

# MDCT-ANGIOGRAPHY IN DIAGNOSING THE ACCURACY OF RENAL ARTERY VARIATIONS IN LIVING RENAL DONORS

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## ABSTRACT

**OBJECTIVE:** To evaluate the effectiveness of MDCT-Angiography in diagnosing the accuracy of renal artery variations in living renal donors. **METHODS:** A cross-sectional retrospective exploratory study to review medical records of 522 patients referred to Radiology department for pre-operation Renal Angiography of donors for renal transplantation from 2010 to 2012. The study group comprised of 304 males and 218 females with age range between 19 - 64 years. The Sensitivity and reliability analyses were carried out using SPSS 22. **RESULTS:** Out of 522 patients, 443 single arteries found on CT and 444 were found on surgery with a mean difference of minus one, 73 cases were identified on CT and 71 cases were verified by the gold standard surgery with a mean difference of plus two. Whereas, six cases were diagnosed in CT and seven cases were verified by gold standard surgery with a mean difference of minus one in triple arteries. **CONCLUSION:** MDCT-Angiography is found to be highly accurate for the diagnosis of renal artery variations as compared to the conventional method. Our findings are significantly associated with the surgical diagnosis.

**Keywords:** MDCT-Angiography, Renal Donors, Renal Artery Variations

## Introduction

The advent of technology in medicine like computed tomography (CT) in the recent past provide us opportunities for improving the quality of CT image, clinical practice as well as to discover the clinical application of CT image (Kyongtae, 2010). Administration of contrast medium with respective scan timing has also a challenge. Computerized simulated information is analyzed and provides a detailed knowledge regarding the factors associated with intravenous contrast as well as scan timing. Particularly, during the recent past, multi-detector CT showed efficient improvement not only spatial but temporal resolution. Nowadays, CT angiography technique is preferred on catheter-based conventional angiographic diagnosis. Most of the physicians are interested in multi-detector CT urography for their

investigation. Due to the latest CT technology and their advent, frustrates users to adopt obsolete protocols which fail to provide desired imaging quality and a force to change in practice. A state-of-the-art technique was published in research journals to address the required protocol revisions and considerations in contrast material administration for the living organ. Such things also enlighten us to improve our technique for enhancing the diagnostic efficiency and patient care. Living related donor is a major treatment option for a patient with ESRD (Ylian et al., 2010). It is mandatory for the survival of such patients as compared to the maintenance hemodialysis as it associated with good quality of life and longer survival. Better graft survival is associated with living donor and renal transplantation than cada-

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ver donor transplantation (Jee W.C., 2008). Adequate pre-operative imaging workup of living renal donors is mandatory to determine if a patient is suitable for donor nephrectomy to avoid the various complications that may threaten the transplanted kidney and sometimes survival of recipient. The imaging work-up involves anatomic and functional evaluation of donor's kidney. Traditionally, IVP ultrasounds and conventional angiography along with Radioisotope scanning were used for this purpose. Advances in imaging technology now allow very accurate, rapid, relatively non-invasive and safe evaluation of potential renal transplant candidate (Satomi et al., 2003). Diagnostic imaging of CT has modified as MDCT, detector elements replaced from linear array to two-dimensional array and it permits CT scanners to acquire multiple sections rapidly. Although reconstruction of MDCT image considered complicated image processing as compared to the CT, the advent of MDCT has changed the scenario and widely used in CT application like CT angiography. In this recently advent technology, MDCT angiography due to its shorter image acquisition time, narrow collimation, and very thin slices leading to enhanced temporal as well as spatial resolution which is nearly isotropic data resolution found advantageous for 2D and 3D imaging. It has become a key imaging technique used for renal assessment and has challenged the role of conventional angiography (Aysel et al., 2009).

## Patients and Method

522 patients were reviewed during the year 2010 to 2012, referred to Radiology department, SIUT-Karachi, Pakistan for donor Angiography. The group was consisting of 304 males and 218 females age ranged from 19 - 64 years. The average age was found to be 41.5 years.

MDCT was performed with following parameters.

Parameters	Values
Kvp	120
MAs	ATCM
Slice thickness	1.25mm
Pitch	1:1
Rotation time	7sec
Collimation	30 to 40 dfov

The helical length was found to be normal.

