



## Anatomical Variations Of Ureters With Its Clinical Importance – A Cadaveric Study

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### Abstract

**Introduction:** The ureters are two muscular ducts measuring about 25-30 cm in length. These ureters drain urine from the corresponding kidney to the urinary bladder. The ureters have two segments: abdominal and pelvic. Congenital anomalies of kidney and urinary tract (CAKUT) are group of abnormalities affecting the kidneys and other structures of urinary tract. Malformations of the urinary system are common and comprise about 3% of live births. Among these, duplication of the ureters is a common anomaly and may be either complete or incomplete types and is often accompanied by various complications.

Duplication of ureter or double ureter results from early splitting of ureteric bud. Double ureter has been reported through various studies with prevalence of 0.1% to 6%. Incomplete duplication is more common than complete. It may be associated with or without other congenital defects.

**Aim:** To study the prevalence of double ureter in cadavers.

**Materials and methods:** The present study was conducted in the Department of Anatomy, Mysore Medical College & Research Institute, Mysore, on 50 formalin-fixed adult human kidney specimens irrespective of age and sex (25 right and 25 left) and was mainly focused on the ureteric variants. The formation of ureters and its duplication were noted.

**Results:** Out of 50 specimens, 4 specimens showed variations in the formation of ureter i.e duplication.

1. Incomplete – 2 (1Right, 1Left)
2. Complete – 2 (Left)

**Conclusion:** The comprehensive knowledge of these developmental anomalies of the urinary system helps to detect it early and evaluate disease conditions, which helps the surgeons during renal transplant or gynecological surgeries and also in laparoscopic procedures and avoids accidental injuries and complications.

**Keywords:** Congenital anomaly, Mesonephric duct, Ureter duplication

### Introduction

The ureters are two muscular tubes measuring about 25-30 cm in length and the diameter is normally 3mm. The peristaltic contractions of the ureters convey the urine from the kidneys to the urinary bladder. Each ureter is continuous superiorly with the funnel shaped renal pelvis and inferiorly opens into the base of the urinary bladder.

Embryologically, the ureters develop from the ureteric bud, a diverticulum from the mesonephric duct. The ureteric bud elongates to form the ureter and undergoes repeated branching to form the major and minor calyces (1).

Congenital anomalies of the kidneys and urinary tracts (CAKUT) are the disorders that arise during development of the fetus and result in a spectrum of

defects in the kidneys and outflow tracts which includes the ureters, the bladder, and the urethra.

Most cases of CAKUT are diagnosed antenatally by ultrasound imaging, which examines the kidneys, ureters, urinary bladder correlating it with amniotic fluid volume. After the gestational period of 18 weeks, amniotic fluid is primarily composed of urine produced by the fetal kidneys. Antenatal ultrasound imaging correctly diagnoses CAKUT in around 60%–85% of infants. The remaining cases of CAKUT are mostly diagnosed after an infant or child presents with a urinary tract infection (2).

The wide range of anomalies related to Congenital Anomalies of the Kidney and Urinary Tract (CAKUT) includes horseshoe kidney, obstructive renal dysplasia, autosomal dominant polycystic kidney, autosomal recessive polycystic kidney, ureteral duplications, ureteropelvic junction obstruction, posterior urethral valve and Prune belly syndrome (3).

Among these, duplicated ureter is a frequent malformation that occurs in approximately 1 in 20 people (4). Duplication of ureter results from early splitting of ureteric bud (5). Double ureters can be classified as complete and incomplete. Complete duplication is also called double ureter wherein two pelves on the same side, one superior to the other, drained by separate ureters and having separate orifices on the floor of the bladder. In Incomplete or Bifid ureter, upper end is bifid and lower third of their course (two ureters) join and open by a common orifice into the urinary bladder (6). Incomplete duplication is three times more common than complete (7). Ureteral injuries are the most common complications of abdominal and pelvic surgeries (8).

Hence, comprehensive knowledge of variations of kidney and ureter are of utmost important for the operating surgeons and radiologists which helps them in diagnosing various malformations and to prevent iatrogenic or accidental injury while performing surgeries.

### Materials And Methods;

The present study was conducted in the Department of Anatomy, Mysore Medical College & Research Institute, Mysore, on 50 formalin-fixed adult human kidney specimens irrespective of age and sex (25 right and 25 left) and was mainly focused on the

ureteric variants. The formation of ureters and its duplication were noted.

