Variations of Renal Vasculature in Multi Detector Computed Tomography Evaluation of Abdomen

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ABSTRACT

Introduction: Normal vascular supply to each kidney is by a single artery and vein on each side. This normal pattern is not found in all cases. Arterial variations can be accessory renal arteries which can be hilar, upper polar or lower polar and early branching. Venous variations can be late confluence, multiple renal veins and on left there can be retroaortic or circumaortic course of the left renal vein. **Aims:** To evaluate renal vasculature variations in patients who undergo contrast enhanced MultiDetector Computed Tomography of the abdomen. **Methods:** This was a hospital based cross sectional study done in 290 consecutive patients who underwent contrast enhanced Multi Detector Computed Tomography abdomen in Nepalgunj Medical College. Normal as well as variations in renal vasculature was evaluated. **Results:** Total of 158 (54.48%) cases had normal arterial supply. Out of 132 cases with renal arterial variation, 96 cases (72.7%) were unilateral and early branching was the most common unilateral renal arterial variation (36.4%) followed by upper polar (20.8%), lower polar (20.8%) and hilar (16.6%) arteries. Concurrent upper and lower polar arteries and combined early branching and lower polar arterial system were the most common multiple unilateral renal arterial variation seen in 2.08% cases respectively. 36 (27.27%) cases had bilateral renal arterial variations. Most cases had early branching in bilateral renal arteries seen in 9.09% cases. Venous variations were seen in 11.03%.Late confluence was the most common variation seen in 62.5% cases with variations. Rest were multiple renal veins. Left sided retroaortic and circumaortic course and bilateral renal vein variations were not found in our study. **Conclusion**: Renal vasculature variations were frequently observed in routine contrast enhanced Multi Detector Computed Tomography evaluation of abdomen. Renal arterial variation was more common than venous variations. Unilateral variations were more common than bilateral.

Keywords: Computed Tomography, Renal artery, Renal vasculature, Renal vein

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INTRODUCTION

Normal renal arterial supply is by a single renal artery(RA). It branches into multiple branches near the hilum.[1-4] Normal arterial supply is seen in approximately 25% of cases only.[5] More than one RA on each side are known as accessory RAs. Accessory RA is called hilar if it enters the hilum and polar if it directly pierces upper or lower pole of the kidney. Any branch diverged within 1.5 cm from the lateral wall of abdominal aorta in the left kidney or in retrocaval segment in the right kidney is classified as early branching of the RA.[2,4,6] Single renal vein (RV) draining each kidney is normal. More than one RV on each side is accessory RV. Left RV entering into the inferior vena cava(IVC) by passing posterior to the aorta is retroaortic left RV. Left RV dividing into ventral and dorsal limbs that encircle the abdominal aorta is circumaortic left RV. Late venous confluence is diagnosed on the left side when venous branches join within 1.5 cm from the left lateral wall of abdominal aorta and on the right side when venous branches join within 1.5 cm of the confluence with the IVC.[7] Multidetector Computed Tomographic (MDCT) angiography is the imaging modality of choice for the demonstration of renal vessels.[8,9] Knowledge of the variations in renal vascularity is crucial during operative, diagnostic and endovascular procedures.[10,11] This study aims to establish the prevalence of variations in renal vasculature in patients undergoing contrast enhanced MDCT of the abdomen in our hospital.

METHODS

The prospective cross-sectional study was done in 290 consecutive patients who underwent abdominal CT for various indications between February 2021 and February 2022 in Nepalgunj Medical College, Banke. Patients with history of contrast reactions, impaired renal function, images with artifacts, non-opacified renal vessels in different phases of CECT and presence of any pathology causing evaluation of the renal vessels difficult were excluded from the study. Ethical

clearance was obtained from the Institutional ethical review committee of the Nepalgunj Medical College. Patients were placed in supine position and advised quiet breathing. An 18 gauze peripheral line was inserted into the antecubital vein. 2 ml/kg of non-ionic iodinated contrast agent (Iohexol) with a concentration of 300 mg/ml was injected using the bolus tracking technique with an automatic injector at a flow rate of 4-5 ml/sec. The scan area was taken from the diaphragm to the mid sacrum as per routine CT abdominal protocol. Scans were performed in a General Electronic 128 slice CT machine. A voltage of 120 kVp, current of 220 mA and slice thickness of 0.5mm and pitch ratio of one was taken. Patients were advised breath hold technique during the scan. Three phase scans were done namely; arterial (18-20 sec), portal (45-55sec) and venous (65-70sec) phases. Image reconstruction and interpretation were done using multiplanar reconstruction (MPR), maximum intensity projection (MIP) and volume rendering (VR) technique.

