Innovations

Cadaveric Study of Ureteral Duplication: Developmental Perspective and Clinical Implications

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Abstract

Background: *Normally, there is one ureter for each kidney, which conveys urine from the renal pelvis to the bladder. Duplication of the ureter occurs as a congenital variation due to abnormal division of the ureteric bud. It can be complete or incomplete. Though many cases are asymptomatic, this variation can be associated with urinary tract infection, reflux, hydronephrosis, or ureteroceles. Cadaveric study helps describe such patterns and supports their embryological basis as well as clinical significance.* ***Methods:*** *Thirty adult cadavers were studied in the Department of Anatomy at the Konaseema Institute of Medical Sciences and Research Foundation, Amalapuram, Andhra Pradesh, from May 2024 to October 2025. Exclusion criteria included cadavers with trauma or previous renal or ureteric surgery. The posterior abdominal wall was dissected through standard steps according to Cunningham's Manual. The kidneys and ureters from both sides were examined. All variations were recorded and photographed, and were classified according to variation type, laterality, and sex distribution.* ***Results:*** *Sixty kidneys and sixty ureters were evaluated. Fifty-six kidneys were normal and four showed lobulated kidneys. Three were unilateral and one was bilateral. Among ureters, fifty-seven were normal and three exhibited double or bifid ureters. All these were unilateral. The incidence of duplication of the ureter in this material was five percent.* ***Conclusion:*** *Ureteral duplication is rare but important clinically. Most cases are unilateral and incomplete. Cases of persistent fetal lobulations of the kidney might be encountered as well. Knowledge of such variations is beneficial in image interpretation, intervention, and surgical planning. The small sample size and limited demographic range restrict generalization. Functional correlation was not possible since the work was limited to cadaveric material.*

Keywords: *Ureteral duplication, Bifid ureter, Kidney variations, Cadaver study, Anatomical anomalies*

Introduction

The ureters act as conduits of urine from the renal pelvis to the urinary bladder. Normally, one ureter is associated with each kidney (Lescay et al., 2024). The duplication of ureters is a congenital abnormality due to improper division of the ureteric bud; this condition can be either complete, where two ureters enter the bladder independently, or incomplete, where the ureters join before entering the bladder (Arumugam et al., 2020). While it often remains asymptomatic, ureteral duplication can lead to rise to urinary tract infections, hydronephrosis, reflux, or ureteroceles; hence, the treating physician's awareness is critical of such an anomaly (Luo et al.,2025). Cadaveric studies play a significant role in documenting these variations and tracing their developmental patterns while emphasising their clinical significance. The present study is aimed at investigating and documenting cases of ureteral duplication with an emphasis on their developmental and clinical considerations.

Materials and Methods

Studies on cadavers were performed in the Department of Anatomy, Konaseema Institute of Medical Sciences and Research Foundation, Amalapuram Andhra Pradesh, during May 2024 and continued till October 2025 as a part of routine undergraduate dissections of abdomen.

Thirty well-preserved adult cadavers of known ancestry (17 males and 13 females) have been taken up in the work. Cadavers with obvious gross abnormalities, traumatic injuries, and previous surgery on the kidneys or ureters were excluded from study. The posterior abdominal wall was dissected as per Cunningham's Manual of Practical Anatomy and kidneys and ureters were exposed on both sides. The anatomical and developmental variations were recorded, paying special attention to ureteral duplication, its pattern, origin, termination, and relation to nearby structures.

All findings were photographed and documented, along with variation classified according to type (complete or incomplete), laterality (unilateral or bilateral), and sex distribution.

