

## A CADAVERIC STUDY OF VARIATIONS IN THE UROLOGICAL SYSTEM

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### ABSTRACT

**Introduction:** Knowledge of anatomical variations of the urinary system is important for urological surgeries involving renal transplant and radiological interpretations. When urologists and clinicians have a sound knowledge of anatomical variations, it eases management, surgical interventions and helps to reduce complications.

Advanced imaging technology is the boon for the patients requiring minimally invasive approaches for various kidney disorders. These approaches require precise knowledge of normal and variant anatomy of the kidneys, ureters and vascular structures at the hilum of the kidney. Therefore, the objective of this study was to furnish the clinicians with the major anatomical variations of urological system.

**Method:** Ninety adult human cadavers were examined for number, shape and position of kidneys and the ureters over a period of 5 years. Out of these, 85 were males and 15 were female cadavers.

**Results:** Kidneys were bilaterally present in all the cadavers. Hypoplastic kidneys were seen bilaterally in 3.3% cadavers. Out of 90 cadavers, 3 showed bilateral and 6 showed unilateral lobulated kidneys. 2 cadavers showed unilateral (1 L, 1 R) incomplete double ureter. One showed bilateral and 5 showed unilateral accessory renal artery amongst 90 cadavers. Ectopic kidney was seen in one cadaver.

**Conclusions:** Morphological variations in the kidney are very common and are clinically important for urosurgeons.

**KEY WORDS:** Double ureters, hypoplastic human kidney, renal hilum relations, variations, ectopic kidney.

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### INTRODUCTION

The kidneys are a pair of bean - shaped organ. They are located in the back of the abdomen between the 12th thoracic and 3rd lumbar vertebrae. Each kidney is about 4 or 5 inches long. Each ureter is about 25 - 30 cm long, thick

walled, 3 mm in diameter and is continuous superiorly with the funnel shaped renal pelvis. The ureter runs downwards to enter the lateral angle of urinary bladder. The ureter passes for about 1.9 cm obliquely through the wall of the bladder before opening into the urinary bladder [1].

Diminutive kidney can be due to aplasia or hypoplasia or atrophic pyelonephritis. It is one of the causes of hypertension, lumbar or abdominal pain, obscure gastrointestinal symptoms or chronic urinary infection accompanied by chills and fever. Thorough radiographic examination and renal function studies including the more accurate quantitative phenolsulfonphthalein test of each kidney helps in diagnosis. In unilateral disease causing symptoms, nephrectomy is the treatment. For localized atrophic pyelonephritis, partial resection is preferred. Since urinary stasis invites infection, obstructing ureteral strictures should be dilated. Pyelectasis and ureteropelvic obstruction should be corrected by nephropexy or plastic repair. These conservative measures may prevent renal destruction [2]. As sufficient information is lacking regarding incidence of renal hypoplasia, hence present study highlights this parameter.

A kidney 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 [3]. During fetal life; multiple lobulations of kidney are seen [4]. Most of them disappear during the first year of birth. If there is incomplete fusion of developing renal lobules varying degrees of lobulations may persist in the adult life.

A duplex collecting system (or duplicated collecting system) is one of the commonest congenital renal tract abnormalities. Duplex collecting systems are seen in 0.7% of the normal adult population and in 2 - 4% of patients investigated for urinary tract symptoms. The incidence of duplex kidneys in post-mortem series is between 0.5-1.25%. Duplicated ureter is more common in females. However, this may be due to the higher frequency of urinary tract infections in females, leading to a higher rate of diagnosis of duplicated ureter. Diagnosis is important for operative planning and long-term follow up.

There appears to be a strong genetic predisposition. In those with duplex kidneys, up to 30% have relatives with complete duplex kidneys and two thirds with bifid systems, suggesting autosomal dominant inheritance with variable

expression and incomplete penetrance.

Double ureters have been classified as [5]:

1. **Complete**, 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.
2. **Incomplete**, wherein two pelves and the two ureters join to enter the bladder by one common ureteric orifice. The bifurcation in this latter group may be situated at any point in the course of the ureter, from just above the bladder, up to the renal pelvis.

