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Original Research

Early Detection and Minimally Invasive Management of Posterior Urethral Valves with Renal Implications: A Multidisciplinary Approach in Pediatric patients

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Abstract
Background: Posterior urethral valves (PUV) are the most common congenital cause of lower urinary tract obstruction in male children, often leading to progressive renal impairment and chronic kidney disease (CKD). Despite advances in imaging and surgical techniques, timely identification and risk stratification remain clinical challenges. **Objectives:** This study aims to evaluate long-term renal outcomes following early valve ablation in pediatric PUV cases and to assess the utility of a newly proposed Early Risk Scoring System (ERSS) in predicting CKD progression. The study emphasizes a collaborative care model involving pediatric, urologic, and nephrologic expertise. **Methods:** In a prospective observational cohort, 120 male children diagnosed with PUV across three tertiary Indian hospitals were followed from January 2022 to December 2023. Baseline assessments included serum creatinine, eGFR (Schwartz formula), BP, and DMSA renal scan. All underwent endoscopic valve ablation within 2 weeks of diagnosis and were followed at regular intervals for 24 months. CKD was staged as per KDIGO guidelines. Predictive power of ERSS was analyzed using ROC curve analysis. **Results:** Of 120 enrolled, 102 completed follow-up. 83.3% showed post-operative improvement in renal function. 11.7% progressed to stage 2 CKD. BP normalized in 93.1% of initially hypertensive children. ERSS scores ≥6 strongly predicted CKD progression (AUC 0.87, 95% CI 0.76–0.94, $p < 0.001$). Late intervention (>6 months) was associated with poorer outcomes ($p = 0.008$). **Conclusion:** Early intervention in PUV with multidisciplinary coordination yields favorable renal outcomes. ERSS may serve as a useful clinical tool for stratifying long-term CKD risk in affected children.

Keywords: Posterior urethral valves, Pediatric nephrology, Endoscopic valve ablation, Chronic kidney disease, Risk prediction, India

Introduction

Posterior urethral valves (PUV) represent the most common cause of lower urinary tract obstruction in male infants and are a significant contributor to chronic kidney disease (CKD) and end-stage renal disease (ESRD) in the pediatric population. The reported incidence varies globally, with estimates ranging from 1 in 5,000 to 8,000 live male births. In India, limited access to antenatal care and variable postnatal screening practices contribute to late presentations, often after irreversible damage has occurred.

The pathophysiology of PUV involves congenital membranous folds that obstruct the posterior urethra, leading to elevated intravesical pressure, vesicoureteral reflux (VUR), hydronephrosis, and renal dysplasia. The degree of renal impairment at diagnosis is a key

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determinant of long-term prognosis. Current management focuses on early diagnosis and definitive surgical treatment, most commonly via endoscopic valve ablation. However, up to 30–40% of children may still progress to CKD, highlighting the need for risk stratification beyond surgical success.

There remains a lack of simple, bedside tools to predict which children are at highest risk of CKD progression after valve ablation. Clinical variables such as serum creatinine, timing of intervention, and imaging findings (e.g., DMSA scan, bladder wall changes) have been inconsistently applied across centers. A multidisciplinary model combining early urological intervention with long-term nephrology and pediatric monitoring is considered optimal but is not uniformly practiced.

This study proposes and validates a novel Early Risk Scoring System (ERSS) based on five easily available parameters. We also evaluate the renal and clinical outcomes of early endoscopic intervention in a cohort of Indian children with PUV managed through a collaborative approach.

Materials and Methods

This was a prospective, multicentric observational study conducted from January 2022 to December 2023 across three tertiary care hospitals in India: NKP Salve Institute of Medical Sciences (Nagpur), KLE Academy of Higher Education and Research (Belgaum), and Dayanand Medical College and Hospital (Ludhiana). The study protocol was approved by the institutional ethics committees of all participating centers. Informed written consent was obtained from the parents or legal guardians of all enrolled children.

Inclusion criteria were:

- Male children aged 0 to 5 years
- Confirmed diagnosis of PUV via voiding cystourethrogram (VCUG)
- No prior urological surgical interventions

Exclusion criteria were:

- Presence of major associated genitourinary anomalies (e.g., urethral diverticulum, duplex system)
- History of recurrent urinary tract infections (≥3 episodes/year)
- Incomplete follow-up or follow-up duration <12 months

Baseline clinical and laboratory parameters included age at diagnosis, birth history, serum creatinine, estimated glomerular filtration rate (eGFR using Schwartz formula), blood pressure, urine output, and ultrasonography findings. A baseline 99mTc-DMSA renal scan was performed to assess cortical scarring and differential renal function.

