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FACTORS ASSOCIATED WITH GOOD OUTCOMES IN PAEDIATRIC RENAL DUPLEX ANOMALIES: A RETROSPECTIVE CHART REVIEW

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ABSTRACT

Background: The aim is to describe the demographic profile, anatomical patterns, associated anomalies, management strategies, and outcomes in children diagnosed with duplex renal collecting systems in a tertiary care centre. **Materials and Methods:** This observational study included 72 paediatric patients with duplex renal systems. Demographic and clinical data, presentation, laterality, and type of duplex (complete/incomplete) were recorded. Evaluation was based on standard imaging and functional assessment as indicated, and management was individualised according to moiety function, drainage pattern, and associated anomalies. Surgical and conservative interventions, as well as post-treatment complications and follow-up outcomes, were analysed descriptively. **Result:** The study included 72 children, predominantly female (58.3%), with most aged 1–5 years. Most were asymptomatic (68.1%), and diagnosis was made almost equally by antenatal (48.6%) and incidental/postnatal detection (51.4%). Complete duplex systems were most common (91.7%). The major associated findings were hydroureteronephrosis (95.8%), vesicoureteric reflux (50.0%), and ureterocele (36.1%); ectopic ureter was identified in 10 cases, mainly in females. Management was predominantly renal-preserving, with nephron-sparing procedures in 59.7% and heminephrectomy for non-functioning moieties in 12.5%. Eighteen complication events were recorded, most frequently de novo VUR after ureterocele incision (n=8), with low-grade reflux often resolving on follow-up. **Conclusion:** Duplex renal systems in this cohort were predominantly complete and frequently associated with hydroureteronephrosis, reflux, and ureterocele. An anatomy- and function-based approach enabled renal preservation in most children, with heminephrectomy reserved for non-functioning moieties. Structured follow-up is essential, particularly after ureterocele incision, due to the risk of de novo or persistent reflux and recurrent infection.

INTRODUCTION

Duplex kidney, defined as congenital duplication of the renal collecting system, is a well-recognized yet clinically heterogeneous anomaly within the paediatric urinary tract. The reported incidence is approximately 0.7%–1%, and presentations range from incidental, asymptomatic detection to recurrent urinary tract infections (UTIs), hydronephrosis, ureterocele, ectopic ureter, vesicoureteral reflux (VUR), and obstructive uropathy.[1,2] The present study evaluates a sizeable paediatric cohort with duplex systems, characterising the distribution of complete and incomplete duplications, delineating moiety-specific involvement (upper versus lower moiety), documenting coexisting anomalies, and outlining the spectrum of management strategies employed—from endoscopic decompression to nephron-sparing reconstruction and heminephrectomy. Diagnostic evaluation in this cohort was guided by imaging and functional assessment, enabling tailored, anatomy- and function-based decision-making in keeping with contemporary approaches that prioritise renal preservation when feasible.[1,3,4] The discussion integrates these findings with current evidence, highlighting how anatomical phenotypes (including ureterocele, ectopic ureter, and reflux patterns)

influence outcomes and inform surgical selection, alongside the evolving role of minimally invasive and robot-assisted techniques in appropriately selected patients.[5-8]

Given the marked variability in duplex system anatomy and physiology, management is primarily determined by moiety function, drainage dynamics, and associated anomalies. Non-functioning upper or lower moieties may require heminephrectomy, whereas functioning segments complicated by obstruction, ectopia, or ureterocele are often amenable to nephron-sparing procedures such as endoscopic ureterocele incision, ureteric reimplantation, or ureteroureterostomy. The literature increasingly supports nephron-sparing strategies as the preferred initial approach when salvageable function is present, aiming to relieve symptoms while preserving overall renal reserve, with heminephrectomy reserved for poorly functioning moieties or complex anatomical configurations.[4,6,8,9] In this context, the cohort distribution—66 complete duplex and 6 incomplete duplex cases—offers a pragmatic depiction of the clinical phenotypes encountered in routine paediatric practice and the management pathways adopted in response to these underlying Patho physiologies.

MATERIALS AND METHODS

Study design and setting: This was an observational, descriptive study conducted in a tertiary care paediatric urology/surgery setting, analysing children diagnosed with a duplex renal collecting system. The study evaluated demographic characteristics, clinical presentation, anatomical patterns, associated anomalies, management pathways, and post-treatment outcomes.

Study population and sample size: A total of 72 paediatric patients with duplex renal systems were included. In addition to case-based analysis (N = 72), a renal unit–based analysis was performed wherever relevant (132 renal units), to better represent moiety-level pathology and side-specific disease distribution.

Eligibility Criteria

Inclusion Criteria

- Children diagnosed with a duplex renal collecting system (complete or incomplete duplication), identified on imaging and/or cystoscopic evaluation.
- Children managed conservatively or surgically at the study centre, with adequate clinical and imaging documentation for analysis.

Exclusion criteria (applied pragmatically based on record completeness):

- Incomplete clinical records precluding confirmation of duplex anatomy and/or management details.
- Cases where duplex system diagnosis could not be reliably established.

Data collection and variables

Clinical and imaging details were extracted from patient case records and procedure documentation using a structured proforma.

Variables included:

- Demographics: age, sex.
- Clinical status: symptomatic/asymptomatic presentation and primary presenting complaints (e.g., UTI, pyelonephritis, incontinence/ dribbling, pain, obstruction/ retention).
- Mode of detection: antenatal detection vs incidental/postnatal diagnosis.
- Anatomical characterization: complete vs incomplete duplex; laterality (unilateral/bilateral); moiety involvement (upper vs lower); and associated structural findings (e.g., ureterocele, ectopic ureter).
- Associated anomalies: hydronephrosis/ hydroureteronephrosis, VUR, UPJO/PUJO, VUJ obstruction, ureterocele with calculus, and other specific non-urological comorbidities.

