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ROLE OF MULTI-DETECTOR COMPUTED TOMOGRAPHY IN THE PRE-OPERATIVE WORK UP OF POTENTIAL LIVING RENAL DONORS

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ABSTRACT

Background: Kidney Transplantation is limited by severe shortage of cadaver kidneys. To ameliorate this limitation, use of living donors is now widely accepted. Preoperative evaluation of living renal donor is important to select the appropriate kidney for transplantation and to decrease donor surgical complications. Aims: The aim of this study was to observe the accuracy of multi-detector computed tomography (MDCT) to evaluate vascular anatomy in potential living renal donors using surgical findings as reference standard. Settings and Design: Prospective observational nonrandomized study. Subjects and Methods: A total number of 30 living renal donors who underwent open surgical approach for transplantation were selected. Renal anatomy and renal vessels of donors evaluated by CT angiography was compared with surgical findings in all patients. Results: The accuracy for detecting number of main renal arteries was 96.66%. The accuracy for detecting number of main renal veins and ureters was 100%. Conclusions: MDCT using 64-channel scanner represents a single step highly accurate imaging modality for the anatomic evaluation of kidneys, their vascular anatomy and ureters with good patient comfort in potential living renal donors.

KEYWORDS: Kidney transplantation, Living renal donors, Multi-detector computed tomography.

KEYMESSAGES

Kidney Transplantation, although the most cost-effective and preferred treatment in patients with end-stage renal disease, is limited by severe shortage of cadaver kidneys. To ameliorate this limitation, use of living donors is now widely accepted. Preoperative evaluation of living donor with MCDT is important to select the appropriate kidney for transplantation and to decrease donor surgical complications.

INTRODUCTION

Kidney Transplantation, although the most cost-effective and preferred treatment in patients with end-stage renal disease, is limited by severe shortage of cadaver kidneys.[1] To ameliorate this limitation, use of living donors is now widely accepted, in particular because it results in better recipient and renal graft survival.[2,3] It has been shown that transplantation survival for kidneys from living donors, is higher than cadaveric sources (80% vs. 67% at 5 years).[4] Increasing success in the harvest of donor kidneys and development of less invasive laparoscopic nephrectomy also contributed to

substantial growth in living-donor kidney transplantation.[2,3,5]

To minimize donor risk and preserve maximum graft function, precise evaluation of the donor is a major focus during preoperative preparation.[6–9] Laparoscopic surgery has definite advantages over the open approach. However, conversion to the open approach is not infrequent, with vascular injury the most common reason.[9–11] Therefore, special attention must be paid to preharvest assessment of donor renal vessels in surgery planning. Anatomical evaluation of the donor kidneys is essential to select the kidney to be used and to choose the appropriate surgical approach.[12]

Multidetector Computed Tomography (MDCT) is less invasive technique with advantages over conventional catheter angiography and excretory urography for assessment of potential renal donors.[13]

The Objective of this study was to observe the accuracy of MDCT to evaluate vascular anatomy in potential living renal donors using surgical findings as reference standard.

SUBJECTS AND METHODS

This is a prospective observational study of 30 consecutive potential renal donors who underwent MDCT at our hospital between June 2012 to May 2014. All candidates were evaluated using 64 slice MDCT scanner with 0.6 mm collimation 120 kVp (Somatom Sensation 64; Siemens Medical Solutions; Forchheim, Germany).

Selection criteria were age more than 18 years; candidate should be tobacco free since eight weeks prior to donation; normal renal function tests; non-reactive for HIV/AIDS, Hepatitis B and C; not a known case of Hypertension, Diabetes, Coronary heart disease, valvular heart disease or Peripheral vascular disease. Exclusion criteria were ABO Incompatibility with potential recipient; Known case of Diabetic or Hypertensive Nephropathy; BMI > 35 Kg/m2; Donors with family history of polycystic kidney disease; Patients on Nephrotoxic drugs like Aspirin, Ibuprofen, Valdecoxib, etc.

