

Anatomical Evaluation of Renal Arteries and Veins in Kidney Donors by CT Angiography

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Abstract

Background: Renal transplantation (RT) is the transplantation of a kidney into a patient with end-stage renal disease and has become the treatment of choice for most patients with end-stage renal disease. The knowledge of renal vascular variations is of a great importance for the surgeons who approach the kidneys from the retroperitoneal or laparoscopic route for renal transplants. The aim of this study was to detect renal vascular variations of kidney donors in Kerman by using CT angiogram.

Methods: This cross-sectional study examined the CT angiograms of all kidney donors referred to the Radiology Ward of Shafa Medical center affiliated to Kerman University of Medical Sciences from 2010 to 2012.

Results: The results of CT angiograms of 344 kidney donors were as follow: Right Renal Arteries: 236 cases with one artery; 97 cases with two arteries; 9 cases with three arteries; and one case with four arteries Left Renal Arteries: 225 cases with one artery; 103 cases with two arteries; and 16 cases with three arteries Right Renal Veins: 277 cases with one vein and 12 cases with two veins Left Renal Veins: 279 cases with one vein and 10 cases with two veins.

Conclusion: There is no significant difference between our results and those of previous studies. In more than 30% of cases, our findings were associated with other incidental findings.

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Introduction

Organ transplantation has been one of the most important medical successes in past century. There are numerous stories on this issue from the prehistoric times which are unwritten and thus they cannot be labeled as fact or fiction. However, the first recorded organ transplantation dates back to the first half of the first century A.D., when following the illness of a Parthian noble, blood transfusion was conducted by a Persian

physician named Agias. The procedure was performed by blood transfusion from son to father and provided the patient with more time to manage some of his affairs before death. What is noteworthy is that the named physician knew about blood type incompatibility and a first degree relative was selected as blood donor (1).

Organ transplantation was a point of consideration in the second and third centuries, but most of the performed cases

failed. There are some reports of transplantation of skin and other organs (2). According to some studies, Avicenna performed nerve graft (3). Organ transplantation has received serious attention since the 1900s. Following his studies on the immune system in 1970, Peter Medawar created a turning point in organ transplantation (4). Discovery of cyclosporine and suppressing the immune system accelerated organ transplantation across the world (2).

Organ and tissue transplantation have a long history in Iran too. The first corneal transplantation in Iran was performed by Professor Shams in Farabi Hospital, Tehran in 1935 and the first renal transplantation was performed in 1963 at Shiraz University (6, 5). The first renal transplantation in Kerman was performed by Azizolahi at Shafa Medical Center in 1991 (unpublished data).

Renal transplantation (RT) is the transplantation of a kidney into a patient with end-stage renal disease. RT is typically classified as deceased-donor or living-donor transplantation. Living-donor renal transplants are further characterized as genetically related (living-related) or non-related (living-unrelated) transplants, depending on whether a biological relationship exists between the donor and the recipient or not. RT has become the treatment of choice for most patients with end-stage renal disease. The superiority of RT over dialysis has been well established, warranting a better quality of life and an improved survival for all patients, including those with advanced age (7).

Donors must be healthy individuals. If a donor has a past history of suffering from some problems, or if these are discovered during the medical evaluation, a donor may be declined.

The knowledge of the renal vascular variations is of extreme importance for the surgeons who approach the kidneys from the retroperitoneal or laparoscopic route for renal transplants (8). Modern multislice CT (MDCT) and MRI scanners allow highly accurate evaluation of the vascular

anatomy, especially for vessels of ≥ 2 mm diameter (9,10). CTA may provide slightly better depiction of very small arteries (11). Overall, the accuracy of renal main artery anatomy was 100% for both CTA and conventional angiography. Accuracy of renal main vein anatomy was 97.1% and 96.6% for CTA and conventional angiography respectively (12). MDCT angiography is highly accurate for detecting vascular anomalies and providing anatomic information for laparoscopic living donor nephrectomy (13). The renal arteries show ethnic and racial differences (14). The occurrence of these variations is important because of the gradual increase of interventional radiological procedures, urological vascular, and transplantation surgeries (15). In Kerman there has been no study on the variations of renal arteries by CTA. Therefore, our goal was to determine these variations across normal population of Kerman.

