ACCURACY OF SPIRAL CT RENAL ANGIOGRAPHY OVER CONVENTIONAL ANGIOGRAPHY IN LIVING RENAL DONORS

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ABSTRACT

BACKGROUND

Potential donors for renal transplantation undergo an exhaustive pretty operative examination including medical assessment, laboratory testing and radiological imaging. The goal of imaging in these subjects is to delineate the kidneys and their vascular anatomy to determine if the subject is a suitable donor nephrectomy candidate and if so to assess which kidney maybe technically easier to transplant. This traditional imaging workup has consisted of two examinations, the IV Urogram (IVU) and renal arteriography.

MATERIALS AND METHODS

Totally 18 healthy adults who were potential renal donors were taken for spiral CT angiography. The study was conducted in Viswabharathi Medical College, Penchikalapadu, Kurnool, Andhra Pradesh, between May 2015 and May 2016.

RESULTS

In the present study, supernumerary renal arteries were present in 7 cases (38.8%) and consisted of one artery in 4 cases (11.1%) two arteries in 3 cases (16.6%). Early branching of the main renal artery was seen in one case (2.7%) venous anomaly in the form of retroaortic renal vein. Nonvascular abnormality noted in one case in the form of simple renal cyst in right upper pole (2.7%). Overall, CTA sensitivity, specificity and accuracy are 100%. In one case, axial sections could not find early branching, however, it was depicted in MIPS.

CONCLUSION

It is superior to conventional angiography in demonstrating accessory renal artery when it is arising from aorta immediately behind the main renal artery in anteroposterior direction and incidental findings like aortic calcifications, renal vein anomalies and renal cysts.

KEYWORDS

CT Angiography, Kidney Arteries, Conventional Angiography, Renal Donors.

BACKGROUND

Recent advances in CT technology now allow better vascular assessment. Helical CT and 3-dimensional (3D), reforming of CT data allow improved vascular imaging suggesting that CT has the potential to be a single imaging method in the preoperative examination of kidney donors.[1]

The angiography evaluation of renal anatomy is usually the last procedure performed on a potential renal donor before nephrectomy. After routine blood chemistry and haematologic and urinalysis studies, a screening excretory urogram is performed. This is used for assessment of renal anomalies such as foetal lobulations, renal dysmorphism, dromedary humps and focal renal scarring, which may be consistent with old pyelonephritis or renal infarction. In a review of 151 potential renal donated by Frick et al only one patient could be excluded from renal angiography on the basis of findings determined by excretory urography.[2]

The conventional indications for preoperative renal donor angiography assessment have been the determination of the number and length of renal arteries in the transplantable kidney and presence of early branching and vascular disease.[3]

Helical CT technology has made it possible to image the kidney in a single breath hold and image of the kidney arteries. CT angiography has an accuracy rate sufficient to replace conventional renal arteriography, which is traditionally used to evaluate potential renal transplantation donors. This study would be the elimination of second exposure to contrast material and decreased cost, discomfort, morbidity and radiation exposure, which are all primary related to arteriography.[4]

Since its introduction, helical (spiral) CT has dramatically changed the performance of body of CT scans. The elimination of misregistration artefacts, the minimisation of motion artefacts and the production of overlapping images without additional radiation exposure are the most important technical advantages of helical CT.[5]

The helical CT technique that one uses greatly influence the success of multidimensional imaging. The correct choice of helical CT scan parameters such as collimation and table feed as well as post processing parameters such as reconstruction interval, editing technique and rendering technique have an impact on the depiction of small structures with fine detail. Care must be taken to mine longitudinal resolution by minimising collimation, table feed and reconstruction interval.[6]

Few helical CT applications are more challenging than depiction of small vessel stenoses such as occurring in the renal artery. Helical CT angiography may both overestimate and underestimate such stenoses. Volume averaging tends to overestimate the diameter of blood vessels when high subject contrast exists, however, the degree of overestimation is greater for stenotic vessel than normal caliber vessels.

Conversely, vessel stenoses are likely to be overestimated when low subject contrast is present.

AIM
To determine the accuracy of spiral CT arteriography over conventional renal arteriography in living renal donors.

MATERIALS AND METHODS
Eighteen healthy adults who were potential renal donors were recruited for spiral CT angiography. 12 subjects were females and 6 subjects were men. The mean age is 35 years (age range 15-54 years). 18 potential living renal donors underwent CTA and conventional angiography between May 2015 and May 2016. All potential donors had normal serum creatinine and blood urea nitrogen levels. Informed consent was taken from all patients.

