Postoperative Outcome of Laser Fulguration of Posterior Urethral Valve – An Observational Study

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Abstract: Introduction: Posterior urethral valve (PUV) is the most common cause of congenital bladder outlet obstruction in male children. Timely diagnosis and surgical ablation are crucial to prevent long-term renal and bladder dysfunction. **Holmium:** YAG laser fulguration has emerged as a precise and minimally invasive technique. **Aim:** To evaluate the postoperative outcomes of laser fulguration of PUV in terms of renal function, bladder dynamics, and complications. **Materials and Methods:** An observational study was conducted on 8 male patients (age range: 2 weeks–8 years; median: 6 months) who underwent laser fulguration of PUV. All patients were followed for 6 months with serial serum creatinine, estimated GFR, ultrasonography, Voiding cystourethrogram (VCUG), and uroflowmetry in toilet-trained children. **Results:** Preoperative mean serum creatinine was 1.6 ± 0.4 mg/dL, which improved to 0.9 ± 0.2 mg/dL at 6 months. eGFR improved from 42 ± 12 to 75 ± 15 ml/min/1.73m^2. Hydronephrosis improved in 6 patients, while 2 developed chronic kidney disease stage 3. Vesicoureteral reflux was present in 3 patients; it resolved in 2, while 1 persisted. Bladder dysfunction was noted in 2 patients requiring pharmacotherapy. Among 3 toilet-trained children, 2 achieved good continence with improved uroflowmetry patterns. Postoperative complications included febrile UTI in 2 patients and residual valve requiring re-ablation in 1 case. **Conclusion:** Laser fulguration of PUV is a safe and effective technique providing significant improvement in renal function and urinary dynamics. However, some patients continue to experience persistent bladder dysfunction or CKD, underscoring the importance of early intervention and long-term follow-up.

Keywords: Posterior urethral valve (PUV), Laser fulguration, **Holmium:** YAG laser, Voiding cystourethrogram (VCUG), uroflowmetry, Pediatric Urology, Bladder Outlet Obstruction, Hydronephrosis, Endoscopic Surgery, Chronic Renal Insufficiency

Author's Contribution:
SS- Definition of intellectual content, Literature survey, Prepared first draft of manuscript, implementation of study protocol, data collection, data analysis, manuscript preparation and submission of article; **SM**- Concept, design, clinical protocol, manuscript preparation, editing, and manuscript revision; **PKS**- Design of study, statistical Analysis and Interpretation; **AB**- Review Manuscript; **AKG**- Review Manuscript; **SSa**- Literature survey and preparation of Figures; **IP**- Coordination and Manuscript revision

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Introduction

Posterior urethral valves (PUV) represent the most common cause of congenital bladder outlet obstruction in male children and are a leading cause of chronic kidney disease and end-stage renal disease in childhood [1,2]. The reported incidence ranges from approximately 1 in 5,000 to 1 in 8,000 live male births [3]. Obstruction at the level of the posterior urethra results in progressive pathological changes involving both the upper and lower urinary tracts, including hydroureteronephrosis, vesicoureteral reflux, bladder wall hypertrophy, reduced compliance and progressive renal parenchymal damage [4,5].

The clinical presentation of PUV is highly heterogeneous and depends upon the severity and duration of obstruction as well as the degree of associated renal dysplasia. With the widespread use of antenatal ultrasonography, many patients are now detected in utero, commonly presenting with bilateral hydronephrosis, a distended thick-walled bladder and dilated posterior urethra [3]. Despite advances in prenatal detection and postnatal management, long-term renal and bladder morbidity remains common, and a substantial proportion of affected children progress to chronic kidney disease during childhood or adolescence [1,2].

The definitive treatment of PUV is early endoscopic ablation of the obstructing valve leaflets after initial stabilization and bladder drainage. Conventional endoscopic techniques using cold knife incision or monopolar electrocautery have been widely employed with acceptable technical success [1,6]. However, concerns persist regarding limited precision, bleeding, thermal injury and the risk of urethral trauma, particularly in neonates and small infants [7,8].

Holmium: YAG laser fulguration has emerged as an attractive alternative modality for PUV ablation. The laser offers precise tissue vaporization with a shallow depth of penetration and excellent hemostasis, thereby minimizing collateral tissue damage to the immature urethra [7,8]. Early clinical experience has demonstrated the technical feasibility and safety of laser ablation in infants and young children [7,8]. More recent

clinical series have reported encouraging short-term outcomes with respect to renal function recovery and procedural morbidity following laser fulguration [9,10].

