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Role of Arterial Phase Imaging In Assessing Venous Anatomy and Venous Anomalies in Multi-Detector Row CT Angiography of Living Related Renal Donors

Asma Maqsood[1], Muhammad Salman Rafique[2], Sana Kundi[3], Muhammad Haseeb Iqbal[4], Asad Bashir[5], Umar Farooq[6]

[1]Senior Registrar, [2,3]Consultant Radiologist, [4]Consultant Radiologist, [5]Ex-Senior Registrar, [6]Consultant Renal Transplant Surgeon, (Pakistan Kidney and Liver Institute and Research Centre, Lahore)

Correspondence:

Asma Maqsood
drasmazaman11@gmail.com

Abstract

Objective: To determine the role of arterial phase imaging in assessing venous anatomy and venous anomalies in multi-detector row CT angiography of living related renal donors

Methodology: This retrospective study was conducted in the Radiology Department of Pakistan Kidney and Liver Institute and Research Center, Lahore (PKLI & RC). After institutional review board approval, we evaluated MDCT images of 56 consecutive renal donors. Two consultant radiologists independently assessed the renal venous anatomy on the arterial and venous phase images. The sensitivity of detection of accessory renal veins, gonadal veins and lumbar veins was determined. Interobserver agreement was assessed using Cohen's kappa.

Results: Both radiologists characterized renal venous anatomy variants correctly on arterial and venous phases. Circumaortic left renal vein (n=4) and retro aortic left renal vein (n=4). The sensitivity of detection of the accessory renal veins, right gonadal and left lumbar veins on arterial phase images was 97% each whereas that for left gonadal vein was 100%. Cohen's kappa showed a substantial inter-observer agreement (kappa coefficient: 0.9; p<0.005).

Conclusion: The renal venous anatomy, including the detection of anatomic variations, can be assessed on arterial phase MDCT images alone in renal donors, excluding the venous phase from the protocol in renal donor evaluation.

Keywords: Arterial, Anomalies, Donors, Multi-detector, Renal, Venous.

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Introduction

There is a progressive increase in chronic renal failure in South Asian countries such as Pakistan. Pakistan requires a basic framework for providing adequate care to ESRD patients.[1] This progression depends on multiple factors that include improper health education, scarce primary healthcare facilities, insufficient funding, and increasing prevalence of underlying diseases like diabetes mellitus and hypertension.[2] Diabetic kidney disease a major contributor to chronic kidney disease (CKD) leading to ESRD.[3] One of the prime target organs affected by hypertension is the kidney and hypertensive nephrosclerosis is a significant cause of CKD.[4]

Moreover, various infections and dry weather lead to glomerulonephritis and renal stones that are known etiologies of CKD; there is evidence of chronic recurrent dehydration being associated with CKD.[5] The approximate yearly incidence of new ESRD cases in Pakistan is 150 to 200 per million population.[6] The replacement therapy of choice in patients with ESRD is a renal transplant.[7] Transplant surgery has decreased the mortality and morbidity of patients with ESRD. The traditional preoperative imaging workup used to consist of conventional angiography and intravenous urography of renal donors. This has been replaced by multi-detector computed tomography (MDCT) angiography.[8-11]

Traditionally it included imaging the renal donor in arterial and venous phases for evaluating renal and corresponding vascular anatomy.[12] The addition of a dedicated venous phase poses further contact to ionizing radiation in otherwise fit youthful renal donors.[13] If necessary, the venous anatomy and its anomalies can be assessed through the arterial phase. Our research aimed at assessment of the renal vein anatomy on the arterial phase images alone on MDCT angiography of renal donors. In this way, we can reduce the radiation burden on the young population. Since there is no local

evidence in the literature, this will improve our practice and we can implement the use of arterial phase only, to delineate venous anatomy reducing the radiation dose to young individuals.

Material and Methods

This project was performed in the Radiology Department of Pakistan Kidney and Liver Institute and Research Center, Lahore (PKLI & RC). After institutional review board (IRB) approval we evaluated 54 consecutive renal donors who had undergone MDCT from December 2019, to April 2020. They underwent a CT scan on GE 128 slices CT scanner. A quantity of 120 mL of IV iodinated contrast at an injection rate of 3-4 mL/sec was used. We conducted an abdominal and pelvic CT scan prior to injection of IV contrast to serve as a baseline for enhancement of the lesions and to detect nephrolithiasis. This was followed by intravenous contrast administration to acquire an arterial phase at 15 seconds and a venous phase at 45 seconds extending from the diaphragm to pubic symphysis. Lastly, a delayed phase that was acquired 5-minutes after IV contrast injection outlined the calyces, renal pelvis and ureters. Axial images which were 1 mm and 5 mm thick, were acquired in all phases and transferred to the workstation. The renal lengths were measures on sagittal images. Axial thin-section maximum intensity projection (MIP) images, oblique coronal images and three-dimensional (3D) volume-rendered images were employed to assess renal arteries and veins.