Kidneys are a pair of excretory organs situated one on each side of the vertebral column retroperitoneally. Being with a bean shape, it presents thick and rounded superior pole and thin and pointed inferior pole. Renal hilum is deep vertical slit situated in its medial border which lies about 5 cm from the midline opposite the lower border of L1 vertebra. It communicates with the renal sinus within the kidney. According to conventional description in standard anatomy textbooks, at the hilum, usually the renal vein is the anterior, with the renal artery posterior to it and the pelvis of kidney lying further posteriorly and inferiorly. Various case reports have been published which report possible variations in the arrangement of structures at the hilum.

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>6</sup> There is a need for developing techniques for careful identification of multiple renal vessels, particularly aberrant vessels, at the time of donor nephrectomy and also to the different techniques available for anastomosis of multiple renal arteries in kidney transplant recipients [7].

Knowing the anatomy of the ureteropelvic junction of the kidney is essential for understanding urinary tract disorders and various nephron sparing surgical procedures. Double ureter and duplex system reported in the literature time and

again have potential for future complications, such as the collecting system obstruction, lithiasis, ureterocele, and vesicoureteral reflux. Hence, their early detection may be helpful in better management and increased survival rates.

An ectopic kidney is a birth defect in which a kidney is located above, below or on the opposite side of its usual position. The incidence of ectopic kidney is about one in 900 people. During fetal development, fetal kidneys first appear as buds inside the pelvis near the bladder. With development, kidneys move gradually toward their usual position in the back near the rib cage. Sometimes, one of the kidneys remains in the pelvis or stops moving before it reaches its usual position. In other cases, the kidney moves higher than the usual position. Rarely does a child have two ectopic kidneys. Most kidneys move toward the rib cage, but one may cross over so that both kidneys are on the same side of the body. When a crossover occurs, the two kidneys often grow together and become fused.

Factors that may lead to an ectopic kidney includes [8]

- poor development of a kidney bud
- a defect in the kidney tissue responsible for prompting the kidney to move to its usual position
- genetic abnormalities
- the mother being sick or being exposed to an agent, such as a drug or chemical, that causes birth defects

Thus, knowledge of anatomical variations of the urinary system is important for urological surgeries involving renal transplant and radiological interpretations. When urologists and clinicians have a sound knowledge of anatomical variations, it eases management, surgical interventions and helps to reduce complications. Therefore, the objective of this study was to furnish the clinicians with the major anatomical variations of urological system.

**Aim:** To study the morphological characteristics and variations of urinary system in the adult human cadaver

**Objectives:** The objectives of the study were:

To note and compare the size of kidneys, To observe for any lobulations in the kidneys, To look out for cortex- medulla differentiation of sectioned kidneys, To note for presence of partial or complete duplication of ureters, To observe the relation at hilum of kidneys, To note for presence of accessory renal arteries and their origin, To note the location of kidneys

## MATERIALS AND METHODS

The study included 90 adult human cadavers from the Department of Anatomy at a Medical College in Mumbai, India from October 2012 to October 2017. The cadavers were well preserved in formalin solution. There were 85 male and 15 female cadavers. 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 [9]. Anterior abdominal wall was reflected. The abdominal viscera were removed. The kidneys, ureters and renal arteries were identified and traced. Accessory renal arteries if present were noted. The results obtained were recorded and tabulated. Variations were documented by photography.

**Inclusion Criteria:** All the cadavers available during the study period

**Exclusion Criteria:** Specimens showing pathological involvement or crush and cut injuries of kidneys or ureter

## RESULTS

Out of 90 cadavers, 69 were normal. 3 of them (3.3%) were hypoplastic, 9 of them (10%) showed lobulated kidney, 2 of them (2.2%) showed presence of unilateral bifid ureter, 6 (6.6%) showed presence of accessory renal arteries and 1 (1.1%) showed ectopic kidney. Therefore, 21 cadavers in total showed variations in the urinary system. (Table 1)

Kidneys were bilaterally present in all the cadavers. Hypoplastic kidneys (Fig.1, 2 and 3) were seen in 3 cadavers. As seen in Fig. 1, the left kidney is hypoplastic as well as its surface is lobulated. On section, this kidney shows cystic degeneration (Fig. 5).

Out of 90 cadavers, 3 showed bilateral (Fig. 1)



and 6 showed unilateral lobulated kidneys (Fig. 2 and 3).