Nevertheless, anatomical relief of obstruction does not necessarily translate into complete functional recovery. Experimental and clinical studies have demonstrated that prolonged intrauterine and early postnatal obstruction leads to irreversible bladder wall remodeling, characterized by detrusor hypertrophy, increased collagen deposition and altered neural regulation, a phenomenon commonly described as the post-valve bladder or valve bladder syndrome [4,5]. Furthermore, renal outcome is primarily influenced by the degree of congenital renal dysplasia rather than by the adequacy of surgical ablation alone [11,2].

Although laser fulguration is increasingly adopted in pediatric urological practice, there remain limited data regarding postoperative renal recovery, bladder dynamics, resolution of vesicoureteral reflux and early complications, particularly from developing healthcare settings [9,10]. The present prospective observational study therefore evaluates postoperative outcomes following **Holmium:** YAGlaser fulguration of posterior urethral valves, with specific emphasis on renal function, bladder dynamics, vesicoureteral reflux and procedure-related complications.

Aims and Objectives

- To evaluate the postoperative clinical outcome following laser fulguration of posterior urethral valves.
- To assess improvement in renal function and bladder dynamics.
- To study the resolution of vesicoureteral reflux (VUR) and postoperative complications.

Materials and Methods

Study Design and Ethical Considerations This prospective observational study was conducted over an 18-month period in the Department of Urology at Calcutta National Medical College, Kolkata. Ethical clearance was obtained from the Institutional Ethics Committee, and informed written consent was secured from the parents or legal guardians of all participants prior to enrollment. The study adhered to the principles of the Declaration of Helsinki.

Patient Selection and Recruitment A total of eight male children diagnosed with posterior urethral valves (PUV) were recruited for the study. Diagnosis was primarily established through clinical presentation and confirmed by voiding cystourethrogram (VCUG), which typically demonstrated a dilated posterior urethra and a thick-walled, trabeculated bladder.

- **Inclusion Criteria:** Male patients diagnosed with PUV by VCUG or cystoscopy who underwent primary laser fulguration and completed a minimum follow-up of 6 months.

- **Exclusion Criteria:** Patients with previous surgical interventions for PUV, associated major congenital anomalies of the urinary tract, or those with incomplete follow-up data.

Preoperative Evaluation Baseline evaluations included biochemical assessment of renal function, specifically serum creatinine and estimated Glomerular Filtration Rate (eGFR). Imaging via ultrasonography was utilized to assess the degree of hydronephrosis and bladder wall changes. Functional assessment was performed using VCUG to confirm the presence of the valve and identify any associated vesicoureteral reflux (VUR).

Surgical Technique: Holmium: YAG Laser Fulguration

The procedures were performed under general anesthesia. A pediatric cystoscope was used for visualization.

- **Instrumentation:** A **Holmium:** YAG laser was utilized for the ablation.
- **Laser Settings:** The laser was set at an energy of 0.5–0.8 Joules and a frequency of 8–10 Hz.
- **Ablation Protocol:** The valve leaflets were systematically fulgurated at the 5 and 7 o'clock positions until an adequate urethral lumen was achieved, ensuring the scope could easily pass into the bladder.

Postoperative Follow-up Patients were standardized for follow-up at 3-month and 6-month intervals:

- **Renal Function:** Serial serum creatinine and eGFR measurements.
- **Imaging:** Repeat ultrasonography to monitor hydronephrosis and repeat VCUG at 3 to 6 months to confirm successful valve ablation and assess VUR status.
- **Voiding Dynamics:** Uroflowmetry was utilized in the subset of patients who were toilet-trained to assess the maximum flow rate and voiding pattern.

Statistical Analysis

Data Management: Data were prospectively collected and subsequently entered into a secure electronic database. Categorical variables (e.g., presence of VUR, antenatal detection) were summarized as frequencies and percentages. Continuous variables (e.g., serum creatinine, eGFR, age) were expressed as mean ± standard deviation (SD) or median with range.

Outcome Measures The primary outcome was the change in renal function from baseline to 6 months post-intervention. Secondary outcomes included:

- Rate of spontaneous VUR resolution.
- Improvement in uroflowmetry patterns in toilet-trained children.
- Incidence of postoperative complications, including febrile UTI and residual valve tissue.