Computed Tomography
All patients were imaged with a somatosensory plus 4 power sub-second helical CT scanner (Siemens AG, Erlang, West Germany). First, an abdominal scout projection was obtained. Subsequently, conventional axial CT scans were obtained with 8 mm collimation from the top of the L1 vertebral body inferiorly to the bottom of the L4 vertebral body (to include superior pole and inferior pole of both kidneys). These images were evaluated to identify the volume of interest for CT angiography. The images were evaluated to identify the volume of interest for CT angiography. The images were also evaluated for the presence of calculations within the kidneys.

After placement of a 20-gauge IV catheter into an antecubital vein, all patients were instructed to hyperventilate and maintain a degree of inspiration similar to the held on preliminary localising sections for 30 seconds.

Scans were obtained using a standard CT protocol (slice collimation 2 mm, table feed distance 5 mm/s, reconstruction interval 1 mm, gantry rotation 0.75 secs, delay 20 secs). Subsequently, 90 mL of nonionic iodinated contrast material (Omnipaque, 300 mg of iodine per millilitre; total dose of 27 mg of iodine, Nycomed) was injected with a pressure injector (Medrad, MCT plus USA) at a rate of 3 mL/sec after a scan delay of 20 sec and spiral volumetric data was obtained.

The Acquisition Parameters That We Adopted In Our Study Are As Follows:

Acquisition Parameters for CTA of Renal Arteries in Living Renal Donors

Sl. No.	Parameters	Value
1	Collimation	2 mm
2	Table increment	5 mm
3	Reconstruction interval	1 mm
4	Gantry rotation time	0.75 secs.
5	Contrast	Nonionic
6	Strength	300 mg/mL.
7	Volume	90 mL
8	Rate	3 mL/secs.
9	Scan delay	20 secs.
10	Volume of interest	L_1 to L_4
11	Renal artery and accessory renal artery	Upper pole-lower pole
12	Rendering techniques	MIPS Edited MIPs
Table 1		

The spiral acquisition was reconstructed with low spatial frequency reconstruction kernel with axial sections generated at 1 mm increments. Axial images were visualised with a center of 50-70 HU and a window width of 450-700 Hu.

Two dimensional regions of interest were selected to include the kidneys, renal arteries, aorta and surrounding retroperitoneal fat. The 3D/EDIT tool on the SOMATOM plus console was used to perform the editing, which required 45-60 minutes of a technologist's time. Once completed, the segmented data set was used to generate shaded surface display and MIPS.

In all patients following findings were analysed;
1. Number of renal arteries.
2. Presence of early branches.
3. Any pathology of renal artery (stenosis, occlusion).
4. Perfusion of kidney and segmental perfusion defects.
5. Kidney size, contour, any pathology.
6. Any congenital anomalies.
7. Renal vein anomaly.

Conventional Renal Arteriography
All patients underwent conventional arteriography on a digital angiography system [HICOR, Siemens, AG West, Germany]. Arteriography was performed by using the Seldinger approach with a 5F pigtail catheter placed in the abdominal aorta. All patients were imaged with a screen film combination with an average contrast dose of 17.5 grams of iodine (50 mL ionic contrast material). In doubtful cases regarding origin and course of main arteries and accessory

renal artery selective catheterisation was done. Venography was not done, but delayed images were obtained in an attempt to visualise the veins.

RESULTS

The arterial calcification was graded into 3 grading;

Grade 1 - 64%.

Grade 2 - 33%.

Grade 3 - 3%.

Results of the arterial anatomy interpretation was performed.

Interpretation of Arterial Anatomy by CTA in 36 Kidneys

Types of Images	Single Artery	One Accessory Artery	Two Accessory Arteries	Early Branching
AXIAL	22 (61.1%)	4 (11.1%)	3 (8.33%)	2 (5.4%)
MIPs	22 (61.1%)	4 (11.1%)	3 (8.33%)	2 (5.4%)
MPRs	22 (61.1%)	4 (11.1%)	3 (8.33%)	2 (5.4%)
Table 2				

In one case, accessory renal artery could not be seen on right side in MPR.

In one case, axial sections could not early branching, but MIPs and MPRs depicted.

In one case, bilateral single main renal arteries could not be seen clearly in MIPs due to overlapping veins.

Respiratory artefacts were seen in one case.

Nonvascular Findings

Findings of helical CT revealed retroaortic renal vein on left side in one patient and simple cortical cyst in region of right kidney.

Renal Artery Anatomy

There were 36 renal units in the 18 subjects. Helical CT demonstrated 10 (27.7%) accessory renal arteries in 36 renal units and early division of main renal artery on right side in one renal unit 1 (2.7%).

