

**Original article**

## **Bifid ureter and multiple renal arteries: clinical and embryological significance**

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### **Abstract:**

**Introduction:** Bifid ureter is an incomplete type of double ureter. Multiple renal arteries which supply the kidney are commonly present in 30% of individuals. The aim of this study was to find out the incidence of bifid ureter and multiple renal arteries in cadavers and to correlate it with surgical and embryological significance.

**Methods:** The study was conducted in 52 adult embalmed cadavers of both sexes. Using conventional dissection techniques, the abdomen and pelvis were dissected. The presence of bifid ureter and multiple renal arteries were observed on both sides. Following fine dissection, the bifid ureter and multiple renal arteries were painted and photographed.

**Observation and results:** Bifid ureter and multiple renal arteries were found in three out of 52 specimens (6%). In all three specimens, the bifid ureters were present on the right side. In specimen 1 and 2 the left kidney was supplied by three renal arteries and the right kidney was supplied by a single artery. In specimen 3, both side kidneys were supplied by two renal arteries each. All the arteries were arising from the abdominal aorta opposite to the second lumbar vertebrae.

**Conclusion:** The incidence of bifid ureter and multiple renal arteries are 6% in the present study. Patients with bifid ureters may be accompanied by other ureteral anomalies such as ectopic ureter and have an increased risk of developing urinary tract infection, hydronephrosis and stone formation. Multiple renal arteries are important for the surgeons performing kidney transplantations as the renal arteries are end arteries and anastomoses must be made to all the arteries of the donor kidney.

**Key words:** ureteral duplication, multiple renal arteries, renal transplantation

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### **Introduction:**

Normally each kidney is drained by a single ureter, which conveys urine from the kidneys to the urinary bladder. Single kidney drained by double, triple and quadruple ureters has been reported. The double ureter may be associated with double renal pelvis or double kidney. Bilateral double ureters are much rarer than ipsilateral double ureters. Bifid ureter is an incomplete type of double ureter. In the incomplete type, the two ureters join at any level between the renal pelvis and the bladder itself. The incidence of bifid ureter is 3% to 4% and more

frequent in woman than in men. One of the segments of bifid ureter may end blindly without being associated with renal tissue<sup>1</sup>. Complications like frequent urinary tract infections, ureteric stenosis, urinary lithiasis and non-functioning of kidney units are associated with bifid ureter<sup>2</sup>.

In 70% of individuals, a single renal artery supplies to each kidney. Renal arteries are lateral branches of the aorta arising just below the origin of the superior mesenteric artery. Accessory or multiple renal arteries are common in 30% of individuals; usually arise from the aorta above or below the

main renal artery and follow it to the renal hilum. Rarely, accessory renal arteries arise from the coeliac or superior mesenteric arteries or from the common iliac arteries<sup>3</sup>. Accessory renal arteries have been described as aberrant, anomalous, supernumerary, supplementary, multiple, accessory aortic hilar, aortic superior polar, aortic inferior polar, upper polar, and lower polar<sup>4</sup>. Although kidney grafts with multiple renal arteries have been considered a relative contraindication because of the increased risk of complications. Allografts with multiple renal arteries were used successively in kidney transplantation<sup>5, 6</sup>. The ureteric bud gives rise to ureter, renal pelvis, major and minor calyces. Duplication of the ureter results from early splitting of the ureteric bud. Splitting of the ureteric bud may be partial or complete and metanephric tissue may be divided into two parts, each with its own renal pelvis and ureter<sup>7</sup>.

#### **Aim & Objectives:**

The knowledge about the incidence of bifid ureter, multiple renal arteries and its surgical & embryological significance is immense value for urologist and renal transplant surgeon. Hence the present study is undertaken to find out the incidence of bifid ureter and multiple renal arteries with its surgical and embryological correlation.

