

The pattern of renal vessels in live related potential donors pool

A multislice computed tomography angiography review

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ABSTRACT

Objectives: To assess the renal vessel anatomy, compare the findings with the perioperative findings, to determine the sensitivity of multislice computed tomography (CT) angiography in the work-up of live potential donors and to discuss and compare the results of the present study with the reported results using single slice CT, magnetic resonance (MRI) and conventional angiography (CA).

Methods: Retrospective analysis of the angiographic data of 118 of prospective live related kidney donors was carried out from October 2004 to August 2005 at the National Organ Transplant Centre, Tripoli Central Hospital, Libya. All donors underwent renal angiography on multislice (16-slice) CT scan using 80 cc intravenous contrast with 1.25 mm slice thickness followed by maximum intensity projection (MIP) and volume rendering techniques (VRT) post-processing algorithms. The number of vessels, vessel bifurcation, vessel morphology and venous anatomy were analyzed and the findings were compared with the surgical findings.

Results: Multislice spiral CT angiography (MSCTA) showed clear delineation of the main renal arteries in all donors with detailed vessel morphology. The study revealed 100% sensitivity in detection of accessory renal vessels, with an overall incidence of 26.7%, which is the most common distribution in the parahilar region.

Conclusion: The present study showed 100% sensitivity in the visualization and detection of main and accessory renal vessels. These results were comparable with conventional angiography which has so far been considered as the gold standard and were found superior in specificity and accuracy to the use of single slice CT (SSCT) and MR in the angiographic work-up of live renal donors. Due to improved detection of accessory vessels less than 2 mm in diameter, a higher incidence of aberrant vessels was seen on the right side as has been suggested so far.

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Renal transplantation has grown rapidly over the years and so has been the evaluation of potential kidney donors. Graft retrieval from live donor requires accurate assessment of renal anatomy and its blood supply. Imaging forms an essential step in the prospective evaluation of a potential kidney donor.

Conventional angiography (CA) has traditionally been used as an investigative tool in the final preoperative planning of the kidney donor. With the advances in imaging technology, safe and non-invasive methods of evaluation are now available using single-slice spiral computed tomography angiography (SSCTA),

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magnetic resonance angiography (MRA) and now multislice spiral CT angiography (MSCTA). Multislice computed tomography (MSCT) is a useful imaging modality that is replacing conventional angiography in assessment of vascular anatomy. Many studies have been carried out over the last few years comparing CT angiography, MR angiography and conventional catheter angiography with surgical findings and have shown good but varying results depending upon the techniques and the equipment used.^{1,12,15} The aim of this study was to assess the sensitivity of MSCTA in the evaluation of prospective renal donors and to compare the findings with the intraoperative findings and also to discuss its role as compared to other available imaging modalities in the pre-operative work-up of renal donors.

Methods. The study included 118 prospective donor renal angiogram, which were performed on multislice spiral CT (Lightspeed GE 16 slice, USA). First, the plain scanogram of the abdomen was carried out, followed by the selection of the region of interest from the upper margin of D12 vertebra to the lower margin of L3 vertebra. The circulation time was determined using 'smart prep' software (GE, USA) with a scan delay of 15-20 seconds depending upon the circulation time determined. This was followed by an intravenous injection of 80 ml iopromide 300 mgI/ml. (Ultravist 300, Schering Germany AG) along with 20 ml normal saline bolus chase with the use of a dual-head pressure injector (Medrad, USA). 1.25 mm slices were acquired in a single breath-hold using 2.5 mm collimation, 120 KV, 350 mAs, with table feed of 6 mm per rotation and reconstruction interval of 0.625 mm with a total scan length of 320 mm. Post-processing was carried out using various techniques such as multiplanar reconstructions (MPR), freehand maximum intensity projection (MIP), volume rendering techniques (VRT) on the advantage windows 3D workstation. Retrospective analysis of the renal arteries of all the renal donors was carried out in double-blinded way by at least 2 personnel. The following parameters were assessed: a) The visualization of the main renal arteries, their length (from the ostium to the renal hilum) and diameter at ostium, along with the bifurcation pattern for which each main renal artery was divided into 3 equal segments namely proximal, middle and distal third parts. b) The location of the accessory renal arteries on each side and their morphologic details. c) Renal vein assessment was also carried out for its number, size and location. Each of the observations made were looked for in the axial, MIP, MPR and the VRT mode to compare the findings. All the findings seen on imaging were then finally compared with the operative findings.