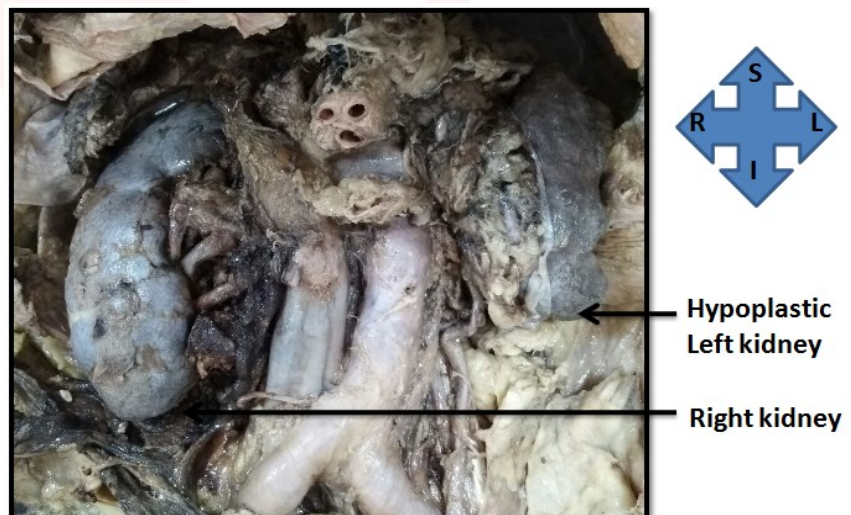
In 6 specimens, cortex- medulla differentiation was absent (Fig.4). In one specimen, cysts were seen along with absence of cortex- medulla differentiation. In addition that kidney was also hypoplastic (Fig. 5). 2 male cadavers showed unilateral incomplete double ureter. Both belonged to the left side. In one of that male cadaver of approximately 40 years age, a partial double ureter along with altered relation of structures at the hilum of left kidney (Fig.6) was observed. The hilar region was dissected carefully and the structures and their relations were clearly defined. The two ureters were uniting at the level of S2. The altered relation of structures at the hilum of left kidney from anterior to posterior were anterior segmental branches of left renal artery, left renal vein, posterior segmental branch of left renal artery and two ureters. On the right side, no such variation was observed. The length of upper moiety and lower moiety of left ureter before union was 16.4cm and 15cm respectively. The length of left ureter post union till urinary bladder was 11.6cm. Thus left upper pole and lower pole ureter measured 28cm and 26.6cm respectively.

The right single ureter measured 28.5cm. Similar measurements for the other cadaver were noted as shown in Table 2. The diameter of both the ureters was almost equal. The opening of the ureter into the bladder did not show any abnormality. Examination of the other thoracic, abdominal and pelvic viscera revealed normal gross morphology in both the cadavers.

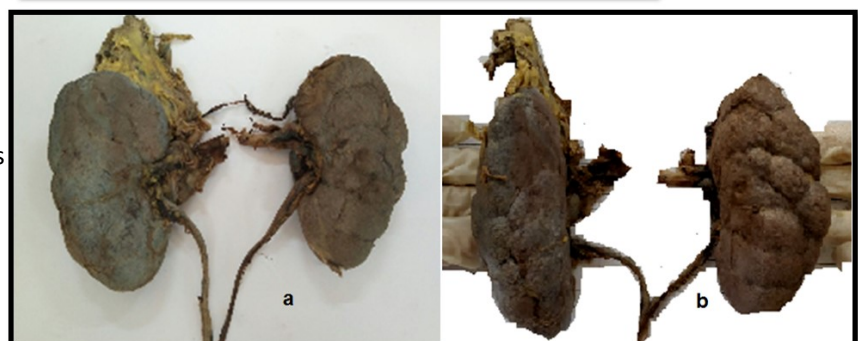
Ones showed bilateral and 5 showed unilateral accessory renal (Fig.7) artery amongst 90 cadavers. Out of the 5, 2 were from right side (inferior polar arteries) and 3 (one inferior polar and 2 superior polar arteries) from left side.

Ectopic kidney (Fig.8) was seen in one male cadaver of around 45 years. It was at the level of pelvic brim. The coronal section of the left kidney showed normal cortex, medulla and renal pyramids; minor and major calyces. No cysts were observed. The right kidney was morphologically normal. This was however associated with non-rotation of gut. The small bowel was located predominantly on the right side within the peritoneal cavity and the colon was located on the left side. There was also presence of right aortic arch with aberrant origin of great vessels. Aortic arch aneurysm was also present.

