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Original Research Article

Anomalous Renal Vasculature Existing With Congenital Anomalies of Kidneys, Ureters and Suprarenal Glands: A Cadaveric Study

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Abstract

Variations in the renal vessels have been observed frequently in routine dissection and surgical practice, but existing with congenital anomalies of kidneys or ureters or suprarenal glands is very rare. Accordingly the aim of this study was designed to evaluate the prevalence of anomalous renal vasculature existing with congenital anomalies of kidneys, ureters and suprarenal glands. This study was carried out on 48 human cadavers (including dissected cadaveric specimens) irrespective of age and sex used for routine dissection of abdomen conducted for medical undergraduates teaching purpose. The kidneys, ureters and suprarenal glands along with their arteries were exposed and the anomalous variations of renal vasculature existing with congenital anomalies of kidneys or ureters or suprarenal glands were observed. Photographs of the anomalous and developmental variations were taken for proper documentation. Out of 48 human cadavers following anomalous / developmental variations were noted- unilateral retro aortic left real vein, extra-hilar artery (branch of renal artery that presents an extra hilar penetration) to the superior pole of left kidney, existing with very rare and unusual double suprarenal gland with unusual blood supply was noted in one cadaver. Bilateral double renal arteries existing with unusual incomplete double ureters on right side and incomplete triple ureters on left side were found in one cadaver. Left triple renal arteries, right double renal arteries existing with bilateral polycystic kidneys with distended ureters were found in one cadaver. Double extra-hilar arteries to the superior pole of right kidney, existing with unusual blood supply to the right suprarenal gland and right testis was found in one cadaver. Bilateral Early division of renal artery existing with bilateral polycystic kidneys fond in one cadaver. Anatomical and developmental variations of renal vasculature, ureters, kidneys and their relationship to surrounding structures are clinically significant as they interferes several operative procedures like kidney transplantation, surgical reconstruction of the abdominal aorta, interventional radiologic procedures and urologic operations; hence detection of the possible developmental variations of the renal vasculature, ureters, kidneys and their relationship to surrounding structures is clinically necessary for adequate surgical management to preserve renal functions.

Keywords

Accessory renal arteries, aberrant adrenal gland, extra-hilar arteries, nutcracker syndrome, polycystic kidneys, triple ureters.

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Introduction

The urinary system includes pair of kidneys and their ureters, urinary bladder and urethra. The kidneys are essential excretory organs, situated retro-peritoneally in the posterior abdominal wall, which elaborate urine and eliminate nitrogenous waste products of protein metabolism from the blood and maintain electrolyte and water balance. The ureters are the muscular tubes which convey the urine from the corresponding kidney to the urinary bladder for temporary storage. Each kidney is supplied by one renal artery which is a lateral branch of abdominal aorta immediately below the level of superior mesenteric artery at the upper lumbar level (L1-L3). Suprarenal or Adrenal glands are a pair of retro-peritoneal endocrine glands situated near superior pole of corresponding kidney. Each gland consists of outer cortex which synthesizes three types of steroid hormones from plasma cholesterol: glucocorticoids, mineral corticoids, and sex steroids; and inner medulla under direct control of the central nervous system and synthesizes catecholamines along the sympathetic nervous system. Variations in the renal vessels have been observed frequently in routine dissection and surgical practice, but such occurrence existing with congenital anomalies of kidneys or ureters or suprarenal glands is rare. Accordingly this study was designed to evaluate the anatomical and developmental variations of renal vasculature existing with congenital anomalies of kidneys or ureters or suprarenal glands.

Materials and Methods

This study was carried out on routine human cadaveric dissection of abdomen (including dissected cadaveric specimens) conducted for medical undergraduates at Varun Arjun medical college- Banthra,-UP, KMCT Medical College, Manassery- Calicut and Melaka Manipal Medical College-Manipal. The kidneys, ureters and suprarenal glands along with their arteries were exposed and the anatomical and developmental variations of renal vasculature existing with congenital anomalies of kidneys or ureters or suprarenal glands were observed. Photographs of the anatomical and developmental variations were taken for proper documentation.