Angiography correlation was available in all subjects (36 renal units).

Two renal units with early branching main renal arteries were depicted with both CT and angiography.

We compared the results of the axial CT image interpretation to the 3-dimensional image interpretation in the 18 subjects with angiographic correlation.

All imaging findings in CT angiography are well correlating with conventional angioplasty.

Renal Vein Findings

One subject had a retroaortic left renal vein, which was well depicted in axial images.

Surgical findings were available in 11 to 18 patients (7 right and 4 left kidneys). Imaging findings were confirmed in all except in one cases, which revealed double renal vein on right side.

Joseph J. Del et al reported that supernumerary renal arteries were present in 40 cases (23%) and consisted of 2 arteries in 33 (19%) and 3 in 7 cases (4%). Early branching of the main renal artery was seen in 26 cases (15%) venous anomalies occurred in 11 patients (6.3%). Nonvascular abnormalities like renal calculi were seen in 5 and simple renal cyst were identified in 12 patients.[7]

Arteriographic Findings and Donated Kidney for each Patient

Patient No./Age/Sex	Accessory Renal Arteries		Perihilar Branching		Transplanted Kidney
	LT	RT	LT	RT	
1/35/M	0	1	0	0	LT
2/43/M	0	2	0	0	NONE
3/47/M	1	0	0	0	RT
4/43/F	0	1	0	0	LT
5/33/F	1	0	0	0	RT
6/42/F	2	0	0	0	RT
7/35/F	0	0	0	0	LT
8/36/M	0	0	0	0	LT
9/15/M	0	0	0	0	NONE
10/45/F	0	0	0	1	NONE
11/54/F	0	0	0	0	NONE
12/26/F	0	0	0	0	LT
13/44/F	0	0	0	0	LT
14/33/F	0	0	0	0	NONE
15/18/F	0	0	0	1	RT
16/33/M	0	0	0	0	LT
17/21/F	0	0	0	0	NONE
18/33/F	1	1	0	0	NONE
Table 3					

Detection of Prehilar Renal Artery Branches with Axial and 3D CT Angiography

Axial CT-A

Sensitivity - 50%

Specificity - 100%

Accuracy - 100%

Three Dimensional CT-A (MRP MIP)

Sensitivity - 100%.

Specificity - 100%.

Accuracy - 100%.

Overall CTA sensitivity, specificity and accuracy are 100%. In one case, axial sections could not find early branching, however, it was depicted in MIPS.

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Detection of accessory renal artery with CT angioplasty axial CTA

Axial CT-A	Three Dimensional CT-A (MRP MIP)
Sensitivity - 100%	Sensitivity - 100%.
Specificity - 100%	Specificity - 100%.
Accuracy - 100%	Accuracy - 100%.

Axial and 3D CTA were both 100% sensitivity for detection of accessory renal arteries.[8]

DISCUSSION

Main aim of current study was to determine the accuracy of spiral CTA over conventional angiography. Preoperative conventional arteriography has four recognised objectives in the evaluation of potential renal donors.

1. Identification of renal artery number.
2. Renal artery length.
3. Renal arterial aneurysmal and occlusive disease.
4. Unsuspected renal parenchymal abnormalities.

If spiral CT is to replace conventional arteriography in the preoperative screening of potential living renal donors, it must satisfy all of the objectives of conventional arteriography.[7]

Prevalence of accessory renal arteries in this population is higher than that reported in large series of living renal transplant donors, which ranges from 27% to 44% of donors.[9]

In studies of 22 and 31 patients with renal CT angiography, 11 of 11 accessory renal arteries were detected in each series. These results suggest that spiral CT might be an effective means of screening potential living renal donors for the presence of multiple renal arteries. This study further establishes the accuracy of CT angiography for the detection of accessory renal arteries.

In our study, 10 accessory arteries are identified and correlated with conventional angio (100%).

Accessory renal arteries seen at conventional arteriography were identified with 100% accuracy at both axial and three dimensional rendered CT angiography.

The identification of renal artery branches that occur within 1-2 cms of the origin of the renal artery is of equal importance to the identification of accessory renal arteries. The main renal artery must be long enough to allow a sufficient cuff on either side of a 3-5 mm clamp when the vessel is cut. Main renal arteries less than 2 cms in length are technically problematic and have been reported in 10% to 13% of potential renal donors.[9] Kjellen and colleagues [2] found that the identification of left renal prehilar arterial branching resulted in procurement of the right kidney in 5% of donors. Geoffrey D. Rub[10] and colleagues found that 21% of the main renal arteries are less than 2 cms in length and the decision to procure the right kidney was made in 17% of the patients on the basis of the detection of prehilar branching.