Compared to single-detector helical CT, multi-detector CT (MDCT) offers shorter image acquisition times, reduction in tube heating, and improved spatial resolution. MDCT has been used to evaluate the renal vasculature (16-18) and promising results have been reported.

Method

In this cross-sectional study, CT angiograms of all kidney donors referred to the Radiology Ward of Shafa Medical center affiliated to Kerman University of Medical Sciences from 2010 to 2012 were evaluated. Angiography was conducted by 16-slice, multi-detector, TOSHIBA CTS canner TSX-101A (Japan) using 300 mg Lopaque contrast. Data analysis was performed through SPSS16 and using Chi square test.

Results

CT angiograms of 344 kidney donors were examined. Of the images, 270 items were taken from men and 74 items, from women, in the age range of 19-55 years old, at an

average age of 28 yrs. Images of both kidneys of donors were studied concerning arteries and veins. The results were as follow:

Right Renal Arteries: 236 cases with one artery; 97 cases with two arteries; 9 cases with three arteries; and one case with four arteries (Table 1)

Left Renal Arteries: 25 cases with one artery; 103 cases with two arteries; and 16 cases with three arteries (Table 2)

Right Renal Veins: 277 cases with one vein and 12 cases with two veins

Left Renal Veins: 279 cases with one vein and 10 cases with two veins (Table 3)

In cases with two veins (left side), one vein crossed the front and another behind the aorta and entered the inferior vena cava. The left renal vein was placed behind the aorta in 10 cases (7 men and 3 women). There was one case of aortic aneurysm, one case of left renal artery aneurysm, two cases of aortic stenosis, two cases of celiac artery stenosis, and one case of left renal artery stenosis in men and there was one case of multiple aneurysms and one case of left renal artery stenosis in women. Stenosis of other arteries (renal, aortic and celiac, aortic aneurysm) was observed in 14 cases.

Twenty two cases had two veins (six cases were female and sixteen cases were male). The gender difference was not significant for both right kidney ($P=0.240$) and left kidney ($P=0.650$). Two men had three veins. One case had congenital abnormality of inferior vena cava. Forty three cases did not have any report about veins (missing data).

Out of 107(31%) cases of incidental findings [female 26 (35%), male 81(30%)] without significant differences, 30 cases were renal cysts. The results are shown in Table 4.

Aortic branch points were, most of all, seen at L1-L2.

Early branching of the right kidney was seen in 42 cases, and for the left kidney, it was seen in 30 cases.

Table 1: Frequency Distribution of the Number of Right Renal Arteries based on sex

No. of Arteries	Men	Women	Total
One	184 (74%)	52 (26%)	236
Two	79 (84%)	18 (16%)	97
Three	6 (66%)	4 (34%)	10
Total	270 (77.5%)	74 (22.5%)	344

Sex difference is not significant ($P=0.187$)

Table 2: Frequency Distribution of the Number of Left Renal Arteries based on sex

No. of Arteries	Men	Women	Total
One	173 (77%)	52 (23%)	225
Two	84 (82%)	19 (18%)	103
Three	13 (81%)	3 (19%)	16
Total	270 (79%)	74 (21%)	344

Sex difference is not significant ($P=0.374$)

Table 3: Frequency Distribution of the Number of Renal Veins based on sex

No. of Veins	Men	Women	Total
One Right Vein	213	64 (17.9%)	277(100%)
Two Right Veins	9	3	12
One Left Vein	215 (81.7%)	64 (18.3%)	279 (100%)
Two Left Veins	7	3	10

Table 4: Frequency Distribution of Incidental Findings based on Sex

Finding	Men	Women	Total	P Value
Renal Cyst	25	5	30	0.602
Lymphadenopathy	17	6	23	0.162
Hepatic hemangioma	9	3	12	0.472
Splenomegaly	6	2	8	0.472
Renal Anomalies	13	8	21	---
Other	12	1	13	---

Renal Anomalies Include: focal atrophy, urethral dilatation, stone, and calcification

Other: fatty liver, adrenal tumor, lipoma, and kidney stone

Discussion

In our study, donors mostly had single artery which is very desirable for renal transplantation. Multiple arteries were seen on the right side in 31% (Table 1) and on the left side in more than 34% of the cases (Table 2). In comparison, the results were similar to the majority of previous reports. In a study on 204 kidneys in India, single renal artery was reported in 74.5% and single renal vein was seen in 87.5% of the cases. Multiple renal arteries were more common on the left side (31%) than on the right side (20%) (19). In a study in South Korea on 153 cases of living donors, the prevalence of multiple renal arteries were 31% (20). Eighteen supernumerary renal arteries (24% of the donated kidneys; two arteries to 16 kidneys and three arteries to one kidney) were found to 74 donated kidneys at surgery (13). A total of 115 renal arteries in 60 kidneys of donors were depicted by (CTA). Only 57 kidneys (49%) were shown to have more than one or multiple arteries, 52 kidneys had two, and 6 ones had three renal arteries (21). In another study, 80% of the cases had one artery (22) and in a study on 102 subjects, multiple arteries was seen in 12% of the cases (23).

