n=70)	EMS Trilogy (n=50)
Stone Size (Mean ± SD)	16.21 ± 5.58 mm	17.68 ± 6.29 mm
Right-sided Stones	48.60%	58.00%
Left-sided Stones	51.40%	42.00%
Single Stone	44.40%	40.00%
Multiple Stones	31.90%	40.00%
Staghorn Stones	23.60%	20.00%

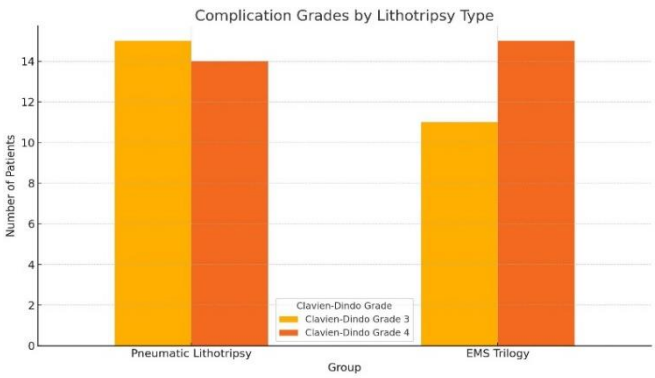

Figure 1 Complication Grades by Lithotripsy Type

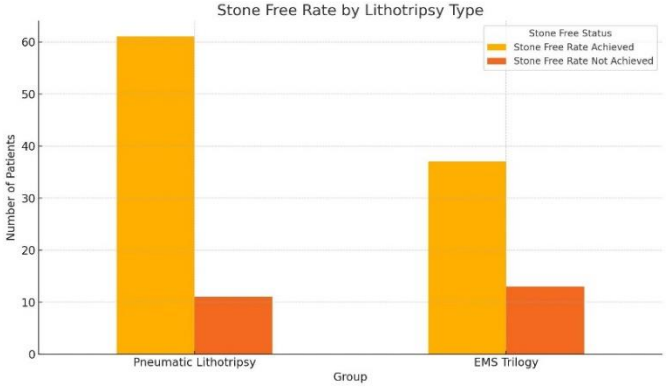

Figure 2 Stone free Rate by Lithotripsy Type

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DISCUSSION

The findings of the present study demonstrated a higher stone-free rate in the pneumatic lithotripsy group compared to the EMS Swiss LithoClast Trilogy group (84.7% vs. 74.0%), although the difference did not reach statistical significance. This pattern aligns with previous reports where stone-free rates between the two modalities remained statistically comparable, despite numerical variation. In some studies, EMS Trilogy achieved marginally higher clearance rates, whereas others reported a reverse trend, as seen in the current results. Differences in patient selection, stone complexity, and surgical expertise may account for these variations, emphasizing the influence of contextual clinical parameters on treatment outcomes (12,13). The average age of participants in this study was notably lower than that observed in comparable literature, where reported means ranged in the mid-forties. This discrepancy may be attributed to a narrower inclusion age range in the current investigation, which focused solely on patients aged 18 to 45 years. While the male predominance observed in this cohort was consistent with several existing studies, a few previous investigations demonstrated a more balanced gender distribution or even female predominance, highlighting regional and demographic variability in disease patterns (14,15). Stone characteristics also showed some variation from published data. Right-sided renal stones were slightly more frequent in this study, contrasting with earlier findings where left-sided stones were often more prevalent. Similarly, the mean stone size in this study was relatively smaller than reported in prior literature, suggesting a potentially lower stone burden in the current patient population. This may have influenced procedural ease and postoperative outcomes (16). Importantly, subgroup analysis revealed that multiple and staghorn stones were more common in the EMS group, which may partly explain the slightly lower stone-free rate and higher complication profile in that cohort. In terms of safety, the incidence of Clavien-Dindo grade 3 and 4 complications was higher in the EMS group, although not statistically significant (17,18). These results are consistent with the existing body of evidence where complication rates varied between studies but often showed overlapping ranges between the two techniques. Reports of hemothorax, hemorrhage, respiratory complications, and transfusion needs have been documented with both devices, and outcomes appeared to depend largely on surgical expertise, patient comorbidities, and stone complexity rather than the lithotripter alone (19,20).

The study contributes valuable data by directly comparing the clinical performance of pneumatic and EMS Swiss Trilogy lithotripsy in a low-resource setting. Its strengths include a well-defined patient cohort, standardized operative protocols, and consistent postoperative imaging to confirm outcomes. However, several limitations should be acknowledged. The non-randomized design and surgeon-led assignment to lithotripsy type introduce potential selection bias. Additionally, important perioperative parameters such as operative time, blood loss, and need for secondary procedures were not recorded, which could have enriched the outcome analysis. Future research should incorporate randomized controlled designs with stratification based on stone burden, type, and anatomical complexity to yield more definitive conclusions. Inclusion of additional objective endpoints such as operative duration, intraoperative complications, and long-term recurrence rates would provide a more holistic comparison. Furthermore, multi-center studies with larger sample sizes would help validate the findings and assess cost-effectiveness, especially in resource-constrained healthcare systems.

CONCLUSION

This study concluded that both pneumatic lithotripsy and EMS Swiss LithoClast Trilogy are effective and clinically viable options for stone fragmentation during conventional percutaneous nephrolithotomy. While pneumatic lithotripsy demonstrated a modest advantage in terms of stone clearance and a lower rate of clinically significant complications, the differences between the two modalities were not statistically significant. These findings suggest that either technique can be safely and effectively utilized based on clinical judgment, patient characteristics, and resource availability. The study underscores the importance of individualized treatment planning, especially in resource-limited settings, to optimize patient outcomes in the management of renal calculi.

Author Contribution

Author	Contribution
Siraj Ul Islam*	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published
Khalid Farooq	Substantial Contribution to study design, acquisition and interpretation of Data Critical Review and Manuscript Writing Has given Final Approval of the version to be published

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