Although, axial and three-dimensional CT angiography were both 100% accurate for identifying accessory renal arteries, three-dimensional CT angiography was more useful for the identification of prehilar branches.[8]

The reported prevalence of stenotic lesions involving renal arteries of potential renal donors ranges from 3% to 6%.[11] No arterial stenosis were detected with CTA and conventional angiography in our study.

Rubin et al[12] found 3D CTA to have 92% specificity and 83% sensitivity for the detection of haemodynamically significant (> or -70% stenosis using MIP techniques).

Kattee et al found 96% sensitivity and 96% specificity for the detection of stenosis graded between 51% and 99% using 3D-CTA was 100% sensitive and specificity for detecting renal artery occlusion.

CT angiography allows the visualisation of the renal arteries in multiple planes and projections so that the renal arteries can be observed in their entirety and stenosis quantified.

The presence of intravascular contrast within the artery distal to the discontinuous segment suggests severe stenosis rather than occlusion.[6]

Poststenotic dilation and nephrography asymmetry have been found to be 85% and 98% sensitivity and 50% and 53% specificity for the presence of significant renal artery stenosis.[10]

After live donation, 1 and 3 year graft survival rates are shown to be 96.6% and 93.2%, respectively. This compares with 1 and 3 year graft survival rates for cardiac donation of 83.9% and 71.4%, respectively.

The traditional preoperative evaluation includes classic renal arteriography and excretory urography for definition of renal arterial anatomy and exclusion of renal parenchyma or collecting system anomalies. The invasive nature of the traditional preoperative evaluation has caused reluctance for some family members to become donors.[6]

We identified retroaortic renal vein on left side in one case, but surgery was done on right side. Surgery revealed double renal vein on right side in one case, but CTA could not pick up due to the scan being done in arterial phase.

The 3D CTA provided better detail of venous anatomy before Laparoscopic Nephrectomy [LN] compared with classic angiography. The depiction of venous anatomy was not sought for the preoperative evaluation of patients undergoing open donor nephrectomy because venous anomalies do not alter surgical techniques or donor selection. However, with the LN and limited field of view available with the laparoscopic surgery, venous anatomy needs to be found preoperatively.

Rubin et al showed 3D-CTA to be 100% accurate for identification of accessory renal arteries and that 3D-CTA was useful for identifying perihilar branching pattern.[7]

Platt et al evaluated 154 patients with 3D-CTA and classic angiography before donor nephrectomy and found 3D-CTA to be as accurate as classic angiography for predicting renal donor anatomy.[13]

3D-CTA can provide a complete and accurate preoperative evaluation for renal donor candidates in a single study. This noninvasive preoperative examination

may encourage some potential candidates to become renal donors.

An evaluation of axial CT sections was considered conclusive in 15 of the 22 patients of renovascular hypertension, however, the addition of multiplanar and 3D renderings to axial CT evaluation resulted in all cases being considered diagnostic.[11]

In 14 patients SSD (shaded surface displays) and MIPs were compared. SSD were found to be only 59% sensitive, whereas MIP CTA was 92% sensitive for the detection of greater than 70% stenosis. Both techniques were of equal specificity (82% to 83%).

The poor performance of SSD relative to MIPs can be explained by two features that limit surface display: (1) Calcification associated with stenosis and (2) Partial volume averaging in regions of stenosis will be accentuated by the thresholding process and result in arterial discontinuities that overestimate stenosis. Curved planar reformations additionally can be very helpful in evaluating renal arteries with calcified plaques.

Both axial sections and 3D CTA were 100% sensitive for identifying seven accessory renal arteries in 12 patients. Axial CT angiogram was only 14% sensitive for identifying five perihilar renal artery branches (less than 2 cms. from the renal artery origin), whereas 3D CT angiogram was 93% sensitive for identifying the five prehilar renal artery branches. Additional advantage of helical CT angiography is that the renal parenchymal abnormality and renal veins can be depicted. The identification of renal arterial anomalies resulted an arterial operative management in 4 to 11 cases where the right renal artery was donated rather than the left.[8] In this study, both axial section and 3D-CTA were 100% sensitive for identifying 10 access of renal arteries in 7 patients. Axial CTA was 50% sensitive in identifying perirenal branching.

