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Research Article

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Complications of Transurethral Pneumatic Lithotripsy in Children with Bladder Stone Disease

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Abstract

Background

Pediatric bladder stone disease remains prevalent in developing countries and poses unique management challenges due to anatomical and physiological differences in children. Transurethral pneumatic lithotripsy (TPL) has emerged as a minimally invasive alternative to open surgery; however, procedure-related complications remain a concern.

Objective

To determine the frequency and types of complications associated with transurethral pneumatic lithotripsy in children with bladder stone disease.

Methods

This descriptive cross-sectional study was conducted from January 2024 to January 2025 at two tertiary care centers. Sixty children aged 2–15 years with imaging-confirmed bladder stones underwent TPL. Demographic data, stone characteristics, operative details, and postoperative complications within 30 days were recorded and analyzed descriptively.

Results

The mean age was 7.8 ± 3.2 years, with a male predominance (66.7%). Mean stone size was 13.5 ± 4.2 mm. Postoperative complications included hematuria (13.3%), fever (10.0%), acute urinary retention (8.3%), and bladder perforation (3.3%). All complications were managed conservatively, with no reoperations or mortality.

Conclusion

Transurethral pneumatic lithotripsy is a safe and effective minimally invasive procedure for pediatric bladder stones, with a low rate of mostly minor and manageable complications.

Keywords: Pediatric Urolithiasis, Bladder Stones, Transurethral Pneumatic Lithotripsy, Complications

1. Introduction

Although urinary bladder stones are relatively rare in children, they pose a notable health issue in developing countries, where their occurrence is considerably higher than in industrialized nations [1]. In these regions, the causes of pediatric vesical calculi are often multifactorial, with contributing elements such as inadequate nutrition—especially vitamin A deficiency—and a high prevalence of recurrent urinary tract infections, both of which increase

the risk of stone formation in children [1,2]. Epidemiological evidence shows that pediatric urolithiasis affects about 5% to 15% of children in developing countries, whereas in developed nations, the reported prevalence is typically lower, ranging from 1% to 5% [2]. Even with progress in urological techniques and enhancements in healthcare infrastructure, treating bladder stones in children continues to be challenging, largely due to anatomical and physiological differences from adults. The narrower urethra in pediatric patients restricts the use of conventional endoscopic instruments, frequently requiring adapted or specialized equipment to ensure safe access and effective stone management in this age group [4].

Traditionally, open surgery was the primary approach for managing pediatric bladder stones; however, such procedures carry higher morbidity, prolonged recovery times, and an elevated risk of complications [5]. The introduction of endoscopic techniques, particularly transurethral cystolitholapaxy and pneumatic lithotripsy, has transformed bladder stone management by allowing minimally invasive removal, leading to shorter hospital stays and lower overall complication rates, Transurethral pneumatic lithotripsy (TUL) uses high-frequency pneumatic impulses delivered through a cystoscope to break calculi into smaller fragments, enabling efficient removal while reducing trauma to the urinary tract [3,6]. In pediatric urology, the popularity of this procedure has increased because it offers benefits such as reduced post-operative pain, shorter hospital stays, and a lower risk of complications compared to open surgery or suprapubic cystolithotomy [5,6].

However, performing TUL in children presents significant technical challenges, as their smaller bladder capacity, fragile mucosal lining, and narrow urethral caliber increase the risk of complications, including mucosal injury, bladder perforation, hematuria, and urinary retention [7]. Previous research on the safety and effectiveness of TUL in children has shown differing rates of adverse events, likely due to variations in patient selection, surgical techniques, and institutional expertise. For instance, a retrospective study conducted by Ali et al [8]. Reported bladder perforation in 5% of pediatric cases, hematuria in 7%, acute urinary retention in 4%, and post-operative fever in 7% after TUL for bladder stones. Similar outcomes have been noted in other studies, emphasizing that certain complications can still occur despite the adoption of minimally invasive techniques [9,10]. Although these complications are typically manageable, they can still lead to notable morbidity, making thorough preoperative planning, appropriate patient selection, and diligent post-procedural monitoring essential. Moreover, various studies have identified potential risk factors for such complications, including stone size and hardness, anatomical variations, and socioeconomic factors that may affect access to healthcare and adherence to postoperative instructions [11-15].

Male children have been reported to show a higher rate of complications, which may be attributed to the comparatively narrow caliber and increased vulnerability of the male pediatric urethra to procedural trauma [13].