Results. The study retrospectively analyzed the findings in 118 live related renal donors of which 111 were males and 7 females in the age group of 20-50 years. Multislice spiral CT angiography showed excellent visualization of the main renal arteries of all the potential donors with an average length of the main renal arteries of 6.82 cms on the right side and 7.34 cms on the left side (**Figure 1**). The average diameter of the main renal artery was 1.09 cms on the right side and 1.10 cm on the left side. The total incidence of accessory vessels was 26.67% of which single accessory renal arteries were seen in 28 (11.86%) on the left side and 34 (14.47%) donors on the right side (**Figure 2**). Double accessory renal arteries were seen on the right side in 2 (0.84%) and 6 (2.1%) donors on the left side, while only one donor had triple accessory renal arteries on the left side. The distribution of the accessory vessels was most commonly seen in the parahilar region followed by equal incidence in both the polar regions. The main renal arteries were also assessed for vessel bifurcation. Early bifurcation was seen in 11 donors on the left side and 3 on the right side. The most common pattern of the main renal artery bifurcation was late/distal seen in 93 (right side) and 76 donors (left side) with a mid-vessel bifurcation seen in 25 (right side) and 33 patients (left side). Observations were also made on the parahilar branching pattern for surgical anatomic view-point. We observed up to 3 parahilar branches as the most common pattern in 61 (right side) and 69 (left side) donors with the second common pattern of 3-6 branches in 42 and 44 patients. No donor showed more than 6 parahilar branches of the main renal artery (**Figure 4**). The renal vein was visualized in all patients with a proximal renal vein bifurcation in 13 donors, retro-aortic left renal vein in 5 and renal vein duplication in one potential renal donor (**Figure 3**). The comparison was also made for visualization of the above findings on axial as well as on VRT images which revealed good correlation in visualization of main renal arteries and their branches. However, only 22 of the 71 accessory vessels, especially those in the polar region, were visualized on the axial images prospectively.

Discussion. As SSCTA and MSCTA are carried out as an outpatient procedure, they show a better donor compliance compared to CA, with excellent depiction of main renal arteries. The incidence of aberrant renal arteries in this study was 26.7% which is comparable to earlier reported incidence (25-30%). However, interestingly, this study showed single accessory renal arteries to be more common on the right side 14.4% as compared to 11.8% on the left side which is contrary to the earlier reported studies

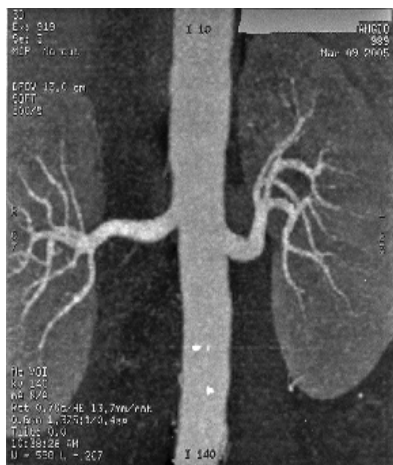


Figure 1 - Multislice spiral computerized tomography renal angiogram of the main renal vessels in a 3D MIP display.



Figure 3 - Multislice spiral computerized tomography renal angiogram showing double renal veins on right.

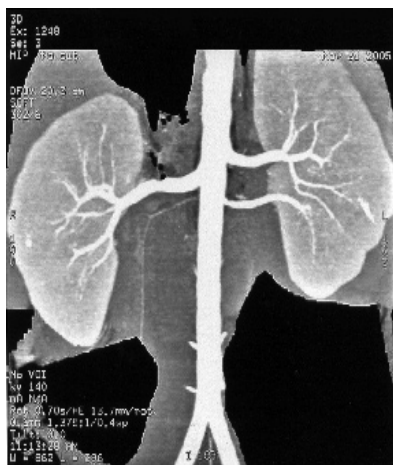


Figure 2 - Multislice spiral computerized tomography angiography of donor kidneys showing single accessory renal artery.