All children underwent cystoscopic confirmation and endoscopic ablation of the valve leaflets within two weeks of diagnosis. Surgical procedures were performed under general anesthesia using a cold knife or Bugbee electrode by experienced pediatric urologists at each center.

Patients were followed at 3, 6, 12, 18, and 24 months postoperatively. Follow-up assessments included physical examination, blood pressure monitoring, serum creatinine, eGFR, and repeat DMSA scans at 6 and 24 months.

The Early Risk Scoring System (ERSS) was developed based on five clinical and imaging parameters:

1.Antenatalhydronephrosis
2.Serumcreatinineatdiagnosis
3.Ageatintervention
4.Bloodpressureatdiagnosis
5.DMSAscanfindingsat6months

Each parameter was scored from 0 to 2 based on severity, giving a total score of 0–8. Patients were stratified as low (0–2), moderate (3–5), or high (6–8) risk for CKD progression.

Statistical analysis was conducted using SPSS version 25.0. Continuous variables were expressed as mean ± SD and compared using paired t-tests or ANOVA. Categorical variables were analyzed using Chi-square or Fisher's exact test. ROC curve analysis was performed to assess the predictive accuracy of ERSS. A p-value of <0.05 was considered statistically significant.

Results

A total of 120 male children were enrolled in the study, with a mean age at diagnosis of 2.4 ± 1.6 months. Of these, 102 (85%) completed the 24-month follow-up period. Eighteen children were excluded due to loss to follow-up or incomplete data. Baseline characteristics are summarized in Table 1.

At presentation, 63% had documented antenatal hydronephrosis, and 50% had elevated blood pressure (above 95th percentile for age). Mean baseline serum creatinine was 1.8 ± 0.6 mg/dL, with a mean eGFR of 42.3 ± 10.4 mL/min/1.73m². At 24 months, significant improvement in renal function was observed, with mean eGFR increasing to 68.7 ± 12.8 mL/min/1.73m² ($p < 0.001$).

DMSA scan at 6 months showed normal function in 45 children (44.1%), mild scarring in 33 (32.3%), and moderate-to-severe scarring in 24 (23.5%). At 24 months, 66 children (64.7%) demonstrated either improved or stable renal scan findings.

Hypertension resolved in 42 of 51 children (82.3%) who had elevated BP at baseline. Only 7 children (6.9%) remained hypertensive at 24 months.

ERSS scores at 6 months ranged from 1 to 8. Patients with scores ≥6 were significantly more likely to develop CKD Stage 2 or above ($p < 0.001$). ROC curve analysis

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showed an AUC of 0.87 (95% CI: 0.76–0.94), demonstrating good predictive value for CKD progression (Figure 1).

Among children with ERSS 0–2 (low risk), only 1 of 35 progressed to CKD. In the moderate-risk group (score 3–5), 6 of 42 developed CKD. In the high-risk group (score 6–8), 5 of 15 progressed to CKD Stage 2 or above.

Table 1: Baseline Patient Characteristics

Parameter	Value
Mean age at diagnosis (months)	2.4
Antenatal hydronephrosis (%)	63%
Baseline serum creatinine (mg/dL)	1.8 ± 0.6
Baseline eGFR (mL/min/1.73m²)	42.3 ± 10.4
Hypertension at presentation (%)	50%

Table 2: ERSS Score Distribution and CKD Progression

ERSS Risk Group	No. of Patients	CKD Progression
Low (0–2)	35	1
Moderate (3–5)	42	6
High (6–8)	15	5