Result

Table 1: Incidence of Variations in Kidney and Ureter among 30 Cadavers (60 specimens each)

Organ	Total Specimens Examined	Normal (n, %)	Variations Observed (n, %)	Type of Variation	Laterality (Unilateral/Bilateral)
Kidney	60	56 (93.3%)	4 (6.7%)	Lobulated kidney	3 unilateral, 1 bilateral
Ureter	60	57 (95.0%)	3 (5.0%)	Double (bifid) ureter	All unilateral

Out of 30 cadavers examined (60 kidneys and 60 ureters), 56 kidneys (93.3%) were normal, while 4 (6.7%) showed lobulation—three unilaterally and one bilaterally. Among the ureters, 57 (95%) were normal, and 3 (5%) exhibited double (bifid) ureters, all of which were unilateral.

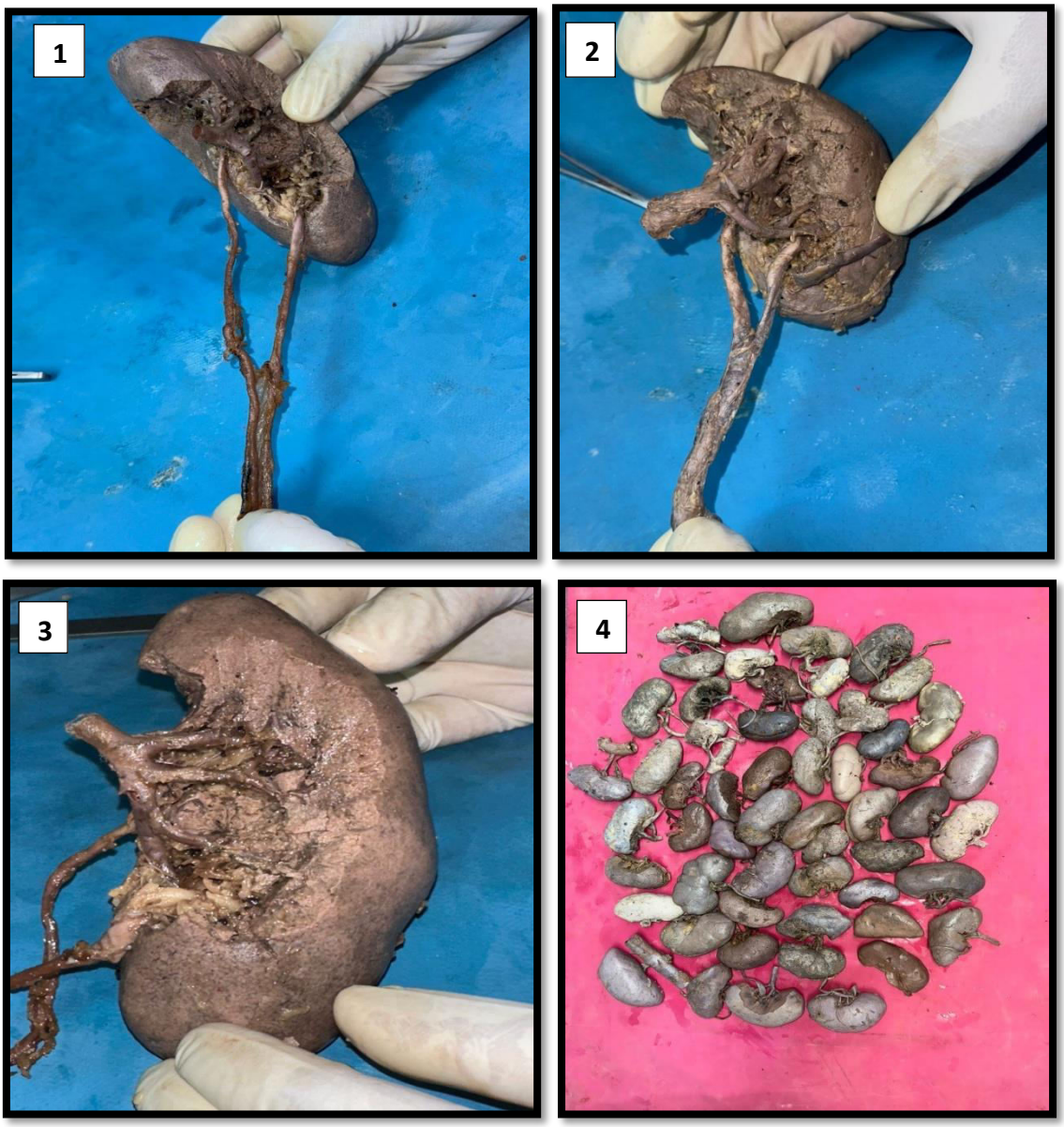

Figure 1: Right double ureter; Figure 2: Left double ureter; Figure 3: Right double ureter; Figure 4: Dissected kidney and ureter specimens showing anatomical variations