Diagnostic evaluation: All children underwent baseline anatomical assessment using ultrasound, and further evaluation was individualised according to presentation and suspected anomaly. Where clinically indicated, the diagnostic work-up included:

- Voiding cystourethrogram (VCUG) for assessment and grading of vesicoureteric reflux (VUR) and lower urinary tract configuration.
- Functional assessment (e.g., radionuclide renography such as DTPA where performed) to evaluate drainage and differential function, particularly when obstruction or poorly functioning moieties were suspected.
- Cystoscopy/diagnostic cystoscopy for direct visual evaluation of ureteroceles, ureteric orifices, and relevant intravesical anatomy, and as part of endoscopic management when indicated.

Management approach: Treatment was individualised based on moiety function, degree of obstruction, reflux severity, presence of ectopia/ureterocele, and infection history. Management was recorded under broad categories and specific procedures, including:

- Conservative management: antibiotics for UTIs and surveillance for low-grade reflux or mild dilatation where appropriate.
- Diagnostic cystoscopy only when definitive intervention was not required at that stage.
- Nephron-sparing procedures: including endoscopic ureterocele incision, ureteric reimplantation, ureteroureterostomy, and Anderson–Hynes pyeloplasty.
- Extirpative procedures: heminephrectomy (open or laparoscopic) for non-functioning/poorly functioning moieties or complex anatomy with recurrent infection and non-salvageable function.

Outcomes and follow-up assessment: The primary outcomes included the distribution of duplex anatomy and associated anomalies, treatment modalities used, and post-treatment course. Post-treatment complications were documented as event-

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based outcomes, including recurrent UTI, de novo VUR after ureterocele incision, persistence of reflux after reimplantation, stent-related issues, residual ureterocele requiring re-intervention, and post-heminephrectomy site changes (e.g., cyst formation). Resolution/improvement was assessed through clinical follow-up and repeat imaging as indicated.

Statistical analysis: Data were analysed descriptively. Categorical variables were summarised using frequency (n) and percentage (%), with clear specification of denominators (case-based N = 72 or unit-based N = 132/66 per side where applicable). No comparative hypothesis testing was planned, as the primary objective was to characterise patterns of presentation, anatomy, management, and outcomes.

Ethical considerations: The study was performed in accordance with institutional ethical standards. Patient confidentiality was maintained throughout data extraction and analysis. Where applicable, informed consent/assent and institutional permissions were obtained as per local policy for clinical data use in academic research.

RESULTS

Table 1: Demographic and Clinical variables

		Frequency	Percent
Age (years)	<1	10	13.9
	1-3	22	30.6
	3-5	25	34.7
	>5	15	20.8
Gender	Male	30	41.7
	Female	42	58.3
Symptoms	Symptomatic	23	31.9
	Asymptomatic	49	68.1
Diagnosis	Antenatal	35	48.6
	Incidental	37	51.4
Management	Diagnostic cystoscopy only	20	27.8
	Non-functioning moiety requiring heminephrectomy	9	12.5
	Nephron-sparing procedures	43	59.7
	Total	72	100.0

[Table 1] summarises the baseline demographic and clinical profile of the 72 children included in the study. Most children were aged 3–5 years (25/72; 34.7%), followed by 1–3 years (22/72; 30.6%). Infants aged <1 year constituted 10/72 (13.9%), while children aged >5 years accounted for 15/72 (20.8%). Overall, females predominated (42/72; 58.3%) compared with males (30/72; 41.7%).

Regarding presentation, two-thirds were asymptomatic (49/72; 68.1%) and were identified either on screening or evaluation for other reasons, whereas 23/72 (31.9%) were symptomatic at diagnosis. Detection was almost equally distributed between antenatal diagnosis (35/72; 48.6%) and incidental/postnatal diagnosis (37/72; 51.4%).

In terms of management, nephron-sparing procedures were the most common approach (43/72; 59.7%), while diagnostic cystoscopy alone was performed in 20/72 (27.8%). Heminephrectomy for a non-functioning moiety was required in 9/72 (12.5%).

Table 2: Characteristics of Duplex

		Frequency	Percent
Type of Duplex	Complete	66	91.7
	Incomplete	6	8.3
Side affected in incomplete duplex	(i)Right side affected	3	4.2
	(ii)Left side affected	3	4.2
Condition of Opposite kidney in incomplete duplex	(iii)Opposite kidney Normal	2	2.8
	(iv)Ectopic vagina	1	1.4
	(v)VUR	3	4.2
Laterality of duplex cases	Unilateral	48	66.7
	(i) Right side	22	30.6
	(ii) Left side	26	36.1
	Bilateral	18	25.0
	Total	72	100.0

[Table 2] describes the anatomical characteristics of the duplex system in the study population. The vast majority of cases were complete duplex systems (66/72; 91.7%), while incomplete duplex systems were uncommon (6/72; 8.3%), indicating that complete duplication constituted the predominant structural pattern in this cohort.

Among the six incomplete duplex cases, the side affected was evenly distributed: right-sided in 3 cases (4.2%) and left-sided in 3 cases (4.2%) (percentages calculated using the overall denominator N=72). With respect to the contralateral kidney in incomplete duplex, 2 cases (2.8%) had a normal opposite kidney, whereas associated contralateral anomalies included

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ectopic vagina in 1 case (1.4%) and vesicoureteral reflux (VUR) in 3 cases (4.2%).