**Fig. 1:** Illustration showing left sided hypoplastic and lobulated kidney



**Fig. 2:** Bilaterally lobulated kidneys. Note the multiple lobules on the surface (a) and lateral borders (b) of both the kidneys.



**Table 1:** Prevalence and distribution of variations in the urological system.

Sr. No.	Cadavers	Total (out of 90 cadavers)		%
		U/L	B/L	
1	Normal kidneys and ureters	69		76.67
2	Variant kidneys and ureters	21		23.3
3	Hypoplastic kidneys	1	2	3.3
4	Lobulated kidneys	6	3	10
5	Partial double ureters	2	0	2.2
6	Aberrant renal arteries	5	1	6.7
7	Ectopic kidney	1	0	1.1

**Table 2:** Measurements of the partial double ureters and normal ureters.

Side	Measurements	Length in cm	
		Cadaver 1	Cadaver 2
Left	Before union upper moiety	16.4	17.2
Left	Before union lower moiety	15	16
Left	Post union till urinary bladder	11.6	12.8
Left	Upper pole ureter	28	30
Left	Lower pole ureter	26.6	28.8
Right	Single ureter	28.5	30

**Table 3:** Comparison of prevalence of lobulated kidneys.

Sr. No.	Study	Right (%)	Left (%)	Bilateral (%)
1	Manisha et al.	5	10	-
2	Choudhary U et al.	-	6.25	3.12
3	Present study	2.2	4.5	3.3

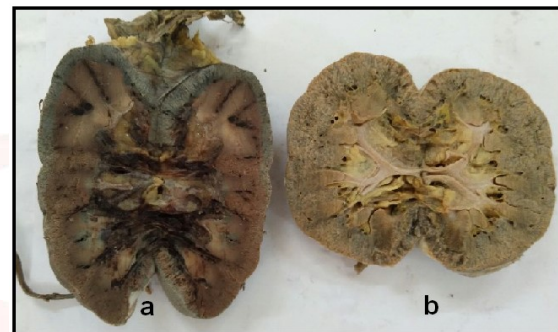
**Table 4:** Comparison of prevalence of duplex collecting system.

Sr. No.	Study	Total material	Total			
			Incomplete		Complete	
			U/L	B/L	U/L	B/L
1	Lowsly et al.	4215	7	2	8	0
2	Asakawa S et al.	340	5	0	0	0
3	Standing S et al.	1251	1	0	0	0
4	Choudhary U et al.	32	2	0	0	0
5	Present study	90	2	0	0	0

**Fig. 3:** Illustration showing cut section of the Lobulated Kidneys



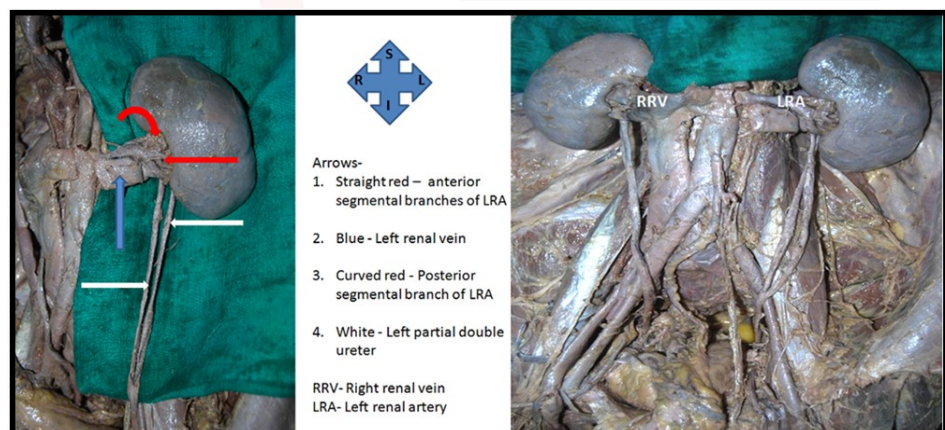
**Fig. 4:** Illustration showing loss of cortex and medulla differentiation in Kidney (a) while normal but hypoplastic kidney section in Kidney (b)