Results

Out of 48 human cadavers (including dissected cadaveric specimens) irrespective of age and sex, dissected during the medical undergraduates teaching purpose the following developmental variations of renal vasculature existing with congenital anomalies of kidneys or ureters or suprarenal glands were noted -

Case - I: Left retro aortic real vein, extra -hilar branch of left renal artery to the superior pole of left kidney, existing with very rare and unusual double suprarenal gland with unusual blood supply was noted in one cadaver (Fig. 1, Fig. 2 and Fig. 3).

- Left real vein (7.2 cm) found larger than right renal vein (1.1 cm). Left real vein after emerging from hilum of left kidney it descends obliquely and joined the inferior vena cava by passing behind the abdominal aorta.

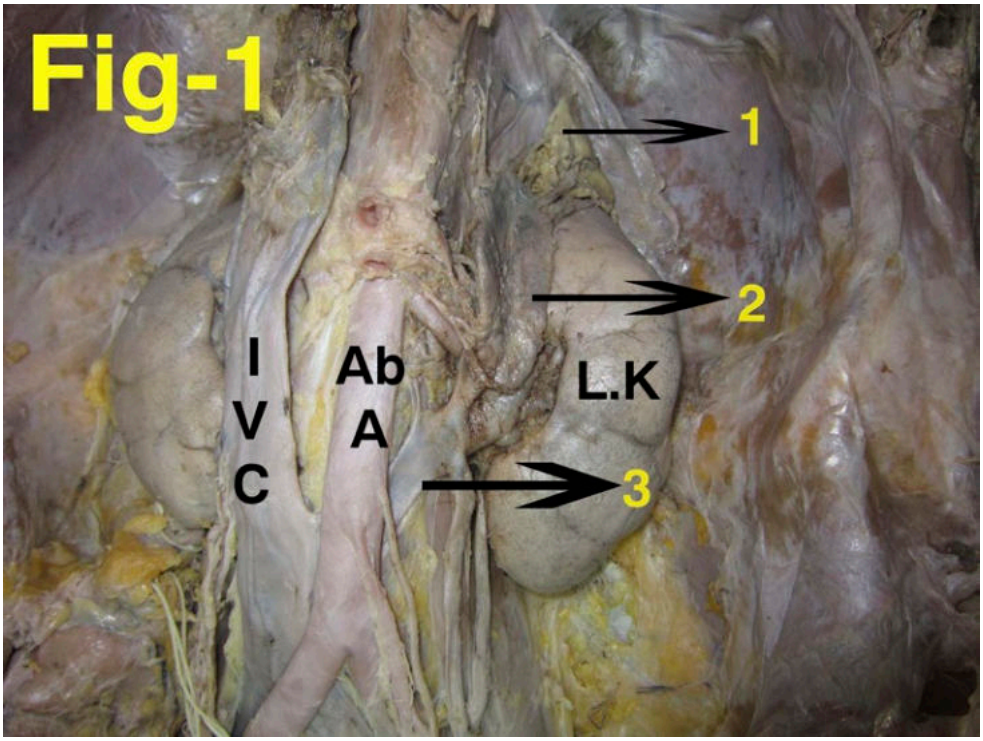


Figure 1. Showing left retro aortic real vein existing with double suprarenal glands. 1 and 2- left double suprarenal glands; 3- Left retro aortic real vein; IVC- Inferior Vena Cava; AbA- Abdominal Aorta; L.K- Left Kidney.