In our study, single renal vein was seen in 94% of the cases (without significant differences between right and left kidneys) and this finding is similar to most previous reports (Table 3). In a study on Indian renal donors, multiple renal veins were mostly on the right side (20%) than on the left side (5%), and one patient was found to have double inferior vena cava (19). In one study, twenty-five renal vein anomalies were detected only by CT in 154 donors (24). In another study, more than 98% had one vein (22). In another study on 102 subjects, multiple veins (7%), late venous confluence (5%), circumaortic renal veins (5%), and retroaortic vein (1%) were reported as the anatomical variants of veins (23). In a similar study, 156 consecutive patients underwent open donor nephrectomy following pre-operative MDCTA and venous

anomalies were seen in 13 cases (25). Multiple veins were seen in 5% of 153 Korean subjects (20).

In our study, early branching in the right renal artery was seen in 13% of the cases, and in the left renal artery it was seen in 7% of cases which is similar to the findings of some other reports. In one study, early branching of the arteries was seen with equal frequency on the right and left sides (19) and in a number of Korean subjects, it was seen in 12% (20). According to another study, early branching of the renal arteries was observed in 14 arteries (13). Pre-hilar branching in 2 cases out of 30 donors (R=2 L=0) (22) and early arterial bifurcation in 13% of the cases (23). are some other reported results. In a study on 156 subjects, early branching was seen in 30 cases (25).

In the present study, the incidental findings (extra renal) were seen in more than 31% of the cases and renal cysts were as the most frequent ones (Table 4). In a study done about incidental findings in lumbucasral MRI, the rate of incidental findings was approximately 30% (26). A majority of studies have reported similar results. According to a study on 154 subjects, nonvascular renal findings included renal calculi (n = 11), cysts (n = 12), duplicated ureters (n = 6), horseshoe kidney (n = 1), and pelvic kidney (n = 1) (24). A similar study on 102 donors, using CT, revealed cortical cysts (four cases), duplex collecting system (two cases), hydronephrosis (one case), renal stone (one case), and liver haemangioma (two cases) (20). Yet, in another study on 30 kidney donors, 3 cases of renal cyst (5%) and one case of renal calculus (1.67%) have been reported (22). Urethral duplication was seen in 2% of the cases in a similar study (23).

