International Surgery Journal
Gupta V et al. Int Surg J. 2017 Jun;4(6):1930-1935
http://www.ijsurgery.com
pISSN 2349-3305 | eISSN 2349-2902

DOI: http://dx.doi.org/10.18203/2349-2902.isj20172101

Original Research Article

Multi-detector CT in the pre-operative assessment of live donors for liver transplantation

Vandana Gupta[1]*, Pallavi C. J.[2], Arjun Kalyanpur[3], Dayananda L.[4]

[1]Department of Radiology, MRA Medical College, Ambedkarnagar, Lucknow, Uttar Pradesh, India
[2]Department of Radiology, Narayana Hrudayalaya Hospital Bangalore, Karnataka, India
[3]Department of Radiology, Teleradiology Solutions, Bangalore, Karnataka, India
[4]Department of Radiology, Tata Memorial Hospital, Calcutta, West Bengal, India

Received: 03 May 2017
Accepted: 08 May 2017

***Correspondence:**
Dr. Vandana Gupta,
E-mail: drvandanagupta725@gmail.com

ABSTRACT

Background: Transplantation surgeons are now performing living donor liver transplantation because of the severe shortage of cadaveric livers. This study was undertaken to assess the role of 64-slice multidetector CT in the pre op evaluation of living related liver donors for transplantation.
Methods: This was a prospective correlation study of 26 patients who were referred to the Department of Radiodiagnosis, Narayana Hrudayalaya, Bangalore for evaluation of living related donors for liver transplantation from March 2008 to May 2009.
Results: MDCT has 100% sensitivity, 93.7% specificity in detecting the hepatic arterial anatomy; 100% sensitivity and specificity in detecting portal venous anatomy and its variants, and 93.3% sensitivity and 100% specificity in detecting hepatic venous anatomy.
Conclusions: Multi-detector CT is a single comprehensive, non-invasive and accurate imaging modality for pre-operative and postoperative evaluation of liver transplant patient. It allows an accurate assessment of liver parenchyma, hepatic vascular anatomy, graft volume and detection of post-operative complications in donors and recipients of LRLT.

Keywords: MDCT, Liver transplant, patients

INTRODUCTION

Liver transplantation has become the treatment of choice for end stage acute or chronic liver disease in adults and children when no other effective medical or surgical therapy is available. Over 3000 transplants are performed each year in Europe and 4000 in the United States. Progress in surgical techniques, immunosuppression and medical care have led to an improved survival of around 85-90% at a 1 year in elective cases, with longer term survival almost as good.[1]

Application and success of orthotropic liver transplantation has continued to grow, and liver transplantation has become accepted therapy for several causes of irreversible liver disease.

As of 2008, 90,830 liver transplants had been reported to the United Organ Sharing network since it created a national database in 1988. In 2007, 6,493 liver transplants were performed, while 16,761 patients continue to be on the waiting list for transplantation.[2] The common indications in adults include end stage chronic liver disease due to primary biliary cirrhosis, primary sclerosing cholangitis, autoimmune chronic active hepatitis, cirrhosis due to chronic viral hepatitis and alcoholic liver disease. Biliary atresia and inherited metabolic disorders are common indications in children.[1]

Because of the severe shortage of cadaveric livers, transplantation surgeons are now performing living donor liver transplantation. Because of the complexity of the hepatic resection, preoperative imaging plays an important role in patient selection and surgical planning.

The main goal of pre-surgical imaging is to provide a vascular arterial and venous road map, which is critical for surgical guidance. In addition, the donor's liver parenchyma must be examined for size, shape, incidental lesions, fatty infiltration, or other abnormalities. Knowledge of total and segmental liver volume is equally important to avoid donor-recipient volume mismatch, which may cause graft failure. In potential donors, sufficient left lobe liver volume must be maintained to permit metabolic function during regeneration. Also, the resected right lobe should be large enough to meet the recipient's metabolic demand. Multidetector CT is a technologic advance that permits high-speed and high-resolution helical imaging of the entire liver volume during a single breath-hold. Rapid helical data acquisition has resulted in increased body coverage, decreased motion artifact, better use of contrast bolus, and multiphase organ scanning that allows accurate vascular mapping.