**Fig. 5:** Illustration showing section of hypoplastic kidney showing multiple cysts and absence of cortex-medulla differentiation



**Fig. 6:** Illustration showing partial double ureter and altered relation at the hilum of left kidney.

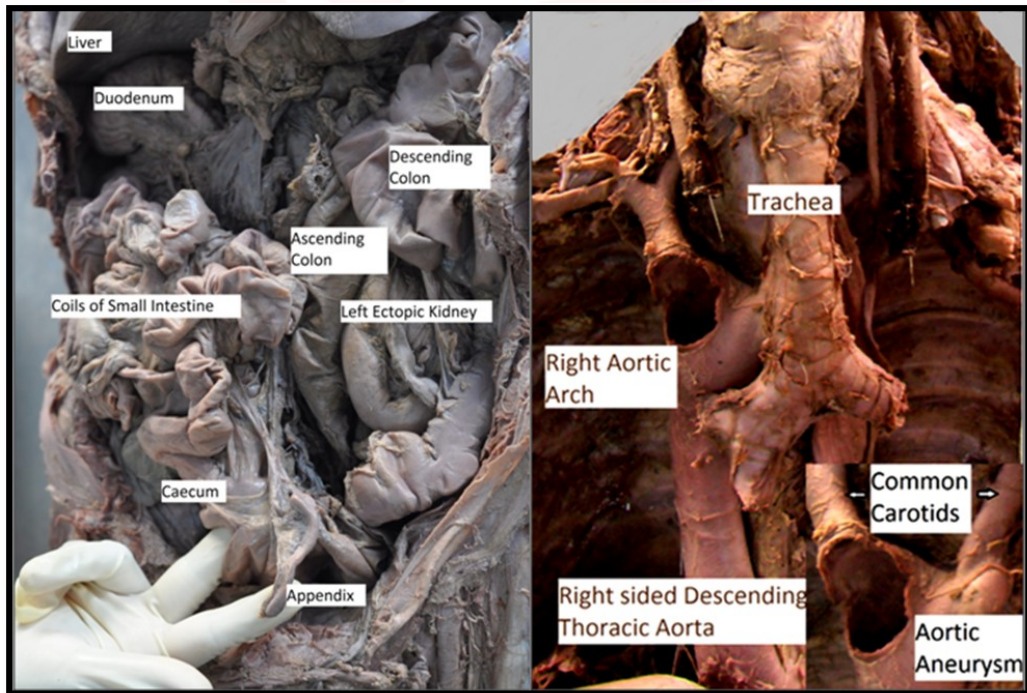




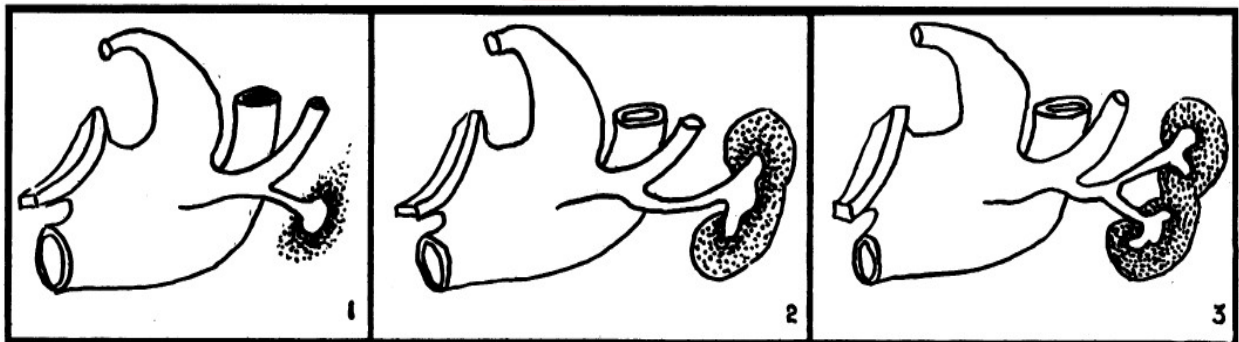
**Fig. 7:** Aberrant right renal artery or inferior polar artery arising from right renal artery (forceps).



