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LIVER TRANSPLANTATION: VASCULAR AND BILIARY ANATOMICAL VARIANTS OF LIVING DONORS AND THEIR IMPORTANCE IN SURGICAL PLANNING

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Abstract

Background: Pre-operative imaging and evaluation of living donors play a crucial role in the success of liver transplantation. Identification of variant vascular and biliary anatomy, in addition to planning surgical technique, aids in predicting the risk of surgical complications, subsequent biliary strictures, and liver abscesses. Good functioning of the graft depends on the intact arterial and portal blood supply as well as biliary and venous drainage from the liver segments. The purpose of this study was to determine the frequency with which surgically important hepatic vascular and biliary variants occur and their correlation with intraoperative findings.
Methods: This was a prospective observational study conducted over a period of 20 months involving 38 healthy liver donors between 18 and 60 years. A 128-slice MDCT scan was carried out to assess the arterial and portal anatomy. Arterial phases were taken after 20-30s, and portal phases approximately after 60-70 seconds. The delayed phase was taken following 90-100 seconds after the injection. To study the biliary anatomy, imaging was performed with 1.5 Tesla MRI T2-weighted images of 28 slices. Preoperative MRCP was assessed by a radiologist, not aware of the intra-operative findings. Intra-operative cholangiography was performed through a 4- or 5-F catheter inserted into the cystic duct while manually injecting 10 to 20 ml of iohexol.
Results: Comparing CT volumetry with post-hepatectomy volume, we found a mean deviation of 53.9±63.7 (17.8% discrepancy) in measurement of the right lobe. In the case of the left lobe, there was a mean deviation of 14.6±26.8 gms (18% discrepancy). Type I arterial anatomy was found in 71% of patients, type II arterial anatomy was found in 7.9%, type III anatomy in 13.2%, and 7.9% had type V arterial anatomy. Longer RHA hepatic artery was found in patients with type III arterial anatomy (replaced RHA from SMA). Shorter RHA was found in patients with type V arterial anatomy. The quadrate lobe is mainly supplied by the left hepatic artery. In a majority of the cases (55%), MHV and LHV join to form a common orifice before entering IVC, while RHV opened separately into IVC. One, two, or more accessory hepatic veins were seen in the majority of the cases. 81.6% had type I portal anatomy, and 13.2% had type II anatomy. Type III anatomy was found in 5.3% of patients, whereas in literature, type III anatomy was more common than type II.

Conclusion: Anatomical variants in the vascular and biliary systems are common in living liver donors and can pose challenges for the transplant. It's important to recognize and manage these variants to ensure the safety of the donor and reduce complications for the recipient.

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Introduction:-

Orthotopic liver transplantation is a commonly done technique in which the recipient's damaged liver is removed and replaced by a part of the donor's healthy liver in the same anatomical position. Liver should be taken out carefully and promptly implanted, which requires thorough knowledge of the relevant anatomy of the area. A successful liver transplantation depends on how much of a portion of viable liver the surgeon leaves for the donor and how much liver is transplanted to the recipient.[1] When the recipient is a child, the left lobe of an adult liver will be of adequate size. But if the recipient is an adult, the right lobe of the liver is transplanted, as a larger volume is required.

Preoperative imaging and evaluation of living donors play a crucial role in the success of liver transplantation. Despite improvements in surgical techniques, biliary complications, e.g., leaks and strictures are observed on average in 5–15% of transplants and are the second most frequent cause of transplant failure after acute rejection.[2] Assessment of the potential liver donors is done to study their vascular and biliary anatomy, to look for anatomical variants, to exclude focal lesions and to exclude diffuse lesions including cirrhosis, Budd-Chiari syndrome, etc. A patient is selected if his or her liver appears normal on imaging and the patient does not have other co-morbidities.

The most common LDLT technique in adults is right hemihepatectomy, whereby segments V-VIII are harvested, leaving the MHV (Middle Hepatic Vein) with the donor. Variant vascular and biliary anatomy is not a strict criterion for exclusion of liver transplantation. Variations are more common in the right lobe of the liver. The anatomical details involved in the division of the donor liver play a vital role in the surgery. One anatomical variation may be associated with other variations; for example, portal vein anatomical variation may be associated with biliary variations. The volume of the liver is also important. The right lobe should never be underestimated, and the left lobe should never be overestimated. The success of the surgery depends on the volume of viable liver available for the donor and transplanting enough for the recipient.