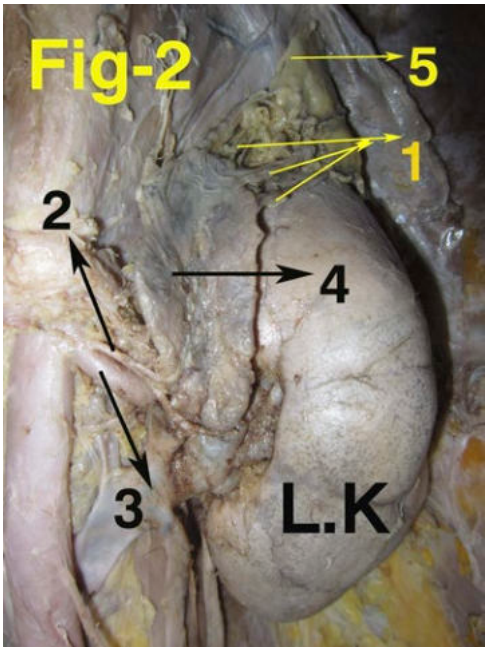
- Out of two suprarenal glands one was located across the hilum and on the anterior surface of left kidney, another suprarenal gland was found on the upper pole of the same kidney. Left suprarenal gland located across the hilum received blood supply from the left renal artery by two branches. Surprisingly another left suprarenal gland located on the upper pole of kidney received blood supply from the suprarenal gland located across the hilum by three branches.

Case - II: Bilateral double renal arteries existing with unusual incomplete double ureters on right side and incomplete triple ureters on left side were noted in one cadaver (Fig. 4).

Case - III: left triple renal arteries, right double renal arteries existing with bilateral polycystic kidneys with distended ureters were noted in one cadaver (Fig. 5).

Case - IV: Double extra-hilar arteries to the superior pole of right kidney, existing with very rare and unusual blood supply to the right suprarenal gland and testis was noted in one cadaver (Fig. 6 and Fig. 7).

- A common trunk originated from the right renal artery gave off double extra-hilar arteries to the superior pole of right kidney and a lower suprarenal branch to the right suprarenal gland. Surprisingly the middle suprarenal branch originated from



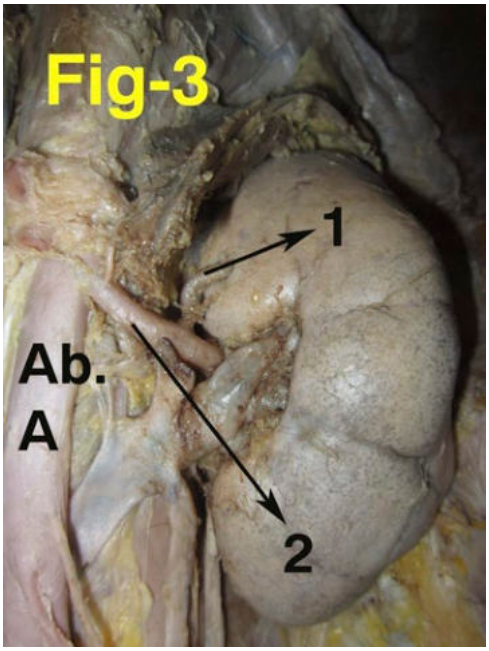


Figure 2. Showing unusual blood supply of left double suprarenal glands. 1- Three suprarenal branches originating from the suprarenal gland located across the hilum of left kidney; 2- Suprarenal branches originating from the left renal artery; 3- Left renal artery; 4- Suprarenal glands located across the hilum and on the anterior surface of left kidney; 5- Suprarenal glands located upper pole of the left kidney; L.K- Left Kidney.

