ORIGINAL ARTICLE

Study on variations of apical segmental branches of renal artery in human cadaver kidneys by dissection method

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Abstract

Background: The arterial supply of the kidney shows frequent variations. The kidney gets its arterial supply by renal artery which is a direct branch from abdominal aorta. At the hilum the renal artery divides into segmental branches. *Aim and Objectives:* The present study was conducted to understand the variations in the apical segmental branches of renal artery by dissection method. *Material and Methods:* Sixty kidneys (30 right and 30 left side) with intact abdominal aorta were collected from the department of Anatomy, Mysore Medical College and Research Institute, Mysore. Careful dissection was done, the apical segmental branch of the renal artery was observed and noted. *Results:* In the present study the type 1 apical segmental artery was noted in 53.3% of specimens, type 2 in 26.6% of specimens, type 3 in 3.3% of specimens, type 4 in 10% of specimens, type 5 in 3.3% of specimens and type 6 in 6.6% of specimens. *Conclusion:* The variations of arterial supply of the kidney are very frequent. The knowledge is important in various surgeries especially in nephrectomy and renal transplantation, the various radiological procedures involving the kidney and also in routine dissections. The present study shows the anatomical variations of the apical segmental branch of the renal artery by dissection method.

Keywords: Apical segmental, Nephrectomy, Renal Artery

Introduction

The kidneys are normally supplied by a single renal artery, originating from the lateral aspect of the abdominal aorta, typically at the level of the L1/L2 intervertebral disc, immediately inferior to the origin of the superior mesenteric artery. The right renal artery is usually longer in its course due to the location of the abdominal aorta more towards the left side of the body or median plane, runs in an inferior course behind the inferior vena cava to reach the right kidney, while the left renal artery originates slightly higher and from a more lateral aspect of the aorta, and runs almost horizontally to the left kidney [1]. Each renal artery further divides into anterior and posterior divisions at or very close to the hilum of the kidney, which receive approximately 75% and 25% of the blood, respectively. Later each division forms into segmental arteries to supply different renal segments i.e. the anterior division further divides into the upper, middle, lower, and apical segmental arteries while the posterior division forms the posterior segmental artery. Segmental arteries subsequently divide into lobar, interlobar, arcuate, and interlobular arteries before forming the afferent arterioles which feed into the glomerular capillaries [2].

It was Bartholin (1665 – 1738), who first reported the anatomical variations of the renal arteries with respect to its number and origin [3]. In at least 30%

of the population, accessory renal arteries are found. In rare cases, there are aberrant renal arteries which do not enter the renal hilum but enters the renal capsule. In about 10% of the population, there can also be early branching of the renal arteries. This early-branching typically occurs 15 mm to 20 mm from the renal hilum; this is vital to know when performing a kidney transplant [4-5]. The comprehensive knowledge and awareness about variations in renal vasculature are important to the urologists, nephrologists, and radiologists because of its rising interventional radiological procedures, vascular operations like repair of abdominal aorta aneurysm, renal artery stenosis, for surgical management of donor nephrectomy and other retroperitoneal urological procedures [6-7]. Variations of the renal vasculature has gained importance with the advent of renal transplantation as it is important in selecting and procuring the appropriate kidney (left or right). The ideal renal artery for ease of vascular anastomosis is one which is solitary, of good diameter and length. Various cadaveric and radiological studies have shown that the classical description of the renal vasculature, formed by one renal artery and vein are found in less than 25% of the population [7]. The aim of this study was to report the various types of apical segmental branches of renal artery, so as to help surgeon for the better planning and programming of diagnostic and therapeutic procedures.

Material and Methods:

Sixty kidneys (30 right and 30 left side) with intact abdominal aorta were collected from the Department of Anatomy, Mysore Medical College and Research Institute, Mysore. Ethical approval was taken. The convenient samples were taken during the study period (Jan 2019 to Dec 2020). Normal adult kidney with intact vessels were included. Any injured, distorted, decomposed and anomaly kidneys were excluded. Once the abdomen was opened and all the viscera were removed, firstly the kidneys with their intact blood supply were traced in situ. Then kidney with the intact abdominal aorta was removed. Fine dissection was done, the apical segmental branch of the renal artery was observed, noted, photos were taken and tabulated.

Results

Figure 1 shows the various types of origin of the apical artery. In the present study,

Type 1- apical segmental artery i.e apical segmental artery arising from the anterior division of renal artery was noted in 53.3% of specimens (Figure 2).

Type 2- anterior division giving a common trunk which giving rise to apical and upper segmental artery was seen in 26.6% of specimens (Figure 3).