There may be prohibitive anatomical variation in a few patients. Identification of variant vascular and biliary anatomy, apart from planning surgical technique, also helps in predicting risk of surgical complications and of subsequent biliary strictures and liver abscesses. Good functioning of the graft depends on the intact arterial and portal blood supply as well as biliary and venous drainage from the liver segments. Absence of portal bifurcation is a contraindication for the partition of the liver. Unpredicted variations may require additional anastomoses, which leads to several complications like increasing graft ischemia or failure of the graft.

Many vascular liver variants have been described in several studies, but their importance in surgical planning and correlation with the intraoperative findings in living liver donors has not been studied much. The purpose of this study was to determine the frequency with which surgically important hepatic vascular and biliary variants occur and their correlation with intraoperative findings.

Methods:-

This was a prospective observational study conducted over a period of 20 months involving 38 healthy liver donors between 18 and 60 years. Patients with liver attenuation index less than +5 HU. Those with malignant liver SOLs, diffuse liver pathology like cirrhotic liver/other liver pathology like Budd Chiari malformation, and other serious comorbidities were excluded from the study.A 128-slice MDCT scanner with the following parameters was used to scan the donors. First of all, a frontal AP topogram was done, following which a plain CT scan of the liver and then triple-phase scanning was done. The scans were done with 2 mm slice thickness and 1 mm couch movement. Nonionic contrast agent like Iohexol was injected into the IV cannula. Bolus tracking was done automatically. Arterial phases were taken after 20-30s and portal phases approximately after 60-70 seconds. The delayed phase was taken following 90-100 seconds after the injection.To study the biliary anatomy, imaging was performed with a 1.5 Tesla Philips Achieva MR magnet machine. The imaging plane was selected from the initial axial T2-weighted images, acquisition aligned to the CBD (Common Bile Duct). A stack of 28 slices is obtained, contiguous and each of 4 mm in thickness. As the images are heavily T2-weighted, the pancreatico-biliary tree is displayed as high signal intensity, whilst adjacent structures are of reduced signal intensity.

Pre-operative MRCP was assessed by a radiologist, not aware of the intraoperative findings. In general, the biliary anatomy was reported using the classification published by Choi et al.[3] Intra-operative cholangiography was performed through a 4- or 5-F catheter inserted into the cystic duct while manually injecting 10 to 20 ml of iohexol. Fluoroscopy is performed in anterior–posterior orientations.

Statistical Analysis

The collected data were analysed with IBM SPSS Statistics software version 23.0. Frequency and percentage analysis were used for categorical variables. Mean and S.D. were used for continuous variables. To find the significance of differences in the variables, multivariate analysis using one-way ANOVA with Tukey's post hoc test was carried out. To assess the relationship between the variables, Pearson's correlation was used. To find the significance in categorical data, a chi-square test was used. In all the above statistical tools, the probability value of< 0.05 was considered significant.

Results:-

In the present study with an age group ranging from 20 years to 50, most of the patients were in the age group of 31-40 years (42%). Out of 38 patients included in the study, the majority were females, i.e., 23 (60.5%), and the remaining 15 (39.5%) were males.

Table 1:- Age Distribution of Study Population.

Age (in years)	Frequency	Percentage (%)
< 30 yrs.	11	28.9
31 - 40 yrs.	16	42.1
41 - 50 yrs.	8	21.1
Above 50 yrs.	3	7.9
Total	38	100.0

The majority of the patients (68%) had a total volume of liver of 1101-1400 g, and 26% of patients had a volume between <1100 g; only nearly 7.8% of patients had a volume more than 1400 g. 31.6% of patients were having a right lobe volume < 700 gm, 21% had volume more than 900 gm, 18% were having volume between 700-800 gm, and 28% had volume between 800-9900 gm. 21 patients had a left lobe with a volume of 301-400 mg, 11 patients had a volume of more than 400 gm, and 6 patients had a volume of less than 300 gm.

Out of the total study subjects, 71.1% of patients had normal arterial anatomy variations. 13.2% of patients had type III anatomy. Type II and type V anatomy were found in 7.9% each. None of the subjects had a type IV anatomy.

Out of 38 donors (total study population), in 57%, the middle and left hepatic veins drained into the IVC, uniting as a single orifice; in 42% the left and middle hepatic veins drained into the IVC individually. Two MHVs were found in 5.3% of the population. 60% of the total study population had two accessory hepatic veins, 28% had a single accessory hepatic vein, and 2.6% of patients had three accessory hepatic veins. The rest of 9% of patients had no accessory veins.