Despite the expanding literature, there is still a scarcity of local research focusing on the frequency and determinants of complications linked to TUL in children with bladder stone disease. Considering the higher prevalence of pediatric urolithiasis in resource-limited settings, along with potential variations in risk factors and healthcare delivery, generating context-specific evidence is crucial for guiding clinical practice and enhancing patient outcomes. This gap in knowledge highlights the importance of systematically investigating TUL-related complications in local pediatric populations, as such data are vital for refining procedural protocols, improving risk assessment, and directing resource allocation in urological care [14].

Therefore, this study was undertaken to systematically evaluate the frequency and determinants of complications associated with transurethral pneumatic lithotripsy in children with bladder stone disease at a tertiary care center. By exploring this research question, the study seeks to improve understanding of the risk factors for adverse outcomes in this group and to contribute to the development of safer, more effective treatment approaches for pediatric bladder stone disease.

2. Materials and Methods

2.1. Study Design, Setting, and Patient Selection

This was a descriptive cross-sectional study and was conducted for the assessment and evaluation of complications associated with TPL in children presenting with bladder stone disease. The study was conducted from January 2024 to January 2025 at the Department of Urology, MTI Mardan Medical Complex, Bacha Khan Medical College, Swabi, and the Institute of Kidney Diseases, Hayatabad, Peshawar.

A consecutive sampling technique was used. All pediatric patients with a presenting complaint of bladder stone disease throughout the study period were evaluated for inclusion. Children aged 2–15 years with ultrasonography- or radiological imaging-confirmed bladder stones were included consecutively until the final sample size was reached.

Patients with concomitant renal or ureteric calculi; congenital urogenital anomalies, including posterior urethral valves and neurogenic bladder; patients who had undergone other surgical procedures, such as open cystolithotomy or percutaneous cystolithotripsy; and incomplete case records were also excluded.

A total of 72 patients were evaluated, and based on the above exclusion criteria, 12 were excluded; thus 60 patients formed the final analysis. The flow diagram of the patient selection process is depicted in (Figure 1) below.

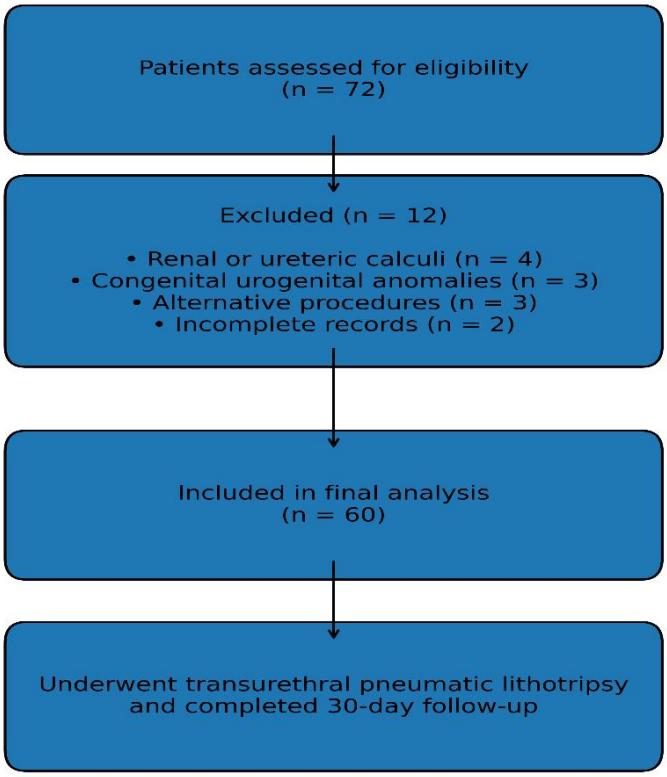

Figure 1: Flow Diagram Illustrating Patient Screening, Exclusion Criteria, Inclusion, and Follow-up

1.2. Preoperative Evaluation

All patients who were enrolled in the study underwent standardized preoperative assessment including detailed clinical examination, urinalysis, complete blood count, renal function tests, and radiological imaging (ultrasound ± plain radiography). Written informed consent was obtained from the parents or legal guardians of the patients before surgery. Stone size was measured preoperatively using ultrasonography and/or plain radiography, and the maximum stone diameter was recorded in millimeters for analysis.

1.3. Operative Technique and Perioperative Protocol

All procedures were carried out under general anesthesia. A pediatric cystoscope was used (9.5-12 Fr; Karl Storz, Germany). Stone fragmentation was done with a pneumatic lithotripter (Swiss LithoClast®, EMS, Switzerland). Continuous irrigation with normal saline was carried out using gravity-assisted flow, with attention to maintaining low intravesical pressure in order not to over distend the bladder. Irrigation along with mild suction was done to evacuate the stone fragments. At the end of procedure, bladder mucosa was examined carefully for injury and urethral calibration was done.