The combination of fast helical scanning and image processing in three-dimensional (3D) and multiplanar reconstructions has resulted in dramatic improvement of image quality and the ability to depict fine anatomic vascular detail.[3] With this background, this study was undertaken to assess the role of 64-slice multidetector CT in the pre-op evaluation of living related liver donors for transplantation.

METHODS

This was a prospective correlation study of 26 patients who were referred to the Department of Radiodiagnosis, Narayana Hrudayalaya, Bangalore, Karnataka, India for evaluation of living related donors for liver transplantation from March 2008 to May 2009. Institutional ethical committee permission was obtained. All cases referred to the department for CT-hepatic angiogram to evaluate the potential living related liver donors were included in the study. All Patients with absolute contraindications to intravenous contrast media were excluded.

Study technique was 18G venocath in a peripheral vein preferably in either of the antecubital fossa was inserted.

Contrast agent used in this study was Iohexol 350 (non-ionic) available as Omnipaque (Nycomed Amersham, Princeton, NJ) or Iodixanol 320 (non-ionic, iso-osmolar) available as Visipaque (Amersham Health, Cork, Ireland).

Contrast volume: 150 ml of contrast with injection rate of 4-5 ml /second.

Mode of administration: power injector (Nemoto pressure injector).

CT hepatic angiography was performed

From the right dome of diaphragm upto the lower pole of kidneys.

All donors were scanned on 64-slice GE - Helical CT (GE high speed advantage) scanner. The following technical parameters were used: KV of 120, mAs of 250-790, rotation time of 0.50sec, table speed of 55 mm/rotation, detector Collimation: 0.625 mm, rows: 64 x 0.625, detector coverage: 40 mm, slice Thickness: 0.625 mm, pitch: 1.375:1, standard algorithm, matrix size: 512 x 512, Window setting: Abdomen and pelvis.

Oral contrast was not given. An 18G venocath in a peripheral vein preferably in either of the antecubital fossa was used for intravenous access. The image acquisition was done in cranio-caudal direction. An initial scanogram of the abdomen was obtained followed by a plain study of the abdomen covering from domes of diaphragm upto the pubic symphis. This is followed by CT hepatic angiography covering from the right dome of diaphragm upto the lower pole of kidneys.

Non-ionic contrast medium namely, Iohexol 350 available as Omnipaque was routinely used. Iodixanol 320 which is a non-ionic, iso-osmolar contrast medium was used in cases of renal dysfunction. 120-150 ml of contrast medium was injected at the rate of 4-5 ml /second using a power injector. 18 seconds delay was given for arterial phase, 50 sec for early portal venous phase and 65 sec for delayed portal venous phase. Volume rendered (VR), maximum intensity projection (MIP), 3D multiplanar reconstructions (3D-MPR) were done on Advantage windows 4.2; GE medical systems, Milwaukee, Wisconsin work station. Liver attenuation index and total liver volumetry were also done using the same workstation.

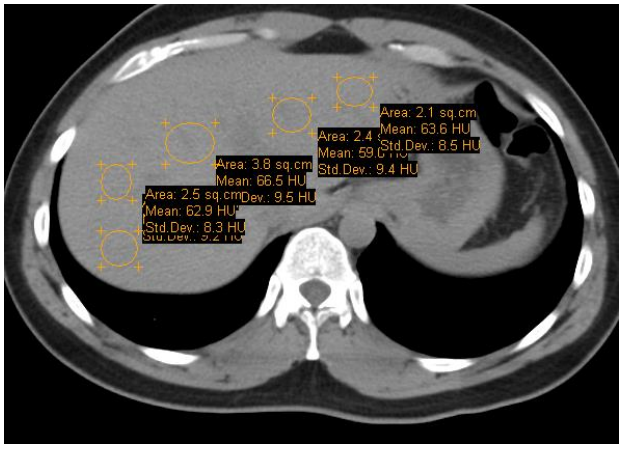

Figure 1: Mean hepatic attenuation.

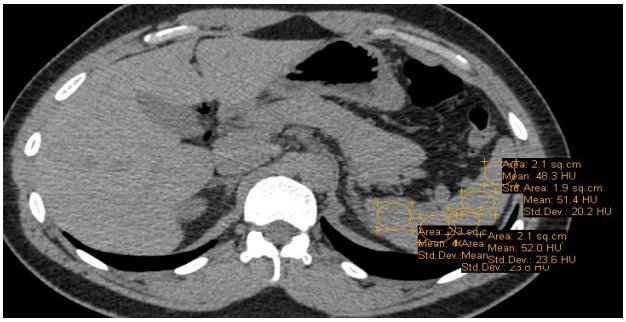

Figure 2: Mean splenic attenuation.