Type 3- apical segmental artery arising from the junction between anterior and posterior division was seen in 3.3% of specimens (Figure 4).

Type 4- apical segmental artery arising from the renal artery was seen in 10% of specimens.

Type 5- apical segmental artery arising from the abdominal aorta was seen in 3.3% of specimens (Figure 6).

Type 6- apical segmental artery arising from the posterior division of renal artery was seen in 6.6% of specimens (Figure 7).

Table 1 shows the comparison between right and left kidneys. Statistically, there is not much significance between them.

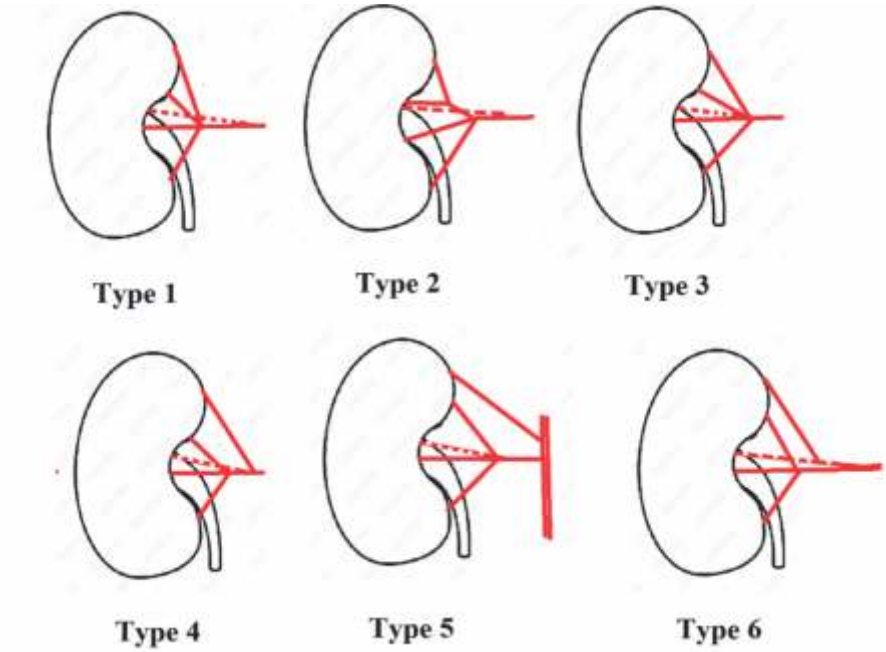

Figure 1: Various types of apical segmental branch of renal artery

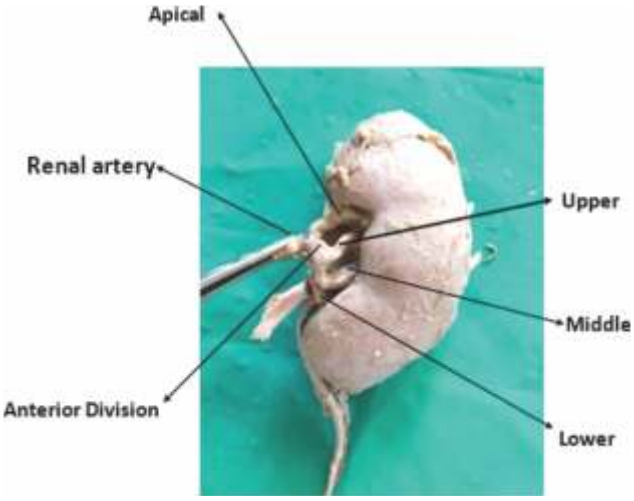

Figure 2: Type 1 apical segmental artery i.e. apical segmental artery arising from the anterior division of renal artery was noted in 53.3% of specimens

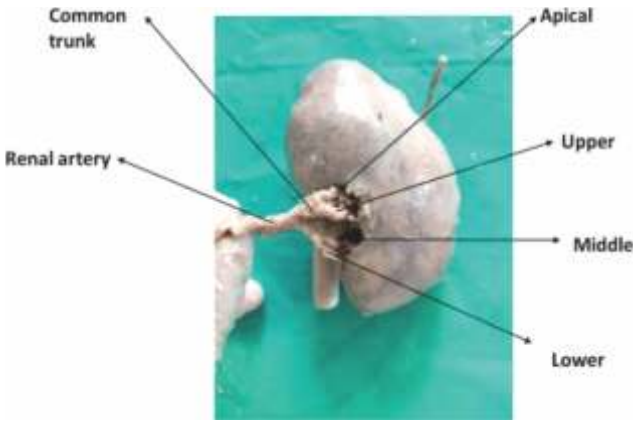

Figure 3: Type 2 anterior division giving a common trunk which giving rise to apical and upper segmental artery was seen in 26.6 % of specimens

