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MDCT Angiography in the Assessment of Vascular Variants in Potential Liver Donors

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ABSTRACT

BACKGROUND: Liver transplantation is currently considered as a definitive therapeutic option for managing patients with chronic liver disease. Due to the considerably greater complexity of LDLT surgical technique, safe harvesting and successful transplantation necessitate cautious donor selection and preoperative mapping of the vascular anatomy. The aim of this study was to evaluate the vascular variations in potential living liver donors and to assess the association between the vascular variance with intra operative and post operative complications.
METHODS: Study population included 87 cases potential living liver donors selected from June 2020 to June 2022. Prior to liver transplant, each donor underwent MDCT angiography of the abdomen. Recipients were then monitored intraoperatively and postoperatively for up to six months to determine the presence or absence of various problems in grafts with normal arterial anatomy vs those with variable arterial morphology.
RESULTS: A total of 56 cases (64.4%) had standard type I arterial anatomy and 31 cases (35.6%) had variance in artery. The Michels' type III anatomy is the most prevalent variation (13.8%) of cases, followed by type II arterial anatomy (11.5%). Standard type I portal vein anatomy was seen in 70 cases (80%). A total of 19 people (22%) had accessory right hepatic vein (RHV) and 28 cases (32%) had inferior hepatic vein (IHV). Results of grafts with standard anatomy were compared with grafts with variant anatomy. We found no statistically significant association found between vascular variations with intra operative and post complications.
CONCLUSION: Nearly two-third of prospective liver donors had variant in any of vascular supply. Most prevalent variations involve hepatic arterial anatomy which was found in 35.6% patients. Michels' type III arterial anatomy was found to be the most common variation followed by Michels' type II. With regard to the portal vein anatomy, type II portal vein anatomy was found to be the most common variation. We found no statistical significant association between the grafts with variant vascular anatomy with intraoperative and postoperative complications.

Keywords: Living donor liver transplantation (LDLT), multi detector computed tomography (MDCT), right hepatic vein (RHV), inferior hepatic vein (IHV), right hepatic artery (RHA).

INTRODUCTION

Liver transplantation is currently considered as a definitive therapeutic option for managing patients with chronic liver disease. Since there is restricted availability of deceased donor organ across the world, living donor liver transplants are becoming more widely used as an alternative to DDLT. This innovative surgery enables healthy individuals to donate a part of their liver to patients having advanced liver disease.(1)

Due to the considerably greater complexity of LDLT surgical technique, safe harvesting and successful transplantation necessitate cautious donor selection and preoperative mapping of the vascular anatomy. As of November 2021, about 1000 liver

transplantations were done in our institution, majority of them being LDLT.(2–4)
Vasculature complications are the second most common factor for graft failure after primary dysfunction. Evaluation of the hepatic vascular variance is essential in the presurgical assessment of prospective donors due to the significant variance of this anatomy. Not all anatomical variations are equally significant. CT Angiography has a distinct advantage over MR angiography because of its better delineation of the vascular anatomy, high spatial resolution, and easiness of protocol setup and execution.(5–8)

MATERIALS & METHODS

Study design: Cross sectional study
Study period: For two years (2020 to 2022) after obtaining authorization from the Thesis Protocol Review Committee (Scientific, Ethical & Financial), AIMS, Kochi.
Study setting: Department of Radiodiagnosis, Amrita Institute of Medical Sciences, Kochi
Study population: All prospective liver donors who are undergoing pre-operative CT angiography.

Sample size
Based on the results of proportion of vascular variations such as hepatic artery variant(70%), portal vein variant(80%) and hepatic vein variant (90%) in potential living liver donors with CT Angiography, observed in an earlier publication (Role of MDCT angiography in assessment of vascular variant in potential living liver donor transplantation, 23 July 2013) & with 20% relative precision and 95% confidence, the minimum sample size for the study comes to 41,24 and 11. Then the minimal sample size for the study will be 41.

Inclusion criteria:
Candidates as prospective liver donors for transplant.

Exclusion criteria:
Age less than 18 or over 60
Severe fatty liver
Renal insufficiency
chronic lung disease
Documented coronary artery disease

TECHNICAL INFORMATION:
OBJECTIVES:
Primary objective: To prospectively assess the hepatic vascular variations in potential living liver donors with CT Angiography.
Secondary objective: To evaluate the implications of vascular variations in liver transplantation and its surgical techniques.