Liver attenuation index was calculated using plain study. Mean hepatic and splenic attenuation in each donor liver was calculated by averaging 25 region-of-interest (ROI) measurements on five sections (five ROIs per section). Liver attenuation index (LAI) was derived and defined as the difference between mean hepatic and mean splenic attenuation. LAI greater than 5 HU correlated with macrovesicular steatosis of <5%. The LAI between -10 and 5 HU correlated well with macrovesicular steatosis in the mild-to-moderate range of 6%–30%. The LAI of less than -10 HU correctly predicted four of four donor livers with greater than 30% macrovesicular steatosis.

Figure 3: Whole liver volume.

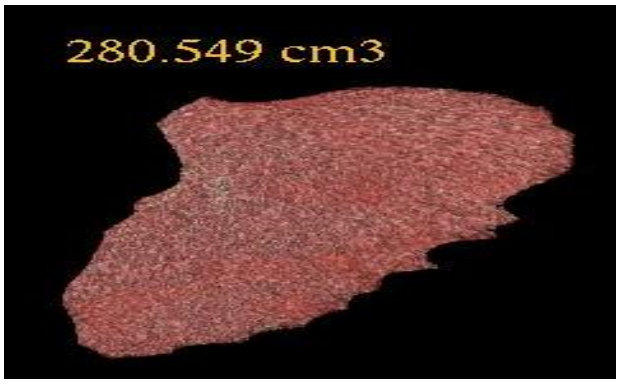

Figure 4: Left lateral segment.

Total liver volumetry was calculated by manually tracing the liver boundary and summation of the liver area on each section excluding the IVC, extrahepatic portal vein, and major fissures. Virtual hepatectomy plane for right lobe harvest is avascular plane 1 cm to the right of MHV; for LLS it is along the falciform ligament.

SPSS software was used for data analysis.

RESULTS

Among the subjects studied, 12 (46.2%) were males and 18 (53.8%) were females.

Maximum subjects belonged to age group between 21-30 years (46.2%), 9 (34.6%) subjects were between 31-40 years and 5 (19.2%) subjects between 41-50 years.

16 (62%) subjects were donors for pediatric patients and 10 (38%) were donors for adult patients.

23 (88.5%) subjects had liver attenuation index of 0-5%; 3 (11.5%) subjects had liver attenuation index of 6-30% and none had greater than 30%.

Among the 26 subjects evaluated by MDCT, 15 subjects were considered fit for liver donation. Intra-operatively the hepatic arterial, portal vein and hepatic venous anatomy were correlated with the pre-op imaging findings. There was no discrepancy between the graft volume calculated by MDCT and that measured intra-operatively.

In 14 subjects the intraoperative hepatic arterial anatomy correlated with imaging. In one subject, there was a discrepancy between the pre and intraoperative findings. In this subject, the segment 4 was seen to be supplied by two arteries one each from RHA and LHA on MDCT; whereas intraoperatively there was only one artery from LHA. On retrospective review of the CT images, the segment 4 arteries arising from LHA was very small to be surgically significant (Table 1).

Sensitivity: 100%, specificity: 93.7%.

There was high correlation between the preoperative and intraoperative findings of the arterial anatomy (Table 2).

Sensitivity is 100%, specificity is 100%.

There was 100% correlation between the preoperative and intraoperative findings of the portal venous anatomy (Table 3).

Sensitivity is 93.3%, specificity is 100%.

There was discrepancy in the intraoperative correlation of hepatic venous anatomy in one subject. In this subject, the segment 3 hepatic vein was draining into MHV which was not detected on MDCT. In all the other 14 subjects, there was correlation between the pre and intraoperative findings (Table 4).

Table 1: Correlation of CT findings with intra operative findings.