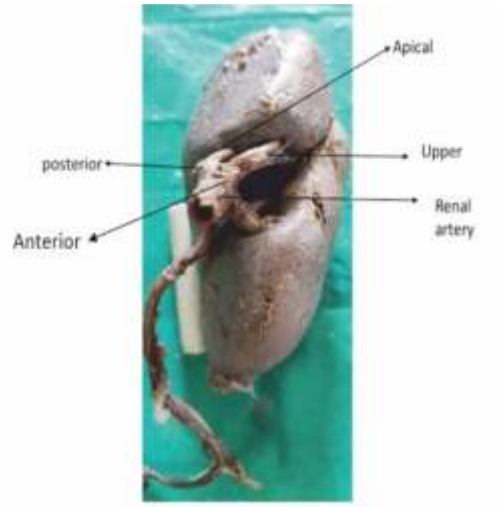

Figure 4: Type 3 apical segmental artery arising from the junction between anterior and posterior division was seen in 3.3% of specimens

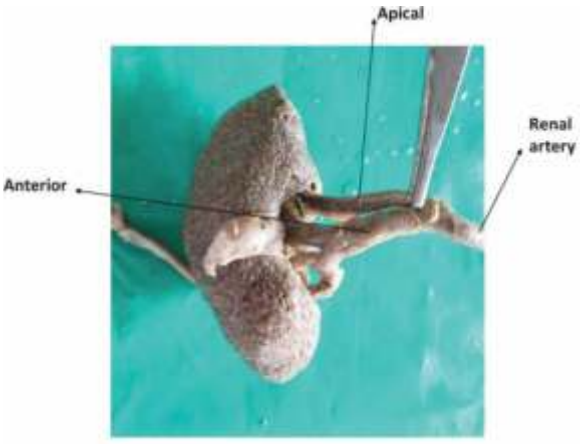

Figure 5: Type 4 apical segmental artery arising from the renal artery was seen in 10% of specimens

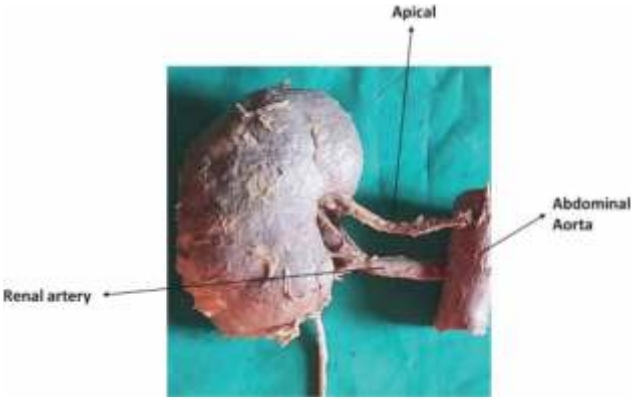

Figure 6: Type 5 apical segmental artery arising from the abdominal aorta was seen in 3.3% of specimens

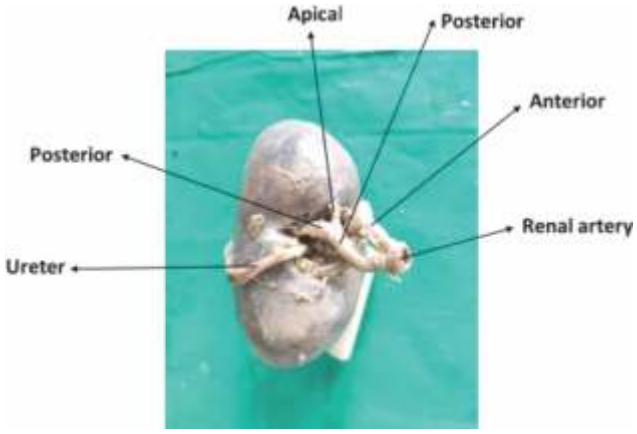

Figure 7: Type 6 apical segmental artery arising from the posterior division of renal artery was seen in 6.6% of specimens

Table 1: Comparison between right and left kidneys

Types	Right	Left
Type 1	46.6%	60%
Type 2	23.3%	23.3%
Type 3	3.3%	3.3%
Type 4	13.3%	2.66%
Type 5	6.6%	--
Type 6	6.6%	6.6%

