CLINICAL PRACTICE ARTICLE

Diagnostic accuracy of CT angiography in evaluation of vascular anatomy in comparison with intraoperative findings an assessment of 392 patients [version 1; peer review: peer review discontinued]

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Abstract

Introduction: Transplantation of kidneys from living related donors is the treatment of choice for patients with end stage renal disease. With less

morbidity and early recovery, laparoscopy has become the standard of care for donor nephrectomies. The precise knowledge of vascular anatomy is crucial to a successful outcome. Computed tomography (CT) findings are misleading and less informative in a small number of cases. The reported accuracy of CT angiography in assessing the vascular anatomy is around 85 to 100 %. We did a prospective study to assess the diagnostic accuracy of CT angiography in the evaluation of vascular anatomy in comparison with intra operative findings.

Aim: To assess the accuracy of CT in predicting the anatomy in patients who underwent laparoscopic donor nephrectomy.

Materials and methods: 392 patients who underwent laparoscopic donor nephrectomy in our institute between January 2010 and December 2012 were included in our study.

Results: CT scan correlated well with the intra operative findings in most of our patients with good sensitivity and specificity. CT interpreted a case of double renal vein as single and a case of circum-aortic vein reported on CT was not detected intra operatively. A case of right side early branching was not detected on CT. A case of a retro-aortic branch of renal vein was missed on CT scan. The incidental findings detected on CT scan such as calculi, mass and hemangioma or fibroid can be of help in managing the patient after surgery.

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Keywords

Computed tomography , Conventional angiography , laparoscopic donor nephrectomy , renal artery , renal vein , Vascular anatomy

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Introduction

Renal transplantation is the treatment of choice for patients with end stage renal disease. With less morbidity and early recovery laparoscopy has become the standard of care for donor nephrectomies¹⁻³. Laparoscopic donor nephrectomy has a steep learning curve and the most limiting factor of the surgery is the vascular anatomy of the kidney. There are different ways of imaging the kidney before donor nephrectomy. These include conventional angiography (CA), digital subtraction angiography (DSA), computed tomography (CT) and magnetic resonance imaging (MRI).

The most preferred imaging modality worldwide is CT angiography. Traditionally conventional angiography was used for assessing the vascular anatomy in case of donor nephrectomies. The advantages of conventional angiography is that it uses less dye than CT angiography and it gives information regarding differential contribution in case of multiple arteries. The drawback of conventional angiography is that it does not delineate the venous anatomy. It does not give an idea about the surrounding anatomy and their relations. Conventional angiography is not useful in diagnosing associated findings such as gall stones and adnexal pathologies. The disadvantage of CT angiography is the larger amount of contrast used and the radiation exposure.

There is paucity of literature describing the accuracy of CT angiography in detecting the vascular anatomy. The reported accuracy of CT angiography in assessing the vascular anatomy is around 85 to 100%^{4,5}. We did a retrospective study to assess the diagnostic accuracy of CT angiography in evaluation of vascular anatomy in comparison with intraoperative findings in 392 patients who underwent laparoscopic donor nephrectomy in our hospital from January 2010 to December 2012.

Materials and methods

392 consecutive patients who underwent laparoscopic live donor nephrectomy from January 2010 to December 2012 were included in the study. Their CT scan findings were noted from the stored archives of our hospital. The data of patients who did not consent to participate in the study were excluded. All CT data were obtained using a 4-MDCT scanner. The parameters noted in the CT angiography are the artery and vein number on both the sides, any prehilum branching, the number of lumbar veins, relationship of the artery to the vein and other morphological abnormalities or any other incidental findings. Ethical approval was obtained from the institutional ethics committee (EC/317/2015).

The patients were accepted for donor nephrectomy after approval by the transplant board of the hospital and after due clearance from the regulatory authorities. Donor nephrectomy was done using a laparoscopic approach and recipient surgery was done using an open approach. One patient required conversion to open surgery. The intraoperative findings noted were the artery and vein number, prehilum branching, and lumbar vein anatomy. The intraoperative findings were recorded by viewing all the operative videos of patients who underwent laparoscopic donor nephrectomy. All the data obtained were analysed. The preoperative findings in terms of number of artery, vein, and lumbar vein were compared with the intraoperative findings. The specificity, sensitivity, and positive and negative predictive values were calculated. Any incidental finding present during the surgery was also noted.

