Original Article

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Evaluation of Renal Vascular Anatomy in Prospective Renal Donors Using 128 Slice CT Angiography

Radiology Section

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ABSTRACT

Introduction: 3D spiral CT angiography has become indispensable in numerous clinical settings and one of its important application is the evaluation of renal transplant donors. With the increasing use of laparoscopic nephrectomy, the transplant surgeon has numerous advantages, but at the same time faces additional changes especially if the vascular anatomy is complex. So a pre-operative knowledge of the arterial and venous anatomy is a must to avoid damage to anomalous vessels.

Aim: To map the renal vascular anatomy in prospective renal donors and study the anatomical variants and their prevalence.

Materials and Methods: This was a prospective study conducted from June2016 to June 2017. CT angiography of the renal vessels was done in all prospective renal donors using a 128 slice Philips Ingenuity Core CT scanner. Volume rendered and Maximum Intensity Projections (MIP) were acquired and the renal vessel anatomy was mapped and studied for variations.

Results: Total 150 patients were studied, 66(44%) of them had variations, 41 of them in renal arteries, 20 in renal veins and tributaries, five in both. Accessory renal artery was the most common (25 out of 41). 22 of them had a hilar variant, whereas the rest three had the polar variant. 12 cases of early branching were found, nine of them on the left side. Late venous confluence into the IVC was the commonest venous variant, more on the left side (14 out of 20). Rare variants included two cases of retro aortic left renal vein and one case of circumaortic left renal vein, eight cases of prominent lumbar/gonadal veins, one case of ectopic kidney with the artery arising from the left common iliac artery.

Conclusion: CT angiography proves to be an indispensable tool for assessing the renal vessels thereby avoiding the need for catheter angiography. In our study, 45% of donors had variations. Hence, sound knowledge of the variants and their prevalence is imperative with laparoscopic nephrectomy being the current modality of choice.

Keywords: Circumaortic, Prehilar, Retro-aortic, Transplant

INTRODUCTION

3D spiral CT angiography has become indispensable in numerous clinical settings and one of its important application is the evaluation of renal transplant donors. With the increasing use of laparoscopic nephrectomy, the transplant surgeon has numerous advantages, but at the same time faces additional changes especially if the vascular anatomy is complex. So a pre operative knowledge of the arterial and venous anatomy is a must to avoid damage to anomalous vessels.

Conventional angiography is still regarded as the gold standard in renal vascular imaging, but MDCT angiography is increasingly used since CT has the advantages of being less invasive, easily applicable and available [1]. The accuracy of CT in detecting these variations is more than 90% as demonstrated in recent studies [2].

Anatomical variations of renal arteries are quite common. In the current world, CT angiography is superior to magnetic resonance angiography especially in the evaluation of the abdominal vessels, particularly in identifying those with a diameter of less than 2 mm [3].

So, the need for a thorough CT knowledge of the prevalence and types of variations in renal vascular anatomy in various different populations is on an all time high.

MATERIALS AND METHODS

This prospective study was conducted between the time period of June 2016 to June 2017. All the renal donors who were referred to the Department of Radio diagnosis, at Victoria Hospital, Bangalore Medical College and Research Institute Bengaluru, India, were considered for the the study. Total 150 sample size was calculated based on the prevalence rates in our hospital and in prior studies. Ethical Committee Approval was obtained prior to the study.

All cases of prospective renal donors who were referred to the department of Radiodiagnosis for CT-angiography of renal vessels, indication being to look for its variations were included in the study. While the patients with deranged renal functions (Serum creatinine 2.0 mg/dL) and those with hypersensitivity to contrast media were excluded from the study.

Technique: CT angiography of the renal vessels was done for all using a 128 slice Philips Ingenuity Core CT scanner. Prior Informed consent was taken from all the patients. A preliminary non contrast axial abdominal CT-scan was done with 10 mm collimation to assess for any abnormal renal or vascular calcification. Contrast phase was done with a collimation of 3 mm, table speed of 4 mm/sec and a pitch of 1.33. A total of 120 mL of non ionic contrast containing 350 mg of Iodine per mL was injected at a rate of 4 mL per second using a power injector. The marker for the region of interest was placed on the abdominal aorta at origin of the renal arteries and a threshold value of 180 HU was fixed. Venous phase images were acquired at 70 seconds. The axial images obtained were reconstructed at 2 mm intervals. Volume rendered and MIP were acquired at the workstation and the renal vessel anatomy was mapped and studied for variations.