The donors whose arterial phase CT images were degraded by artifacts were excluded. The CT images were retrieved from PACS (Picture Archive and Communication System). A couple of radiologists carrying at least 5-years' experience evaluated the renal vascular anatomy independently on the arterial and venous phase images separately. They also assessed the number of the bilateral renal veins and the anatomic variants. The data was gathered on specifically constructed proformas. For statistical analysis, SPSS version 20 was utilized. Frequency and percentage were calculated for arterial phase imaging in assessing venous anatomy and venous anomalies. Sensitivity calculation done by number of detection cases of renal venous anatomy on arterial phase keeping venous phase anatomical evaluation as gold standard Kappa statistics (k) were used for comparison of numbers of anatomical structures identified on arterial phase images and venous phase images.

Results

In all, 56 renal donors were enrolled in this study. All of them underwent CT angiography. The ages extended from 24 to 50 years. The number of male donors was 29 whereas that of female donors was 27. The radiologists described the renal vein anatomical variants accurately on arterial and venous phases. The two anatomic variants characterized were the circumaortic left renal vein (n=4) and retro aortic left renal vein (n=4). Supernumerary right renal veins were also recorded (n=20). It was an uphill task to distinguish a retroaortic left renal vein from the lumbar vein in the arterial phase. The venous phase images revealed remarkably greater opacification of renal veins, lumbar veins, and gonadal veins as it was anticipated. However, this did not restrain the assessment of renal vein anatomical details in the arterial phase. The sensitivity of recognition of the right gonadal and left lumbar veins on arterial phase images was 97% each whereas that for left gonadal vein was 100%. The sensitivity for revealing accessory renal veins was 95%. Cohen's kappa showed a substantial inter-observer agreement (kappa coefficient: 0.90; $p<0.005$).

Table I: Sensitivity of detection of renal venous anatomy on arterial phase keeping venous phase anatomical evaluation as gold standard.

	Total number (n)	Venous Phase	Arterial Phase	Sensitivity (%)
Accessory Renal veins	20	20	19	95
Right Gonadal veins	56	56	54	97
Left Lumbar veins	56	56	54	97
Left Gonadal veins	56	56	56	100

Discussion

Laparoscopic nephrectomy is widely used as a minimally invasive procedure serving as a substitute to open nephrectomy for harvesting kidneys from living renal donors for over a decade. Because of the limited view of laparoscopy, radiological imaging has a pivotal place in the pre-operative evaluation and surgical planning of the renal donor.[13] Even if open donor nephrectomy is to be undertaken, an awareness of renal artery and renal vein anatomy beforehand, acquired through imaging, is helpful in surgical planning and donor selection. MDCT angiography has been the technique of choice in this regard, with an accuracy of

95%-100%.[14,15] It is a proven imaging technique for evaluating renal morphology, its vascular anatomy, and associated anatomic variants.[16] However, the increased use of CT has also resulted in a significant surge in the cumulative radiation dose to the population through the last few decades.[17] This has led to the need for educating radiology personnel, patients, and referring physicians about the significance of medical radiation and its associated risks. We need to define alternate CT techniques to reduce the radiation dose while providing accurate diagnostic information.[18]

Different CT imaging protocols for renal donor evaluation have been used in various institutions, particularly the timing of the arterial phase. According to Del Pizzo, et al.[19] an arterial phase acquisition at 14-20 seconds following injection of IV contrast resulted in four missed accessory tributaries. On the other hand, Kim et al.[20] observed that with an arterial acquisition using bolus-tracking at 24-31 seconds on a 4-MDCT, the renal artery, and renal vein recognition rate was 98% each. The arterial phase images were acquired at 15 seconds following IV contrast administration in our study. The retro aortic and circumaortic left renal veins (Figure 1) were not easy to discriminate from the lumbar veins. This was because anatomically, retroperitoneal veins such as the lumbar, ascending lumbar and hemizygous veins frequently drain into the left renal vein.[21]