Donor	Right /left lobe	Arterial type (Correlated with intra op findings)	Portal vein type (Correlated with intra op findings)	Hepatic vein	Intra-op findings correlated with CT
1.	Left	Segment 4 from LHA (Yes)	Type A (Yes)	Normal (Yes)	Yes
2.	Right	Michel's type 3 (Yes)	Type A (Yes)	Normal (Yes)	Yes
3.	Right	Michel's type 3 (Yes)	Type A (Yes)	Normal (Yes)	Yes
4.	Left	Segment 4 from LHA (Yes)	3 portal vein branches supplying segt 4 (Yes)	Normal (Yes)	Yes- decided for entire left lobe resection
5.	Left	Trifurcation of CHA (Yes)	Type A (Yes)	Normal (Yes)	Yes
6.	Left	Segt 4 artery from RHA and LHA (Yes)	Type A (Yes)	Normal (Yes)	Yes
7.	Left	Segt 4 art from RHA, LHA (only from LHA)	Type A (Yes)	Normal (Yes)	No- Segt 4 artery from LHA alone
8.	Left	Segt 4 artery from RHA (Yes)	Type A (Yes)	Normal (Yes)	Yes
9.	Left	Type 1HA (Yes)	Type A (Yes)	Acc LHV (Yes)	Segt 3 draining MHV, not picked up on CT
10.	Left	Type 8 HA, (Yes)	Norm PV (Yes)	Normal (Yes)	Yes
11.	Left	Type 1 (Yes)	Norm PV (Yes)	Normal (Yes)	Yes
12.	Left	Type 1 (Yes)	Norm PV (Yes)	Normal (Yes)	Yes.
13.	Left	Early origin of RHA from celiac trunk, LHA from PHA (Yes)	Norm PV (Yes)	Normal (Yes)	Yes.
14.	Right	LHA origin from celiac trunk, before GDA (Yes)	PV-N (Yes)	Normal (Yes)	Yes.
15.	Left	Type 5, anatomy (Yes)	PV (Yes)	Normal (Yes)	Yes

Table 2: CT and intraoperative correlation of arterial anatomy.

	Detected intra-op	Not detected intra-op	Total
Detected on CT	14 True positive	1 False positive	15
Not detected on CT	0 False negatives	15 True negatives	15
Total	14	16	30

Table 3: CT and intraoperative correlation of portal venous anatomy.

	Detected intra-op	Not detected intra-op	Total
Detected on CT	15 True positive	0 False positive	15
Not detected on CT	0 False negatives	15 True negatives	15
Total	15	15	30

Table 4: CT and intraoperative correlation of hepatic venous anatomy.

	Detected intra-op	Not detected intra-op	Total
Detected on CT	14 True positive	0 False positive	14
Not detected on CT	1 False negatives	14 True negatives	15
Total	15	14	29

DISCUSSION

Living donor liver transplantation is a complex surgical procedure balancing between the safeties of two lives. A successful transplantation requires a thorough evaluation of the recipient as well as the potential living donor before undertaking such an operation and MDCT has a definite role in the evaluation of both. Our study analysis reveals that MDCT has 100% sensitivity, 93.7% specificity in detecting the hepatic arterial anatomy; 100% sensitivity and specificity in detecting portal venous anatomy and its variants, and 93.3% sensitivity and 100% specificity in detecting hepatic venous

anatomy. This is comparable to the findings reported by Elrakhawy et al.[5] No statistically significant difference was found between CT volumetry and intraoperative findings by them. Compared to surgical findings, MDCT identified hepatic arterial and portal venous anatomy with 100% sensitivity and specificity, while for hepatic venous anatomy; it showed sensitivity and specificity of 85.7% and 84.2% in their study.

Based on one anatomic variant detected on MDCT and intraoperatively the surgical decision was changed from left lateral segment resection to entire left lobe resection. In this subject segment 4 was supplied by three branches from left portal vein.

Eleven subjects were excluded from being liver donors. Among these 11 subjects, 3 had liver attenuation index consistent with 6-30% (moderate) hepatic steatosis which is a relative contraindication. These subjects can be taken for liver donation if there are other risk factors, such as poor medical status of the recipient, long cold ischemia time, emergency situations, and retransplantation. However, among the three, one subject had CT findings suggestive of hepatic cirrhosis with portal hypertension; another had type C portal vein and third subject had a low body mass index of 16.

In 6 subjects, there were vascular variants which precluded them to be considered as donors. The vascular contra-indications observed are as follows.