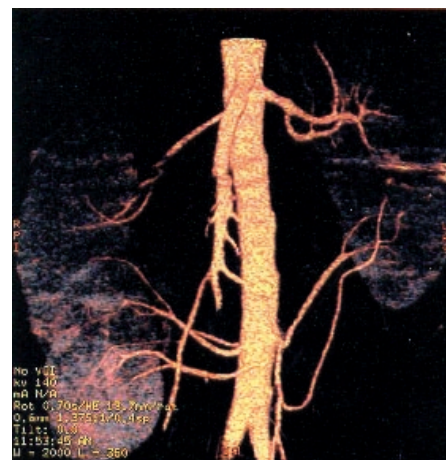


Figure 4 - Multislice spiral computerized tomography angiogram showing multiple accessory renal arteries on both sides.

showing a higher incidence of accessory vessels on the left side. This variation could be explained due to better detection rate of small accessory vessels on MSCTA 16-slice. On CTA and MRA, accessory vessels less than 2 mm. diameter were difficult to recognize while in this study MSCTA showed 13 accessory vessels with diameters of 1 - 2 mm; in the present study, this could account for the variation in the result of the percentage of accessory vessels of the right and left side. This however requires confirmation with more studies using this modality. Many different techniques have been used earlier to study donor kidney vessels namely: Single slice CT angiography (SSCTA), Conventional catheter angiography (CA) and MR angiography (MRA). Determination of the detailed anatomy of the accessory renal vessels

forms an important factor in the selection of the donor kidney. The sensitivity of accessory vessel detection rate in this study is 100% which strongly suggests the use of MSCTA 16-slice as useful tool to evaluate the renal vessels in kidney donors. It is therefore worthwhile here to compare the results of MSCTA with the other available diagnostic modalities in use for doing a vascular workup of a potential renal donors. Comparison of the results of this study with various studies reported in literature was carried out; The use of single-slice CTA show a variable number of false negatives with 8-23% of the accessory renal arteries being not visualized by the single slice CTA and these commonly involved arteries with diameter less than 2 mm.³ Catheter angiography, so far was considered being the gold standard, also

shows a varying sensitivity for accessory vessel detection between 91-100%.^{4,10} Magnetic resonance angiography using intravenous Gadolinium on 1.5 Tesla also gives promising results for aberrant vessel detection with studies reporting a sensitivity of 80-100%.^{1,7} Another important finding in the evaluation of donor renal vessels is the detection of early bifurcation of main renal artery and plays an important part in the preoperative evaluation of the donor renal vessels and its visualization can change the surgical technique for reimplantation in the recipient kidney. This study showed 100% accuracy in the detection of early vessel bifurcations with the use of volume rendered post-processing technique.⁹ The results for detection of early vessel bifurcation were also superior with the use of MSCTA 16-slice as it was observed in this study than the reported result with the use of SSCTA with an accuracy of 93% and CA with 91%. The mid- and distal vessel bifurcation was also accurately determined on MSCTA, however the observation was regarded as surgically irrelevant. Accurate parahilar branching pattern was also seen in all the patients in this study and matches the results of CA.¹⁰ However, on SSCTA and MRA, the reported sensitivity of detection of the number of parahilar branches is 70-90% and 50-80%.⁷ With the use of MSCTA 16-slice, renal venous duplication anomalies and retro-aortic renal veins can also be accurately detected, which is a major advantage over CA and MRA.¹⁴ Another significant advantage seen in the present study by the use of MSCTA 16-slice was the reduced dose of intravenous contrast which was less than half of what is used in single slice CT. Protocols are also being recommended which shall obviate the need of intravenous urography by combining plain skiagrams of the abdomen and MSCTA thus, avoiding re-injections and reducing the cost.¹⁶

To conclude, MSCTA is a highly accurate investigation¹⁵ not only for detection of supernumerary vessels but also gives accurate morphological details of the main and the aberrant vessels. The use of multiplanar reconstructions and the MIP and VRT protocols improves the detection of supernumerary vessels than being studied in the axial plane only. Review of the literature showing the results of MSCTA in the present study show the latter to be definitely superior to the above modalities in the renal vessel evaluation of the prospective donors and is on the way to replace CA as the gold standard for renal angiography studies.¹² The MSCTA is an excellent method to evaluate supernumerary arteries, early branching as well as venous anatomy.

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