#### **Materials & Methods:**

The study was conducted in 52 adult embalmed cadavers of both sexes for the purpose of teaching first year MBBS students of Mahatma Gandhi Medical College and Research Institute, Puducherry, from the year August 2011 to June 2015. Using conventional dissection techniques following Cunningham's practical manual, the abdomen and pelvis were dissected in all 52 cadavers and the dissection of kidney and ureter was carried out. Presence of bifid ureter and multiple renal arteries were observed on both sides.

Following fine dissection, the bifid ureter and multiple renal arteries were painted and photographed. Length of bifid ureter from renal sinus to the level of fusion and from the level of fusion to open in the bladder was measured using thread and measuring scale. The level of origin of renal arteries in relation to lumbar vertebra and the superior mesenteric artery was noted; the length and diameter of renal arteries were measured using a measuring scale and vernier caliper.

#### **Observation & Results:**

In the present study, out of 52 specimens bifid ureter and multiple renal arteries were found in three specimens (6%) only. All the three specimens had unilateral bifid ureters which present on the right side. In specimen 1 and 2 (males) and specimen 3 (female), the right kidney was drained by bifid ureter; which lower down joined to open into the urinary bladder at a single orifice. Similarly in specimen 1 and 2 (males) the left kidney was supplied by three renal arteries and the right kidney was supplied by a single artery. In specimen 3 (female), both kidneys were supplied by two renal arteries each. All the arteries were arising from the abdominal aorta opposite to the second lumbar vertebrae (Fig 1-3).

In all three specimens, kidneys of both sides were normal in size and shape; urinary bladder, urethra, external genitalia and gonads were normal. And the kidneys were drained by a single renal vein. The left gonadal vein and left supra renal veins were drained into left renal vein in all three specimens. Length of bifid ureters from the renal sinus to the level of fusion and from there to open in to the bladder was measured in all three specimens (Table 1). Length and diameter of each renal artery and its level of origin in relation to lumbar vertebra and distance from the superior mesenteric artery were observed (Table 2).

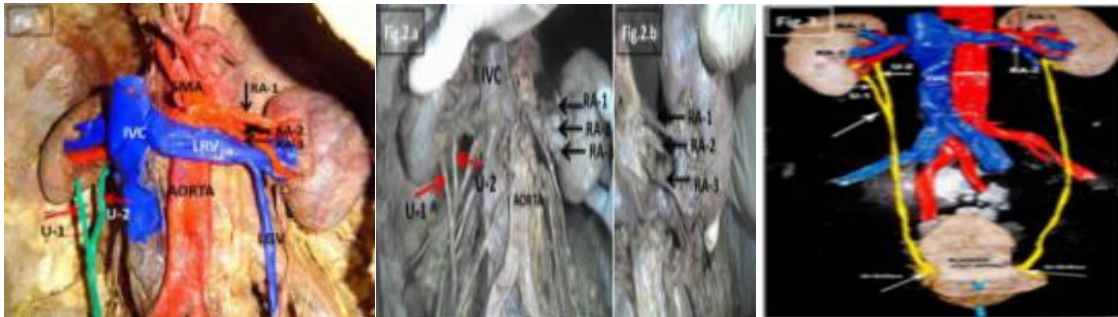
Table.1. Length of ureters

Specimens	Length of ureters (in mm) from renal sinus to the level of fusion		Length of ureters (in mm) from the level of fusion to opening in the bladder
	Ureter-1 (upper)	Ureter-2 (lower)	
Specimen-1 (Rt)	55	42	168
Specimen-2 (Rt)	49	41	157
Specimen-3 (Rt)	47	45	161

Table.2. Length and diameter of renal arteries.