Statistical Testing

Given the small sample size (n=8), non-parametric tests were primarily utilized to ensure statistical rigor:

- **Comparison of Means:** The preoperative and 6-month postoperative values for serum creatinine and eGFR were compared to assess the significance of functional recovery.
- **Proportions:** Comparative analysis was used to evaluate categorical shifts, such as the resolution of hydronephrosis or VUR.
- **Significance:** A p-value of < 0.05 was considered statistically significant for all tests performed.

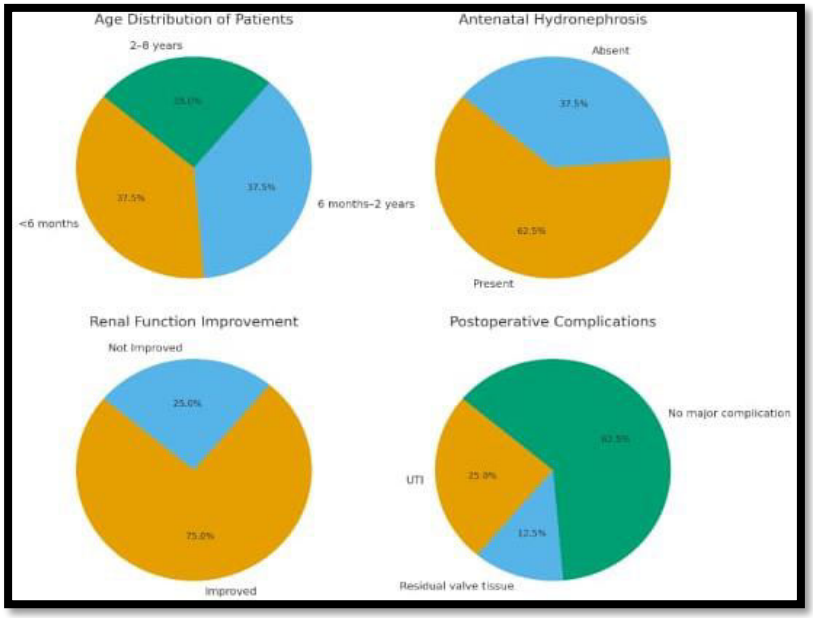
Subgroup Analysis A descriptive subgroup analysis was performed for patients with antenatal versus postnatal diagnosis to assess differences in baseline characteristics. Additionally, patients progressing to CKD Stage 3 were analyzed separately to identify potential clinical predictors of poor renal survival despite technically successful ablation.

Results

Patient Demographics and Baseline Characteristics

The study included a cohort of 8 male children with ages ranging from 2 weeks to 8 years, with a median age of 6 months. Antenatal hydronephrosis was a significant clinical indicator, present in 5 out of 8 patients (62.5%). All patients presented with classic features of posterior urethral valves (PUV) on preoperative voiding cystourethrogram (VCUG), characterized by a dilated posterior urethra and a trabeculated bladder.

Figure 1: Result analysis



Postoperative Renal Function Trends

Significant biochemical recovery was observed following **Holmium:** YAG laser fulguration.

- The preoperative mean serum creatinine was 1.6 ± 0.4 mg/dL, which significantly decreased to 0.9 ± 0.2 mg/dL at the 6-month follow-up.
- Concurrently, the mean estimated Glomerular Filtration Rate (eGFR) improved from a baseline of 42 ± 12 ml/min/1.73m² to 75 ± 15 ml/min/1.73m².
- Overall, 6 of the 8 patients (75%) exhibited a positive trend in renal function recovery.
- In contrast, 2 patients (25%) showed persistently elevated creatinine levels and eventually progressed to Chronic Kidney Disease (CKD) Stage 3, indicating irreversible parenchymal damage sustained prior to intervention.

Table 1: Comparison of Pre-Operative and Post-Operative Renal Function

Parameter	Pre-operative	6 Months Post-operative
Serum Creatinine	1.6 ± 0.4 mg/dL	0.9 ± 0.2 mg/dL
eGFR (ml/min/1.73 m²)	42 ± 12	75 ± 15

Lower Urinary Tract and Bladder Dynamics

The impact of ablation on bladder function and vesicoureteral reflux (VUR) was closely monitored.