Platt et al[13] who settled on protocol of 4 mL/sec for 133 of their 156 patients, 3 mm collimation, pitch of 1.3-2.0 and a standard scan delay of 20 secs. with routine axial 1.5 mm overlapping reconstructions. They found four discrepancies between CT and arteriography: CT missed one accessory artery and found three arteries not seen on arteriography. Correlation with surgery showed six (5%) of 117 discrepancies on CT, five small accessory arteries and one case of early branching. In our study, we used 2 mm collimation, 5 mm table feed, pitch 1.2 to 1.8 and 1 mm overlapping reconstruction. We found no discrepancies between CTA and conventional angiography.

Platt[13] et al apparently made use of multiplanar reconstructions, but did not standardise or describe their technique. In five cases, accessory vessels were seen only on axial images and not on reformatted images. However, 3D images revealed four cases of early branching not seen on the axial images.

Strauser[14] et al described four objectives of preoperative renal arteriography. The first is determination of arterial number multiplicity of renal arteries increased the complexity of renal transplantation.

Bojesen[15] et al reported that the frequency of multiple renal arteries is approximately 24% of 638 kidneys.

Spring[16] et al reported 27% of 888 kidneys, in another 444 prospective renal donor series, he reported a 6% incidence of renal vascular disease such as fibromuscular dysplasia, atheromatous changes and renal artery aneurysms.

Galanski[11] and co-workers have reported the only case of renal artery stenosis due to fibromuscular dysplasia identified with CTA.

Identification of early (prehilar) branching of the main renal artery is another important goal of renal vascular imaging in potential donor. Early division of the main renal artery may complicate or even contraindicate surgery. Joel F. Platt, MD[1] et al reported early branching in eight kidney (<1.5 cms. from the origin of the renal artery). All were identified equally with CT angiography. In our study, early branching was seen in two case. Early branching was very well depicted in both CT angio and conventional angio. Rubin et al[17] who found prehilar branching in 21% of the kidneys in their study.

In our study, we used 2 mm collimation, 5 mm table feed and 1 mm reconstruction interval. In 99% of the cases, renal artery originates from the aorta between origin of SMA to bifurcation of common iliac artery.[15] Preliminary data suggest that use of 3 mm collimation enables detection of accessory renal arteries and accurate grading of most renal artery stenosis.[11][12]

The scan duration is linked closely to the scan coverage. Majority of patients undergoing renal artery imaging should be able to maintain up to 30 seconds of breath holding without difficulty.[18]

Spiral CT angiography is an attractive alternative to intravenous urography and conventional arteriography because the renal vasculature collecting system and parenchymal abnormality can be assessed with a single examination.[8] In this series of 12 potential renal donors who underwent correlative angiography, all seven accessory renal arteries were identified with both axial CT sections and 3D renderings (100% sensitivity).

In our study, ten accessory renal arteries were found (single accessory renal arteries noted in 4 patients in which 2 on right side and 2 on left side and double accessory renal arteries found in 3 patients.

In contrast to CT angiography, MR angiography has not been successful in consistently identifying accessory renal arteries or prehilar branching and MR angiography currently does not provide a method for identifying urinary collecting system anomalies.[19] For these reasons, MRA cannot be used as the sole method for assessing renal transplant donors.

By ROC curve analysis, both the MIP film and the combined MIP and MPR film reading showed good diagnostic performance for the detection of haemodynamically significant RAS.[20] No single renal artery stenosis noted in our study.

Of nine accessory renal arteries, eight accessory renal arteries were found by using axial CTA. The one missed

artery was small and located 30 mm proximal to the main renal artery. It was not enhanced enough.[21]

In our study, all accessory renal arteries were identified in all axial CTA.

To further evaluate the accuracy of the CT in assessing the renal vasculature, CT results were compared with surgical findings in 117 kidneys that were removed for transplantation. CT and surgical vascular findings agreed in 111 (95%) of 117 kidneys.[1]

In our study, 11 patients of 18 subjects underwent surgery. Surgical vascular findings agreed in all patients except in one case in which double renal vein was noted on right side.

Careful axial image review is crucial for all subsequent reformatting including 3D. Small accessory arteries can be identified an axial image and then not well displayed on reformatted images.[1]

In our study, one accessory renal artery was missed in MIP. Review axial images showed small accessory artery.

In our study, 26.6% of all kidneys had accessory arteries, a percentage that compares favourably with the results of a recent large angiographic study that found accessory arteries in 28% of kidney.[22]

LIMITATIONS
One limitation of our study is that surgical comparative data was available only of the kidney taken of transplantation. No surgical proof is possible for the contralateral kidney, which in many instances was not transplanted because imaging showed it to have the complex vascular anatomy.