1. The subjects were called after 6hour of fasting.
2. The 18-20G cannula was used for venous access in the antecubital vein or a large vein in the forearm. To avoid motion artifacts in scanning the subjects were taught to hold breath during scanning and remain still. MDCT scans were obtained with the patient in the supine position with the feet first entering the gantry (Uday et al., 2001). About 100 ml of contrast media was injected using a power injector at a rate of 4 ml/sec. The whole examination was performed in four phases described as under:

The plain study was performed with the patient in supine position caudocranially, from the top of the kidney to pubic symphysis. It is used to locate the kidneys and to detect the presence of stones in the renal tract or nephrocalcinosis. To ensure appropriate scan timings bolus triggering methods are used.

The arterial phase was started when triggering level of mid descending thoracic aorta reached 150HU (Hounsfield units). The area of scan included from the level of D10 to L5 vertebra. The acquisition parameters used were:

Parameters	Values
Kvp	120
mAs	80 to 500
Slice thickness	1.25mm
Pitch	1:1
Rotation time	0.5 to 01 sec
Collimation	30 to 46 dfov

In venous phase, the area included was from D12 to the pubic symphysis.

Delayed phase was performed after 10 to 12 minutes of IV contrast injection to outline the pelvicalyceal system ureter and urinary bladder.

In post processing, thin sections of images were transferred to a work station. The images were post processed with a work station of Advanced Work Station 4.4.

The axial source images were reformatted on another console in coronal and/or sagittal planes. Several vessels length and branches were noted.

Thin section axial images were transferred to a work station where the individual volume data is loaded to the 3D program. This data is utilized for the generation of MIP (maximum intensity projection) images and

volume rendered images. MIP reconstruction enhances the area of high radio density. It is excellent in outlining high attenuation high contrast well-defined structures such as arteries. Whole multiplanar reformatting is preferred for the analysis of small less well-opacified veins.

In volume rendering transparency and colors are used to allow better representation of the volume to be shown in a single VR image. VR is particularly useful for outlining the anatomy of larger vessels such as the aorta and its branches. The volume rendered 3D images of kidney provide surgeons with a preoperative map of relevant vascular anatomy. The 3D reconstructed images were carefully correlated with the axial source images to ensure that no important vascular structures were inadvertently deleted from the 3D model. The images are clearly analyzed in coronal, sagittal and oblique planes and properly reviewed by a radiologist (Satomi et al., 2004).

The reconstructed axial images were thoroughly examined by the cine evaluation. The interpreting radiologist followed each artery as it arose from the aorta and tracked it until it enters kidney and perfused it completely or partially. The veins were similarly examined. The hilum and capsule of each kidney were assessed and all the visualized vessels were traced back to their origin. This is a very useful method applied by Satomi and coworkers in their study for detecting small capsular and polar arteries with distant origin such as iliac arteries.

## Results

MDCT-Angiography is found to be highly accurate for the diagnosis of renal artery variations as compared to the conventional methods. Out of 522 cases, 443 single renal arteries were identified on CT and confirmed by gold standard surgery with a mean difference of minus one shows under-reporting in CT with the sensitivity ratio 0.997 (Fig.1). 73 cases of double arteries were identified on CT out of which 71 were verified by the gold standard surgery with a mean difference of (+02) with the specificity of 97.2% (Fig.2). Whereas, six triple arteries were noted in CT and seven arteries were reported by gold standard surgery with mean difference (-01) with the sensitivity of 85.7% (Fig.3; Table-1)