### Results;

Out of 50 specimens, 4 specimens showed variations in the formation of ureter i.e. duplication. Among these 4 specimens, 3 were of left side and 1 of right side. Incomplete double ureters were noted in 2 specimens – 1 right and 1 left. Complete double ureters were noted in 2 left sided specimens. All these structures were confirmed by histological examination.

### Discussion;

Dr. Edith potter was a pioneer in originally describing the developmental abnormalities of the kidneys and urinary tracts, who examined necropsies from fetuses and babies to understand normal and abnormal development (9).

The formation of the kidneys begins by 3rd week and nephrogenesis continues until 36 weeks of gestation. So, the development of kidneys and its outflow tracts are susceptible to environmental risk factors that may affect normal anatomy of urinary system. Many genes have been implicated in the development of kidney and its outflow tract and mutations have been identified in patients with CAKUT. In cases of severe CAKUT, the kidneys do not form and the fetus will not survive. In less severe cases of CAKUT, the baby can survive with combined kidney and outflow tract defects or sometimes these defects may be only detectable only at adulthood (2).

There are wide anatomical spectrum involving congenital anomalies of the kidney and urinary tract and these anomalies include renal anomalies, ureteropelvic anomalies, duplex collecting systems, and anomalies of the bladder and urethra. Anomalies of the ureter can be in terms of formation, termination, its structure, number or position (10).

Duplex system or double ureters are the most commonly encountered congenital abnormalities of the renal tract, with a reported prevalence of 0.1% to 6.25% (11).

Anatomical variants of ureter and its relationship to the surrounding structures are important for diagnostic and therapeutic purposes, which further helps in preserving renal functions. Duplication of ureters results from early splitting of ureteric bud into

two or more. These duplex ureters may be complete or incomplete (5).

Complete duplication is also called as double ureter wherein two pelves of the same side, one superior to the other is drained by separate ureters and having separate orifices on the floor of the bladder. In incomplete or also bifid ureter, upper end is bifid and in their lower part of the course two ureters join and open by a common orifice into the urinary bladder (6). Single kidney drained by double, triple, and quadruple ureters has been reported, and the double ureters (DUs) may be associated with double renal pelvis in single kidney or double kidney (12).

Single kidney drained by double ureter open in the urinary bladder either by a common orifice or by two separate orifices-upper and lower. In the latter condition, a mesonephric duct gives rise to two ureteric buds, upper and lower, which invade the metanephric blastema independently and induce the development of the upper and lower poles of kidney respectively. As the mesonephric duct undergoes loop formation in the posterior wall of the urinary bladder, the lower ureter opens into the bladder as in normal position, whereas the upper ureter draining urine from the upper pole of the kidney migrates more caudally along with the caudal shift of the terminal part of the mesonephric duct and opens in ectopic position. Here the normal and ectopic ureters cross each other (13). The ectopic opening may sometimes find its abnormal entrance into the urethra, vagina, or may be into epididymis (5).

Unilateral duplication has an incidence of 1 in 125 while bilateral duplication has an incidence of 1 in 800 cases. Duplication is two to five times more common in females than in males. Incomplete type may remain asymptomatic or may cause complications like ureteric stenosis, urinary lithiasis and pyelonephritis (14).

According to the study done by Lowsly *et al*, 4215 cadavers were studied among which 18 showed duplication of ureter. Out of 18, 7 were unilateral incomplete duplication, 2 were bilaterally incomplete and 8 were unilateral complete duplication (15). According to the study done by Russel *et al*, showed an average of 3% showing ureteral duplication (16). Asakawa M *et al* studied 340 cadavers and reported five cases of double pelvis and ureter (17).

Prakash *et al* studied 100 specimens and reports; one male cadaver aged 43 years showed complete double ureter on the right side and incomplete double ureter on the left side. Another male cadaver aged 56 years showed incomplete double ureter only on the right side. They also studied 50 intravenous pyelograms and reported, 43-year-old man showed incomplete double ureter on the right side (18). Praveen *et al*, 10 reported one incomplete duplicated left sided ureter in their study with no other associated abdominal or renal anomaly. Umesh *et al* observed two incomplete duplicated ureters in his study with prevalence of 3% (14). Payal Arvind examined 90 specimens and found two incomplete left sided duplicated ureter associated with hypoplastic and lobulated kidneys (19).