Prior Informed consent from each patient was taken. A plain scan of the kidneys was first acquired (Fig.1 a). Subsequently, using a mechanical injector, 70 to 80 ml of nonionic iodinated contrast material containing 300 mg/mL of iodine (Omnipaque) was administered intravenously at 4 to 5 mL/sec via 18-gauge cannula placed in an antecubital vein. Bolus tracking method was used to obtain arterial phase (Fig.1 b) images followed by venous phase (Fig.1 c at about 40-60 seconds after contrast injection. Delayed images were then acquired after about 5 to 10 minutes. All images were transferred to a workstation (Somatom Sensation 64; Siemens Medical Solution, Germany) and reconstructed for CT angiography and CT urography using maximum intensity projection (MIP), a volume-rendering technique (VRT) (Fig.3), and multiplanar re-formation. The respective reconstruction increments were 1 mm (unenhanced phase), 1 mm (vascular phases) and 1.5 mm (excretory phase). The images were reviewed for anatomical details including renal system and its vascular anatomy.

Nephrectomy was then performed in donors. Intra-operatively, the surgeon noted the number, location, and course of renal arteries and veins, the presence of early arterial branching, and number of ureter. The surgical findings at each donor nephrectomy constituted the standard of reference for the imaging findings.

RESULTS

Thirty patients underwent open donor nephrectomy. Most of the subjects (96.7%, 29 pts) were donors of left sided Kidney while only 3.3% were right kidney donors. The mean age of the study subjects was 47.7 ± 9.9 years. Two third (20 patients) of the patients belonged to age group of 41 to 60 years. Out of the total, 70% of the donors were females (21 patients) while 30% were males (9 patients). Right sided calculus was observed in 23.3% (7 patients) subjects while only 1 case had left sided calculus**.** Left sided cortical cyst was observed in 23.3% (7 patients) subjects and none on right side.

On left renal side, out of total 30 patients, 66.6% (20 patients) subjects had single renal artery, 16.7% (five patients) had single artery with prehilar branching pattern (Fig. 2) and 16.6% (five patients) had accessory renal artery (Fig.3). One patient out of 20 single renal artery patients had proximal renal artery plaque.

On right renal side, out of total 30 patients, 66.6% (20 patients) subjects had single renal artery, 20% (six patients) had single artery with prehilar branching pattern, 9.9% (three patients) had accessory renal artery and 3.3% (one patient) two renal arteries (two renal arteries of same caliber). One patient out of 20 single renal artery patients had mid renal artery plaque while in one patient with two renal arteries, proximal artery had plaque.

Dual renal vein was observed in a single subject on right side while no dual renal vein on left side but 23.3% (seven) patients had retroaortic course (Fig.4). On both sides, single renal ureter found in all 30 patients without any duplications.

In our small observational study, using the intra-operative as standard reference, the overall accuracy for depicting surgically relevant arterial, venous and ureteric variants was 96.66%, 100% and 100% respectively.

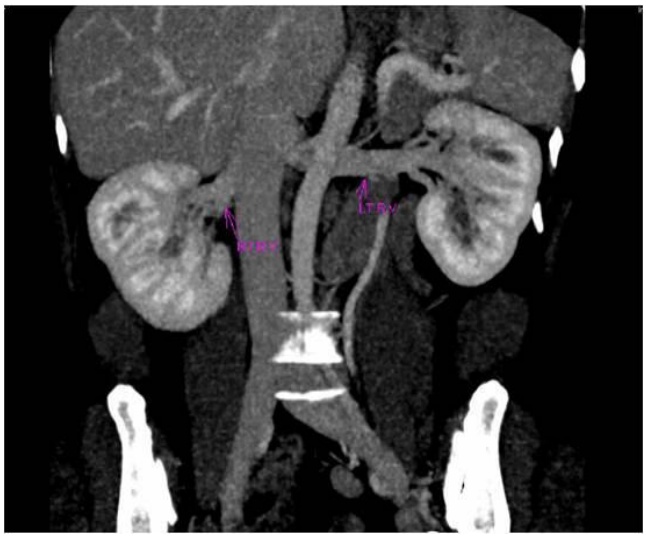

Fig 1.

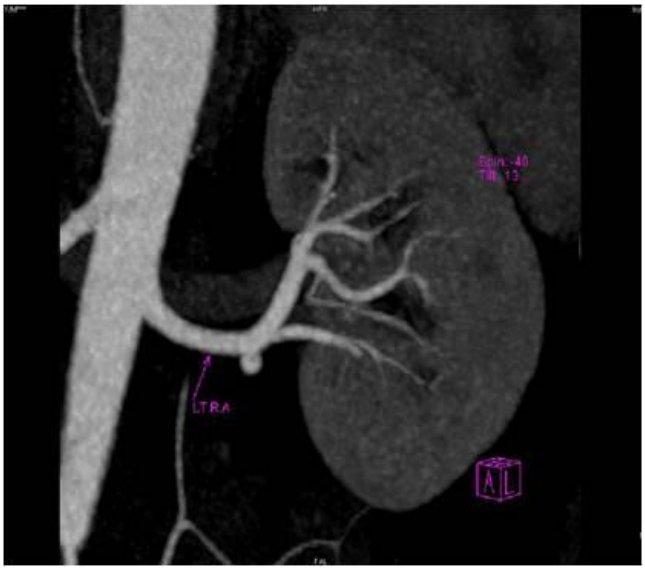

Fig 2.