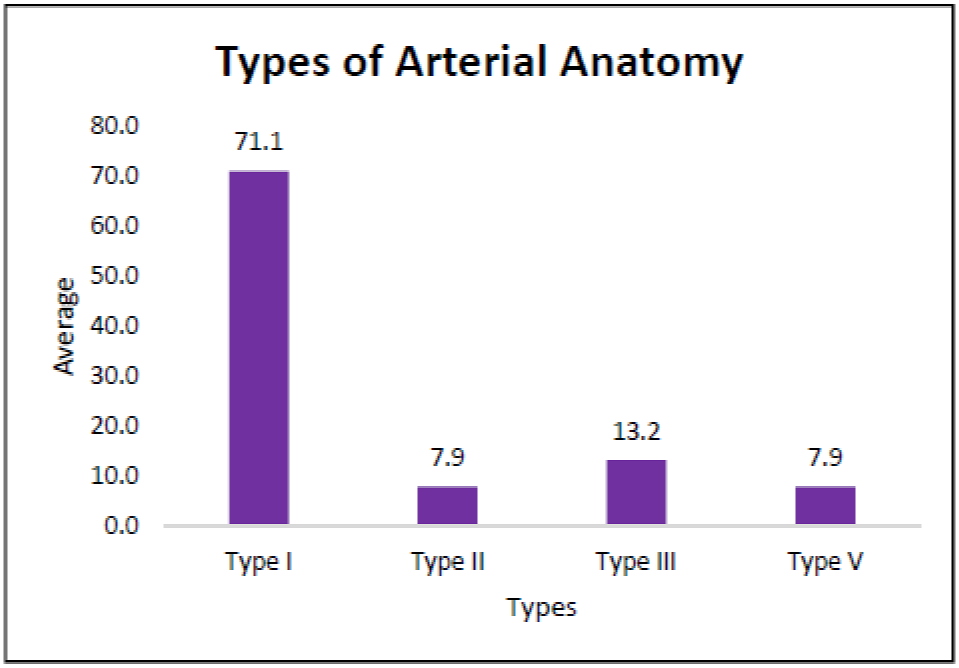

Figure 2:- Types of Arterial Anatomy.

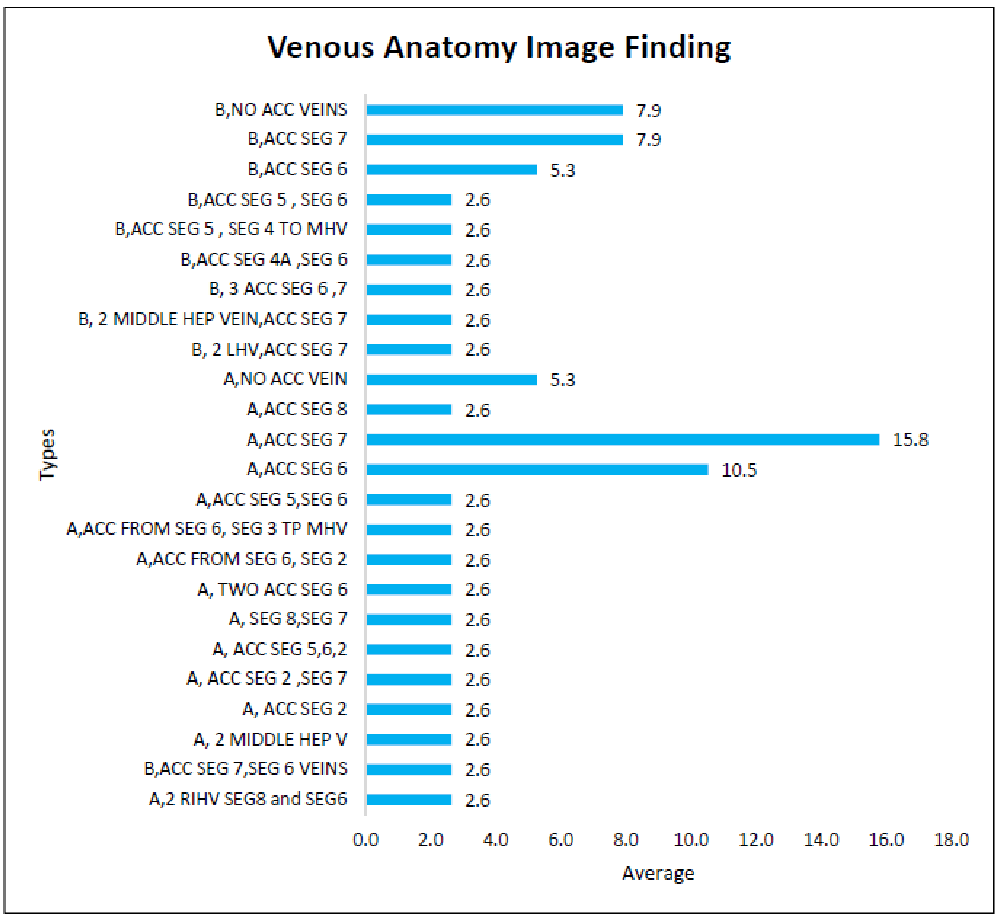

Figure 2:- Venous Anatomy and Variations. A- MHV and LHV Drains as a Single Channel B- RHV, LHV, MHV JoinIVC Separately.

