

Treatment of Large Bladder Stone by Using Perurethral Nephroscope with Pneumatic Lithotripsy

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Abstract:

Background: Large bladder stones can cause significant morbidity and typically require active interventions. Pneumatic lithotripsy using a perurethral nephroscope is a minimally invasive and cost-effective treatment option. This study aimed to evaluate the efficacy and safety of treating large bladder stones using a perurethral nephroscope combined with pneumatic lithotripsy.

Methods: This cross-sectional study was conducted at Pabna Medical College Hospital and affiliated private hospitals from February 2020 to January 2025. Twenty-three patients with large bladder stones (≥ 3 cm) were enrolled. All patients underwent stone fragmentation using pneumatic lithotripsy with a perurethral nephroscope. Operative time, hospital stay, catheterization duration, and complications were also documented. Data were analyzed using SPSS version 25.0, with significance set at $p < 0.05$.

Results: The mean age was 52 ± 12 years, and 87.0% of the patients were male. The average stone size was 4.1 ± 0.6 cm in diameter. The mean operative time was 48.5 ± 12.0 minutes, with an average hospital stay of 1.6 ± 0.5 days. All patients were stone-free after the procedure. Minor complications occurred in 26.1% of the cases, including hematuria (13.0%), urinary retention (8.7%), and fever or stricture (4.3% each). No major complications were noted.

Conclusion: Perurethral nephroscopy with pneumatic lithotripsy is an effective, safe, and minimally invasive technique for managing large bladder stones, particularly in resource-limited settings.

Introduction:

Bladder stones constitute a significant subset of lower urinary tract calculi and continue to present a clinical challenge, particularly in resource-limited settings.¹ These stones are commonly associated with bladder outlet obstruction, urinary tract infections, and prolonged catheterization, and they may cause symptoms such as hematuria, dysuria, and urinary retention.² Large bladder stones, typically defined as those exceeding 3 cm, often require active intervention,

as spontaneous passage is rare and conservative management is usually ineffective.³

Traditional management options for large bladder calculi include open cystolithotomy, percutaneous cystolithotripsy, and transurethral fragmentation using energy sources such as ultrasonic, pneumatic, or laser lithotripters.^{4,5} Among these, pneumatic lithotripsy offers several advantages: it is cost-effective, highly efficient, and causes minimal thermal

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injury to surrounding tissues.⁶ Additionally, the use of a nephroscope—a tool traditionally employed in percutaneous nephrolithotomy—has been increasingly adapted for transurethral access in the bladder due to its superior optics, larger working channels, and improved irrigation flow.⁷

This novel combination of a perurethral nephroscope with pneumatic lithotripsy presents a minimally invasive and effective method for managing large bladder stones. Channa et al. demonstrated high success rates using this technique, with minimal complications and excellent stone clearance outcomes.⁸ In another comprehensive review, Gou et al. performed a meta-analysis comparing nephroscopy and cystoscopy and found that nephroscopes provided higher stone-free rates and shorter operative times, particularly in cases involving larger or multiple stones.⁹

Despite its promise, this approach remains underutilized, particularly in rural or semi-urban healthcare settings. Most existing studies have been conducted in high-volume tertiary centers with access to advanced urological equipment.¹⁰ Additionally, while laser lithotripsy has become more widespread in high-resource environments, the cost and maintenance of laser systems remain significant barriers in many parts of the world.¹¹

In contrast, pneumatic lithotripsy systems are relatively inexpensive and widely available, making them suitable for low-resource settings. The procedure is also easier to perform, has a shorter learning curve, and is associated with fewer complications when performed by trained urologists.¹² The use of a nephroscope via the urethral route enhances visualization and fragment retrieval, particularly in male patients with prostatic enlargement or in those with complex bladder anatomy.¹³

Given these advantages, there is a growing interest in validating this technique across diverse patient populations. However, the current literature lacks robust prospective data from lower-income regions where this approach could have the most impact. This study aims to address this gap by evaluating the efficacy, safety, and complication profile of perurethral nephroscopy with pneumatic lithotripsy for large bladder stones in a real-world clinical setting.