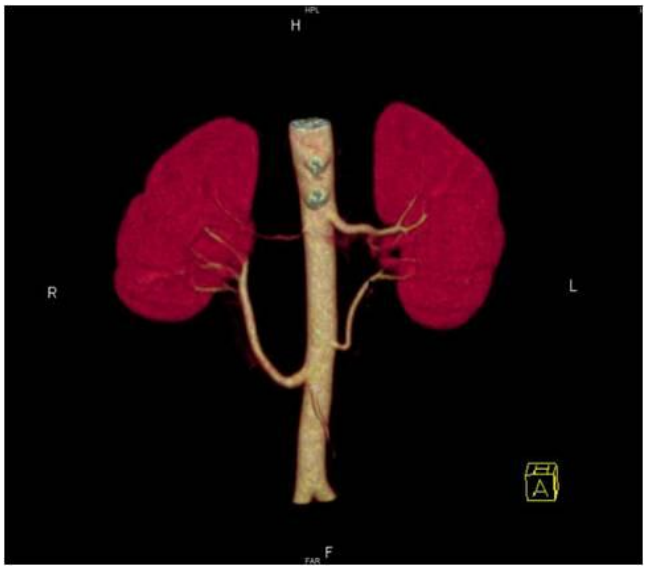

Fig 3.

Fig 4.

Figure legends

Figure 1 (a): Plain MDCT Axial image showing normal both kidneys.

Figure 1 (b): MDCT renal angiography arterial phase – Axial Maximum Intensity Projection (MIP) reconstruction image showing normal appearing single renal artery on both sides.

Figure 1 (c): MDCT renal angiography venous phase – Coronal MIP reconstruction image showing normal appearing single renal vein on both sides.

Figure 2: MDCT renal angiography arterial phase in another patient – coronal MIP reconstructed image showing single left renal artery with prehilar branching.

Figure 3: MDCT renal angiography arterial phase in another patient – anterior volume rendered reconstructed image showing main renal artery with accessory renal artery on both sides.

Figure 4: MDCT renal angiography venous phase in another patient – coronal MIP reconstruction image showing two renal veins on right side and retroaortic renal vein on left side.

DISCUSSION

A Prospective Observational study was conducted with the aim of evaluating the role and accuracy of MDCT in the pre-operative work up of potential renal donors. Medical work-up, renal functional assessment and anatomic technical considerations including confirmation of the absence of any parenchymal disease or tumours are crucial during the evaluation of potential living renal donor and contribute to the decision to accept the donor and on the side of nephrectomy.[14] In a healthy donor the left kidney is usually harvested because of its longer pedicle.

Digital subtraction angiography (DSA) has been used to recognize the number and length of renal arteries and assessment of unsuspected renal artery diseases such as atherosclerosis, aneurysm or fibromuscular dysplasia and renal parenchymal diseases such as cyst, scar or tumor. Although DSA is an accurate technique for this proposes,

it is invasive, expensive and accompanies with more major complications such as arterial perforation, thrombosis and hematoma [(15)]. Development of CT technology currently allows faster scanning and MDCT scanners have provided more detailed data sets than single detector spiral CT. Three-dimensional (3D) CT angiography has been reported to be as accurate as renal angiography for arterial anatomy.[16] CT scan with IV contrast provide assessment of renal parenchyma, pyelocalyx system, ureteral anatomy so MDCT scan can be used as one step evaluation of potential renal donor including evaluation of renal parenchyma, arteries and veins.[15]

Mean age of the subjects in our study was 47.7 ± 9.9 years. Two third of the patients belonged to age group of 41 to 60 years. Out of the total, 70% of the donors were female while 30% were male. Our findings were in accordance with a study conducted by Asghari et al.[15] to compare the accuracy of the use of multi-detector computed tomography (MDCT) to evaluate vascular anatomy in living kidney donors with traditional angiography. In a similar study by Kawamoto et al., 74 consecutive living kidney donors who underwent MDCT were evaluated. The mean age of study subjects was 41.7 years, with 30 men and 44 women.[8]