Imaging protocol and data collection:
All potential liver donors were scanned with Philips 256 slice CT scanner after obtaining informed consent. The arterial, portal, and d elayed phases were acquired at 8 seconds, 2 8 secondsand 58 seconds after the IV contra st (Omnipaque) was injected. Every potentia l donor's arterial anatomy, portal and hepatic vein anatomy was studied.
All the recipients were followed post operatively for a period of not more than 6 months to look for: hepatic artery thrombosis, portal vein thrombosis, overall Graft survival and re-exploration The recipients were also evaluated intraoperatively for the following: Intraoperative blood loss, arterial warm ischemia time and total duration of recipient surgery

STATISTICAL ANALYSIS

Statistical Details:
Statistical Analysis was done using IBM SPSS version 20(Chicago USA). Continuous variables were represented using mean ± SD also median(Q1, Q3). Categorical variables were represented in number and percentage. To test the statistical significance of the difference in the mean/median values of all continuous variables between two categories, independent sample t test for normally distributed data and Mann Whitney U test for skewed data were applied. To test the

statistical significance of the difference in the mean/median values of all continuous variables between three categories, One way ANOVA and Kruskal Wallis test was determined respectively. To test the statistical significance of the difference in the proportion of categorical variables between more than two classifications, Pearson Chi Square test was applied. A p value of <0.05 was considered to be statistically significant.

RESULT

I. Assessment of vascular variants in potential liver donors.

- **Arterial variations:**

On preoperative MDCT angiography of the graft livers (78 grafts), 56 cases (64.4%) had standard type I arterial anatomy. The Michels' type III anatomy is the most prevalent variant, found in 13.8% of cases. Type II arterial anatomy is found to be 11.5%. Type IV variant is observed in 3.4%. Type V was found in 1.1% of the cases. Type VIII is observed in 3.4 % of cases. We did not find any VI, VII, or X types of arterial anatomy variations in our study sample. One patient (1.1%) in this study had a non-classical variant, in which the accessory right hepatic artery arising from the dorsal pancreatic artery. Out of 78 grafts, standard RHA was found in 63 patients (81%), replaced RHA is found in 14 patients (18%), and one patient had accessory RHA (1.1%).

- **Portal vein variations:**

70 people (80%) had type I portal vein anatomy. Type II portal vein anatomy was recognized in 11 cases (13%). 6 people (7%) had type III portal vein anatomy.

- **Hepatic vein variations:**

19 people (22%) had Accessory right hepatic vein was seen in 19 patients (22%), 68 (78%) people had normal RHV. Inferior hepatic vein presence was found in 28 cases (32%), IHV is not seen in 59 cases (68%).

II. Implications of vascular variations in liver transplantation.

The incidence of portal vein thrombosis among 78 patients who underwent right lobe transplantation is 9 (12%). Standard type I anatomy has an incidence of 8% portal vein thrombosis, compared to 20% in type II variation and 30% in type III variation. No statistical association found in this (p = 0.121).

The incidence of re-exploration in type I, II and III portal vein grafts are 19.4, 40% and 33.3% respectively. This was not found to be statistically significant (p = 0.293).

We had observed that the 6-months survival rate with the standard type I portal vein was 79% as opposed to 50% in the type II portal vein graft and 50% in the type III portal vein graft. The association of portal vein variations with PV variance was found to be not statistically significant (p = 0.066).

The average intra-operative blood loss in the type I portal vein group is 3000 ml, type II portal vein is 3000 ml and that of type III portal vein group is 3500 ml, this difference was not statistically significant (p = value is 0.524).

The median warm ischemia time with a type I portal vein graft, type II anatomy, and type III anatomy was observed to be 21, 21, and 31 minutes, respectively. There is no statistically significant association found in this (p = value is 0.478).

The duration of surgery (in minutes) in the type I, type II and type III portal vein were 593.44, 593.30 and 596.7 respectively, this difference was not statistically significant (p = value is 0.997).

Only two of the 78 people who had undergone LDLT got hepatic artery thrombosis. Both the patient's graft liver had standard arterial anatomy. None of the people with variant RHAs had any complications with their arteries, however this is not statistically significant (p = value is 0.121).

The incidence of re-exploration in standard arterial anatomy is 22.2%. Re-exploration in replaced hepatic artery is 28.5% and the patient with accessory RHA did not undergo

re-exploration. There is not statistically significant association found in this (p = value 0.754).