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References

- Zadeh KA. Roman slave. 3rd ed., Tehran, Heydari press; 2009.
- Zahedi F, Fazel I, Larijani B. An overview of organ transplantation in Iran over three decades: with special focus on renal transplantation. *Iranian Journal of Public Health* 2009; 38(Suppl. 1):138-49.
- AkhlaqPezeshki be-enzemamemokhtasaryaztarikhpezeshki. Tehran, Sepehr press; 1991 [In Persian].
- Starzl TE. Peter Brian Medawar: father of transplantation. *Journal of the American College of Surgeons* 1995; 180(3):332.
- Ghods AJ. Renal transplantation in Iran. *Nephrol Dial Transplant* 2002; 17(2):222-8.
- Broumand B. Living donors: the Iran experience. *Nephrol Dial Transplant* 1997; 12(9):1830-1.
- Wolfe RA, Ashby VB, Milford EL, Ojo AO, Ettenger RE, Agodoa LY, et al. Comparison of mortality in all patients on dialysis, patients on dialysis awaiting transplantation, and recipients of a first cadaveric transplant. *N Engl J Med* 1999; 341(23):1725-30
- Fernandes RMP, Conte FHP, Favorito LA, Abidu-Figueiredo M, Babinski MA. Triple right renal vein: an uncommon variation. *Int J Morphol* 2005; 23(3):231-3.
- Sutton D. Text book of radiology and Imaging. 7th ed., London, Churchill Livingstone 2003.
- Helms C, Brant WE. Fundamentals of diagnostic radiology. 7th ed., Edinburgh, Churchill Livingstone, 2007; pp 982-6
- Engelken F, Friedersdorff F, Fuller T, Magheli A, Budde K, Halleck F, et al. Pre-operative assessment of living renal transplant donors with state-of-the-art imaging modalities: computed tomography angiography versus magnetic resonance angiography in 118 patients. *World J Urol* 2013; 31(4):983-90.
- Razavizadeh RT, Tabasi KT, Rana TM. Pre-operative evaluation of living kidney donors using computerized tomographic angiography (CTA) and conventional angiography: comparison with intraoperative findings. *Saudi J Kidney Dis Transpl* 2012; 23(3):471-6.
- Kawamoto S, Montgomery RA, Lawler LP, Horton KM, Fishman EK. Multidetector CT angiography for preoperative evaluation of living laparoscopic kidney donors. *American Journal of Roentgenology* 2003; 180(6):1633-
- Boijesen E. Renal angiography: techniques and hazards; anatomic and physiologic considerations. *Vascular and Interventional radiology*. 1997; 4:1101-31.
- Khmanarong K, Prachaney P, Utravichien A, Tong-Un T, Sriporaya K. Anatomy of renal arterial supply. *Clinical anatomy* 2004; 17(4):334-6.
- Behar JV, Nelson RC, Zidar JP, DeLong DM, Smith TP. Thin-section multidetector CT angiography of renal artery stents. *American Journal of Roentgenology* 2002; 178(5):1155-9.
- Scatarige JC, Horton KM, Ratner LE, Fishman EK. Left adrenal vein localization by 3D real-time volume-rendering CTA before laparoscopic nephrectomy in living renal donors. *Abdom Imaging* 2001; 26(5):553-6.
- Rydberg J, Kopecky KK, Tann M, Persohn SA, Leapman SB, Filo RS, et al. Evaluation of Prospective Living Renal Donors for Laparoscopic Nephrectomy with Multisection CT:

- The Marriage of Minimally Invasive Imaging with Minimally Invasive Surgery 1. *Radiographics* 2001; 21(suppl_1):S223-S36.
19. Patil UD, Ragavan A, Murthy K, Shankar R, Bastani B, Ballal SH. Helical CT angiography in evaluation of live kidney donors. *Nephrol Dial Transplant* 2001; 16(9):1900-4.
 20. Chai JW, Lee W, Yin YH, Jae HJ, Chung JW, Kim HH, et al. CT angiography for living kidney donors: accuracy, cause of misinterpretation and prevalence of variation. *Korean J Radiol* 2008; 9(4):333-9.
 21. Sattar A, Naeem S, Ali A, Akhtar M, Rizvi A, Naqvi A. Evaluation of Number of Renal Arteries in Live Related Renal Donors by CT Angiography and Conventional Angiography. *International Journal of Endorsing Health Science Research* 2014; 2 (1):1-15.
 22. Alam A, Chander BN, Joshi DP. 3-D spiral computerised tomographic angiography in evaluation of potential renal donors. *Med J Armed Forces India* 2003; 59(3):205-8.
 23. Kulkarni S, Emre S, Arvelakis A, Asch W, Bia M, Formica R, et al. Multidetector CT angiography in living donor renal transplantation: accuracy and discrepancies in right venous anatomy. *Clin Transplant* 2011; 25(1):77-82.
 24. Platt JF, Ellis JH, Korobkin M, Reige K. Helical CT evaluation of potential kidney donors: findings in 154 subjects. *AJR American journal of Roentgenology* 1997; 169(5):1325-30.
 25. Shashikala P, Anjali W, Anshuman N, Jayshree D. A case report: double renal arteries. *International Journal of Anatomical Variations* 2012; 5:22-4.
 26. Laugharne M, Haslam E, Archer L, Jones L, Mitchell D, Loveday E, et al. Multidetector CT angiography in live donor renal transplantation: experience from 156 consecutive cases at a single centre. *Transplnt* 2007; 20(2):156-66.
 27. Saba M, Ebrahimi H-A, Ahmadipour H, Taziki M-A. Evaluation of Incidental Findings on Lumbosacral MRI in Patients with Low Back Pain. *Journal of Kerman University of Medical Sciences* 2015; 22(4):433-9 [In Persian].