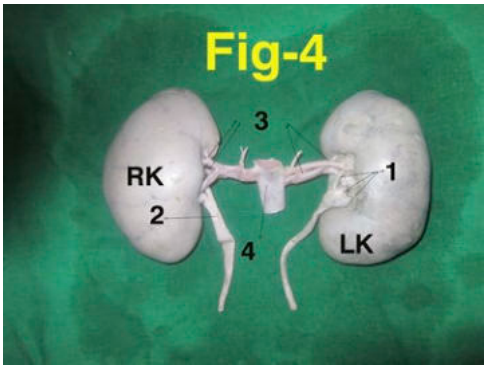
Figure 3. Showing extra -hilar branch of left renal artery. 1- extra -hilar branch of left renal artery to the superior pole of left kidney; AbA- Abdominal Aorta. ; 2- Left renal artery.

the abdominal aorta after supplying suprarenal gland, within the gland it gave off a testicular artery which descends in front of the hilum of the right kidney.

Case-V: Bilateral Early division of renal artery existing with bilateral polycystic kidneys fond in one cadaver (Fig. 8 and Fig. 9).

Discussion

During the embryological period the metanephric kidneys lies in the pelvic cavity and obtain their blood supply from the median sacral artery. As the kidneys ascend, and reaches the iliac fossa blood supply is obtained from the common and internal iliac arteries. As the kidneys ascend further and reach undersurface of the diaphragm blood supply is obtained from the lowest supra-renal artery and this branch persists after birth as the permanent renal artery. Accessory renal arteries are common, and usually arise from abdominal aorta above or below the main renal artery they are regarded as persistent embryonic lateral splanchnic arteries. Rarely, accessory renal arteries arise from the celiac trunk, superior mesenteric arteries, inferior mesenteric



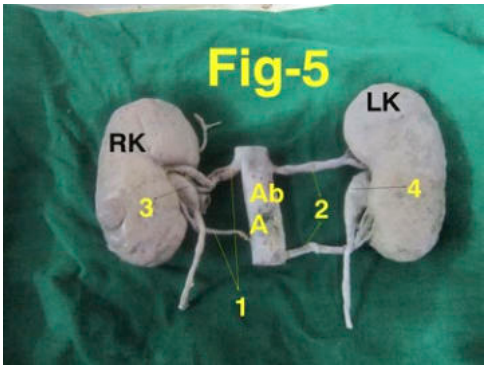
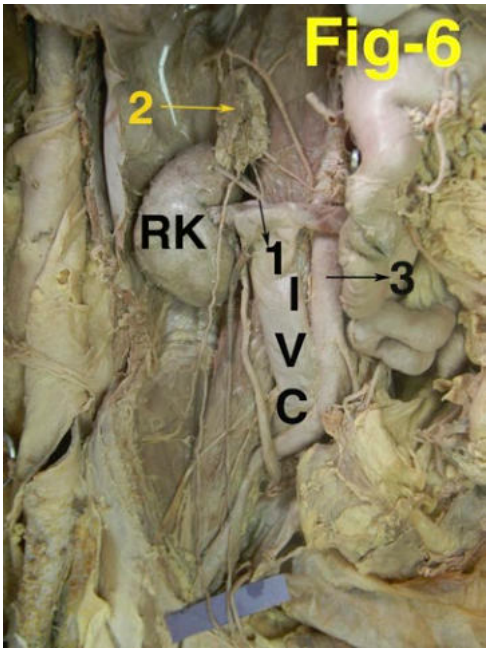


Figure 4. Showing Bilateral double renal arteries existing with double and triple incomplete ureters. 1- Left incomplete triple ureters; 2- Right incomplete double ureters; 3- Bilateral double renal arteries; 4- Abdominal Aorta; LK- Left Kidney; RK- Right Kidney.

Figure 5. Showing Bilateral accessory renal arteries existing with bilateral polycystic kidneys with distended ureters were. 1- Right triple renal arteries; 2- Left double renal arteries; 3 and 4- distended ureters; LK- polycystic Left Kidney; RK- polycystic Right Kidney.