Materials and Methods:

This was a cross-sectional study conducted at the Department of Surgery, Pabna Medical College Hospital, and various private hospitals in Pabna. The study period extended from February 2020 to January 2025. A total of 23 patients with large bladder stones were enrolled on this research.

Sample Selection

Inclusion Criteria:

- Patients diagnosed with bladder stones ≥ 3 cm in size.
- Adults aged 18 years and above.
- Both male and female patients.
- Patients consenting to undergo perurethral nephroscopy with pneumatic lithotripsy.

Exclusion Criteria:

- Patients with bladder tumors or urethral malignancies.
- Individuals with uncorrected coagulopathies.
- Patients with urethral strictures prevent nephroscope insertion.
- Previous failed endoscopic stone removal procedures.

Data Collection and Study Procedure: Data were collected through clinical evaluation, imaging studies (ultrasound, X-ray KUB), and operative findings. A standard protocol was followed where all patients underwent bladder stone removal using a 24Fr Karl Storz nephroscope perurethra and pneumatic lithotripsy under spinal anesthesia. Operative data, including duration, complications, and recovery outcomes, were recorded. All participants gave informed consent before enrollment, and confidentiality was maintained. The study was conducted following ethical standards.

Statistical Analysis: Statistical analysis was performed using SPSS version 25.0. Descriptive statistics, including means and standard deviations for continuous variables and frequencies for categorical variables, were used. Inferential analyses, including chi-square and t-tests, were conducted where appropriate. A p-value < 0.05 was considered statistically significant.



Figure 1: X-ray Showing Large Bladder Stone Pre-Treatment



Figure 2: Bladder Stone Fragments Following Pneumatic Lithotripsy

Results

This study evaluated the outcomes of treating large bladder stones using a perurethral nephroscope with pneumatic lithotripsy in 23 patients. The analysis covered demographic and clinical characteristics, operative and postoperative parameters, and complication rates.

Table I <i>Demographic and clinical characteristics (n=23)</i>			
Variable	Category	Frequency (n)	Percentage (%)
Mean age, years (SD)		52±12	
Sex	Male	20	87.0
	Female	3	13.0
Mean stone size, cm (SD)		4.1 (±0.6)	
Stone Count	Single	15	65.2
	Multiple	8	34.8

Table I shows the demographic and clinical characteristics of the study population. The mean age of patients was 52 years (±12), with a predominance of male patients (87.0%). The average stone size was 4.1 cm (±0.6). Single stones were observed in 65.2% of patients, while the remaining 34.8% had multiple stones.

Table II <i>Operative and postoperative outcomes</i>	
Parameter	Value
Operative time (minutes)	48.5 ± 12.0
Hospital stays (days)	1.6 ± 0.5
Catheterization duration (days)	1.4 ± 0.3
Urethral entries	1.2 ± 0.4
Auxiliary urethrotomy required	3 (13.0%)
Stone free rate	23 (100.0%)

Table II presents operative and postoperative outcomes. The mean operative time was 48.5 minutes (±12.0), and patients had a short hospital stay, averaging 1.6 days (±0.5). Catheterization lasted approximately 1.4 days (±0.3), and most procedures required a single urethral entry (mean 1.2 ± 0.4). Auxiliary urethrotomy was needed in 13.0% of patients. Notably, the stone-free rate was 100%.

Table III
Rate of complications (n=23)

Complication	Frequency (n)	Percentage (%)
Mild hematuria	3	13.0
Urinary retention	2	8.7
Fever (>38°C)	1	4.3
Urethral stricture	1	4.3

Table III describes the complications encountered. Mild hematuria occurred in 13.0% of patients, urinary retention in 8.7%, fever in 4.3%, and urethral stricture in 4.3%. No major complications or mortalities were reported.