Considering laterality across all duplex cases, unilateral duplex was more frequent (48/72; 66.7%) than bilateral involvement (18/72; 25.0%). Within unilateral cases, left-sided duplex (26/72; 36.1%) was slightly more common than right-sided duplex (22/72; 30.6%).

Table 3: Renal Status

	No	%
Normal	43	32.6
(i) right side	22	16.7
(ii) left side	21	15.9
Right hydronephrosis / hydroureteronephrosis	43	32.6
Left hydronephrosis / hydroureteronephrosis	46	34.8
Total Number of Units	132	100.0

[Table 3] presents the distribution of renal status assessed per renal unit (total renal units = 132). Overall, 43/132 units (32.6%) were reported as normal, with a nearly equal split between the right side (22/132; 16.7%) and left side (21/132; 15.9%).

Hydronephrosis/hydroureteronephrosis constituted the remaining abnormalities. Right-sided hydronephrosis/hydroureteronephrosis was noted in 43/132 units (32.6%), while left-sided hydronephrosis/hydroureteronephrosis was seen in 46/132 units (34.8%), suggesting a slightly higher burden on the left side.

Table 4: Clinical Presentation

Clinical Presentation and Diagnosis	No	%
Incontinence / dribbling	5	6.9
Increased frequency of urination	1	1.4
Naturinal enuresis	1	1.4
Urinary tract infections	16	22.2
Pyelonephritis	4	5.6
Bladder outlet obstruction/ urinary retention	1	1.4
Hydronephrosis (HN)	23	31.9
Hydroureteronephrosis (HUN)	69	95.8
Abdominal pain	7	9.7
Abdominal mass	1	1.4
Renal failure	1	1.4
Urosepsis	1	1.4
Uremia	2	2.8
Shock	1	1.4
Small capacity bladder	2	2.8
Total	72	100.0

[Table 4] summarises the spectrum of clinical presentations observed among the 72 children. The most frequent clinical/imaging finding was hydroureteronephrosis (HUN), reported in 69/72 (95.8%), followed by hydronephrosis (HN) in 23/72 (31.9%), indicating that upper-tract dilatation was the dominant presenting feature in this cohort. Infective presentations were also common: urinary tract infection occurred in 16/72 (22.2%), and pyelonephritis in 4/72 (5.6%).

Lower urinary tract symptoms were less frequent and included incontinence/dribbling (5/72; 6.9%), increased frequency of urination (1/72; 1.4%), nocturnal enuresis (1/72; 1.4%), and bladder outlet obstruction/urinary retention (1/72; 1.4%). Pain and mass symptoms were comparatively uncommon, with abdominal pain in 7/72 (9.7%) and abdominal mass in 1/72 (1.4%).

Severe systemic or renal complications were rare but clinically important. Renal failure, urosepsis, and shock were each reported in 1/72 (1.4%), while uremia was documented in 2/72 (2.8%). A small-capacity bladder was noted in 2/72 (2.8%).

Table 5: Associated urinary tract anomalies

Associated anomalies	No	%
Hydronephrosis (HN)	23	31.9
Hydroureteronephrosis (HUN)	69	95.8
Ureterocele (U)	26	36.1
Vesicoureteric reflux (VUR)	36	50.0
Ectopic ureter	10	13.9
Vesico ureteric junction Obstruction (VUJO)	1	1.4
Uretero pelvijunction obstruction (UPJO)	6	8.3
Ureterocele with calculus	1	1.4
Total	72	100.0

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Table 6: Other specific anomalies

Other Specific Anomalies	No
Hypospadiac urethral meatus	2
Bilateral bifrontal craniotomy for excision of cement non-ossifying fibroma	1
Malrotated right kidney with incomplete duplex and ectopic opening	1
Posterior urethral valve	1
Bilateral Moyamoya disease with bilateral hemispheric stroke, seizure, small VSD, and left STA/MCA bypass	1
Tetralogy of Fallot status-post repair, proximal hypospadias with staged repair, and left ectopic ureter	1
Extratemporal epilepsy / nocturnal seizure / possible frontal lobe epilepsy	1
Central hypothyroidism with parasystole murmur and dysmorphism	1

[Table 6] outlines a limited number of additional, patient-level comorbidities observed in the cohort, which were heterogeneous and largely non-urological in nature. Overall, these findings suggest that while the majority of children had isolated urinary tract pathology, a few had associated congenital, endocrine, neurological, or multisystem conditions, indicating the need for holistic clinical evaluation and multidisciplinary follow-up in selected cases.

Table 7: Etiological distribution of hydronephrosis and hydroureteronephrosis in duplex renal units, stratified by side and moiety

	Right side		Left side	
	No	%	No	%
Duplex associated with hydronephrosis / hydroureteronephrosis	46	69.7	46	69.7
Hydronephrosis	9	13.6	14	21.2
(a)Upper moiety hydronephrosis	3	4.5	5	7.6
(b)Lower moiety hydronephrosis	3	4.5	9	13.6
(i)PUJO	2	3.0	4	6.1
(ii)HN	1	1.5	3	4.5
(iii) Ureterocele with calculus	0	0.0	1	1.5
(iv)Non functioning /HN	0	0.0	1	1.5
Hydroureteronephrosis	37	56.1	32	48.5
(a)Upper moiety hydroureteronephrosis	20	30.3	18	27.3
(i)Ureterocele	11	16.7	11	16.7
(ii)Ectopic	5	7.6	6	9.1
(iii)VUR	3	4.5	0	0.0
(iv)HUN	1	1.5	11	16.7
(b)Lower moiety hydroureteronephrosis	17	25.8	14	21.2
(i)Ureterocele	1	1.5	0	0.0
(ii)HUN	16	24.2	0	0.0
(iii) VUR	0	0.0	13	19.7
(iv) Non functioning	0	0.0	1	1.5
Total units	66	100.0	66	100.0