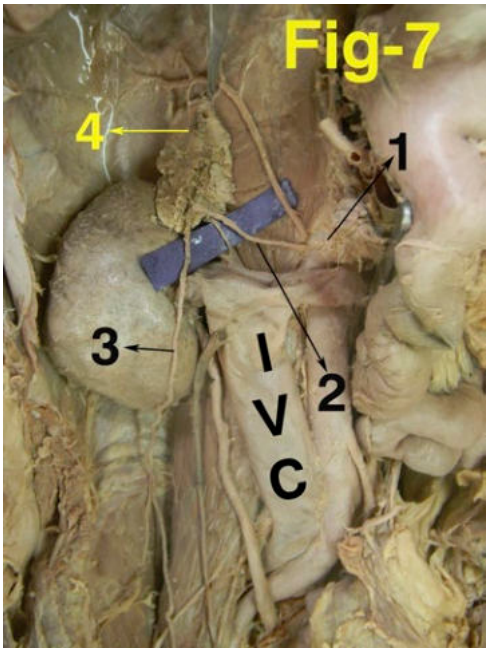
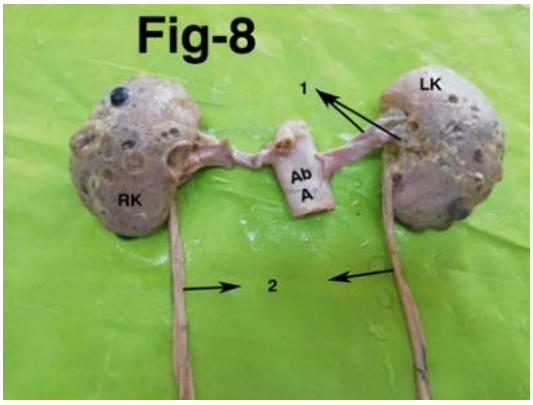


Figure 6. Showing double extra-hilar arteries to the superior pole of right kidney. 1- Common trunk originated from the right renal artery gave off double extra-hilar arteries to the superior pole of right kidney and a lower suprarenal branch to the right suprarenal gland; 2- Right suprarenal gland; 3- Abdominal Aorta; IVC- Inferior Vena Cava.

Figure 7. Showing unusual blood supply to the right suprarenal gland and testis. 1- Abdominal Aorta; 2- middle suprarenal branch; 3- testicular artery; 4- Right suprarenal gland; IVC- Inferior Vena Cava.



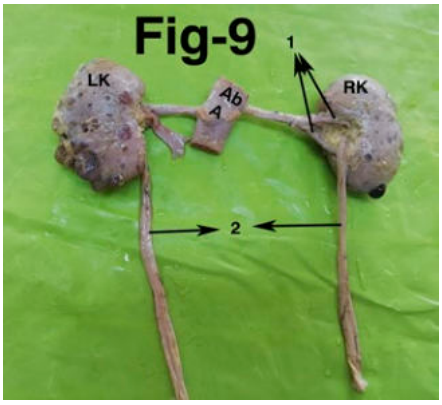


Figure 8. Front view showing Bilateral Early division of renal arteries existing with bilateral polycystic kidneys. LK- polycystic Left Kidney; RK- polycystic Right Kidney; AbA- Abdominal Aorta; 1- Early division of left renal artery;2- Ureters.

Figure 9. Posterior view showing Bilateral Early division of renal arteries existing with bilateral polycystic kidneys. LK- polycystic Left Kidney; RK- polycystic Right Kidney; AbA- Abdominal Aorta; 1- Early division of right renal artery;2- Ureters.