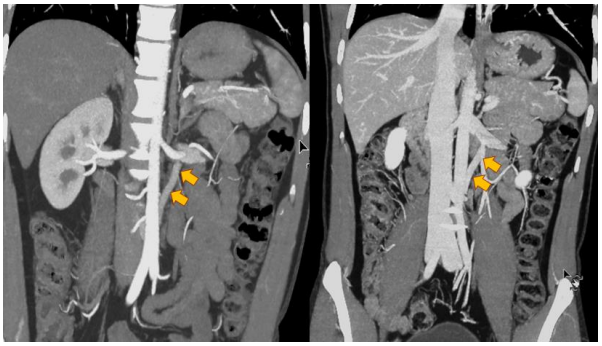

Figure 1. Arterial phase (left) and venous phase (right): Circumaortic left renal vein (arrows)

The sensitivity to detect accessory renal veins in our study (97%) was better than Kim et al. (75%), perhaps owing to the use of 128-slice MDCT compared with 4-slice MDCT by Kim et al. However, the comparative standard in that study was the surgical findings. They reported that a single angiographic acquisition to assess the vascular anatomy, as well as focal renal lesions, would be sufficient in living related potential renal donors thus decreasing the radiation dose.[11] Our findings were also in keeping with the study by Namasivayam et al[12] in which the sensitivity of recognition of renal veins and gonadal veins was 100% each and that for lumbar images was 90%, on arterial phase images.[12] The results of Kawamoto et al[21] were also in agreement with ours though their delay time for arterial phase acquisition was 25 seconds whereas in our study this was 15 seconds.[21] Ikidag et al.[15] recently determined that a single postcontrast arterial phase was enough for arterial as well as venous anatomy delineation. However, the number of donors with variant venous anatomy was smaller than in our study. The reported incidence of circumaortic left renal vein in has ranged from 1-11% but the cadaveric literature has quoted an incidence of 2-17%. This difference can be secondary to the limitations in the surgical and imaging techniques utilized, according to Trigaux et al.[22] Another reason according to Hostiuc et al. is that the variants are not actively sought for, and the surgical visualization of the retro aortic component of the left renal vein can be limited. On imaging, this component may be obscured due to the paucity of retroperitoneal fat or the imaging parameters employed.[24] Our study showed reasonable accuracy for the recognition of the accessory renal veins, right gonadal and left lumbar veins (Figure 2) on arterial phase images (sensitivity of 97% each) and for the left gonadal vein (sensitivity of 100%). The surgical importance of gonadal and lumbar veins is controversial. Some surgeons think that presurgical understanding of the renal venous anatomy is not significant.[24] However, other authors are of the view that recognition of these veins is vital, particularly in laparoscopic nephrectomy.[24]

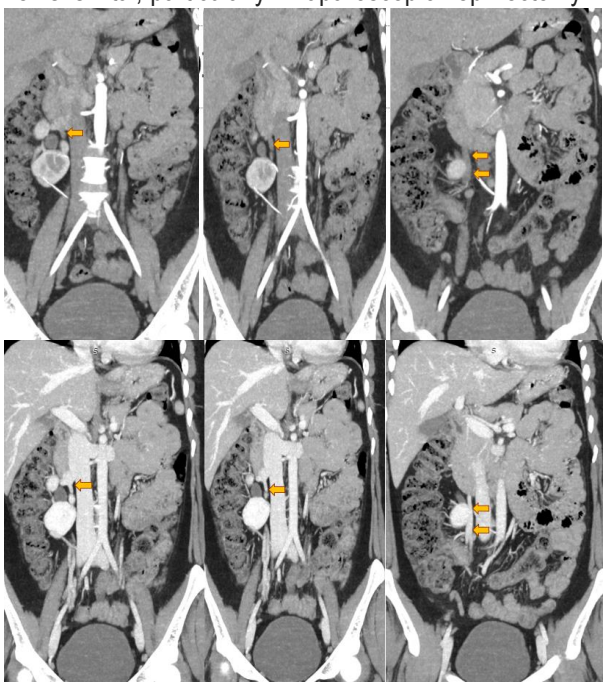

Figure 2. Arterial phase (3 images on the top) and venous phase (3 images on the bottom): The right gonadal vein (arrows) draining into the right renal vein is demonstrated on both the phases.

Our study had two limitations. Firstly, we employed venous phase images as a standard, though taking

surgical findings as the reference would have been more ideal. Secondly, we believe that fewer donors in our project had renal vein anatomical variations. This may be addressed in later studies by extending the sample size to include more individuals with variant renal vein anatomy.

Conclusion

Arterial phase images acquired on MDCT are sufficient for characterizing the renal venous anatomy. Only arterial phase images can be used to identify left tributaries of the renal veins as well as lumbar and gonadal veins. Thus, we can safely eliminate the venous phase from the MDCT protocol for renal donor evaluation.

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