[Table 7] compares the etiological pattern of hydronephrosis (HN) and hydroureteronephrosis (HUN) across right and left renal units (66 units per side). Overall, duplex units associated with upper-tract dilatation constituted 46/66 (69.7%) on both sides, indicating a comparable burden of dilated duplex units on the right and left.

When stratified by type of dilatation, hydroureteronephrosis predominated over hydronephrosis on both sides. On the right, HUN was present in 37/66 units (56.1%), whereas HN alone accounted for 9/66 units (13.6%). On the left, HUN was observed in 32/66 units (48.5%) and HN in 14/66 units (21.2%), suggesting relatively more isolated hydronephrosis on the left compared with the right.

Within hydronephrosis, the distribution by moiety showed that upper moiety HN was less frequent than lower moiety HN on both sides (right: 3 vs 3; left: 5 vs 9). Among lower moiety HN, pelviureteric junction obstruction (PUJO) was an important contributor (right: 2/66, 3.0%; left: 4/66, 6.1%). Additional less frequent left-sided causes included ureterocele with calculus (1/66; 1.5%) and non-functioning/HN (1/66; 1.5%).

Within hydroureteronephrosis, upper moiety involvement was more common than lower moiety on both sides (right: 20/66; 30.3% vs 17/66; 25.8%; left: 18/66; 27.3% vs 14/66; 21.2%). For upper moiety HUN, ureterocele was a major association on both sides (11/66; 16.7% each). Ectopic ureter contributed to a smaller proportion (right: 5/66; 7.6%; left: 6/66; 9.1%). Notably, upper moiety VUR was reported only on the right (3/66; 4.5%) with none on the left.

For lower moiety HUN, the pattern differed by side. On the right, most lower moiety HUN was attributed to HUN without reflux (16/66; 24.2%), whereas on the left, VUR was the predominant lower moiety cause (13/66; 19.7%), with only a single case of non-functioning moiety (1/66; 1.5%).

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Table 8: Clinical Profile, Anatomical Details, and Surgical Management of Ectopic Ureter in Duplex System (n = 10)

Variable	Category	n (%)	Surgical Procedure
Sex	Female	9 (90%)	—
	Male	1 (10%)	—
Laterality	Unilateral	8 (80%)	—
	Bilateral	2 (20%)	—
Right Upper Moiety	Bladder neck	1 (10%)	Open uretero-ureterostomy
	Vagina	2 (20%)	Laparoscopic uretero-ureterostomy (1), Open heminephrectomy (1)
	Below bladder neck (bilateral)	1 (10%)	Ureteric reimplantation
Left Upper Moiety	Vagina	4 (40%)	Uretero-ureterostomy: Open (2), Laparoscopic (1); Laparoscopic heminephrectomy (1)
	Vaginal wall (bilateral)	1 (10%)	Laparoscopic heminephrectomy
	Below bladder neck	2 (20%)	Open heminephrectomy (1), Open uretero-ureterostomy (1)
Other	Vagina (bilateral RUM)	1 (10%)	Ureterostomy → Laparoscopic heminephrectomy

Table 8 describe the total of 10 patients with ectopic ureter in a duplex system were analyzed. The majority were female (9/10, 90%), with only one male patient (10%). Most cases were unilateral (8/10, 80%), while bilateral involvement was seen in 2 patients (20%). Among right-sided upper moiety ectopic ureters, the most common site of insertion was the vagina (2/10, 20%), followed by the bladder neck (1/10, 10%) and below the bladder neck in bilateral cases (1/10, 10%). All patients underwent definitive surgical management tailored to the involved upper moiety (right/left), site of ectopic insertion, and renal unit function.

Right upper moiety involvement was observed in 4 patients. Bladder neck insertion (10%) was managed with open uretero-ureterostomy. Among vaginal insertions (20%), one patient underwent laparoscopic uretero-ureterostomy, while another required open heminephrectomy due to a poorly functioning moiety. The bilateral case with insertion below the bladder neck (10%) was treated with open ureteric reimplantation. Overall, open procedures predominated on the right side (3/4, 75%), with limited use of laparoscopy (1/4, 25%), mainly for reconstructive procedures.

Left upper moiety involvement was more common, seen in 7 patients. Vaginal insertion (40%) was the most frequent, with uretero-ureterostomy performed in three patients (open in 2 cases and laparoscopic in 1 case), while one patient underwent laparoscopic heminephrectomy. Cases with insertion below the bladder neck (20%) were managed with open procedures, including one heminephrectomy and one uretero-ureterostomy. Bilateral vaginal wall insertion (10%) was treated with laparoscopic heminephrectomy. Overall, open surgery remained common on the left side (4/7, ~57%), although laparoscopic procedures were more frequently utilized (3/7, ~43%) compared to the right.