The parameters which were assessed include the site and vessel of origin of renal arteries, number of renal arteries and renal veins on either side, length of the renal artery from the branching, length of the renal vein to its confluence, drainage of the renal veins and any other variations in the course of those vessels.

STATISTICAL ANALYSIS

The results obtained were entered in excel sheets and the descriptive statistics were presented in the form of frequency distribution tables, charts and graphs.

RESULTS

In this study, 150 patients were considered, out of them 63 were males and 87 were females [Table/Fig-1,2]. In our study, 66 (44%) of cases had variations in the anatomy of renal vasculature of which arterial variations were the commonest [Table/Fig-3]. Of the total number of cases with anatomical variations, 26 (39%) of them were not considered for surgery, of which a late venous confluence of left renal vein was the commonest cause.

Arterial Variations

Accessory renal arteries were the most common arterial variation in our study (60%). One of the cases had a malrotated ectopic solitary kidney, renal artery of which was arising from the internal iliac artery.

Sex	n (%)
Males	63 (42%)
Females	87 (58%)

[Table/Fig-1]: Sex distribution (total-150) n (%).

Age Group	n (%)
34-40 years	29 (19%)
40-45 years	60 (40%)
45-50 years	42 (28%)
50-56 years	19 (13%)

[Table/Fig-2]: Age distribution.

Cases		n (%)
Normal		84 (56%)
Variations 66 (44%)	Arterial	41 (28%)
	Venous	20 (13%)
	Both	5 (3%)
Patients who were not considered for surgery because of anatomical variations		26 (39% of the total variations)

[Table/Fig-3]: Distribution of cases.

There was no side predilection for the accessory arteries, while prehilar branching was more common on the left side, which is of significance since the left kidney is the one commonly harvested for transplant [Table/Fig-4-6]. Twelve cases of early/prehilar branching was noted, of which 3 were on the right side and 9 on the left side.

Venous Variations

Late venous confluence was the most common venous variation in our study (70%). Two rare cases of retro-aortic renal vein and one case of circumaortic renal vein, all on the left side were found.

Two cases of double renal veins draining separately into the IVC were noted, one on left side and one on the right side.

Late venous confluence as would be expected was more common on the left side due to the long course of the left renal vein [Table/Fig-7]. Of the 14 cases of late venous confluence, 2 were noted on the right side and 12 on the left side.

Variations	n
Prehilar branching on left side	12
Two accessory arteries	9
Polar accessory artery	1
Cirumaortic renal vein	1
Renal artery arising from internal iliac artery	1

[Table/Fig-4]: Patients not considered for surgery on the basis of variations (total-26 cases)

Variations	n
Accessory artery	25
Pre-hilar branching	12
Both	3
Arising from internal iliac artery	1

[Table/Fig-5]: Arterial variations (total – 41 cases).

Variations		n
Side	Right	11
	Left	12
	Both	2
Termination	Hilar	22 (88%)
	Polar	3 (12%)
Number	One	23 (92%)
	Two	2 (8%) (one on right side and one on left side)

[Table/Fig-6]: Arterial variation: accessory arteries (total-25 cases)

Variations	n
Late venous confluence	14
Supernumerary veins	2
Retroaortic vein	2
Circumaortic vein	1
Prominent lumbar/gonadal veins	8

[Table/Fig-7]: Venous variations (total–20 cases) (not mutually exclusive)

All the patients were followed up in the renal transplant OPD in the Institute of Nephrourology (INU) attached to Bangalore Medical College and Research Institute (BMCRI).

DISCUSSION

The commonly harvested kidney for transplant is the left kidney because of a long venous course [4]. Laparoscopic technique for acquiring kidney from a living donor has advantages over conventional open surgery, but operative visibility is limited [5]. Laparoscopic nephrectomy for harvesting kidneys from renal donors was introduced in 1995. The laparoscopic procedure offers advantages for the donor such as lesser hospital stay, lesser postoperative pain, fewer cosmetic concerns, and lesser convalescence time when compared to conventional open nephrectomy [6,7].

3D CT angiography provides a fast and non invasive modality for assessment of renal vasculature. The sensitivity of CT angiography in depicting the course of renal arteries and veins and for identifying accessory renal arteries is ~100% [1,8,9].

The kidneys are supplied by a pair of arteries arising from the abdominal aorta below the origin of superior mesenteric artery at the level of L2 vertebral bodies. The right renal artery shows a long downward course traversing posterior to the inferior vena cava. The left renal artery has a more horizontal orientation and a rather direct upward course [9].