arteries, and the area near the aortic bifurcation, common iliac arteries or the median sacral artery (Kawamoto S et al., 2004; Urban BA et al., 2001; Pozniak MA., 1998). Incidence of accessory renal arteries had been variously re-ported as 50% (Helstrom 1927) 25% (Edsman 1954) and 30% (Henry Gray 2005). Pollak R et al reported 23% double renal arteries, 4% triple arteries, and 1% quadruple arteries in a cadaver study (Pollak R et al., 1986). In angiographic study Ozkan et al. reported multiple arteries in 24%, bilateral multiple arteries in 5%, and early division in 8% of cases, bilateral aberrant renal arteries were found in 13-16 % of cases (Ozkan et al., 2006). Adult polycystic kidney is an autosomal dominant disease with high penetrance and occurs in 1 out of 400 to 1000 persons and accounts for 5 to 10% of chronic renal failure (Sujatha K et al., 2017). In our study in one specimen bilateral early division of renal artery was present with bilateral polycystic kidneys. Saldarriaga B. et al reported one additional artery 22.3 and two additional arteries 2.6% (Saldarriaga B. et al., 2008). Hemanth Kommuru reported one additional artery 18.5%, two additional arteries 9.7% (Hemanth Kommuru et al., 2012). Renal artery variation including their number, source of origin and course are very common, but left triple renal arteries, right double renal arteries existing with bilateral polycystic kidneys with distended ureters in one cadaver noted in our study are very rare.

Kosuri Kalyan Chakravarthi et al. reported a case of left triple renal arteries in which two originated from the abdominal aorta and one originated from the common trunk gave off accessory renal artery to the left kidney, inferior mesenteric, and left testicular arteries (Kosuri Kalyan Chakravarthi et al., 2013). Where as in our study an unusual common trunk originated from the right renal artery gave off double extrahilar arteries to the superior pole of right kidney and a lower suprarenal branch to the right suprarenal gland, such anatomical variations awareness may provide safety

guidelines for endovascular procedures like therapeutic embolization and angioplasties and helps in the management of renal vascular hypertension. Interestingly in the same case the middle suprarenal branch originated from the abdominal aorta after supplying right suprarenal gland, within the gland it gave off a right testicular artery which descends in front of the hilum of the right kidney. Surgeons should have a thorough knowledge regarding such rare anatomical variations of origin and unusual course of the testicular arteries as any injury to this artery during surgery might cause testicular atrophy.

In 5th week of intrauterine life from dorsomedial side of caudal part of the mesonephric duct gives rise to a diverticulum know as the ureteric bud. The ureteric bud grows head wards and forms a dilation, later it was covered by a cap like investment known as metanephric blastema, where it divides many times and gives rise to the major and minor calyces and the collecting tubules of the kidney. The stalk of the ureteric bud forms the ureter and its dilated end persists as the pelvis of the kidney. Duplicated ureter occurs approximately 1% of the population, Siomou E et al, and Inamoto K et al reported the duplex collecting system (Siomou E et al., 2006; Inamoto K et al., 1983). Kosuri Kalyan Chakravarthi et al. reported a case of unilateral double ureters descended from the separate renal pelvis (double pelvis) originated from the upper and lower renal poles of the right kidney joined at the middle in a Y-shaped manner (Kosuri Kalyan Chakravarthi et al.,2013). Unusual Y- shaped incomplete double (bifid) ureters on right side and incomplete triple ureters on left side found in this study probably due to double/triple ureteric buds arising from the caudal part of the mesonephric duct. Alexander et al has reported a case of duplex ureter which got damaged during laparoscopic hysterectomy and was diagnosed postoperatively (Alexander et al., 2010). Bilateral double renal arteries existing with unusual developmental abnormalities of ureters noted in this study should keep in mind by the urologists, technicians and clinicians for therapeutic and surgical interventions to avoid complications.