- Preoperative VCUG identified VUR in 3 patients. Following successful valve ablation, spontaneous resolution of VUR occurred in 2 of these patients within 6 months, while it persisted in 1 case.
- Bladder dysfunction, characterized by symptoms requiring pharmacological management (e.g., anticholinergics), was noted in 2 patients (25%) postoperatively.
- Among the subset of toilet-trained children (n=3), 2 achieved satisfactory daytime continence.
- Postoperative uroflowmetry in these children demonstrated marked improvement in flow patterns, reflected by a transition from a straining/staccato pattern to a more bell-shaped curve.

Complications and Re-intervention

The surgical procedure was generally well-tolerated with no recorded intraoperative complications.

- Postoperatively, 2 patients (25%) experienced febrile urinary tract infections (UTIs) that were managed with culture-specific antibiotics.
- One patient required a "second-look" cystoscopy and repeat laser fulguration due to the presence of residual valve tissue discovered during follow-up surveillance.

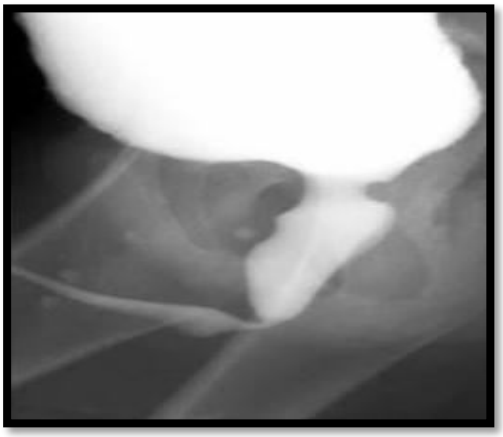


Figure 2: Pre op MCU

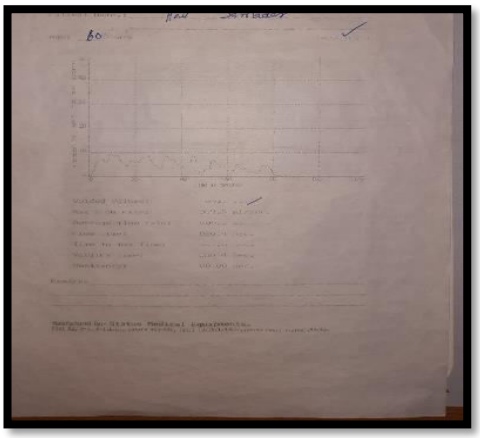


Figure 3: Pre op uroflowmetry

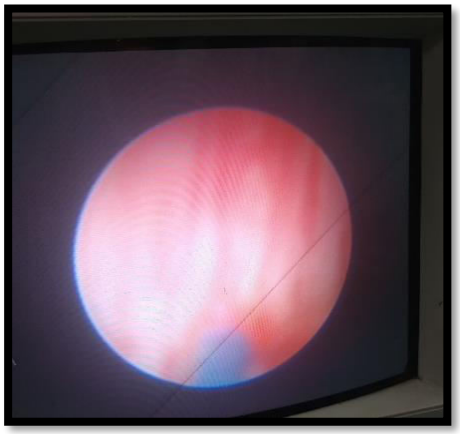


FIGURE 4:LASER fulguration

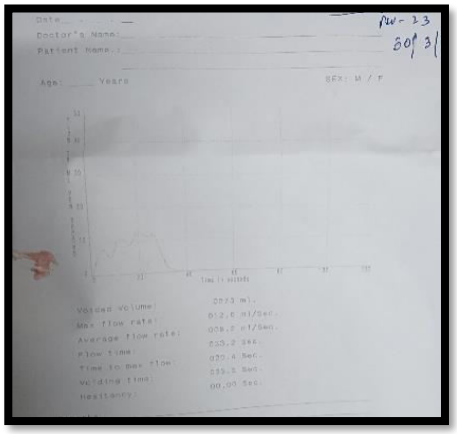


FIGURE 5: Post op uroflowmetry

Discussion

Posterior urethral valve disease is now widely recognized as a chronic urological and nephrological condition rather than a surgically curable anomaly [4,2]. Although endoscopic ablation effectively relieves the mechanical component of obstruction, long-term outcome is largely determined by the extent of pre-existing renal dysplasia and bladder dysfunction [11,2].