The six months survival rate with the accessory right hepatic artery graft was 100% as opposed to 71.4% in the standard right hepatic artery graft and 78.5% in the replaced right hepatic artery graft. There is not statistically significant association found in this (p = value 0.715).

The average intra-op blood loss with a standard RHA was 3000 ml and the average intra-op blood loss was 3500 ml in the variant RHA, this difference was not statistically significant (p = value is 0.442).

The median warm ischemia time with a standard RHA was 21 minutes and the median warm ischemia time was 18 minutes in the variant RHA. There is no significant association between variant RHA and standard RHA with warm ischemia time (p = value 0.228).

Mean duration of surgery in the recipients with a standard RHA was 597 minutes and the mean duration of surgery was 580 minutes in the variant RHA, this difference was not statistically significant (p = value is 0.553).

Incidence of RHV thrombosis in absence of accessory RHV is 4.9%. None of the patients with accessory RHV had RHV thrombosis. There is not statistically significant association found in this (p = 0.826). Incidence of RHV thrombosis in absence of IHV is 1.8% as opposed to 9.5% incidence of RHV thrombosis in presence of IHV. There is not statistically significant association found in this (p = 0.358).

DISCUSSION

The standard vascular anatomy acts as a basis for analyzing the hepatic vascular supply and venous drainage patterns. Many vascular variations exist, although their relevance varies. The occurrence of conventional standard vascular anatomy is not so common, and significant hepatic vascular variance is anticipated in many individuals.(9)

Our study comprises a total of 87 potential donors. Among the donors, 27 (35%) participants were males and 51 (65%) participants were females. Regarding age distribution, majority of donors were in the 41-50 years (37.9%) age group.

The overall prevalence of vascular variations in these 87 potential liver donors found to be 69% which includes variance in hepatic artery, portal vein and hepatic vein with only 31% participants having classical vascular anatomy.

In our study, 56 cases (64.4%) found to have standard (type I) arterial anatomy while 31 cases (35.6%) had variant arterial anatomy. Hasan et al. In a series of 49 potential liver donors, standard hepatic arterial anatomy was found in 70% cases and variant anatomy in 30% cases.

The Michels' (type III) anatomy was found to be most prevalent variant, seen in 12 (13.8%) cases. Type II arterial anatomy is the second most common variation which was found in 10 (11.5%) donors. Type IV and type VIII Michels' arterial anatomy was found in 3 (3.4%) cases each. Type V and type IX variation was found in one (1.1%) subject each. We did not find any VI, VII, or X types of arterial anatomy variations in our study sample. One patient (1.1%) in this study had a non-classical variant, in which the accessory right hepatic artery arising from the dorsal pancreatic artery.

The Michels' type III anatomy is also reported to be the most prevalent variant, in literature seen in 6-15.5% cases. In consistent with this, the most common arterial anatomic variation in our study is type III. Type II arterial anatomy is the second most frequent variation with literature reports of it ranging from 2.5-10%. similarly type II arterial variation is the second most prevalent in our study. Type IV Michels' type is found with incidence of 1-7.4% in the literature. Instances of type VII, VIIII, IX, and X are uncommon in the literature.(10–13)

Regarding Portal venous anatomical variations, in our study group 70 subjects (80%) had type I portal vein anatomy. Type

II portal vein morphology was recognized in 11 cases (13%) while six (7%) potential donors had type III portal vein morphology

Cetin et al(14) in their study of the prevalence of portal vein variants, identified that 64.5% of the 200 patients had the typical (type I) portal vein anatomy. The main portal vein trifurcates into the left portal, right portal, and right anterior and posterior portal divisions in 9.5% of the patients with type II portal vein anatomy. The portal vein variant of type III was present in 23.5% of the individuals. Three patients (1.5%) had non-classical variations.

In our study, 19 people (22%) had accessory right hepatic vein. Inferior hepatic vein presence was recognized in 28 cases (32%). Chi et al(15) in their study of hepatic vein variations in 200 subjects had found inferior hepatic vein in 21% and presence of accessory RHV in 8.5%.

Only 78 out of 87 prospective donors had undergone transplantation. Remaining 9 prospective donors did not undergo surgery due to volumetric issues, fatty liver, systemic condition, and other co-existing reasons other than vascular variations.