Discussion

The vast majority of specimens, specifically 93.3%, exhibited normal renal morphology in this present study involving 30 cadavers (composed of 60 kidneys and 60 ureters). However, three of these had lobulated kidneys unilaterally and one bilaterally. Of the ureters, 95% presented normal and 5%, double- or bifid ureters, which were all unilateral. Most such findings agree very much with the findings of

Deka&Saikia (2016) that reported 6.7% of those variations in renal pelvis and ureter among their specimens, with double ureters in 1.67% of them, all on the left. Likewise found in study(Padmaja et al., 2014)that reported incomplete double ureter with a double pelvicalyceal system with an accessory renal artery on the left side, Arumugam et al., (2020) also observed these incomplete double ureters form a Y-shaped pattern occurring in 6% of the specimens (three out of 50). Another study (Kulkarni et al.,2012) had described bilateral incomplete duplication of ureter present in a 58-year-old male cadaver and was having bilateral accessory renal arteries. Nagar et al., (2017) described here the right unilateral bifid ureter joining 3 cm above the bladder, whereas another study (Praveen & Seema, 2016) observed an incomplete duplex ureter on the right side both ureters joining just before entry into the urinary bladder.

The incidence of double ureters in this study was 5%, lying well within the spectrum of incidence stated in earlier literature, which ranges from 0.4% to 6% for the incidence of duplicated ureters. Study by Choudhary et al., (2017)documented an incidence of 6.25% of unilateral incomplete duplication in their series, while Roy et al., (2017) reported an incidence of 0.64%. Radiological findings from a study (Dähnert, 1999) support the notion that incomplete duplication occurs at least three times more commonly than complete duplication. The duplication was mentioned in large cadaveric studies, by Lowsly&Kirwori, (1956) as 0.43% (18 out of 4215 cadavers) and mostly unilateral complete duplication. Case reports from the literature, such as that of Ennaciri et al., (2019) had also reported bilateral incomplete duplex collecting systems in association with moderate hydronephrosis.

Overall, the findings from the present study support earlier anatomical and radiologic descriptions, suggesting that ureteric duplication, though occasionally, is mostly unilateral and almost always grossly incomplete. The incidence rate in our series (5%) is towards the upper end of most reports and probably better reflects the population diversity or sampling differences. The absence of accessory renal arteries in our study is contrary to some earlier reports (e.g., Padmaja et al.,2014 &Kulkarni et al., 2012), pointing toward a possibility that vascular and ureteric anomalies may not always coexist.

The lobulated kidneys described in our study probably reflect fetal lobulations remaining due to incomplete fusion of renal lobes, while bifid ureters result from partial duplication of the ureteric bud. Although usually asymptomatic, these anomalies may increase the risk of urinary stasis or infection, and the ability of clinicians to detect them is important during imaging interpretations or surgical interventions.

Conclusion& Limitations

Ureteral duplication is a little common but important anatomical variation, mostly unilateral and incomplete. Evidence of lobulated kidneys resulting from preserved fetal lobulations were also found as part of this investigation. It is clinically relevant

to recognize these variations for proper interpretation in imaging, surgical planning, and prevention of possible complication, such as urinary stasis. The study has limitations related to the relatively small sample size with a total of 30 cadavers, and not having a lot of diversity in its demographic which could affect the generalizability of findings. Functional implications of the variations could not be studied, though, as this study was purely anatomical and cadaveric.

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