Specimens	Number of arteries	Level of origin Distance from SMA (in mm)	Length (in mm) from aorta to renal sinus	Diameter (in mm)
Specimen-1 (Lt)	RA1	7	35	5
	RA2	18	45	3
	RA3	22	38	3
Specimen-2 (Lt)	RA1	5	52	4
	RA2	12	48	4
	RA3	14	42	3
Specimen-3 (Lt)	RA1	12	39	5
	RA2	17	47	3
Specimen-3 (Rt)	RA1	13	37	4
	RA2	11	41	3

RA-Renal Artery, Rt-Right, Lt-Left, SMA -Superior Mesenteric Artery



**Figure Legends:**

Fig.1-3 showing the bifid ureter and multiple renal arteries. SMA- superior mesenteric artery, IVC- inferior vena cava, LRV –left renal vein, LGV-left gonadal vein, U-1 & U-2 –lower and upper ureter, RA-renal artery, Ur-Orifice- ureteric orifice.

## **Discussion:**

### **I. Bifid ureter**

Bifid ureter or incomplete duplication is three times more common than complete duplication. It may be discovered in childhood, less frequently in later life or may be occult and discovered at autopsy<sup>8,9</sup>. According to Russelet al<sup>10</sup>, 3% of excretory urograms showed ureteral duplication on routine examination. Das et al<sup>11</sup> reported a case of unilateral (right) isolated bifid ureter out of 32 specimens in their cadaveric study. Mandal L et al<sup>2</sup> reported a case of left sided bifid ureter with bilateral hydronephrosis and multiple renal and gonadal vascular anomalies. RegeVM et al<sup>12</sup> reported a case of the blind ending of bifid ureter on the left side in intravenous pyelogram. Echanget al<sup>13</sup> reported a case of blind ending branch of a bifid ureter in multidetector CT urography.

Previous studies showed that the incidence of bifid ureter was 3% to 4% and more frequent in woman than in men. But in the present study, the incidence of unilateral bifid ureter was 6% and which is more common on the right side and more frequent in men than in woman.

### **Embryological and molecular basis of bifid ureter:**

The ureteric bud (UB) gives rise to the ureter, the renal pelvis, the major and minor calyces. Duplication of the ureter results from early splitting of the ureteric bud. Splitting of the ureteric bud may be partial or complete and metanephric tissue may be divided into two parts, each with its own renal pelvis and ureter<sup>7</sup>. The partial splitting of the ureteric bud explanation seems to be applicable in our study. Actin depolymerizing factors (ADFs), cofilin1 (Cfl1) and destrin (Dstn) are required for ureteric bud branching morphogenesis. SatuKuure et al<sup>14</sup>, observed either deletion of Cfl1 in UB epithelium or an inactivating mutation in Dstn has no effect on renal morphogenesis of mouse

development, but the lack of both genes arrests branching morphogenesis at an early stage, revealing considerable functional overlap between cofilin1 and destrin. Mice with less severe combinations of mutant Cfl1 and Dstn alleles, which retain one wild-type Cfl1 or Dstn allele, display abnormalities including ureter duplication, renal hypoplasia, and abnormal kidney shape. Their results indicate that ADF activity, provided by either cofilin1 or destrin, is essential in UB epithelial cells for normal growth and branching. p53 regulates metanephric development. p53 is best known as a tumor suppressor that regulates cell cycle, differentiation and apoptosis pathways. ZubaidaSaifudeen et al<sup>15</sup>, in their study observed that p53 embryos bred on C57Bl6 background exhibited a spectrum of congenital abnormalities of the kidney and urinary tract. Which include ureteric bud (UB) ectopia, double ureters, delayed primary branching of the UB and hypoplastic metanephroi. Angiotensin II AT2 receptor regulates ureteric bud morphogenesis. Angiotensin II (ANG II) AT2 receptor (AT2R) is expressed in the UB and mesenchyme during metanephric development. Renfang Song et al<sup>16</sup>, reported that angiotensin II (ANG II) AT2 receptor (AT2R) deficient mice exhibit abnormal ureteric bud (UB) budding, increased incidence of double ureters, and vesicoureteral reflux. AT2R performs essential functions during UB branching morphogenesis via control of the GDNF/c-Ret/Wnt11 signaling pathway, UB cell proliferation and survival. Aberrant AT2R signaling down regulates GDNF, c-Ret, and Wnt11 gene expression. It also decreases proliferation and induces apoptosis of the UB cells and impairs UB branching. These results support the hypothesis that abnormal collecting system development in AT2R deficient mice is at least partly due to deregulation of the UB

branching morphogenesis, aberrant UB cell proliferation and apoptosis.