Detection of calculus is important to determine if a renal stone must be treated before the kidney is removed or if it requires no treatment at all. In asymptomatic donors, a kidney with small calculi (<4 mm) may be safely harvested, particularly if calculi are located in the lower inferior pole and the donor has no history of lithiasis or metabolic disease.[17] It is important to monitor the recipient for development of obstructive transplant stones. Kidneys with multiple stones or a single stone larger than 5 mm are excluded from donation until the calculi are removed and metabolic analysis is performed. The presence of renal cysts does not exclude kidney donation. It is important to evaluate the characteristics of the cyst to determine if a solid mass is present. Simple, even large, cysts may be easily excised, a procedure that does not increase morbidity for the transplant recipient.[18] In our study calculus was observed in 26.7% (eight patients) subjects while simple cortical cyst was observed in 23.3% (seven patients) subjects. Similar findings were observed by Steven S et al., who found that incidental parenchymal and urothelial abnormalities, most commonly cysts and calyceal calcifications, were identified in 30% of the kidneys.[19]

Renal artery variations are common in the general population and the frequency of variations shows social, ethnic, and racial differences. Multiple renal arteries are the most important frequent finding in potential renal donor and have been reported in 24-27% of renal arteriogram.[20] Beregi JP et al.[21] showed that CT angiography had a sensitivity of 95% for main renal artery stenosis. Limitation of CT angiography is in the diagnosis of fibromuscular hyperplasia and use of contrast media in it.[22] Magnetic resonance angiography has been used for evaluation of renal donors with reported sensitivity and specificity for main renal stenosis of 93-100% and 92-98%.[23] Low ability to determine calcifications, high cost and limited access to MRI centers are limitations of MR angiography.

Double and triple veins usually are seen in the right kidney and are present in 15% of donors. The circumaortic and retroaortic veins (present in 6% and 3% of donors, respectively) are the most common major venous variants in the left kidney and are related to the embryologic development of the IVC.[24]

In our study, on left renal side, 66.6% (20 patients) subjects had single renal artery, 16.7% (five patients) had single artery with prehilar branching pattern and 16.6% (five patients) had accessory renal artery. Out of 20 patients with single renal artery, one patient had proximal renal artery plaque. On right renal side, 66.6% (20 patients) subjects had single renal artery, 20% (six patients) had single artery with prehilar branching pattern, 9.9% (three patients) had accessory renal artery and 3.3% (one patient) two renal arteries (two renal arteries of same caliber). Out of 20 patients with single renal artery, one patient had mid renal artery plaque while in a patient with two renal arteries, proximal renal artery had plaque. Dual renal vein was observed in a single subject on right side while no dual renal vein on left side but 23.3% (seven) patients had retroaortic course. On both sides, single renal ureter found in all 30 patients without any duplications. Our results are comparable to studies done by Raman SS et al[19], Okzan et al.[25] and Dushyant VS et al.[26]

In this study, we analyzed MDCT with 64 channel scanner and observed that overall accuracy of MDCT for depicting surgically relevant arterial, venous and ureteric variants was 96.66%, 100% and 100% respectively. In one patient, a tiny accessory renal artery missed on left side. Zhang J et al. in their study showed that multi-detector-row computed tomography is helpful in accurately evaluating the renal anatomy of potential donors, thus facilitating planning of surgery.[27] Kawamoto S et al. in their study mentioned that multi-detector row CT scanners offer shorter image acquisition time, narrower collimation, better spatial resolution, and less tube heating than single-detector row CT scanners. Multi-detector scanners also provide more complete anatomic coverage, increased contrast enhancement of the arteries, and greater longitudinal spatial resolution, all of which are important both for accurate imaging of the renal vasculature and for three-dimensional post processing of image data. They also recommended making the most effective use of this method; radiologists must be familiar with its technical aspects, advantages, and potential pitfalls. They also must be able to identify variations in vascular, renal and extra renal anatomy that are important for donor nephrectomy.[6] MDCT has become a single most first line imaging method for pre-

operative evaluation of renal donors, replacing conventional angiography and urography. More important, for pre-surgical planning, MDCT provides highly accurate imaging of the renal collecting and vascular systems, especially in revealing vascular variations.

IN CONCLUSION

MDCT angiography is a safe, non-invasive, first line and highly accurate imaging technique for detection of renal, their vascular and ureteric abnormalities in potential living renal donors.

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