Table 9: Management Outcomes in Duplex Kidney with Ureterocele (n = 26 units)

Category	Subcategory	Management and outcome	n	%
Laterality	Unilateral	Cases	25	96.2
	Bilateral	Cases	1	3.8
Initial Management (Unilateral, n=25)	RUM ureterocele	Total	11	44.0
		Ureterocele incision	8	32.0
		Conservative management (small ureterocele)	3	12.0
	LUM ureterocele	Total	13	52.0
		Ureterocele incision	11	44.0
		Conservative management	2	8.0
Outcomes after Incision (RUM, n=8)	Resolution	Complete resolution	5	62.5
	Complications	Persistent HUN (non-functioning kidney) → laparoscopic heminephrectomy	1	12.5
		De novo VUR → ureteral reimplantation	1	12.5
		Residual ureterocele → redo incision (VUR II, conservative)	1	12.5
Outcomes after Incision (LUM, n=11)	Resolution	Complete resolution of VUR	4	36.4
		Calculi removed → resolved	1	9.1
	Complications	De novo VUR	6	54.5
Details of De novo VUR (n=6)	Grade II	Resolved on follow-up	1	16.7
	Grade III	Resolved on follow-up	2	33.3
	Grade V	Total	3	50.0
		Ureteric reimplantation → Persistent of VUR post-reimplantation , on follow-up	2	33.3
		Conservative management	1	16.7
Bilateral Case (n=1)	RUM	Ureterocele incision → developed VUR → heminephrectomy	1	100
	LUM	Ureterocele incision → resolved	1	100

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Table 9 describe a total of 26 renal units with ureterocele in duplex systems were analyzed. The majority were unilateral (25/26, 96.2%), while bilateral involvement was observed in 1/26 (3.8%).

Among the unilateral cases (n = 25), left upper moiety (LUM) ureterocele was slightly more common, accounting for 13/25 cases (52.0%), compared to right upper moiety (RUM) ureterocele in 11/25 cases (44.0%). In the RUM group, ureterocele incision was performed in 8/25 cases (32.0%), while conservative management was adopted in 3/25 cases (12.0%). In the LUM group, ureterocele incision was performed in 11/25 cases (44.0%), and conservative management in 2/25 cases (8.0%).

Following ureterocele incision in RUM cases (n = 8), complete resolution was achieved in 5 cases (62.5%). Complications were noted in 3 cases (37.5%), including persistent hydroureteronephrosis requiring laparoscopic heminephrectomy in 1 case (12.5%), de novo vesicoureteral reflux requiring ureteral reimplantation in 1 case (12.5%), and residual ureterocele requiring redo incision in 1 case (12.5%).

In LUM cases undergoing incision (n = 11), resolution of vesicoureteral reflux was observed in 4 cases (36.4%), and one case (9.1%) had calculi that were removed with subsequent resolution. However, complications were more frequent in this group, with de novo vesicoureteral reflux occurring in 6/11 cases (54.5%).

Among the cases with de novo vesicoureteral reflux (n = 6), Grade II reflux was seen in 1 case (16.7%) and Grade III in 2 cases (33.3%), all of which resolved on follow-up. Grade V reflux was observed in 3 cases (50.0%), of which 2 cases (33.3%) underwent ureteric reimplantation but had persistent reflux on follow-up, while 1 case (16.7%) was managed conservatively.

In the single bilateral case, the RUM ureterocele underwent incision but subsequently developed vesicoureteral reflux requiring heminephrectomy (100%), whereas the LUM ureterocele was treated with incision and showed complete resolution (100%).

Table 10: Clinical profile, management, and contralateral renal status in incomplete duplex systems (n = 6 cases)

Section	Category	Subcategory / Finding	Management / Details	n	%	Remarks
Side distribution	Right incomplete			3	50.0	
	Left incomplete			3	50.0	
Case-level presentation	Right incomplete	Duplex joining at mid ureter with ectopic opening into vagina	Right ureteric reimplantation done	1	16.7	
Case-level presentation	Right incomplete	VUR grade 2	Conservative management	1	16.7	
Case-level presentation	Right incomplete	VUR	Reimplantation	1	16.7	
Case-level presentation	Left incomplete	Grade III VUR	Cohen's ureteric reimplantation	1	16.7	
Case-level presentation	Left incomplete	Grade IV VUR	Conservative management; on follow-up currently UTI free	1	16.7	
Case-level presentation	Left incomplete	Incomplete bifid pelvis	Cystoscopy	1	16.7	
Opposite kidney status	Normal			2	33.3	Right=1 Left= 1
Opposite kidney status	Associated renal anomaly			4	66.7	
Associated opposite-kidney anomaly	Right	VUR		2	33.3	All right-side associated anomalies were VUR
Associated opposite-kidney anomaly	Left	Ectopic vagina		1	16.7	
Associated opposite-kidney anomaly	Left	VUR		1	16.7	

[Table 10] summarises the six children with incomplete duplex systems, detailing laterality, presenting abnormalities, management, and contralateral kidney findings. Incomplete duplex systems accounted for six cases (100%), with an equal side distribution: right-sided in 3 (50.0%) and left-sided in 3 (50.0%).

Among the right-sided incomplete duplex cases, one child had duplex joining at the mid-ureter with ectopic opening into the vagina and underwent ureteric reimplantation. The remaining right-sided cases were reflux-related, including grade II VUR managed conservatively and VUR managed with ureteric reimplantation (one case each). Among the left-sided incomplete duplex cases, grade III VUR was treated with Cohen's ureteric reimplantation, while grade IV VUR was managed conservatively with follow-up and the child remained UTI-free. The remaining case had an incomplete bifid pelvis, for which cystoscopy was performed.