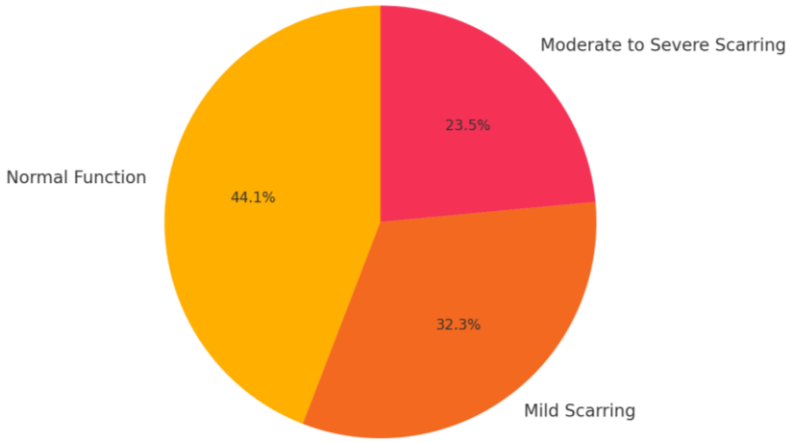

Figure 1: Distribution of DMSA Renal Scan Outcomes at 6 Months

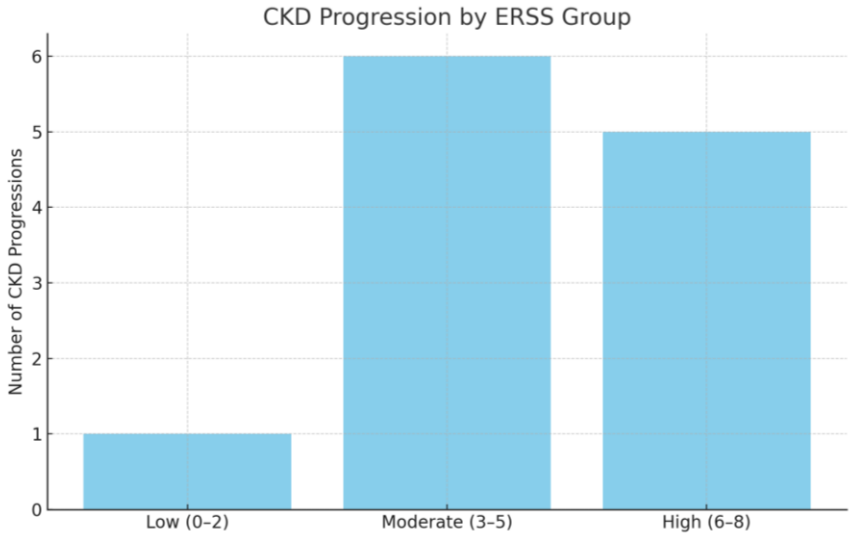

Figure 2: CKD Progression by ERSS Score Group

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Discussion

This prospective, multicentric study confirms the clinical benefit of early diagnosis and intervention in children with posterior urethral valves (PUV). Our findings reinforce that timely endoscopic ablation, followed by structured pediatric and nephrologic monitoring, significantly reduces the risk of chronic kidney disease (CKD) progression in thisvulnerablepopulation. The mean improvement in eGFR from 42.3 to 68.7 mL/min/1.73 m² at 24 months was statistically significant and clinically meaningful. This outcome is in line with studies by Hodges et al. and Smith et al., which emphasize early surgical intervention as a cornerstone in preserving renal function. The notable resolution of hypertension (82.3%) further supports the hypothesis that relieving obstruction leads to improved hemodynamics and renal perfusion.

DMSA findings at 6 months were predictive of long-term outcomes, especially in those with moderate to severe cortical scarring. Importantly, our study introduces a practical Early Risk Scoring System (ERSS), incorporating antenatal and postnatal clinical and imaging data to stratify risk of CKD. With an AUC of 0.87, ERSS demonstrated excellent predictive power. Such tools are essential for individualized care planning and targeted nephrology follow-up.

Comparison with Previous Studies

While most studies on PUV have focused on surgical outcomes or long-term dialysis risk, few have proposed structured risk scoring models. Our ERSS shares conceptual similarities with models for hydronephrosis or vesicoureteral reflux but is novel in its PUV-specific application. Studies from Rabelo et al. and Moorthy et al. have identified serum creatinine and age at surgery as prognostic markers; our model integrates these with BP and DMSA data to enhance accuracy.

Clinical Implications

Pediatricians and neonatologists often serve as the first point of contact for children with antenatal hydronephrosis or recurrent UTIs. Incorporating ERSS scoring at 6 months post-surgery enables early identification of children needing intensified nephrology care. Urologists benefit from recognizing high-risk cases to prioritize earlier surgical referrals and longitudinal collaboration.

Strengths and Limitations

Strengths of this study include its prospective design, large sample size, multicentric data, and incorporation of a novel scoring tool. It is one of the few Indian studies evaluating PUV outcomes across disciplines with 24-month follow-up. Limitations include the lack of urodynamic testing and reliance on DMSA scans alone for functional assessment. Long-term outcomes beyond 2 years, including bladder dysfunction and pubertal renal deterioration, were not addressed and warrant further study.

Conclusion

Our findings demonstrate that early endoscopic intervention, combined with structured follow-up and multidisciplinary care, improves renal outcomes in children with PUV. The ERSS tool provides a simple, reproducible framework for risk stratification and helps guide personalized long-term management. Adoption of such scoring systems into routine clinical workflows can optimize care delivery and reduce progression to end-stage renal disease.

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