

## Original Research Article

# A cadaveric study on anatomical variations of kidney and ureter in India

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**Received:** 29 April 2017

**Accepted:** 02 May 2017

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### ABSTRACT

**Background:** The kidneys are a pair of bean - shaped organ located in the back of the abdomen between the 12<sup>th</sup> thoracic and 3rd lumbar vertebrae. Each kidney is about 4 or 5 inches long - about the size of a fist. The objective of this study was to study the major anatomical variations of kidney and urinary tract.

**Methods:** The study was conducted during routine dissections of 32 cadavers over a period of 5 years. All specimens included in the study was adult cadavers of which 20 were males and 12 were females.

**Results:** Out of 32 cadavers, 1 cadaver showed bilateral and 2 showed unilateral (2 L) lobulated kidney, 2 cadavers showed unilateral (1 L,1 R) and 1 showed bilateral accessory renal artery. 2 cadavers showed unilateral (1 L,1 R) incomplete double ureter.

**Conclusions:** 12.5% of the cadavers showed anatomical variations in kidney and 6.25% showed bifid ureter. The knowledge of anatomical variations of kidney and ureter is of great importance for surgical, radiological and academic perspective. Hence, the early detection may be helpful in better management and increased survival rates.

**Keywords:** Anatomical variations and duplication, Bladder, Cadaver, Congenital anomalies, Kidney, Renal artery, Ureter

### INTRODUCTION

The kidneys are a pair of bean - shaped organ located in the back of the abdomen between the 12<sup>th</sup> thoracic and 3rd lumbar vertebrae. Each kidney is about 4 or 5 inches long - about the size of a fist. As the kidneys filter blood, they create urine, which collects in the kidney's pelvis - funnel shaped structures that drain down tubes called ureters to the bladder. Each ureter is about 25 - 30 cm long, thick walled, 3 mm in diameter and are continuous superiorly with the funnel shaped renal pelvis. The ureter runs downwards to enter the lateral angle of urinary bladder. The ureter passes obliquely through the wall of the bladder for about 1.9 cm before opening into the

urinary bladder.<sup>1</sup> Each kidney has only one ureter but there are cases where ureteral duplication can be seen that can be categorised under congenital anomalies of the kidney. Ureteral duplication may be incomplete or complete. Incomplete duplication of ureter is known as bifid ureter. Incomplete duplications are if there are 2 separate ureters at the proximal aspect and they join at any point below uretero-pelvic junction, but before entering into the bladder whereas complete duplication is when there are two separate ureters that are continuous and enter the urinary bladder separately. Similarly, each kidney is supplied by a single renal artery that usually arises from the abdominal aorta and enters the kidney through the hilum, near the hilum the renal artery divides

into anterior and posterior division. Apart from the renal arteries, the kidneys receive additional blood supply from the accessory or aberrant arteries. Accessory renal arteries occur commonly in 26 - 30 % of individual.<sup>2</sup> Kidneys is the most common site of congenital abnormalities. Congenital anomalies of kidney and urinary tract constitute approximately 20 to 30% of all anomalies identified in the prenatal period.<sup>3</sup> Multiple lobulations of kidney are seen throughout the fetal life.<sup>4</sup> Most of them disappear during the first year of birth but varying degrees of lobulations may persist in the adult life. It occurs due to incomplete fusion of developing renal lobules. As sufficient information is lacking regarding the study of congenital anomalies of kidney and urinary tract in Indian population. Cadaveric study is important and relevant even in the modern era of imaging techniques. Hence, present study was performed.

**METHODS**

The present study was performed over a period of five years from 2012-2017 on 32 well preserved human

cadavers in the Anatomy department of BMCH Chitradurga, HIMS Greater Noida, MIMS Barabanki and HIMS Safedabad, Uttar Pradesh, India. All specimens included in the study was adult cadavers of which 20 were males and 12 were females. Specimens showing crush and cut injuries of kidneys or ureter were excluded from the study. All the specimens were thoroughly dissected and observed on both right and left sides to explore the presence of any anatomical variations in the kidney and ureter. The dissection method used was as per Cunningham's dissection manual.<sup>5</sup>

**RESULTS**

Out of 32 cadavers 28 were normal, 2 of them showed lobulated kidney with presence of accessory renal arteries, 1 showed only lobulated kidney and 1 showed only presences of accessory renal artery therefore 4 cadavers in total showed variations in the kidney (Table 1 and 2). Out of 32 cadavers 2 showed presence of unilateral bifid ureter while rest 30 showed normal ureter (Table 3).