Out of 38 patients, 31 patients (81.6%) had normal anatomy, Type II anatomy was found in 5 patients (13.2%) and Type III anatomy in 2 patients (5.3%).

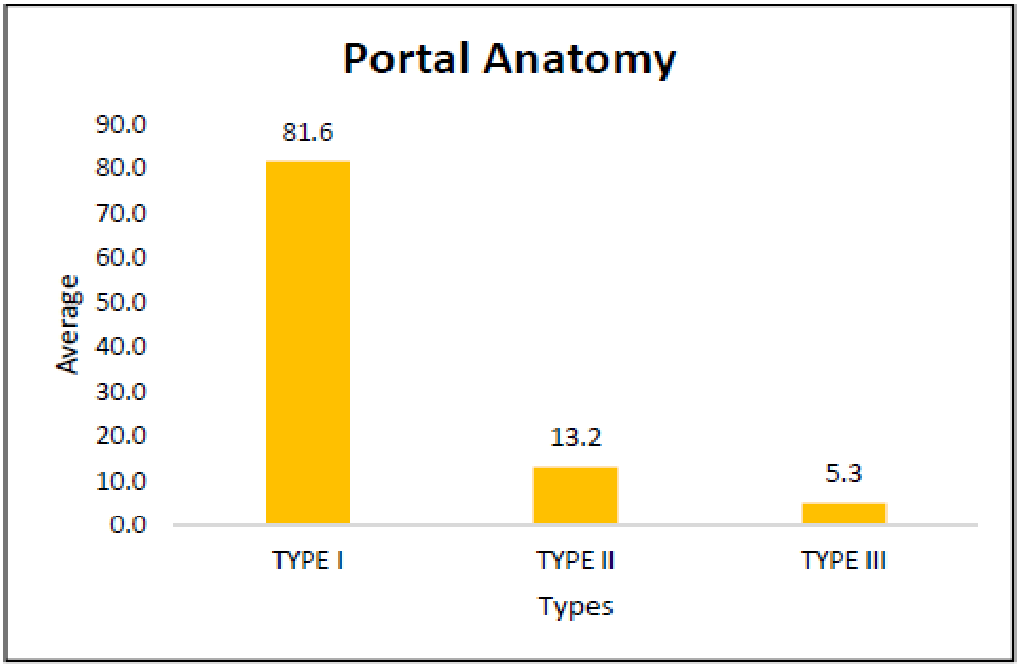

Figure 3:- Types of Portal Anatomy.

The majority of patients (68.4% of the total study population) had normal anatomy. Type II anatomy was found in 10.5% of the population. Type III A and type III B anatomy were found in 13.2% and 5.3% of patients, respectively. Type VI anatomy was found in 2.6% of the patients.