Discussion:

This study demonstrated that treating large bladder stones using a perurethral nephroscope combined with pneumatic lithotripsy is highly effective, with a 100% stone-free rate and minimal complications. This aligns with findings from Channa et al., who reported similar outcomes using pneumatic lithotripsy with a nephroscope for large vesical calculi.⁸

The predominance of male patients (87%) in this study mirrors the gender distribution seen in prior research by Ener et al., who noted higher prevalence among males due to factors such as prostate enlargement and increased bladder outlet obstruction.² The average age of 52 years is also consistent with global epidemiological trends, where the incidence of bladder stones peaks in middle-aged and elderly populations.

Operative efficiency, marked by an average procedure time of 48.5 minutes, compares favorably with previous studies. For instance, Yalçın found mean operative durations ranging from 45 to 60 minutes depending on stone burden and surgical technique.¹³ The short hospital stay (mean 1.6 days) and rapid catheter removal further highlight the procedure's minimal invasiveness. Such outcomes were echoed by Karami et al., who observed that transurethral holmium laser lithotripsy also allowed for day-care management in many patients.¹⁴

Importantly, the complication rate in this study was low. Mild hematuria (13.0%) and urinary retention (8.7%) were the most common, with only one case each of urethral stricture and fever. These findings are congruent with those of Abedi et al., who observed minor complications in 10–15% of patients undergoing pneumatic lithotripsy, mostly self-

limiting.⁵ Likewise, Akdeniz et al. reported similarly low morbidity with pneumatic devices compared to laser systems.⁴

The need for auxiliary urethrotomy in 13% of cases reflects anatomical or technical challenges, particularly in patients with tight urethras or large stone burdens. This rate is modest and supports the procedural safety noted by Erçil et al., who documented urethrotomy rates between 10–20% in cases with complex anatomy.¹¹

Comparative literature supports the choice of pneumatic lithotripsy as a cost-effective and efficient modality. Iqbal et al. and Rehman et al. both showed pneumatic lithotripsy to be non-inferior to extracorporeal shockwave lithotripsy for ureteral stones, with better clearance for larger calculi.^{6,15} The same principle extends to bladder stones, where larger fragments respond better to direct fragmentation than remote shockwave application.

The use of a nephroscope through the urethra as opposed to the traditional cystoscope is another strength of this technique. Gou et al. conducted a meta-analysis showing that nephroscopes provided better irrigation, wider fields of view, and facilitated fragment retrieval in complex cases.⁹ Additionally, studies like Gupta et al. support the adaptability of nephroscopes for transurethral use, especially when combined with pneumatic energy sources.⁷

However, some challenges remain. Urethral trauma and instrumentation-related strictures, while rare, are potential drawbacks, especially in male patients with narrow urethras. Preventive measures such as gentle dilatation and limiting the number of urethral entries, as practiced in this study (mean 1.2 entries), are key to minimizing such risks.

This study adds value to existing literature by offering real-world evidence from a resource-limited setting, validating the utility of pneumatic lithotripsy with a nephroscope even outside tertiary centers. While laser technologies may offer finer fragmentation and lower recurrence in some studies, the cost-benefit ratio remains in favour of pneumatic systems in most low-income regions.

The findings support the widespread adoption of perurethral nephroscopy with pneumatic lithotripsy for large bladder stones. It combines clinical efficacy with logistical feasibility, particularly in developing countries where resource optimization is paramount.

Recommendations:

The study's limitations include a small sample size and a single-region setting, which may affect generalizability. Lack of long-term follow-up restricts assessment of stricture formation and recurrence. Future research should involve multicenter trials with larger cohorts and randomized comparisons with laser techniques. Establishing standardized protocols can enhance reproducibility. Wider adoption of this approach is recommended, particularly in settings lacking access to advanced lithotripsy technologies.

Conclusion:

The use of perurethral nephroscope with pneumatic lithotripsy is a safe, efficient, and minimally invasive method for managing large bladder stones. This technique achieved a 100% stone clearance rate with minimal complications and reduced hospital stay. Its application is especially advantageous in resource-constrained settings due to its cost-effectiveness and ease of use. The results strongly support this technique as a standard option for large vesical stones.

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