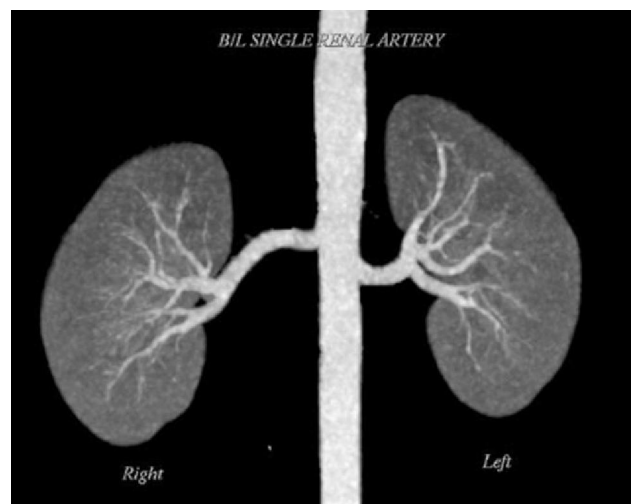


Figure 1: Bilateral single artery on CT

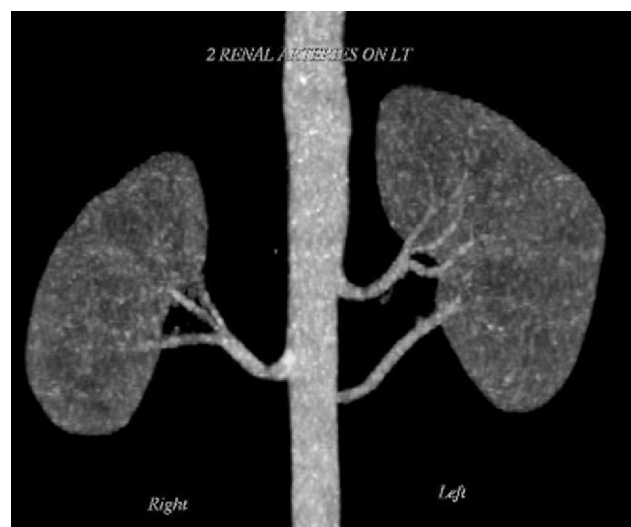


Figure 2: Two renal arteries on left and one on right

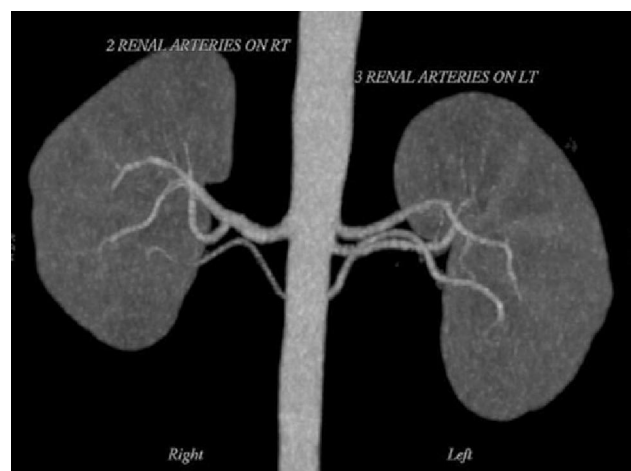
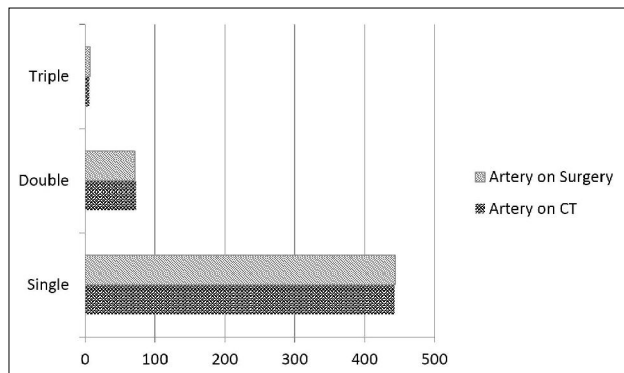


Figure 3: Three renal arteries on left and two on right

	Total	Artery on CT	Artery on Surgery	Mean Difference
Single Artery	522	443	444	-1
Double Artery	522	73	71	+2
Triple Artery	522	6	7	-1

**Table 1:** Arteries on CT and Arteries on Surgery



**Graph 1:** Artery on CT and Artery on Surgery

## Discussion

### Accuracy of MDCT

Our study rules out the accuracy of renal CT-Angiography procedure done with MDCT to predict the renal vascular anatomy variation among the living kidney donors in Pakistani subject.