**Table 1: Prevalence of variations in the kidney.**

No. of cadavers	Cadavers showing normal kidney	%	Cadavers showing variations in kidney	%
32	28	87.50	4	12.50

**Table 2: Unilateral and bilateral variations of the kidney.**

No. of cadavers	Cadavers showing normal kidney	%	Cadavers showing lobulated kidney		%	Cadavers showing accessory renal arteries		%
			U/L	B/L		U/L	B/L	
32	28	87.5	2 (2 L)	1	9.4	2 (1 L,1 R)	1	9.4

**Table 3: Unilateral and bilateral variations of the ureter.**

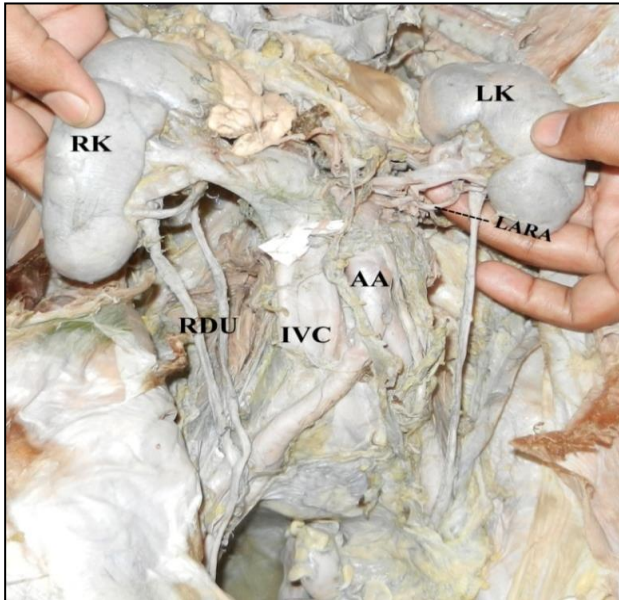
No. of cadavers	Cadavers showing normal ureter	%	Cadavers showing bifid ureter		%
			U/L	B/L	
32	30	93.75	2 (1 L,1 R)	0	6.25

**DISCUSSION**

There are innumerable congenital anomalies involving the kidney and ureter and the authors have attempted to discuss few of them observed during the study. The findings of this study include presence of unilateral bifid ureter, presence of unilateral and bilateral lobulated kidneys and presence of unilateral and bilateral accessory renal arteries. Incomplete duplication of the ureter may be formed due to some error or disturbance in development of uretic bud which arises from mesonephric duct<sup>6</sup>. Duplication of the ureter results from early splitting of the uretic bud. Splitting may be partial and complete, and metanephric tissue may be divided into two parts, each with its own renal pelvis and ureter. One of the buds

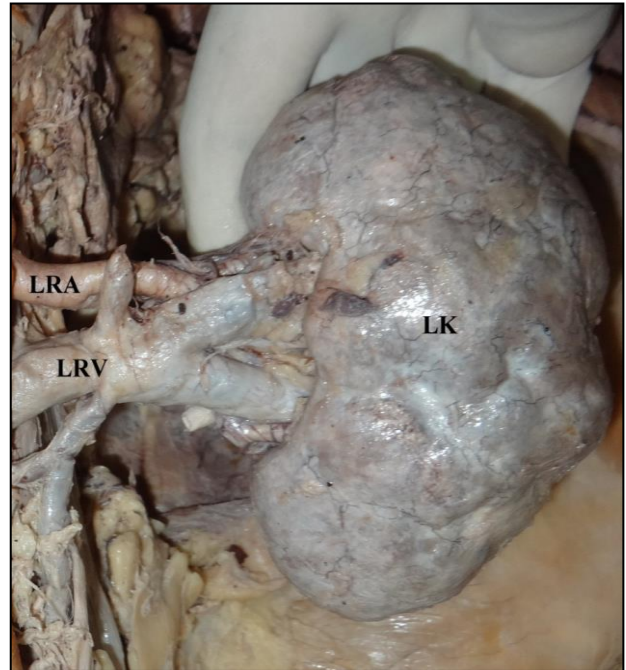
usually has a normal position, whereas the abnormal bud moves down together with the mesonephric duct. Thus, it has a low, abnormal entrance in bladder, urethra, vagina, or epididymal region.<sup>7</sup> The ureters may join before reaching the bladder or remain separate while entering the bladder at two distinct points.<sup>8</sup> According to Lowsly et al, out of 4215 cadavers studied 18 showed duplication of ureter. Out of 18, 7 were unilateral incomplete duplication, 2 were bilaterally incomplete and 8 were unilateral complete duplication.<sup>9</sup> According to Russel et al showed an average of 3% showing urethral duplication.<sup>10</sup> Duplex systems are the most commonly encountered congenital abnormalities of the renal tract, with a reported incidence of 0.8 %.<sup>11</sup> Asakawa M et al reported five cases of double pelvis and ureter among 340

cadavers (1.47%, 1.8% R, 0.3% L).<sup>12</sup> Strandring S et al has described the incidence of unilateral bifid ureter as 1 in 1251. In the present study, out of 32 cadavers 2 cadavers showed unilateral incomplete duplication (6.25%, 3.12% R, 3.12% L) (Figure 1).