One of the right lobe donors had replaced RHA arising from SMA which is a relative contraindication because it requires extra surgical steps in both the donor and the recipient.[4,7] However, this subject also had prominent Median arcuate ligament causing significant extrinsic compression on the celiac trunk. There were two accessory right hepatic veins and the distance between accessory RHV drainage and main RHV drainage was 3cms which also increases the complexity of the surgery because these veins also need to be separately re-implanted on the recipient's IVC.[7]

In one of the right lobe donors, there was a single MHA (segment 4 artery) arising from the RHA and there was no artery to segment 4 arising from LHA. This becomes a contraindication because the hemihepatectomy plane would cut through the course of the segment 4 arteries. Even if this subject was considered for extended right hepatectomy, which involves inclusion of the segment 4 in the graft, the remnant liver volume left in the donor would be significantly less for regeneration, as the segment 4 contributes to 40% of the post-surgical liver volume. Type C portal venous anatomy was also seen in this subject. Type C portal venous anatomy requires two venous openings to be surgically reconstructed in case of right lobe donation.[8]

In one of the right lobe donors there was early origin of RHA from celiac trunk. The celiac trunk divided into splenic artery, LGA and CHA. The CHA divided into GDA and LHA; clamping or ligation of the CHA in this case would cause gastric or duodenal hypoperfusion.[4,7,9] There was also a branch arising from proximal RHA supplying the pancreas; clamping or ligation of HA would cause pancreatic hypoperfusion. In addition, the segment 4 was supplied by both RHA and LHA which was another surgically significant vascular variant. Two small inferior accessory inferior hepatic veins were also seen which were not surgically significant.

In three of the left lobe donors there were accessory LHA arising from LGA (Michel's type 5) which is relative contraindication because it requires extra surgical steps in both the donor and the recipient. Type C portal vein, the proper hepatic artery immediately dividing into RHA and LHA were also seen in one of them.

One of the subjects was not taken for graft resection since the recipient expired. before surgery. One subject who was not taken for surgery was lost for follow up.

Multi-detector CT is a single comprehensive, non-invasive and accurate imaging modality for pre-operative and postoperative evaluation of liver transplant patient. It allows an accurate assessment of liver parenchyma, hepatic vascular anatomy, graft volume and detection of post-operative complications in donors and recipients of LRLT.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: The study was approved by the institutional ethics committee

REFERENCES

1. Grainger and Allison's Diagnostic Radiology: A Textbook of Medical Imaging. Chapter 58, Fourth edition, Simon, Olliff: Vol. 1; 2014:1333-1340.
2. Luu L. Liver transplantation. E-medicine emergency medicine gastrointestinaol surgery; 2008.
3. Kamel IR, Kruskal JB, Pomfret EA, Keogan MT, Warmbrand G, Raptopoulos V. Impact of multidetector CT on donor selection and surgical planning before living adult right lobe liver transplantation AJR. 2001;176:193-200.
4. Catalano OA, Kumar A, Singh H, Uppot RN, Hahn PF, Ferrone CR, et al. Vascular and biliary variants in the liver: implications for liver surgery. Radio Graphics. 2008;28:359-78.
5. Elrakhawy MM, Wahab MA, Mousa AE, Helmy EM. Multidetector CT in pre- and post-operative evaluation of living-related liver transplantation. Egypt J Radiol Nucl Med. 2013;44:147-57.
6. Limanond P, Raman SS, Lassman C, Sayre J, Mark Ghobrial R, Busuttil RW, et al. Macrovesicular hepatic steatosis in living related liver donors: correlation between CT and histologic findings. Radiol. 2004;230:276-80.

7. Sahani D, Mehta A, Blake M, Prasad S, Harris G, Saini S. Preoperative hepatic vascular evaluation with CT and MR angiography: implications for surgery. Radio Graphics. 2004;24:1367-80.
8. Alonso-Torres A, Fernández-Cuadrado J, Pinilla I, Parrón M, de Vicente E, López-Santamaría M. Multidetector CT in the evaluation of potential living donors for liver transplantation. Radio Graphics. 2005;25:1017-30.
9. Erbay N, Raptopoulos V, Pomfret EA, Kamel IR, Kruskal JB. Living donor liver transplantation in adults: vascular variants important in surgical planning for donors and recipients. AJR. 2003;181:109-14.

Cite this article as: Gupta V, Pallavi CJ, Kalyanpur A, Dayananda L. Multi-detector CT in the pre-operative assessment of live donors for liver transplantation. Int Surg J 2017;4:1930-5.