Each renal artery is divided into anterior and posterior branches (pre segmental arteries) at the hilum of the kidney. It further divides into segmental arteries to supply the respective segments of the kidney. Typically, on CT angiography, the branches can be identified upto the segmental level [10].

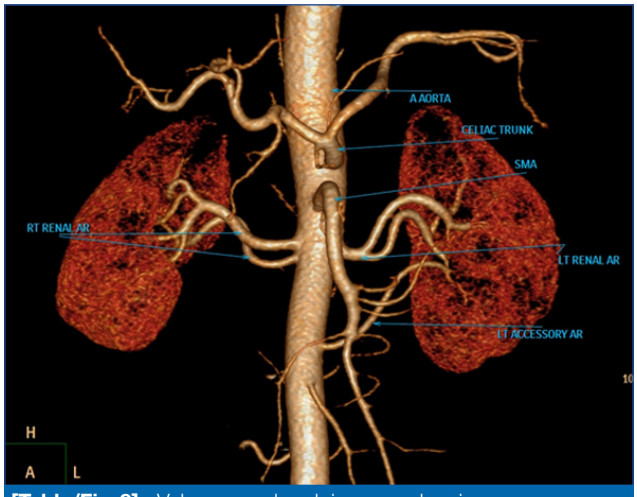
The renal vein is usually located anterior to the renal artery at the renal hilum. Right renal vein is about 2-2.5 cm in length and follows an anterosuperior trajectory, reaching the IVC at the level of the inferior margin of L1. The left renal vein is on average 8.5 cm in length. It normally takes a transverse and ventral course between the superior mesenteric artery and the abdominal aorta before reaching the inferior vena cava at the level of L2-L3.

The most common arterial variation in the present study was the presence of accessory arteries. This was also the most common variation found in a cadaveric study done by Budhiraja V et al., in India [11].

Accessory arteries can supply the kidneys either through the hilum (hilar variant) [Table/Fig-8] or they can directly supply the upper or lower poles (polar variant). They usually arise from the abdominal aorta or iliac arteries, most commonly between T11 and L4 vertebral levels. Very rarely, they arise from the lower thoracic aorta or from lumbar or mesenteric arteries. The presence of accessory arteries is not a contraindication for surgery but knowledge about them is extremely important for proper surgical planning.

Any branch of the main renal artery arising from the proximal 1.5-2 cm is considered as a prehilar branch [Table/Fig-8]. This is important since it may complicate or contraindicate surgery as sufficient arterial length must be present to allow for surgical clamping and to provide a sufficient arterial trunk for vascular anastomosis. In our study, prehilar branching was found in 12 patients, of which three were found on the right side. Similar, study by Ozkan U et al., and Munnusamy K et al., shows early division of renal artery into segmental arteries which was seen in 8% and 13% of individuals [12,13].

Earlier division of renal artery is not a suitable candidate for transplantation, since the surgeon would not have a long pedicle for anastomosis of renal artery [14]. Those on the



[Table/Fig-8]: Volume rendered images showing an accessory renal artery on right side and prehilar branching on left side.

[Table/Fig-9]: Curved MIP image in coronal reformation showing late venous confluence of left renal vein. **[Table/Fig-10]:** Volume rendered image showing late venous confluence of left renal vein. **[Table/Fig-11]:** An axial MIP image at the level of kidneys showing circum-aortic left renal vein.

right side were not disqualified as donors, since the kidney commonly harvested is the left side.

The most common of the venous anomalies in our study was late venous confluence (14 cases) [Table/Fig-9,10]. A distance of 1.5 cm from the lateral border of aorta on the left, to the lateral border of IVC on the right was taken as cut off. It was more common on the left side (12 cases). Two patients had two separate veins emerging and joining the IVC (supernumerary veins).

Identification of prominent tributaries (>5 mm) like gonadal veins and lumbar/retroperitoneal veins is important, so that prior ligation can be done during surgery to prevent accidental injuries and bleeding.

One case of circumaortic renal vein [Table/Fig-11] and two cases of retro-aortic renal vein was found in our study. They are not contraindications for donors, but surgery needs to be done in an open field rather than laparoscopically to prevent inadvertent laceration of the vein during graft procurement.

LIMITATION

Postoperative confirmation of the arterial anatomy and complications could not be included in the study. This is because, many cases were not considered for surgery because of the variations and some were not considered because of other issues with surgical fitness.

CONCLUSION

CT angiography proves to be an indispensable tool for assessing the renal vessels thereby avoiding the need for catheter angiography. In our study, 44% of donors had variations. Hence, sound knowledge of the variants and their prevalence is imperative with laparoscopic nephrectomy being the current modality of choice.

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