Another relative limitation of our study is that we cannot comment in a meaningful way on CT detection of intrinsic renal artery disease such as stenosis or fibromuscular dysplasia. Reports in non-kidney donor populations suggest that CT should also be accurate for identification of intrinsic renal vascular disease.[11][12]

In our study, two discrepancies were identified regarding prehilar branching. In one case, axial CTA could not pick up early branching, but MIPs depicted well. But, it is not confirmed by surgery. In another case, bilateral early branching noted in conventional angio, but CTA not depicted due to less calcification of arteries. Retrospectively, axial CTA sections revealed early branching in bilateral renal arteries.

A consensus has emerged regarding several aspects of renal CT arteriography. A narrow collimation of 3 mm with a pitch of 1.2-2.0 is necessary because helical CT is affected proportionately more by collimation than by pitch. The length of 2 axis coverage must be sufficient to detect aberrant renal arteries.[1]

In general, clinical arteriography does not visualise vessels that are less than 0.3 mm in diameter.[23] When studies compare results of conventional angiography with surgical findings, accessory vessels or early branching are[24][25] comparisons of IV digital subtraction angiography and intra-arterial digital subtraction angiography with surgical findings have yield similar results.[4][22]

In our study, all patients underwent conventional angiography. All surgical findings were correlated with conventional angiography.

Frick MP, Goldberg ME and Flechner SM, Sandler CM, et al reported nonvascular abnormalities[4][5] in 12-13% of donor examination. In our study, 2.7% of nonvascular abnormality noted in the form of simple cortical cyst.
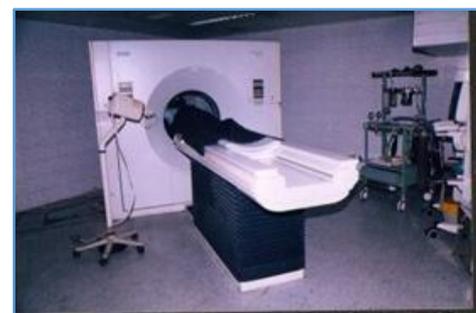

Figure 1. Work Station

Figure 2. Spiral CT Scan with Gantry Table and Pressure Injector

Figure 3. Curved MPR with Lower Pole Accessory Renal Artery on Right Side

Figure 4. Conventional Arteriography with Accessory Lower Pole Renal Artery on Right Side
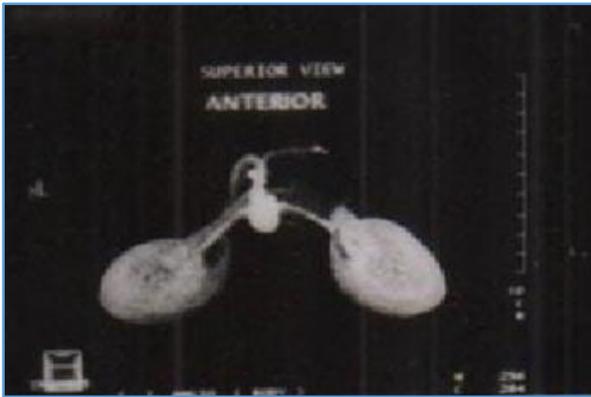
Figure 5. MIP Images with Bilateral Single Renal Arteries

Figure 8. Curved MPR Bilateral Single Renal Arteries

Figure 6. Conventional Renal Arteriography with Bilateral Single Renal Arteries
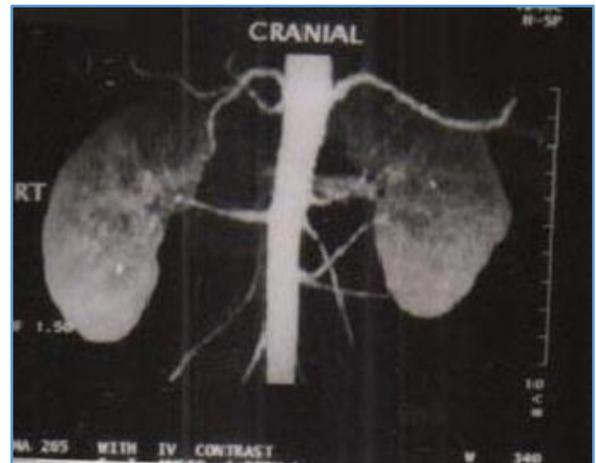