A Foley catheter of 6–10 Fr was selectively placed in patients with mucosal edema, hematuria, prolonged operative time, or injury to the bladder wall. The catheters were usually removed within 24–48 hours.

All patients received perioperative antibiotic prophylaxis intravenous third-generation cephalosporin at induction, followed by oral antibiotics for 3-5 days postoperatively.

All procedures were performed or overseen by consultant urologists with at least 5 years of experience in pediatric endourology to ensure procedural consistency.

1.4. Outcome Measures and Complication Reporting

Information was recorded on a structured proforma and included demographic variables, stone characteristics such as size, number, and consistency, operative details, and complications. Stone consistency was assessed intraoperatively based on fragmentation behavior during pneumatic lithotripsy. Stones that fragmented easily with minimal pneumatic energy were classified as soft, whereas stones requiring prolonged fragmentation time and higher energy were categorized as hard.

Complications were classified as:

- Intraoperative complications include: bladder perforation, urethral trauma
- Postoperative complications: these include such issues as hematuria, fever, urinary retention, and urinary tract infection

Postoperative complications were defined as events occurring within 30 days following surgery. Management strategies and outcomes of each complication were documented. All complications were managed conservatively, and no patient required reoperation.

1.5. Follow-up

Patients were followed for at least 30 days postoperatively through outpatient visits or telephone contact. Follow-up included stone recurrence, urethral stricture, urinary symptoms, or need for reintervention. No long-term complications or reinterventions were identified during the follow-up period. Longer-term follow-up could not be performed and is considered a limitation.

1.6. Statistical Analysis

For data analysis, SPSS version 25 was utilized. Only descriptive statistics were computed. Categorical variables were expressed as frequencies and percentages, while continuous variables were reported as mean ± standard deviation. Since no hypothesis testing or subgroup comparisons were planned, inferential statistics and p-values were not applied.

1.7. Ethical Considerations

Ethical approval was given by the Institutional Review Board of Institute of Kidney Diseases (IKD), Peshawar. Number: 337/chairman/R&E/COMMITTEE/IKD Written informed consent was obtained from the parents or guardians. All data of patients were anonymized, and the study followed the principles stated in the Declaration of Helsinki and ICMJE guidelines.

3. Results

A total of 60 children diagnosed with bladder stone disease underwent transurethral pneumatic lithotripsy during the period. The demographic and clinical characteristics of the study population are summarized in (Table 1).

The mean age of the participants was 7.8 ± 3.2 years. Most children were from the 6–10-year-old age group (22/60, 36.7%), followed by 11–15 years (20/60, 33.3%) and 2–5 years (18/60, 30.0%). Males dominated the cohort (40/60, 66.7%), while females accounted for 20/60 (33.3%). The mean body weight was 26.4 ± 7.1 kg, with almost half of the patients weighing between 20 and 30 kg (28/60, 46.7%).

Stone size ranged between 6 mm and 26 mm, with a mean size of 13.5 ± 4.2 mm. Stones measuring 10–20 mm was most common (30/60, 50.0%), followed by stones larger than 20 mm (16/60, 26.7%) and those smaller than 10 mm (14/60, 23.3%). More than half of the patients were from rural areas (34/60, 56.7%), while 26/60 (43.3%) resided in urban areas. Soft stones were seen in 36/60 (60.0%) patients, while 24/60 (40.0%) had hard stones.

Postoperative complications are outlined in (Table 2). The most common complication encountered was hematuria 8/60, 13.3%, followed by post-operative fever 6/60, 10.0% and acute urinary retention 5/60, 8.3%. Bladder perforation accounted for 2/60 3.3% of patients. The majority of patients had no complications, and overall post-operative morbidity was minimal. All complications were treated conservatively and reoperation or mortality was not encountered in this series.

Variable	Category	n (%)	Mean ± SD
Age (years)	2–5	18 (30.0)	7.8 ± 3.2
	6–10	22 (36.7)	
	11–15	20 (33.3)	
Gender	Male	40 (66.7)	—
	Female	20 (33.3)	—
Weight (kg)	<20	15 (25.0)	26.4 ± 7.1
	20–30	28 (46.7)	
	>30	17 (28.3)	
Stone size (mm)	<10	14 (23.3)	13.5 ± 4.2
	10–20	30 (50.0)	
	>20	16 (26.7)	
Residence	Urban	26 (43.3)	—
	Rural	34 (56.7)	—
Stone consistency	Soft	36 (60.0)	—
	Hard	24 (40.0)	—

Table 1: Demographic and Clinical Characteristics of the Study Population (n = 60)

Complication	Frequency (n)	Percentage (%)
Hematuria	8	13.3
Fever	6	10.0
Acute urinary retention	5	8.3

Bladder perforation	2	3.3
No complications	39	(65.0)
All complications were managed conservatively without the need for reoperation.		