Data were analyzed using Statistical Package for Social Sciences (SPSS) version 25. The results were expressed as frequency and percentage.

RESULTS

290 patients fulfilling inclusion criteria were included in our study. Among them, 152 were males (52.41%) and 138 were females (47.58 %). 158 cases (54.48%) had normal renal arterial system in both sides whereas rest 132 cases (44.55%) had variations in renal arterial system. 68 (51.1%) were males and 64 (48.48%) were females in patients having renal arterial variations.

Renal arterial variant	Right Kidney		Left Kidney		Total
	Male	Female	Male	Female	
Early branching	16	7	7	5	35 (36.4%)
Upper Polar	5	9	3	3	20 (20.8%)
Lower Polar	4	4	5	7	20 (20.8%)
Hilar	6	4	2	4	16 (16.6%)
Both early branching and lower polar	0	0	2	0	2 (2.08%)
Both upper polar and lower polar	1	1	0	0	2 (2.08%)
Both early branching and upper polar	0	1	0	0	1 (1.04%)
Total	33	25	19	19	96 (100%)

Table I: Unilateral renal arterial variants (n=96)

Out of 132 cases with renal artery variations, 96 (72.7%) had unilateral variation. Of them, 54.16% were males and 45.58% were female. Early branching was the most common unilateral single renal artery variation seen in 35 cases (36.4%).23.9% were on right side and 12.5% were on left side. Upper polar arteries and lower polar arteries were seen in same number of patients (20.8% cases).Seven cases had hilar arteries (16.6%). Two cases (2.08%) had combined upper polar and lower polar arteries in right side. Similarly, 1 case (1.04%) had early branching and upper polar arteries. On left side, 2 cases (2.08%) had combined early branching and lower polar arteries.

Right Kidney	Left Kidney	Total
Early Branching	Early branching	12 (9.09%)
Early branching	Hilar	10 (7.57%)v
Hilar	Lower polar	4 (3.03%)
Upper polar	Early branching	4 (3.03%)
Lower polar	Early branching	2 (1.51%)
Upper polar and Lower polar	Lower polar	2 (1.51%)
Upper Polar	Lower polar	2 (1.51%)
Total		**36 (27.27%)**

Table II: Bilateral renal artery variations (n=36)

Among 132 cases with renal arterial variations, 36 (27.27%) patients had variations bilaterally. Most of the cases had early branching in bilateral renal arteries (9.09%) followed by combination of early branching in right kidney and hilar artery in left kidney (7.57%). Other combination of arterial variations in bilateral kidneys were as shown in table II.

Renal Vein	Right Kidney			Left Kidney		Total
	Male	Female	Total	Male	Female	
Normal	144	134	278 (95.86%)	132	138	270 (93.10%)
Late confluence	2	0	2 (0.68%)	14	6	20 (6.89%)
Multiple renal veins	**4**	**6**	**10 (3.44%)**	**0**	**0**	**0(0%)**
Total	**150**	**140**	**290 (100%)**	**146**	**144**	**290 (100%)**

Table III: Variations in Renal Vein

Normal renal venous system in bilateral kidneys was found in 258 cases (88.9%). Rest 32 cases had renal vein variations (20 males, and 12 females). Late confluence was the most common variation found in 62.5% of variations. Multiple renal veins were found in 10 cases, 31.25%. Variations were more common on left side, 62.5% (20) as compared to right (12), 37.5%. Bilateral renal vein variations and circumaortic or retroaortic course of left renal vein were not seen in our study.

	Arterial	Venous	
Male	Right Hilar	Left Late confluence	3
	Right Early branching, Left Early branching And Left Lower polar	Right Late confluence	1
	Right Early branching and Left Early branching	Left Late confluence	1
Female	Right Upper polar	Left Late confluence	1
	Right Early branching and Left Early branching	Right Secondary renal vein	1
	Right Lower polar right Early branching	Right Secondary renal vein	1
	Upper polar	Right Secondary renal vein	1

Table IV: . Combined arterial and venous variations

9 cases (5 males, 55.55% and 4 females, 44.44%) had combined arterial and venous variations. The most common combination was right sided hilar artery with left sided late renal vein confluence seen in 3 cases (33.33%). Other combinations of combined arterial and venous variations were as shown in table IV.