Figure 9. MIP with Bilateral Single Renal Arteries

Figure 7. MIP with Two Accessory Renal Arteries on Left Side

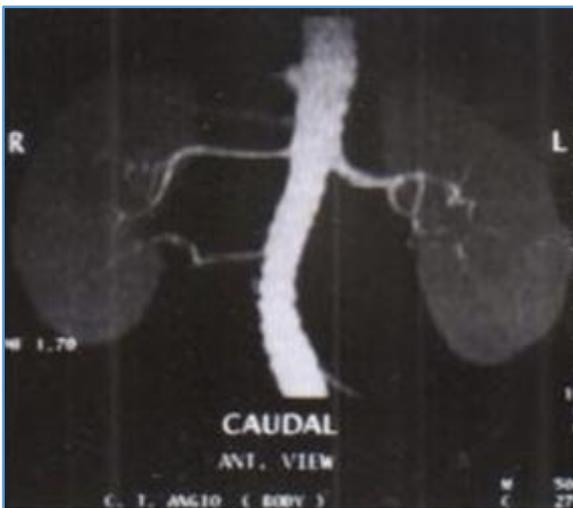*Figure 10. MIP Image with Single Accessory Renal Artery on Left Side*

Figure 11. MIP Image with Double Accessory Renal Arteries on Right Side

Figure 14. Curved MPR with Single Accessory Renal Artery Left Side

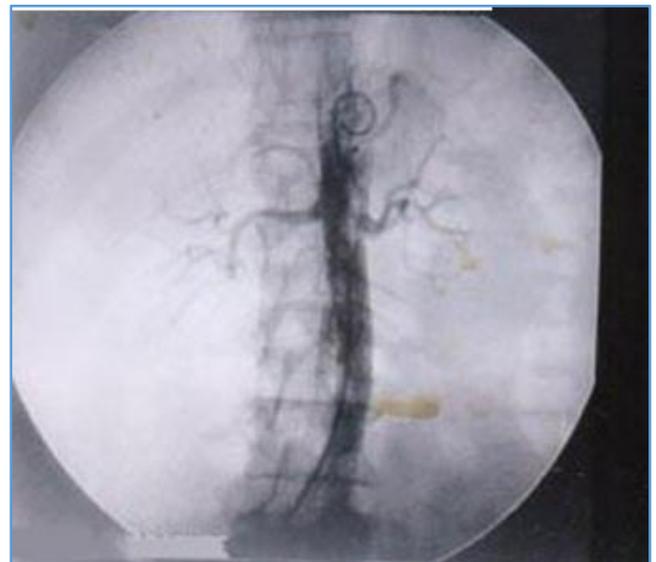**Figure 12. Conventional Arteriography with Two Accessory Arteries on Right Side**

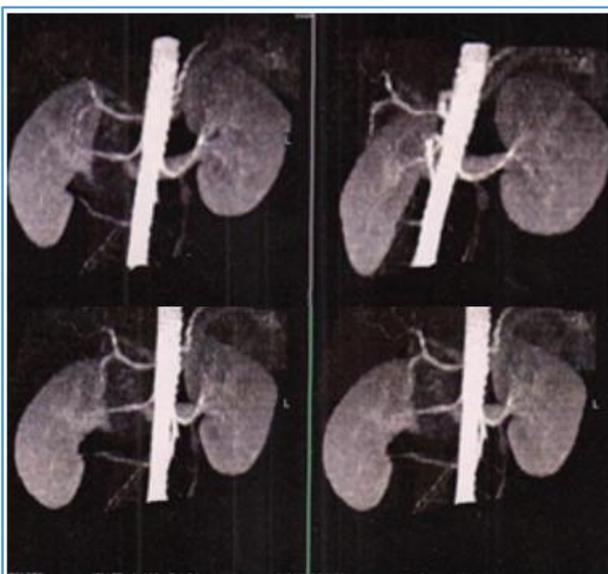**Figure 15. Conventional Arteriography with Single Accessory Renal Artery on Left Side**

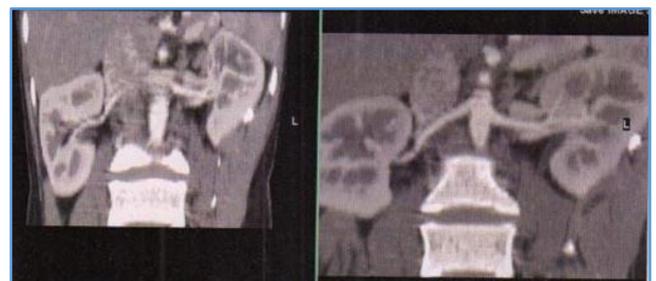**Figure 13. MIP Images with Bilateral Single Renal Arteries**