Table 2: Postoperative Complications Following Transurethral Pneumatic Lithotripsy (n = 60)

3. Discussion

In the present series, TPL was found to be a safe procedure for bladder stones in children, with a low complication rate. Hematuria occurred as the most common complication in 13.3% of the patients, followed by postoperative fever in 10.0%, acute urinary retention in 8.3%, and bladder perforation in 3.3%. These results confirm the earlier series, in which this technique is identified as a minimally invasive and effective alternative to open or percutaneous approach in the pediatric population [16–19].

Variations in complication rates when compared with other published series may be related to differences in stone size, stone consistency, operative technique, and surgeon experience. Our rate of hematuria is similar to that described by Rizvi et al., who reported hematuria in 12% of pediatric patients treated by transurethral cystolithotripsy [16], and by Kumar et al., who described rates of 10-15% [17]. These findings suggest that transient hematuria is a common but self-limiting complication of endoscopic stone fragmentation, most likely as a consequence of minor mucosal trauma.

Stone size represents a critical determinant of procedural complexity and postoperative morbidity. In our cohort, a significant proportion of the patients had stones larger than 20 mm that could explain the relatively higher incidence of hematuria and urinary retention compared to the series with small stone burdens. Larger stone sizes require prolonged fragmentation and increased instrument manipulation, thus increasing the risk of urethral edema and clot retention, especially in pediatric patients with narrow urethral caliber [18,19].

Stone consistency also impacts operative difficulty and complication risk. Hard stones generally require higher pneumatic energy and longer fragmentation times, which may increase bladder wall stress and mucosal injury. Although soft stones predominated in our study, cases involving hard stones were associated with longer operative times, supporting previous reports that stone hardness contributes to increased morbidity during endoscopic management [11–13].

Surgeon experience and technical factors are crucial to maintaining complications at a low rate. In our study, all procedures were performed or directly supervised by experienced consultant urologists, and this no doubt contributed to the relatively low rate of major complications. Low intravesical pressure, avoiding overdistension of the bladder, and the selective use of postoperative catheterization have all been identified as methods of reducing adverse outcomes and were routinely utilized in this series [6,12].

Bladder perforation occurred in 3.3% of our patients-a rate at the lower end of the literature. This rate compares to a reported 2% perforation rate by Goyal et al. [19] and up to 4% by Rizvi et al. [16]. Similar to previous reports, all perforations within our cohort were small, extraperitoneal, and conservatively managed with catheter drainage. This reiterates the importance of early detection and appropriate postoperative management [16,19].

Socioeconomic parameters may relate to the severity of illness and the post-surgical outcomes in these patients. A higher proportion of our patients were from rural areas, where delays in seeking medical advice, limited healthcare facilities, and nutritional deficiencies are common. These factors can result in larger-sized stones at diagnosis and more formidable procedures. Regional studies from developing countries have also pointed out similar correlations between social class and disease severity in pediatric urolithiasis [20,21].

4. Conclusion

Transurethral pneumatic lithotripsy is a safe and effective minimally invasive technique for treating bladder stones in children, with a low complication rate consisting of nearly exclusively minor, manageable conditions. Hematuria, fever, and urinary retention were transient and resolved under conservative management, while bladder perforation was rare. When compared with open cystolithotomy, TPL offers the following advantages: reduced morbidity, shorter hospital stay, and quicker recovery. Stone size and consistency, surgical technique, experience of the surgeon, and the socio-economic profile seem to be the determining factors for complication rates. Careful patient selection, meticulous operative technique, and structured postoperative monitoring are essential to optimize outcomes. Larger prospective studies with long-term follow-up are recommended to further refine strategies for patient management.

Study Limitations

This study has a number of limitations, including its descriptive design and relatively small sample size, which precluded the performance of any inferential statistical analysis to identify independent predictors of complications. The composition of the stones was not analyzed, and their consistency was evaluated intraoperatively, which can be quite subjective. Follow-up was limited to 30 days, precluding assessment of long-term complications such as urethral stricture or stone recurrence. Further multicenter prospective studies with larger cohorts and extended follow-up are needed in order to more precisely define risk factors and long-term outcomes.

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