With respect to the contralateral kidney, two children (33.3%) had a normal opposite kidney (one right-

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sided and one left-sided incomplete duplex), while four (66.7%) had associated contralateral renal anomalies. Contralateral abnormalities were predominantly reflux-related: on the right, both contralateral anomalies were VUR (2 cases), while on the left, anomalies included ectopic vagina (1 case) and VUR (1 case).

Table 11: Selected clinical subtypes of duplex kidney and associated anomalies: laterality, interventions, and outcomes (case-based summary)

		No
Duplex kidney associated with pelvi-ureteric junction anomaly (n=6)	Right lower moiety	2
	(i) Non-function with obstructive drainage on DTPA - right lower pole heminephrectomy; post-operative cyst formation on follow-up.	1
	(ii) Right lower moiety PUJO treated with Anderson-Hynes pyeloplasty	1
	Left lower moiety	4
	(i) Left lower moiety open Anderson-Hynes pyeloplasty	3
	(ii) Left lower moiety open Anderson-Hynes pyeloplasty with retained stent later removed by ureterostomy	1
Duplex kidney associated with posterior urethral valve (n=1)	There was one case of duplex kidney associated with posterior urethral valve, involving a left complete duplex system with grade V vesicoureteral reflux in the lower moiety. A left lower moiety ureterostomy was performed due to pyelonephritis, followed later by closure of the ureterostomy.	1
Duplex kidney with vesicoureteric junction obstruction without ectopic ureter	There was one case of duplex kidney with vesicoureteric junction obstruction without ectopic ureter, involving hydroureteronephrosis of the right upper moiety due to ureteric stenosis at the vesicoureteric junction within the bladder. As the moiety was poorly functioning, a right upper pole heminephrectomy was performed.	1
Duplex system associated with vesicoureteric reflux (n=6 cases) and 12 units)	Bilateral complete duplex with bilateral lower moiety VUR	6

[Table 11] summarises important clinical subtypes of duplex kidney with specific associated anomalies and outlines their management. Duplex kidney associated with pelvi-ureteric junction anomaly (n = 6) predominantly involved the lower moiety, with right-sided involvement in two cases and left-sided involvement in four cases. On the right, one child with non-functioning lower moiety and obstructive drainage on DTPA scan underwent right lower pole heminephrectomy, complicated by post-operative cyst formation, while the other underwent Anderson–Hynes pyeloplasty for a right lower moiety PUJO. On the left, three cases were treated with open Anderson–Hynes pyeloplasty, and one case required open Anderson–Hynes pyeloplasty with a retained stent, which was later removed through ureterostomy.

There was one case of duplex kidney associated with posterior urethral valve, characterised by a left complete duplex system with grade V VUR in the lower moiety. This child underwent left lower moiety ureterostomy due to pyelonephritis, followed later by closure of the ureterostomy. Another single case had vesicoureteric junction obstruction without an ectopic ureter, presenting with hydroureteronephrosis of the right upper moiety due to intravesical vesicoureteric junction stenosis; given poor function, a right upper pole heminephrectomy was performed.

In addition, the table includes duplex systems associated with vesicoureteric reflux (n = 6 cases; 12 renal units), described as bilateral complete duplex with bilateral lower moiety VUR in all six cases.

Table 12: Duplex System Associated Vesicoureteral Reflux (VUR): Detailed Distribution (N = 20)

Major Group	Subgroup	Clinical Details	N	% (Group)	% (Overall)	Management
Bilateral Duplex (N=6)	Bilateral lower moiety VUR	Grade IV–III (1), Grade III (3)	4	66.7%	20%	Bilateral Cohen's common sheath ureteric reimplantation
	Mixed duplex pattern	Right LM VUR + left incomplete duplex (Grade III)	1	16.7%	5%	Cohen's ureteric reimplantation
	High-grade bilateral	Right LM Grade V + left LM VUR	1	16.7%	5%	Combined/common sheath reimplantation
Unilateral – Right (RLM) (N=8)	Conservative	Grade II (4), Grade III (2), Grade IV (1)	7	87.5%	35%	Observation & follow-up
	Surgical	Grade III VUR	1	12.5%	5%	Cohen's ureteric reimplantation
Unilateral – Left (LLM) (N=6)	Surgical	Grade III (1), Grade V (2)	3	50%	15%	Left Cohen's common sheath reimplantation
	Conservative	Grade V (2), Grade IV (1); UTI-free follow-up	3	50%	15%	Observation & follow-up

Table 12 describes the 20 patients with duplex systems associated with Vesicoureteral Reflux (VUR), unilateral involvement predominated, accounting for 14 cases (70%), while bilateral disease comprised 6 cases (30%). All bilateral duplex systems (6/6, 100%) required surgical intervention.

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Among these, 4 cases (66.7%) had bilateral lower moieties associated with Grade III–IV VUR and underwent bilateral common sheath ureteric reimplantation. The remaining 2 cases (33.3%) demonstrated complex or high-grade patterns, including lower moieties associated with Grade V VUR, requiring combined or tailored reimplantation procedures.

Among unilateral cases (14 cases), 4 cases (28.6%) required surgical management. In right-sided duplex systems, only 1 out of 8 cases (12.5%) with a lower moiety associated with Grade III VUR required surgery and was managed with Cohen's ureteric reimplantation, while the remaining cases with lower moieties associated with Grade II–IV VUR were managed conservatively. In contrast, left-sided duplex systems showed a higher surgical rate, with 3 out of 6 cases (50%) requiring intervention; these involved lower moieties associated with Grade III and Grade V VUR and were managed with left-sided common sheath ureteric reimplantation, whereas the remaining cases with lower moieties associated with Grade IV–V VUR were managed conservatively.