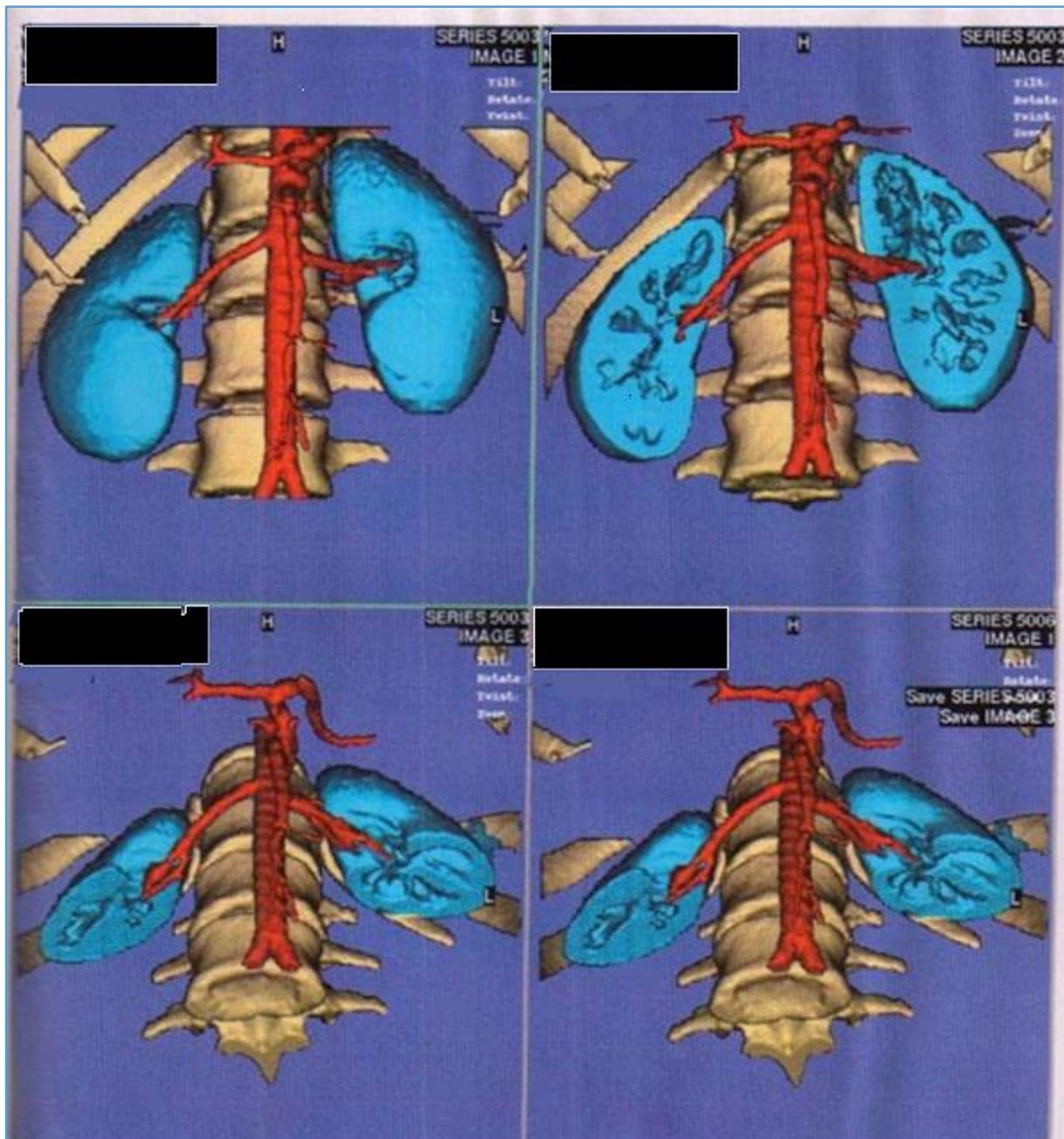**Figure 16. Curved MPR Bilateral Single Renal Arteries**

Figure 17. Shaded Surface Display (SSD) Bilateral Single Renal Arteries.

CONCLUSION

CT angiography is comparable to conventional angiography in detection of multiple renal arteries, early branching of renal arteries, renal vein anomalies and incidental renal parenchymal disorders. It is a minimally invasive and can be performed with IV contrast to demonstrate arterial and venous anomalies. It will reduce hospital stay of donors. Cost and recovery time are reduced. It should be of high quality to provide diagnostically useful information.

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