In the present study, improvement in renal function was observed in 75% of patients at 6-month follow-up, reflected by a significant reduction in serum creatinine and improvement in estimated glomerular filtration rate. Similar short-term improvement in renal parameters following Holmium laser ablation has been reported in contemporary series [9,10]. Studies evaluating outcomes following conventional endoscopic ablation have also demonstrated stabilization or improvement of renal function in the majority of children in the early postoperative period [6].

Despite technically adequate valve fulguration, two children in our cohort progressed to chronic kidney disease stage 3. This finding is consistent with previous long-term

studies demonstrating that postoperative deterioration of renal function may occur despite successful ablation [1,2]. Sarhan et al. demonstrated that nadir serum creatinine and sonographic evidence of renal parenchymal damage are strong predictors of long-term renal outcome, emphasizing the dominant influence of congenital renal dysplasia on prognosis [11]. Longitudinal follow-up studies have similarly shown progressive renal impairment during childhood and adolescence in a significant proportion of patients treated for PUV [1,2].

The use of Holmium: YAG laser in the present series was associated with excellent intraoperative safety and a low re-intervention rate. The technical advantages of laser ablation, including precise vaporization, minimal depth of penetration and superior hemostasis, have been well described [7,8]. These characteristics are particularly beneficial in neonates and small infants, in whom visualization and instrumentation are challenging [7,8]. Recent laser series have consistently reported low complication rates and good early functional outcomes [9,10].

Bladder dysfunction remains one of the most important contributors to long-term morbidity following PUV ablation. In the present study, persistent bladder dysfunction requiring pharmacological therapy was observed in 25% of patients. Earlier studies have demonstrated a high prevalence of detrusor overactivity, reduced compliance and impaired bladder emptying following valve ablation [5,12]. The underlying pathophysiology is related to irreversible structural remodeling of the bladder wall induced by chronic obstruction, including smooth muscle hypertrophy and increased collagen deposition [4,5].

The concept of the valve bladder syndrome highlights the progressive and dynamic nature of bladder dysfunction in children treated for PUV, explaining why lower urinary tract symptoms may persist or even worsen despite early relief of obstruction [4,5]. Persistent bladder dysfunction has also been shown to adversely affect upper tract function and is associated with recurrent urinary tract infections and progressive renal deterioration [13,2].

Vesicoureteral reflux was present in three patients in the present series, with spontaneous resolution observed in two at 6 months. Previous studies have demonstrated that reflux associated with PUV frequently improves following valve ablation due to a reduction in intravesical pressure and improvement in bladder emptying [14,15]. However, persistent reflux, particularly in the presence of bladder dysfunction, may contribute to ongoing renal injury and therefore requires continued surveillance [14,15].

Postoperative febrile urinary tract infection occurred in two patients in our cohort. Bladder dysfunction, residual urine and vesicoureteral reflux are well-recognized risk factors for recurrent urinary tract infection in children with posterior urethral valves [13,2]. Long-term bladder management strategies, including anticholinergic therapy, clean intermittent catheterization in selected patients and close follow-up, have

therefore been advocated to minimize infectious morbidity and protect renal function [13].

Although the short-term functional outcomes observed in this study are encouraging, the relatively short duration of follow-up limits meaningful assessment of long-term renal survival. Previous longitudinal studies have clearly demonstrated that deterioration of renal function may occur many years after apparently successful early intervention [3,1]. Consequently, lifelong surveillance of renal function, blood pressure and bladder behavior is recommended for all children treated for posterior urethral valves [2].

The principal limitations of the present study include the small sample size and short follow-up period. In addition, formal urodynamic evaluation was not performed in all patients, which may have underestimated the true prevalence of bladder dysfunction. Nevertheless, this study supports existing evidence that Holmium:YAG laser fulguration is a safe and effective technique for primary ablation of posterior urethral valves, while emphasizing that long-term outcomes are predominantly driven by renal dysplasia and bladder pathology rather than by the ablation technique itself.

Conclusion

Laser fulguration of posterior urethral valves is an effective and safe procedure, providing significant postoperative improvement in renal function and urinary dynamics. However, bladder dysfunction and CKD progression may persist in some patients, underscoring the need for vigilant follow-up and multidisciplinary care. Larger studies with extended follow-up are necessary to confirm these findings.

Conflict of interest: nil

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