Discussion

Variations in the number of renal arteries are common, with the reported frequency ranging between 9% and 76% [8-9]. The frequencies of renal artery variations show social, ethnic and racial differences for example variations in renal artery and its branching pattern are more common in Africans and less common in Indians. Renal artery variations are divided into two groups as early branching into segmental arteries before reaching hilum and accessory renal artery [10]. Renal vascular segmentation was originally recognized by John Hunter in 1794, but the detailed primary pattern was produced from casts and radiographs of injected kidneys [11]. There are five arterial segments. The apical segment occupies the anteromedial region of the superior pole. The superior (anterior) segment includes the rest of the superior pole and the central anterosuperior region. The inferior segment encompasses the whole lower pole. The middle (anterior) segment lies between the anterior and inferior segments. The posterior segment includes the whole posterior region between the apical and inferior segments.

Accessory renal arteries are not rare, may be seen in 30% of individuals, and usually arise from the aorta above or below the main renal artery and follow it to the renal hilum. They are regarded as persistent embryonic lateral splanchnic arteries [1]. The diversity of vascular pattern can be explained on the basis of its development. The kidney that initially develops in the sacral region gradually ascends up. As it starts ascending, newer renal arteries start developing from the aorta. With the appearance of newer arteries, the caudal branches normally involute and disappear. A less complete reduction results in extra-renal branching or in multiple arteries arising independently from the aorta. Due to this unique character of the kidney, this unusual pattern of vascular distribution is observed [12].

Many studies have been conducted to report different types of variations of renal arteries using cadaveric dissection method, CT angiography and also through plastination methods, since it allows to obtain precise information on vascular anatomic distribution of renal arteries and aorta [7]. The awareness of the morphological variations in renal vascular is crucial before any surgical procedures like laparoscopic donor nephrectomy or partial nephrectomy, vascular treatment for renal artery stenosis, open surgical or endovascular treatment for abdominal aortic aneurysm and also for diagnostic purposes. Table 1 shows the comparison of our study with various authors. The present study shows all the types of origin of the apical artery. Most common type was type 1 and type II. As there is no anastomosis between the segmental arteries, it provides a relative bloodless plane to the surgeon for the resection of affected segment. The accessibility of the origin of the artery should be carefully noted. Usually, the arteries are easily seen in the hilum and they are often at the points which are nearer the aorta. Since the segmental

Table 2: Showing the comparison of origin of the apical artery with the other studies

Authors	Type I Arising from the anterior division	Type II Arising from the upper segmental branch	Type III Arising from the junction of the anterior and posterior divisions of the renal artery	Type IV Arising from the renal artery	Type V Arising from the aorta	Type VI Arising from the posterior division of the renal artery
Raghavendra *et al.* (2007) [13]	51.7%	25%	1.7%	11.7%	1.7%	8.3%
Patil *et al.* (2014) [16]	40%	36%	-	12%	4%	8%
Sudke *et al.* (2015) [17]	40%	23.33%	10%	6.66%	6.66%	13.33%
Kaushik *et al.* (2015) [18]	30%	15%	-	12%	-	43%
Lucas *et al.* (2017) [19]	50%	35%	5%	10%	-	-
Present study	53.3%	26.6%	3.3%	10%	3.3%	6.6%

resection is best carried out from the hilum towards the periphery, awareness of the origin has important practical value [13].

In case of type II Apical artery, sometimes the surgeons may have to sacrifice even the healthy upper segmental branch and the soft tissue. In type III apical artery, the surgeon has to be more careful as it causes more difficulty in the resection and ligature of this segmental branch from the other surrounding branches. In the type V apical artery, the inferior suprarenal artery may arise from the superior accessory renal artery. In type VI apical artery, where the artery arises from the posterior division, the ligation will be easier [13].

The segmental arteries do not have a collateral system, and ligation or occlusion of these arteries results in ischemia and infarction in the downstream segment of the kidney. The relatively a vascular plane of Brodel is useful surgically to access the pelvicalyceal system and hence holds great clinical importance [14-15]. According to Joshi *et al*. the presence of long tortuous, narrow multiple accessory/aberrant arteries in the absence of significant stenosis may contribute to hypertension and hence should be considered in the differential diagnosis of a cause of reno-vascular hypertension in children [20].

Conclusion

The advancements made in the diagnosis or therapeutic interventions, need for more conservative methods in renal vascular surgeries and the increasing number of interventions at the renal region have necessitated a more precise knowledge of variations in the renal vasculature. Much importance is to be given to segmental arteries which arise in common and divide within the renal parenchyma, as healthy renal tissue is often involved during partial nephrectomy of the affected part during ligating the specified segmental artery.

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