**Fig. 8:** Left ectopic kidney associated with non-rotation of midgut loop and other anomalies.



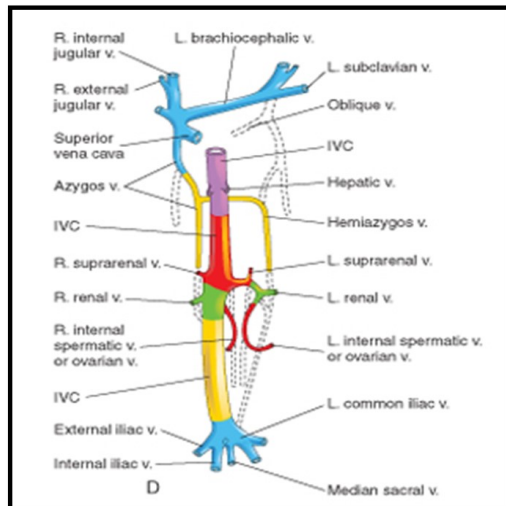
**Fig. 9:** Development of partial double ureter



where

1. Ureteric bud from lower end of Mesonephric duct.
2. Subdivision of primary pelvis into major calyces.
3. Early branching of ureteral bud with formation of incomplete double ureter and pelvis.

**Fig. 10:** Development of the renal veins



## DISCUSSION

There are many congenital anomalies of the urinary system. There is lack of sufficient information regarding this in Indian population. Cadaveric study is important and relevant even in the modern era of imaging techniques. The authors have attempted to elaborate few of them observed during the study. The findings of this study include presence of hypoplastic kidneys, lobulated kidneys, bifid ureter, accessory renal arteries and ectopic kidneys.

Renal hypoplasia is associated with infection, formation of stone, scarring with fibrosis, cystic degeneration and round cell infiltration. It is frequently observed with other congenital anomalies of the genitourinary tract. In a study on diminutive kidneys by Mathe CP [2], two hypoplastic kidney cases out of 53 showed reduplication of the opposite kidney. Hypoplasia is to be differentiated from pyelonephritic atrophy in which the kidney is reduced in size by infection. The kidney develops from the Wolffian body through the stages of pronephros, mesonephros and metanephros. An insufficient blood supply occurring at any of those stages could cause arrest in development [2].

Also, the kidney develops in several distinct lobules. They fuse with growth. Incomplete fusion of these renal lobules can persist after child birth. It gradually disappears during infancy as the nephrons increases and grows. It fully disappears in first 5 years of life. According to Manisha et al lobulations can be seen in 5% of right kidney and 10% of left kidney. 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. Choudhary U et al. reported 6.25% cases with lobulations in left kidney and 3.12% showed bilateral lobulations. (Table 3)

Ureteral development begins in the human fetus around the 4th week of embryonic development [10]. Underlying embryological basis can be explained as development of two ureteral buds separately from a single mesonephric duct give rise to a duplex kidney with complete ureteral duplication. On the other hand, bifurcation of a single ureteral bud proximal to the ampulla (distal dilated part) gives rise to a duplex kidney with a bifid pelvis or ureter [11].

The kidney is formed when the ureteric bud, arising from the mesonephric duct, meets the metanephros, and by a process of reciprocal induction brings about the formation of the kidney. The distal part of the ureteric bud eventually incorporates into the bladder to form the trigone. At the cranial end branching of the ureteric bud gives rise to the ureter, renal pelvis, calyces and collecting ducts. Premature branching of the ureteric bud results in an incomplete duplex with ureters that meet before the bladder, or a bifid renal pelvis (Fig. 9). If more than one bud develops and migrates to the metanephros a duplex kidney with two separate ureters forms. Initially the more cranial ureteric bud connects to the upper pole. However as the ureteric bud incorporates into the bladder, the upper pole ureteric bud rotates and migrates more caudally than the lower pole ureteric bud. This result in the upper pole ureter having an opening that is more caudal than the lower pole ureter: an observation initially made by Weigert and then independently by Meyer. This is the Meyer Weigert Law [12,13].

Reflux is the most common complication of a duplicated collecting system. The exact nature depends on the type of system involved. For example reflux associated with complete duplicated systems is vesicoureteric reflux and that associated with partially duplicated systems 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 the two ureters.