Results

Of the 392 patients who underwent laparoscopic live donor nephrectomy, 353 patients underwent left donor nephrectomy and 39 patients underwent right donor nephrectomy. Of the 392 patients, 263 were females and 129 were males. In 353 patients who underwent left donor nephrectomy, 26 patients had double renal artery and 17 had double renal vein. Two had both double artery and vein. Triple renal artery was found in 4 patients and triple renal vein was found in 1 patient and the rest had single renal artery and vein. Two patients had double ureter. In 39 patients who underwent right donor nephrectomy, 5 had double vein and 1 had double artery and the rest had single renal artery and vein. The CT scan was able to identify prehilum branching on both sides in 84 patients, on the left side in 40 patients and on the right side in 12 patients. The CT angiogram showed retroaortic left vein in 13 patients and circum-aortic renal vein in 7 patients and 1 patient had IVC duplication. The additional findings identified incidentally in CT angiogram are renal calculus in 5 patients bladder mass in one patient, uterine fibroid in 2 patients, renal mass in 1 patient, gall bladder calculi in 2 patients, ovarian cyst in 2 patients, hemangioma of liver in 2 patients, adrenal myolipoma in 1 patient, and utero vesical fistula in 1 patient (Table 1).

Table 1. CT findings of the patients.

Total patients	392
Male : female	263 : 129
Left : right	353 : 39
Left side	
Total	353
Single artery and vein	303
Double artery and single vein	26
Double vein and single artery	17
Double artery and double vein	2
Triple artery	4
Triple vein	1
Right side	
Total	39
Single artery and vein	33
Double artery and single vein	1
Double vein and single artery	5
Prehilum branching	
Left	84
Right	40
Bilateral	12
Venous anomalies	
Retroaortic left vein	13
Circumaortic vein	7
IVC duplication	1
Additional Findings	
Renal calculus	5
Gall bladder calculus	2
Uterine fibroid	2
Ovarian cyst	2
Hemangioma of liver	2
Renal mass	1
Bladder mass	1
Adrenal myolipoma	1
Utero vesical fistula	1

The patient with an utero vesical fistula underwent hysterectomy followed by laparoscopic donor nephrectomy.

CT interpreted a case of double renal vein as single and a case of circumaortic vein reported on CT was not detected intraoperatively. A case of right side early branching was not detected on CT. A case of a retroaortic branch of renal vein was missed on CT scan. Rest of the intraoperative findings were correlating with that of the CT scan.

The intraoperative data was available in the case of 147 patients for lumbar vein and correlated with the CT angiogram in all cases (Table 2).

Single renal artery and vein was found in 86% of patients, 14% of patients had multiple vessels. The incidence of double renal artery was 7.3% on the left side and 12% on right side. The incidence of double renal vein was 4.8% on left side and 2.5% on the right side (Table 3).

Discussion

Precise knowledge of vascular anatomy before laparoscopic donor nephrectomy is vital in avoiding complications as it helps the

surgeon to be better prepared in case of an emergency. The identification of accessory vessels on CT scans helps in avoiding inadvertent injury and reduces complications. When an accessory vessel is identified on CT preoperatively appropriate management of the vessel can be planned i.e bench surgery or separate anastomosis. In our institute it is mandatory for the operating surgeon to study the detailed vascular anatomy of the donor in the CT console before surgery. The surgeon sees the 3D reconstruction of the kidney along with the vascular anatomy. The surgeon discusses the relationship of the artery and vein and the number of vessels with the radiologist and gets the approximate idea about the lie of the artery and vein beforehand which helps in the dissection. Apart from predicting the number of vessels, the CT angiography study helps in strategic planning for laparoscopic donor nephrectomy. For instance in Figure 1, it can be noted that there is a small subcapsular branch from the origin of the artery, the artery lies at the upper border of the vein posteriorly. It shows that the arterial stump is of adequate size. In addition the images show that the splenic vessels are close to the upper pole.

Apart from arterial anatomy, CT angiography also gives us the detailed venous anatomy. For example in Figure 2, it can be seen that the vein branches in two and the adrenal vein is close to the

Table 2. Correlation of vascular anatomy in CT vs surgery.

	CT findings	Intra op findings
Left side		
Single vessels	303	303
Double artery	26	26
Double vein	17	18
Triple artery	4	4
Triple vein	1	1
Prehilar branching	112	112
Retroaortic vein	13	14
Circumaortic vein	8	7
Right side		
Single vessels	33	33
Double artery	1	1
Double vein	5	5
Prehilar branching	96	97

Table 3. Correlation of vascular anatomy in CT vs surgery.