**Surgical significance:**

Bifid ureters have been detected in association with various other congenital anomalies. Incomplete duplication is most commonly associated with uretero-ureteral reflux or uretero-pelvic junction obstruction of the lower pole of the kidney. Complications like frequent urinary tract infection, calculi, ureteric stenosis, urinary lithiasis and non-functioning of kidney units have been reported.

**II. Multiple renal arteries**

Accessory renal arteries are commonly present in 30% of individuals, and usually arise from the aorta above or below the main renal artery and follow it to the renal hilum. Although these congenital anomalies silently remain throughout life or only to be diagnosed during autopsy and they impose immense risk to surgeons during renal transplants. According to Banowsky<sup>17</sup>, unilateral multiple renal arteries occur in approximately 23 percent of the population. Another 10 percent have bilateral multiple arteries. Multiple renal arteries are more common on the left side. Singh et al<sup>18,3</sup> stated that accessory renal arteries are more common on the left side, occurring in as many as 30-35% of cases and usually entering the upper or lower pole of the kidney. Such an accessory artery of the lower pole may produce ureteric obstruction with secondary hydronephrosis. Satyapalet al<sup>4</sup> observed that, single additional renal arteries were more common on the left side (27.6%) than the right side (18.6%). Second additional renal arteries occurred with similar incidence on either side (right, 4.7%; left, 4.4%). Lengths (cm) and diameters (cm) of first and second additional renal arteries were 4.5, 0.4 and 3.8, 0.3 (right) and 4.9, 0.3, and 3.7, 0.3 (left), respectively. They also found that ligation of an accessory renal artery can result in the production of an area of infarction of variable size, though

often small and renovascular hypertension may occur as a sequel of the ischemia. In the present study, we observed the incidence of multiple renal arteries in 6% of cases and more commonly on the left side.

**Embryological basis of multiple renal arteries:**

Multiple renal arteries are regarded as persistent embryonic lateral splanchnic arteries which are arising from the aorta. The complexity of the organogenesis and ascent of the kidneys during the 6<sup>th</sup> to 9<sup>th</sup> weeks of gestation from the pelvis to the final lumbar location predisposes the occurrence of multiple renal arteries. The ascent of the kidney is accompanied by sequential sprouting of branches from the aorta while the preceding lower branches disappear. Failure of disappearance of these branches leads to multiple renal arteries<sup>19</sup>.

**Surgical significance:**

Accessory vessels to the inferior pole cross anterior to the ureter and may cause hydronephrosis by obstructing the ureter. On the other hand, it is important to be aware that accessory renal arteries are end arteries and therefore, if an accessory artery is ligated or damaged, the part of the kidney supplied by it is likely to become ischemic. Urologists must be well aware of the variations in the origin of renal arteries while performing nephron preserving surgery, kidney transplant, management of renal vascular hypertension, operating near renal pedicle or in the retroperitoneum. Preoperative selective angiography can confirm such variations. With the advent of newer surgical and diagnostic techniques, understanding of atypical anatomical presentations gains more important and can provide safety guidelines for endovascular procedures like therapeutic embolizations and angioplasties<sup>2</sup>.

**Conclusion:**

The incidence of bifid ureter and multiple renal arteries are in 6% of cases. The presence of bifid

ureter is due to the longitudinal splitting of a single normal ureteric bud as it grows cranially towards the metanephros and multiple renal arteries are due to persistence of lateral splanchnic arteries. Clinicians must be aware of bifid ureter and multiple renal arteries while treating pathology in the renal system and performing kidney transplant.

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