There is variable incidence of duplex collecting system, associated with complete or incomplete duplication of ureter. A study on urograms conducted by Dahnert<sup>14</sup> showed that the prevalence of partial duplication of the ureter was three times commoner than complete duplication of the ureters. Prakash et al. also had similar opinion as per their study conducted on 50 intravenous pyelograms.<sup>11</sup> According to Lowsly et al, out of 4215 cadavers studied 18 showed duplication of ureter. Asakawa M et al reported five cases of double pelvis and ureter among 340 cadavers (1.47%, 1.8% R, 0.3% L). Standring S et al has described the incidence of unilateral bifid ureter as 1 in 1251. In study by Choudhary U et al., out of 32 cadavers 2 cadavers showed unilateral incomplete duplication (6.25%, 3.12% R, 3.12% L). Table 4

Gynecologists must be aware of such kind of variation so as to avoid accidental traumatic injury of ureter while performing hysterectomy. Radiologists must also be aware of all kinds of variations of ureter to correctly interpret the radiographs.

#### **Altered relation of structures at the hilum [1]:**

Variant patterns are more commonly observed on the left side. This might be because, embryologically left renal vein is a composite structure derived from multiple anastomotic channels, whereas, the right renal vein is derived from a single anastomotic channel. Deviant development of these channels may change interrelationship of renal hilar structures with respect to renal vein. (Fig. 10)

Variations in renal arteries accounts for about 30% of its existence. These variations are classified as aberrant or accessory renal arteries. Arteries which enter the kidney by piercing the renal parenchyma, either through upper pole or lower pole as polar arteries, are called aberrant arteries. Accessory renal arteries are additional arteries which pass along with normal renal arteries through the hilum. Renal, suprarenal and gonadal organs are supplied by dorsal aorta via lateral mesonephric arteries. According to Felix, these lateral mesonephric arteries are divided into upper, middle and lower groups. The middle group, namely 6-9<sup>th</sup>

segment, gives rise to renal arteries. Persistence of more than one renal artery in the middle group results in accessory renal arteries. The various types of pre-hilar branching patterns which are observed are fork, duplicate, triplicate and ladder patterns. These multiple branches represent the segmental distribution of the kidney. Hence, there is risk of haemorrhage during transplantation, segmental ischaemia and post operative haemorrhage. The earlier division of renal arteries is also observed. This is due to delay in communication between the factors present in mesenchyme of the blood vessel and those present in the mesenchyme of metanephros like glial derived neurotropic factor and hepatocytic growth factor. The population with earlier division of renal artery is not a suitable candidate for transplantation as the surgeon would not have a long pedicle for anastomosis of renal artery [15].

Saldarriaga et al., observed a bilateral additional artery in 7.7% of the cases. He also reported that additional arteries had entered through the hilum in 12% of cases and in 1.8% of cases, it was inferior polar arteries. Bilateral additional renal arteries were also observed by Aristotle et al. [16] Apart from this, they also encountered both inferior and superior polar arteries.

Bordei P et al., studied 54 cases, out of which 24 cases had entered through the hilum, 16 were inferior polar arteries and in 5 were superior polar arteries. These double renal arteries arose from the abdominal aorta. These aberrant arteries can arise from inferior phrenic or from internal iliac arteries.

The accessory or aberrant renal arteries are important for the clinicians, since they have a vital role to play in renal transplantations, causation of hydronephrosis and in micro vascular surgeries. Hence the study on anatomical variations in vascularity of kidney is very important to transplant surgeons involved in donor nephrectomies. The surgeon can explore and treat renal trauma, renal transplants, renal vascular emboli, angioplasty and radical renal surgeries when furnished with this knowledge. Belsare (2002) reported a case of ectopic kidney of left side associated with multiple visceral variations were in the form of mechanical displacement of sigmoid colon and mesocolon



to the right side, compensatory hypertrophy of the right kidney, enlarged uterus and displaced ovary and vascular variations included multiple renal vessels on the both the sides, variations in abdominal aorta, inferior vena cava and in the gonadal vessels. Reddy CK (2010) reports a case of left ectopic kidney with non rotation and morphologically normal right kidney in adult male cadaver [17].