	Sensitivity	Specificity	Positive predictive value	Negative predictive value
Single vessel(bilateral)	100	100	100	100
Double artery(bilateral)	100	100	100	100
Double vein(left)	94.4	100	100	99.7
Double vein(right)	100	100	100	100
Triple vessel(left)	100	100	100	100
Prehilar branching	99	100	100	99.6
Retroaortic vein	92.9	100	100	99.7
Circumaortic vein	100	99.7	87.5	100

Figure 1. CT angiogram picture showing a small subcapsular branch taking off from the origin of renal artery.

Figure 2. CT angiogram picture showing the venous anatomy with detailed reconstruction about the length of common stump and the adrenal vein.

upper branch. This gives an idea about the length of the common stump of the vein.

The location of hilum and the relationship of the kidney with the ribs on CT also helps in deciding the port placement. For example if the hilum of the kidney is above the 12th rib, the ports will be placed cranially and vice versa (Figure 3, Figure 4).

In our study the incidence of single renal artery and vein was 86% which was higher than the literature⁷. The incidence of double

renal artery was 7.3% on the left side and 4.8% on the right side in our study, which was lower in comparison to the literature⁷. The incidental findings detected by CT scan such as calculi, mass and hemangioma or fibroid can be of help in managing the patient after surgery. In our case where we incidentally detected a case of uterovescical fistula, the patient underwent a hysterectomy followed by laparoscopic donor nephrectomy (Figure 5).

The incidence of multiple arteries was 14.2% in our study. The incidence of multiple renal arteries was 9% on the left side which was

Figure 3. 3D reconstructed CT angiogram picture showing the distance between umbilicus and the upper pole.

Figure 4. 3D reconstructed CT angiogram picture showing the relationship of the kidney with the ribs which help in planning regarding the port placement.

Figure 5. CT picture showing a case of utero vesical fistula.

lesser compared to the study by Shetty *et al.*⁷ who reported the incidence rate of 17% on the left side. We had 2% incidence of multiple renal arteries on the right side whereas Shetty *et al.*⁷ did not have any multiple vessels on the right side. The incidence of multiple renal veins was 5.6% on the left side and 12.8% on the right side in our study whereas Shetty *et al.*⁷ reported an incidence of 1% on the left side and 8% on the right side.

The positive and negative predictive value in our study for single artery and vein and double artery was 100 for both the left and right side. In case of double vein on the right side, the positive and negative predictive values were 100 whereas on the left side the positive predictive value was 99.7 and the negative predictive value was 100. In a study by Shetty *et al.*⁷ the positive predictive value and negative predictive value for venous anatomy in left side correlation was 99.5. Similarly for arterial anatomy in left side it is was 96.8. It was 100 for arterial and venous anatomy in the right side⁷. Pozniak *et al.*⁸ mentioned that sensitivity and specificity for identifying specific vessels was 99.6% and 99.6% for main renal arteries, 76.9% and 89.9% for polar arteries, and 98.7% and 95.5% for main renal veins, respectively. Satomi *et al.*⁹ found that CT and surgical findings were accurate in 96% of cases for arteries and 99% of cases for veins.

In comparison with traditional angiography which was used in the past for evaluation of donors, CT angiography has the advantage

of visualisation of venous anatomy and better delineation of extravascular anatomy.

Conclusion

Laparoscopic donor nephrectomy requires vital information regarding the vascular anatomy of the kidney. CT scan helps in accurately mapping the vascular anatomy. CT angiography helps in strategic planning of the surgery in terms of port placement and vascular dissection and helps in avoiding vascular complications. The incidental findings detected by CT scan can also help in holistic management of the patient in donor nephrectomy because it is a zero error procedure.

Consent

Written informed consent for the publication of clinical data and images was obtained from each patient.

Author contributions

MV: substantial contributions to conception and design, acquisition of data, and analysis and interpretation of data and drafting the article or revising it critically for important intellectual content; SG: substantial contributions to conception and design, acquisition of data, and analysis and interpretation of data and drafting the article or revising it critically for important intellectual content; AG: substantial contributions to conception and design,

acquisition of data, and analysis and interpretation of data and drafting the article or revising it critically for important intellectual content; VM: Contributions in acquisition and analysis and interpretation of data and drafting and revising the article; SM: contributions in drafting the article or revising it critically for important intellectual content, and final approval of the version to be published; RS: contributions in drafting the article or revising it critically for important intellectual content; and final approval of the version to be published; MD: contributions in drafting the article

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