Overall, 10 out of 20 patients (50%) underwent surgical intervention. Of these, 6 cases (60%) belonged to the bilateral group with lower moieties associated with moderate-to-high grade VUR requiring bilateral or common sheath reimplantation, 1 case (10%) was a unilateral right-sided duplex with a lower moiety associated with Grade III VUR managed with Cohen's reimplantation, and 3 cases (30%) were unilateral left-sided duplex systems with lower moieties associated with higher-grade VUR requiring common sheath reimplantation. Common sheath ureteric reimplantation was the predominant surgical technique, performed in 9 out of 10 operated cases (90%), while Cohen's ureteric reimplantation was performed in 1 case (10%). These findings suggest that lower moieties associated with higher grades of VUR, particularly in bilateral and left-sided duplex systems, are more likely to require surgical management.

Table13: Treatment modalities undertaken for duplex renal anomalies

	No	%
Diagnostic cystoscopy only	20	27.8
Nephron-sparing procedures	43	59.7
Endoscopic ureterocele incision (EUI)	19	26.4
Ureteric reimplantation	13	18.1
Anderson's Hyne's pyeloplasty	5	6.9
Ureteroureterostomy	6	8.3
Non-functioning moiety requiring heminephrectomy	9	12.5
Open heminephrectomy	5	6.9
Laparoscopic transperitoneal heminephrectomy	4	5.6
Total	72	100.0

[Table 13] summarises the treatment approaches adopted in the cohort (N = 72). Nephron-sparing procedures constituted the most common management strategy (43/72; 59.7%), reflecting a preference for preserving functioning renal tissue whenever feasible. Diagnostic cystoscopy alone was performed in 20/72 (27.8%), indicating that a substantial proportion required endoscopic evaluation without immediate definitive reconstruction.

Among specific operative procedures, endoscopic ureterocele incision (EUI) was performed in 19/72 (26.4%), and ureteric reimplantation in 13/72 (18.1%). Reconstructive procedures addressing obstruction or drainage included ureteroureterostomy in 6/72 (8.3%) and Anderson–Hynes pyeloplasty in 5/72 (6.9%). Heminephrectomy for a non-functioning moiety was required in 9/72 (12.5%); of these, open heminephrectomy was performed in 5 cases (6.9%), while laparoscopic transperitoneal heminephrectomy was carried out in 4 cases (5.6%).

Table 14: post-treatment complications and their management (n = 18 complication events)

Complications following definitive treatment	No	Treatment
Recurrent UTI	3	Conservative management with antibiotics
Post ureterocoele incision: De novo VUR Vescio ureteric reflux	8	Low grade I –II resolved on follow-up (n=3)
		High grade VUR – ureteric reimplantation done (n=4)
		Non function – open heminephrectomy done (n=1)
Cyst in heminephrectomy site	2	On follow up
Persistence of vesico ureteric reflux – post reimplantation	2	Conservative management
Stent retention	1	Removed surgically
Residual ureterocele	2	Redo ureterocele incision done
Total	18	

[Table 14] summarises the post-treatment complications observed following definitive management and the approaches used for their treatment (18 complication events in total). The most frequent complication was de novo vesicoureteric reflux (VUR) following ureterocele incision, reported in 8 events. These were managed according to severity: low-grade VUR (grades I–II) resolved on follow-up in three cases, while high-grade VUR required ureteric reimplantation in four cases. In one case, the refluxed unit was non-functioning, necessitating open heminephrectomy.

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Recurrent urinary tract infection was noted in three events and was treated conservatively with antibiotics. Two events of cyst formation at the heminephrectomy site were managed with follow-up observation. Persistence of VUR after reimplantation occurred in two events and was managed conservatively. Less frequent complications included stent retention (one event), which required surgical removal, and residual ureterocele (two events), for which redo ureterocele incision was performed. Ureteral stump symptoms were not observed.

DISCUSSION

In this cohort, several key anatomic and pathophysiologic patterns emerged that help explain both presentation and management choices. Complete duplex systems predominated, and pathology was clearly moiety-specific. Upper-tract dilatation (hydronephrosis/hydroureteronephrosis) was more frequently observed on the left, while a meaningful subset of renal units remained morphologically normal, reinforcing that anatomical duplication alone is insufficient for clinical decision-making and that functional assessment should guide intervention. This pattern is consistent with prior reports indicating that symptomatic disease in duplex kidneys is often driven by upper moiety obstruction—commonly related to ureterocele or ectopic insertion—whereas lower moiety pathology more frequently reflects reflux or alternative obstructive mechanisms.[1,3,10] The cohort also demonstrated ectopic ureters in both unilateral and bilateral configurations, managed through a range of nephron-sparing and extirpative strategies including ureteric reimplantation, uretero-ureterostomy, and open or laparoscopic heminephrectomy. Ureterocele involvement was common (26 renal units) and outcomes after endoscopic incision spanned complete resolution to development of de novo VUR and subsequent need for additional intervention. These observations mirror the ongoing discussion in the literature regarding endoscopic decompression versus primary reconstruction, and highlight that outcomes are strongly dependent on anatomical subtype (orthotopic versus ectopic ureterocele, upper moiety anatomy) and baseline reflux status.[1,3,4,10] Reflux dynamics further shaped management in this cohort: VUR, particularly when involving lower moieties in the setting of concomitant upper-moiety obstruction, influenced selection of reconstructive approaches such as common sheath reimplantation (Cohen) and Paquin techniques. This aligns with published work emphasizing that reflux patterns in duplex systems determine both surgical strategy and the likelihood of de novo reflux following decompression procedures.[3,9,11,12] Although incomplete duplex was relatively uncommon, this subset demonstrated a notable burden of contralateral abnormalities—including reflux and ectopic vaginal openings—supporting prior observations that incomplete duplications may coexist with clinically significant contralateral pathology and therefore warrant careful perioperative planning and long-term surveillance.[2,11,13]