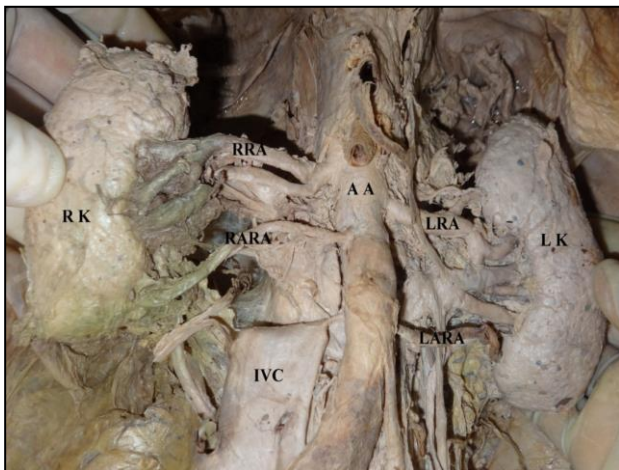


**Figure 1: Left and right kidney with unilateral right double ureter, unilateral left accessory renal artery and bilateral lobulated kidney. (RK: right kidney; LK: left kidney; AA: abdominal aorta; IVC: inferior vena cava; RDU: right double ureter; LARA: left accessory renal artery).**

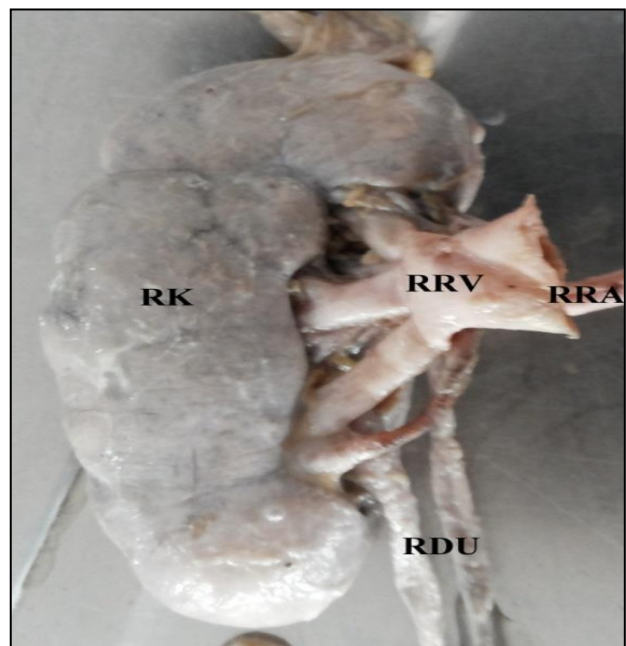
Normally these lobulated structures of the kidney remain apparent at birth and it gradually disappears during infancy as the nephrons increases and grow and fully disappears in first 5 years of life as the kidney grows.<sup>13</sup> According to Manisha et al lobulations can be seen in 5% of right kidney and 10% of left kidney.<sup>14</sup> Patil et al reported a rare congenital condition of the kidney where bilateral lobulation and malrotation were observed in association with open hilar structure of kidney.<sup>15</sup> In the present study 6.25% showed lobulation in left kidney and 3.12% showed bilateral lobulations (Figure 1, 3, 4).



**Figure 3: Unilateral lobulated left kidney.**



**Figure 2: Left and right kidney with bilateral accessory renal artery. (RK: right kidney; LK: left kidney; AA: abdominal aorta; IVC: inferior vena cava; RRA: right renal artery; LRA: left renal artery; RARA: right accessory renal artery; LARA: left accessory renal artery).**



**Figure 4: Unilateral lobulated right kidney.**

Embryologically, the kidney develops in several distinct lobules that fuses as they develop and grow. Incomplete fusion of these renal lobules can persist postnatally.



The artery originating from abdominal aorta or from main renal artery is termed as accessory renal artery. It usually arises between T11 and L4 levels and its incidence range from 11-61%.<sup>16</sup> Persistent foetal renal vessels is also considered a fact for accessory renal arteries and are termed polar arteries; as it enters either to the upper or lower pole.<sup>17,18</sup> Accessory renal arteries weather to the upper or lower pole is always associated with embryological defects.<sup>4,5</sup> According to Tania Regina out of 24 cadavers 6% showed accessory renal arteries.<sup>19</sup> Saritha et al documented an incidence of 8% accessory renal arteries in 25 cadavers.<sup>20</sup> According to Vijaianand et al out of 29 cadavers 2 of them showed accessory renal arteries.<sup>2</sup> According to Satpal et al the incidence of accessory renal arteries is higher in left kidney as compared to the right kidney.<sup>21</sup> In the present study accessory renal arteries were present in 9.37% of which 6.25% showed unilateral (3.12% L and 3.12% R) and 3.12% showed bilateral (Figure 1, 2).

### ACKNOWLEDGEMENTS

Authors would like to thank all the staff of Anatomy department of BMCH Chitradurga, HIMS Greater Noida, MIMS Barabanki and HIMS Safedabad, Uttar Pradesh, India.

*Funding: No funding sources*

*Conflict of interest: None declared*

*Ethical approval: Not required*

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**Cite this article as:** Choudhary U, Kumar S, Jee K, Singh A, Bharti P. A cadaveric study on anatomical variations of kidney and ureter in India. Int J Res Med Sci 2017;5:2358-61.