Figure 1: Coronal volume rendering image showing normal singe renal artery supplying each kidney

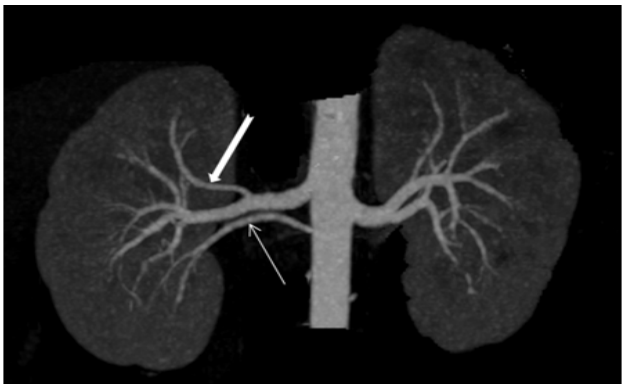

Figure 2: Coronal MIP image showing prehilar branching (shown by bold arrow) and lower polar artery (shown by thin arrow) in right kidney

DISCUSSION

Bilateral normal arterial supply was seen in 158 cases (54.48%) in our study. Similar findings were found in studies by Gumus H et al (53.7%), Armeu A et al (50%) and Famurewa OC et al (50%).[10,14,19] However, Jamkar AA et (75.01%), Cinar C et al (68.7%),Reginelli A et al (69%), Pradhav G et al (70%), Pant OB et al (67%) and Chhetri PK et al (67.76%) found higher prevalence of normal renal arterial system.[2,7,13, 15, 16,17] In our study, male and females had similar number of renal arterial variations. Similar findings were reported in studies by Palmiri BJ et al, Cinar C et al, Reginellia A et al and Chhetri PK et al.[5, 7, 13, 17] However, Gumus H et al found significantly higher variations in male cases.[10]

Renal arterial variations were more common unilaterally (72.7%). Similar findings were reported by Pant OB et al (89.1%), Chhetri PK et al (72%) and Toro JSC et al (77%).[16, 17, 18] The incidence was higher on right side as compared to left (54.54% right and 45.58% left). Studies by Chhetri PK et al (54.84% right and 45.16 % left) and Pradhav G et al also found higher incidence of right sided renal arterial variations.[17, 15] In studies by Palmeri B et al there was no statistical difference in variation of renal artery with laterality.[5] In our study early branching was the most common unilateral renal artery variation seen in 48.9% of variations. Aremu A et al also found higher number of early branching (36%).[14] Howerver, study by Chhetri PK et al (30.25%) and Toro JCS et al (55%) found higher number of polar arteries as renal arterial variations.[17,18]

Ten cases in our study had unilateral multiple renal arterial variations. Right sided combined upper polar and lower polar arteries and left sided combined early branching and lower polar artery were present in 2.08 % cases. Similar to our study, Chhetri PK et al also showed presence of both superior and inferior polar arteries as the most common unilateral multiple renal arterial variation.[17] In our study, 27.27% variations were bilateral. Toro JCs et al also reported 33% of cases having bilateral renal arterial variations. Most common combination was early branching seen in bilateral arteries (33%) in our study. In study by Chhetri PK et al and Torco JS et al, the most common combination was bilateral polar arteries (36.1% and 61%).[17,18]

Our study showed normal venous system in 88.9% of study population. Similar results were found in study by Reginelli A et al (89.8%).[13] Similar to the study by Cinar C et al (7.3%), our study also had late confluence as the most common variation (6.8%).[7] Study by Famurewa OC et al also found late confluence as the main renal variation (5.5%). Similar to our study these studies also had more variations on right side and no bilateral renal variations were found.[19]

In our study, 5.8 % cases had combined renal arterial and venous variations with right sided early branching with left sided late renal vein confluence (3.29%) cases being more common. Higher number of variations were reported in study by Cinar C et al with variations noted in 15.5% and right sided accessory renal artery and right sided secondary renal vein being the most common combination (2.5%).[7]

LIMITATIONS

Digital Subtraction Angiography (DSA) is the gold standard in evaluation of renal vascular. Our results with finding of MDCT could not be compared with DSA findings as DSA is invasive procedure and not routinely done. Other limitation is that a larger multicentric studies with control population is needed for evaluation of variations of renal vasculature.

CONCLUSION

Renal vasculature variations were encountered in routine MDCT evaluation of abdomen. Renal arterial variation was more common than venous. Variation were unilateral or bilateral and single or multiple. Early branching was the most common renal arterial variation whereas late confluence was the most common venous variation. Different combinations of variation between arteries and veins were also noted. Thus, knowledge of the variations in renal vascular anatomy should be noted by reporting radiologist as it is crucial during operative, diagnostic and endovascular procedures in the abdomen especially transplant and vascular surgeries as well as for interventional radiological procedures.

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