Across the cohort, management reflected a function- and anatomy-driven framework grounded in comprehensive imaging and functional assessment. The use of diagnostic cystoscopy alongside ultrasound, VCUG, and functional studies allowed stratification of obstruction, reflux severity, and moiety function, consistent with recommended diagnostic pathways for duplex systems and their associated anomalies.[12,14,15] Therapeutically, a nephron-sparing approach predominated, with nephron-sparing procedures employed in 43 patients, reflecting the contemporary preference for renal preservation when viable function is present. Heminephrectomy—performed via open and laparoscopic routes—was reserved for persistent non-function or complex anatomic scenarios, including certain ectopic ureters, severe reflux with poor function, and ureterocele-related sequelae.[4,6,8,9] Endoscopic ureterocele incision represented the most frequent nephron-sparing intervention in this cohort, particularly for upper moiety obstruction, but a proportion developed reflux requiring secondary management. Ureteric reimplantation and uretero-ureterostomy comprised major reconstructive options, with outcomes closely linked to reflux grade, moiety involvement, and post-decompression evolution. This staged trajectory parallels published experience showing that endoscopic decompression may effectively relieve obstruction yet carries a recognized risk of subsequent reflux, sometimes necessitating reimplantation or additional procedures.[1,3,4,12] While robotic approaches were not universally applied in this setting, the discussion is increasingly relevant as robot-assisted techniques—such as ipsilateral ureteroureterostomy and heminephroureterectomy—are being reported with promising feasibility and perioperative profiles, reflecting a broader transition toward minimally invasive surgery in paediatric urology as evidence continues to accumulate.[5-8]

Clinically, the cohort demonstrated generally favourable trajectories in groups where moiety function was preserved and appropriately targeted decompression or reconstruction was achieved. Although complications were recorded in 18 patients, they did not overshadow the overall pattern of improvement, aligning with literature suggesting that carefully selected interventions can relieve symptoms and preserve renal function while maintaining acceptable morbidity.[1,3,6,12] Symptom resolution was particularly meaningful in children presenting with incontinence, nocturnal enuresis, and dribbling, supporting the premise that addressing upper-pole obstruction and lower-pole reflux can translate into tangible quality-of-life gains. Improvements in bladder capacity in follow-up for select groups further support published observations that urinary dynamics may improve after effective

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management of duplex-associated obstruction or reflux-related consequences.[1,3,12] At the same time, long-term considerations remain central: recurrent UTIs, persistence or recurrence of reflux, and stump-related or post-heminephrectomy complications are well-recognised in the literature and necessitate sustained follow-up and, where indicated, staged or preventive strategies. The present findings reinforce this need, illustrating variable outcomes depending on initial anatomy, functional status, treatment pathway, and surveillance intensity.[2,11,16]

Overall, the present data align with a broad consensus in the literature favouring individualized, phenotype-driven care that prioritizes renal preservation when feasible and reserves heminephrectomy for non-functioning poles or complex anatomy. Endoscopic decompression remains a valuable initial strategy in appropriately selected ureterocele cases, but the risk of de novo reflux and subsequent need for reintervention underscores why decision-making must be anatomy-specific rather than uniform.[3,4,6,8,9]

A persistent area of nuance concerns the optimal timing and sequencing of definitive management for ureterocele-associated obstruction, where the balance between early reconstruction and staged approaches depends on ureterocele location (orthotopic versus ectopic), moiety function, and reflux severity.[1,3,4,12] Finally, as robotic and other minimally invasive techniques continue to expand, the field would benefit from higher-powered, long-term comparative studies using harmonised outcomes—renal function, UTI recurrence, reflux grade, and bladder dynamics—to better define optimal modality selection and procedural sequencing across centres.[5,6,8]

CONCLUSION

Duplex renal systems in this cohort were most commonly complete and unilateral, with hydroureteronephrosis, ureterocele, and vesicoureteric reflux constituting the key associated abnormalities. Despite the heterogeneity of presentations, the overall treatment approach was predominantly nephron-sparing, with heminephrectomy required in a minority for non-functioning moieties. Complications were manageable, and many reflux-related sequelae—especially low-grade de novo VUR after ureterocele incision—resolved with surveillance. These findings support an individualized, anatomy- and function-based management strategy, prioritizing renal preservation whenever feasible, alongside structured follow-up to detect and address reflux, obstruction, and recurrent infection early.

Study limitations: This study has certain limitations. First, as a single-centre, observational analysis, the findings may reflect local referral patterns and surgical preferences, which can limit generalisability to other settings. Second, several tables represent procedure- or event-based counts (with overlapping interventions and complications), so causal inferences regarding the superiority of one approach over another cannot be made. Third, the heterogeneity of duplex phenotypes and relatively small numbers in specific subgroups (e.g., incomplete duplex, rare anomalies) restrict the power for meaningful subgroup comparisons. Finally, longer-term outcomes—particularly renal functional trajectories, late reflux persistence/recurrence, and bladder dynamics—may be incompletely captured without extended, standardised follow-up.

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