Since only adult right lobe liver transplants were included in our analysis, the relevant variation in arterial anatomy will be accessory or replaced right hepatic artery.(16) We classified our cases into three major categories: patients with a standard RHA graft (63 patients), those who had replaced In the past, it was reported that donor anatomical variances of the hepatic artery might be related with a higher frequency of arterial complications.(17)(18)

Only two of the 78 subjects who had undergone LDLT suffered hepatic artery thrombosis. These patient's graft liver had standard arterial architecture which was found to be not statistically significant. After the transplant, none of the people in our study with replaced or accessory graft RHAs had any complications with their arteries. The six months survival rate with the accessory right hepatic artery graft was 100% as opposed to 71.4% in the standard right hepatic artery graft and 78.5% in the replaced right hepatic artery graft. There was no statistical significance found in this.

We had observed that the average intra-op blood loss with a standard RHA was 3000 ml and the average intra-op blood loss was 3500 ml in the variant RHA. There was no statistical significance found in this also. In our study, the incidence of re-exploration in standard arterial anatomy was 22.2%. Re-exploration in replaced hepatic artery is 28.5% and the patient with accessory RHA did not undergo re-exploration. Many of these re-explorations were done for reasons unrelated to the hepatic artery complications, statistical analysis suggested no significance regarding these findings. The median warm ischemia time with a standard RHA was 21 minutes and the median warm ischemia time was 18 minutes in the variant RHA. We had observed that the mean duration of surgery in the recipients with a standard RHA was 597 minutes and the mean duration of surgery was 580 minutes in the variant RHA. No statistical significance was found in these observations.

There were 9 (12%) incidences of portal vein thrombosis among 78 patients who underwent right lobe transplantation. Standard type I anatomy had an incidence of 8% portal vein thrombosis, compared to 20% in type II variation and 30% in type III variation. But no statistically significant association could be depicted between portal vein anatomical variations and incidence of thrombosis. We had observed that the 6-months survival rate with the standard type I portal vein was 79% as opposed to 50% in the type II portal vein graft and 50% in the type III portal vein graft. However, this is also not found to be statistically relevant.

In our study, the incidence of re-exploration in type I portal vein graft is 19.4%. Re-exploration in type II portal vein graft is 40% and the recipients with type III portal vein graft had 33.3% incidence of re-exploration.

The median warm ischemia time with a type I portal vein graft, type II anatomy, and type

III anatomy was observed to be 21, 21, and 31 minutes, respectively. and there was no statistically significant difference in this. We compared duration of surgery (in minutes) in recipients with the portal vein variants. We found that the duration of surgery in the type I portal vein was 593.44, that of the type II portal vein graft 593.30 and that of the type III portal vein variance was 596.7. There was no significant difference seen within these groups.

In our study, we discovered that while the average intra-operative blood loss in the type I portal vein group is 3000 ml, type II portal vein is 3000 ml and that of type III portal vein group is 3500 ml, this difference was not statistically significant.

Out of 78 grafts, 3 subjects (4%) developed RHV thrombosis. None of the patients with accessory RHV had RHV thrombosis. The incidence of RHV thrombosis in absence of IHV was found to be 1.8% as opposed to 9.5% incidence of RHV thrombosis in presence of IHV. This is probably related to small caliber of right hepatic vein making surgical anastomosis difficult. The association between the presence of accessory hepatic vein and inferior hepatic vein with the incidence of RHV thrombosis was found to be not statistically significant.

Meroin et al.(19) found that having a varied hepatic artery morphology is not a risk factor for post-transplant complications.

Kirimkar et al(20) in their retrospective study of 323 grafts, the investigators were unable to establish a link between vascular complications or graft survival with donor vascular anatomical variations.

CONCLUSION

In our study of 87 potential liver donors who underwent preoperative MDCT angiography of the abdomen, we observed significant variation in their vascular morphology, with a variant in any of vascular supply visible in almost two third of the potential donors.

- Most prevalent variations involve hepatic arterial anatomy which was found in 35.6% patients. Michels' type III arterial anatomy was found to be the most common variation followed by Michels' type II.
- With regard to the portal vein anatomy, type II portal vein anatomy was found to be the most common variation.
- We found no statistical significant association between the grafts with variant vascular anatomy with intraoperative and postoperative complications.

Declaration by Authors

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