Suprarenal gland develops from two sources-the cortex of the gland developed from the mesoderm and the medulla from the neuro-ectoderm of the neural crest. The cortex is formed of two parts: a thick fetal cortex surrounded by a second thin layer of cells that will later form the definitive cortex. Within two or three weeks after birth, fetal cortex totally disappears and the definitive cortex differentiates into three zones of cells. In adrenogenital syndrome or any form of adrenocorticotropic hormone stimulation accessory suprarenal tissues are found around the main gland or in relation to the structures formed from the urogenital ridge. Unilateral double suprarenal glands noted in this study were close to the left kidney. Ectopic adrenal tissue has been reported in the testis, spermatic cord, broad ligament, kidney, retrocaval space, celiac region, lungs, central nervous system, colon, pancreas and gallbladder such abnormalities may undergo malignant transformation or become hormonally functional (Ayala AR et al., 200; Leibowitz J et al., 1998). Kirici et al reported a case of ectopically located adrenal gland in the right retrocrural space with compressive symptoms (Kirici et al., 2001). Alexander L Shifrin et al reported adrenal tumor from the aberrant adrenal gland located under hepatic segment (Alexander L Shifrin et al., 2011). Suprarenal gland is supplied by superior, middle and inferior suprarenal arteries. Superior suprarenal artery usually arise from the posterior division of inferior phrenic artery, Merklin and Michel, Gagnon, studies have

shown that superior suprarenal is arising directly from aorta, celiac trunk, and superior polar artery (Merklin R.J et al, 1958). Middle Suprarenal Artery arise from the abdominal aorta, Gagnon have shown the origin from the renal artery and Hollinshed and Cunningham have observed that the middle suprarenal is absent in some cases (Gagnon R, 1964; Gagnon R, 1957; Hollinshed W.H , 1952; Romanes G. J, 1978). Inferior suprarenal artery arise from the renal artery, Gerard et al reported in 23% of cases the inferior suprarenal artery is double, one arising from aorta and other from the renal artery (Gerard G, 1913). Where as in our study superior, middle suprarenal arteries were absent on the left side and inferior suprarenal artery originated from the left renal artery by two branches supplied the accessory suprarenal gland located across the hilum of left kidney. Surprisingly another left suprarenal gland located on the upper pole of kidney received blood supply from the accessory suprarenal gland located across the hilum by three branches. To the best of our knowledge, double suprarenal glands with unusual blood supply observed in this study have not been cited in modern literature.

The inferior vena cava is developed from a vast network of three pairs of veins including the posterior cardinal, subcardinal, and the supracardinal veins. During the development of the IVC, The subcardinal and supracardinal veins form an anastomotic communication network of veins that course along the ventral (pre-aortic) and dorsal (post-aortic) aspect of the abdominal aorta. The portion of pre-aortic anastomotic communication persists as the normal left renal vein. If the post-aortic anastomotic communication persists then the left renal vein is posterior to the aorta, forming a retro aortic left renal vein. Reed et al reported incidence of retro aortic left renal vein anomaly was1.8%, Trigaux et al reported 3.7%, and Satyapal et al reported 0.5% (Reed MD et al., 1982; Trigaux JP et al., 1998; Satyapal KS et al., 1998). In our study the retro aortic left renal vein (with a length of 7.2 cm) after emerging from hilum of left kidney it descends obliquely and joined the inferior vena cava close to the bifurcation of abdominal aorta. Retro aortic left renal vein anomaly is a relatively uncommon condition it may be compressed between aorta and vertebrae and leads to retrograde venous return which results in increases the pressure of gonadal veins leading to varicosity of veins, haematuria, pain, thrombosis and nutcracker syndrome (left renal vein hypertension). Combination of unilateral left retro aortic real vein, extra -hilar artery (branch of renal artery that presents an extra hilar penetration) to the superior pole of left kidney, existing with very rare and unusual double suprarenal gland with unusual blood supply noted in case-I made this study more unique.

Conclusion

To the best of our knowledge, anomalous renal vasculature existing with congenital anomalies of kidneys, ureters, suprarenal glands, and testicular artery observed in this study have not been cited in modern literature. Such anatomical and developmental variations knowledge is immensely important because of its implications in segmental resections, renal transplantation, and surgical reconstruction of the abdominal aorta, interventional radiologic procedures, urologic operations and gonadal surgeries.

Funding

None.

Conflict of interest

None declared.

Ethical approval

Not required.

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