522 cases were studied and 443 single renal arteries accurately matched with the surgical findings of 444 an accuracy of 99%. Our findings are found to be similar with the earlier studies reported the sensitivity of MDCT in diagnosing the accuracy of living renal donors (Chai et al., 2008; Namasivayam et al., 2006). In general population variations found most frequently in renal arteries with a reported prevalence of about 28–30% (Satyapal et al., 2001). Multidetector CT angiography technique is efficient, relatively fast and reliable, non-invasive as well as affordable and renal vascular anatomy is depicting its exquisite anatomical details preferably imaging modality for a comprehensive evaluation (Hazirolan et al., 2011; Urban et al., 2001). Usually numerical variations of renal arteries are found to be of two types and characterized as primary prehilum branching in terms of segmental as well as multiple renal arteries where hilum enter into the hilum along with main renal artery whereas, polar entered directly from the capsule to the renal parenchyma (Ozkan et al., 2006). Experience shows

if the main or extra-renal arteries arise from superior mesenteric, inferior mesenteric or common iliac arteries one can easily find the variation in the renal artery.

With the passage of time radiological and minimally invasive surgical procedure is gained reputation especially for the renal vascular study. Due to the success and familiarity of anatomical variants of open and minimally invasive surgeries, the researchers found multiple renal arteries on the left side more commonly as compared to right (Patil et al., 2001). We are addressing in this study the sensitivity and reliability finding of bilateral multiple renal arteries in both males and females referred to our department, Department of Radiology, SIUT-Karachi, Pakistan. Similar studies conducted by Ozkan and co-workers among 855 angiographies and found the incidence of four left renal arteries in 0.2% and three right renal arteries in 1% case (Ozkan et al., 2006). A study investigated the triple renal arteries in 4% whereas 1% case of quadruple renal arteries (Pollak et al., 1986). Recently, evaluation of a case study of thirty-six years male patient represented seven renal arteries out of which three arise on left side, four arisen on right side. Furthermore, from the left side, two were originated from the aorta and one arose from the inferior mesenteric artery. Three arose from the aortic origin on the right side and one was originated from a right common iliac artery (Koplay et al., 2010). Furthermore, an angiographic study of two hundred and fifteen patients, three additional arteries were observed in 0.4% however, two additional renal arteries in 5.6% cases (Papaloucas et al., 2007). A study was conducted on one hundred and two live kidney donors and showed the presence of three and four renal arteries on right side in 1 case each and five renal arteries on the left side in 1 case (Patil et al., 2001). Jetti and co-worker in 2008, an additional renal artery supplying the lower pole of a left kidney from the left common iliac artery in a male cadaver like our case.

Conventional angiography was long been considered as an imaging technique for evaluation of renal arteries in living related donors (Bruce et al., 2001). The first application of CT angiography was reported in past few decades. It was reported by Rubin and coworkers in 1993, that helical CT angiography with dynamic I.V. contrast injection depicts the anatomical detail of

aorta and its main branches and hence this can be a good alternative to conventional angiography in the evaluation of abdominal aorta and its main branches. This opinion was supported by other authors (Satomi et al., 2004).

Although conventional angiography was considered as reference standard for evaluation of renal arteries in potential renal donors, small caliber arteries of <3mm cannot be visualized by this technique (Andrew et al., 2005), beside this when the findings of conventional angiography was compared with surgical findings accessory vessels or early branching were missed in approximately 8% cases (Sachiko, 1997). The aim of our study is to evaluate the accuracy of MDCT angiography for prediction of renal vascular anatomy and its variation in living kidney donors. The advantage of MDCT is that this is a non-invasive, requires a single peripheral venous access and can be performed as an outpatient procedure and the person can continue his daily routine with no loss of working time. This contrasts with invasive angiography where 6-8 hours of absolute bed rest is mandatory (Satomi et al., 2004).

Villablaca et al., 2007, reported that MDCT can be a reliable tool for quantification of vessel size over 7 mm and the range of size for accessory renal artery was described to be 2 to 3 mm by Satyapal et al., 2001. The MDCT is cost saving as compared with conventional angiography as in this procedure there is no need of special catheters and expertise as well as is easier to perform by the most Technologist in routine radiology services. Besides this, there is no risk of various complications associated with the introduction of the catheter into patient's body.

Out of 522 patients, 443 of single artery were found on CT and 444 were on surgery while 73 double arteries on CT and 71 on surgery. However, 6 cases of the triple artery on CT and 7 cases of surgery have been diagnosed

## Conclusion

Our study revealed that MDCT can provide a highly accurate assessment of the renal vascular anatomy in living kidney donors with a sensitivity of 99.7%, and 85.7% respectively for single and triple arteries

whereas specificity of double arteries determined 97.2% for diagnosing the living kidney donors in Pakistani patient.

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**Conflict of Interest:** None

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