The ectopic kidney which is functional may go undetected in life. It may be observed only after death, either in autopsy or during dissection. The symptoms range from none to pain, hydronephrosis and pyelonephritis, renosigmoid fistulae or renal stone. When acute renal disease develops, renal ectopia presents diagnostic problems. There is always a danger that an off-guard surgeon may be tempted to remove it as an unexplained pelvic mass. In case of females the pelvic kidney may result in obstetric complications. In addition to the routine contrast radiographs i.e. Intravenous pyelograms and ascending pyelograms, the modern methods of investigations such as ultrasonography, computer tomography (CT) and magnetic resonance image (MRI) scan etc. are very useful to diagnose the ectopic kidney. Thus, complications during operation may be avoided. This assures of a good prognosis [17].

## CONCLUSION

In conclusion, the present analysis revealed variations in size, morphology and vascularity of urinary system. These reported variations have great implications in renal transplants, radiological and urological procedures, renal trauma, renovascular hypertension and hydro-nephrosis. To plan the adequate surgical procedure and to avoid any vascular complication, multidetector computer tomography (MDCT), angiography and arteriography can be performed prior to surgery.

**Conflicts of Interests: None**

## REFERENCES

- [1]. Standring S, Borley N, Gray H. Urogenital System-Ureter and Kidney. Gray's Anatomy 40th Ed., Spain, Churchill Livingstone, Elsevier; 2008:1238-1240.
- [2]. Mathe CP. The Diminutive Kidney—Congenital Hy-poplasia and Atrophic Pyelonephritis. California Medicine, 1956; 84(2): 110-114.
- [3]. Mishra A. Renal agenesis: report of an interesting case. Br J Radiol. 2007;80: e167-e169.
- [4]. Williams PL, Bannister LH, Berry MM, Collins P, Dyson M, Dussek JE, et al. Urinary System. Gray's Anatomy. 38th Ed., Edinburgh, Churchill Livingstone; 1995:1815-1836.
- [5]. Glassberg KI, Braren V, Duckett JW, Jacobs EC, King LR, Lebowitz RL et al. Suggested terminology for du-plex systems, ectopic ureters and ureteroceles. J Urol 1984; 132(6):1153-1154.
- [6]. Vijaianand M, Ramamurthi KS. A cadaveric study on accessory renal arteries and its clinical impli-cations. Int J Anat Res. 2017;5(1):3439-42.
- [7]. Ghazanfar A, Tavakoli A, Zaki MR, Pararajasingam R, Campbell T, Parrott NR, Augustine T and Riad HN. The Outcomes of Living Donor Renal Transplants with Multiple Renal Arteries: A Large Cohort Study With a Mean Follow-Up Period of 10 Years, Transplantation Proceedings 2010; 42 (5):1654.
- [8]. Bauer SB. Anomalies of the upper urinary tract. In: Wein A, ed. Campbell-Walsh Urology. 9th ed. Phila-delphia: Saunders Elsevier; 2007: 3269–3304.
- [9]. Romanes GJ. The abdominal cavity. Cunningham's Manual of Practical Anatomy Vol 2, The Abdomen, 15th Edition. 1992; 165:172.
- [10]. Moore KL, Persaud TVN The developing human clini-cally oriented embryology 7<sup>th</sup> edition Page no. 288-296.
- [11]. Prakash et al. Double Ureter and Duplex System: A Cadaver and Radiological Study. J Urol. 2011; 8(2): 145-148.
- [12]. Weigert C. Übereinige Bildungsfehler der Ureteren. Virchow's Arch 1877; 70:490.
- [13]. Meyer R. Normal and abnormal development of the ureter in the human embryo; a mechanistic consid-eration. Anat Rec 1946; 96(4):355-371.
- [14]. Dahnert W. Radiology review manual. 6th ed. Phila-delphia: Lipincott Williams Wilkins. 2007.
- [15]. Satheesha Nayak B, Shetty SD, Rao Sirasanagandla S, Swamy Ravindra S, Kumar N, Jetty R, Abhinitha P. Morphological and vascular variations of the left kidney: A case report. OA Case Reports 2013 Sep 10; 2(10):98.
- [16]. Aristotle, Sundarapandian, Felicia C. Anatomical Study of Variations in the Blood Supply of Kidneys. J Clin Diagn Res. 2013 Aug; 7(8): 1555–1557.
- [17]. Reddy CK. Left ectopic kidney with non rotation: A case report. Nepal Med Coll J. 2010; 12(2):123-124.

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