In the present study, the authors focused on ureteric variants and reported to have higher percentage of variations compared to previous studies. These variations were similar to the studies done by Prakash *et al*, Choudhary *et al* and Sangeetha *et al*. All the variants of ureters were histologically confirmed to know its structure and were normal. The drawback of this study with regard to complete double ureter was – opening of ureters into the urinary bladder or into other structures would not be traced as these were studied on dissected specimens of urinary system, but reporting it as double ureter with respect to its formation was stressed upon, which accounts for 4 specimens i.e. 8%.

Dähnert reported that occurrence of complete duplication in first-degree relatives of a patient with complete duplication of the ureters is sixty times more likely (18). Hascalik S reported that duplication of ureter may be genetically determined by an autosomal dominant trait with incomplete penetrance (20). Bruno and colleagues opined that ureteropelvic obstruction is more common when a duplex kidney exists and can be inherited as an autosomal dominant pattern (21).

According to the Weigert Meyer rule, the ureter from the upper pole of the kidney i.e. longer ureter get inserted more medially and caudally in the urinary bladder than the ureter from the lower pole of the kidney. This reflects the embryological development of the ureter. The ureteric bud which is initially more proximal on the mesonephric duct has a shorter time to be pulled cranially to be inserted into the urinary

bladder and hence it gets inserted into more distal part of the mature bladder (1).

Dorko et al. classification, based on the level of union of double ureters is proximal i.e.ureter fissus proximalis and distal i.e.ureter fissus distalis (22).

Reflux is the most common complication of a duplicated collecting system. The reflux associated with complete double ureter is vesicoureteric reflux and that associated with incomplete double ureter is ureteroureteric reflux. Thus, partial duplication is associated with two problems. a) Ureteropelvic junction (UPJ) obstruction of the lower moiety. b) Retrograde yo-yo peristalsis of urine in ureter (19).

As there are three constrictions along the length of the normal ureter that may predispose the ureter to stagnation of urine flow and occlude the passage of renal calculi (1). In the case of an incomplete double ureter, the angled point of union of the two ureters creates a fourth constriction that can further obstruct normal flow of urine and also leading to reverse urine flow, which may further predispose to complications like hydronephrosis. Due to these reasons, incomplete double ureters are diagnostically more significant than complete double ureters and hence these variants need to be identified (8).

On an average 3% excretory urograms show ureteral duplication on routine examination (16). Diagnosis is usually made in childhood or antenatally, although it can be found in adulthood. Imaging modalities used include ultrasonography, nuclear medicine, excretory urograms and computerized tomography (23).

A study was conducted to evaluate the ability of noncontrast computerized tomography to detect ureteral duplication with that of contrast computerized tomography. It was concluded that accuracy of axial computerized tomography with contrast medium was significantly higher than that of noncontrast axial or noncontrast coronal computerized tomography. Urologists and radiologists should be aware of this limitation and contrast studies can be done when anatomical anomalies are suspected (24).

The advancements in imaging technologies help radiologists, surgeons or urologists in diagnosing various ureteral anomalies. Comprehensive knowledge of anatomical variations of the urinary system and its relations with the surrounding structures is utmost important in performing renal transplants and radiological interpretations and it eases their management.

**Conclusion**

Ureteral injuries are common complications in open or laparoscopic surgical procedures involving the abdomen and pelvic regions. These ureteral injuries can be prevented by prior imaging of the abdomen and pelvis. The comprehensive knowledge of the normal and variant patterns of the ureter and its relationship to the surrounding structures are important and prerequisite for both Radiologists and Surgeons to plan any surgical procedures and to avoid accidental or iatrogenic complications.

**Table 1: Comparisons of double ureters with various previous studies.**

Author	Year	Number of specimens studied	Percentage of double ureter
Lowsly	1956	4215	0.4%
Asakawa	1989	340	5
Russel	2000	-	3%
Prakash et al	2011	100	2%
Parveen et al	2016	180	2.2%
Umesh et al	2017	64	6.25%
Anju et al	2017	72	4%

Roy M et al	2017	156	0.64%
Payal et al	2018	90	2.2%
Froebel Giftly et al	2020	62	1.61%
Sangeetha et al	2020	50	6%
<b>Present study</b>	<b>2021</b>	<b>50</b>	<b>8%</b>

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**Figures**

**Fig 1.**



**Fig 2.**



**Fig 3.**



**Fig 4.**



**FIGURE LEGENDS.**

**Fig. 1: Incomplete duplication of ureter**

**Fig. 2: Incomplete duplication of ureter.**

**Fig. 3: Complete duplication of ureter**

**Fig. 4: Complete duplication of ureter**