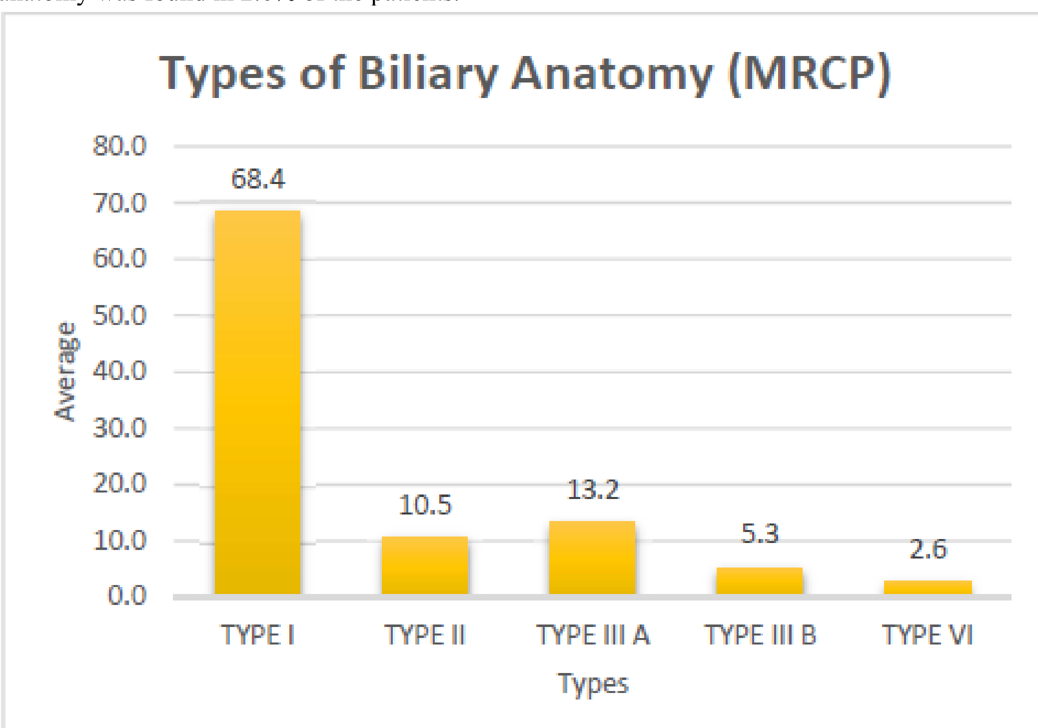

Figure 4:- Types of Biliary Anatomy Imaging Findings.

In the study population, the majority (57.9%) of patients had a quadrate lobe supplied by LHA. LHA and a small branch from RHA to segment 4A were seen in 1 patient. 2 patients were having quadrate lobes supplied by LHA and a small branch from RHA to 4B. A single patient had blood supply from LHA and Accessory LHA. 4 patients were having supply from RHA. 5 patients had a uniform pattern, like segment 4A is supplied by RHA and segment 4B is supplied by LHA.

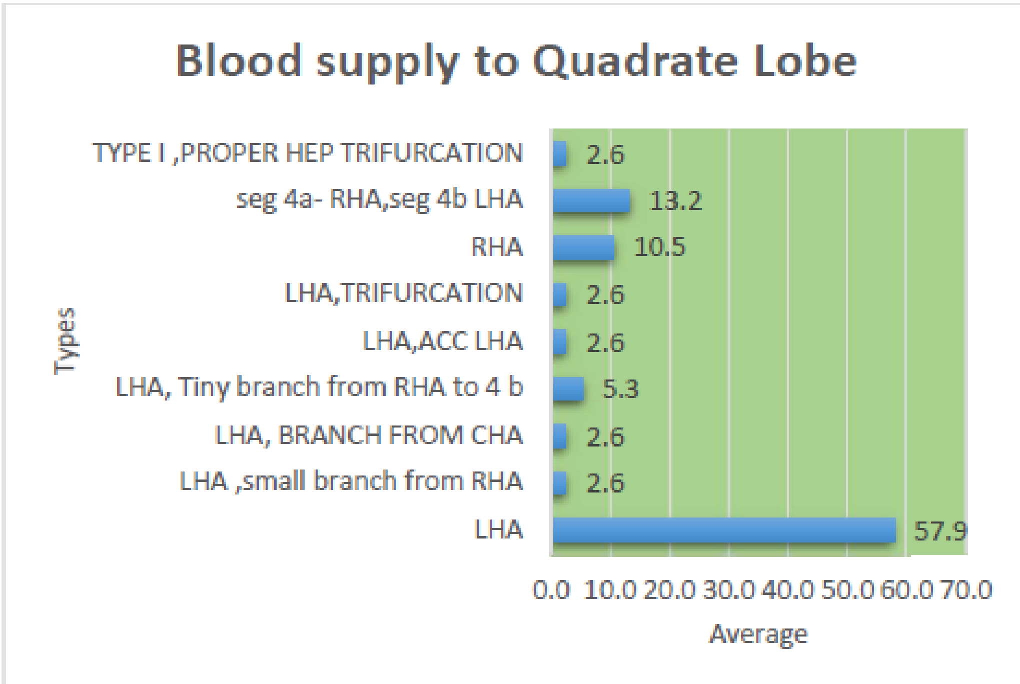

Figure 5:- Blood Supply to Quadrate Lobe.

The majority of the study population had a length of RHA between 31-40 mm; a single patient had RHA less than 10 mm. 5.3% had a longer RHA measuring more than 50 mm. There was a statistically significant variation in the length of RHA and different types of anatomical variations. The length of RHA was longest in type III anatomy and shortest in type V anatomy. The ANOVA test showed that the p-value was 0.0005.

Table 2:- ANOVATest of Length of RHA vs.Type of Arterial Anatomy.

Length of RHA	**Sum of Squares**	**Df**	**Mean Square**	**F**	**Sig.**
Between groups	2506.835	3	835.612	9.259	.0005*
Within groups	3068.533	34	90.251		
Total	5575.368	37			

*p value <0.05 – statistically significant

Intraoperatively, the most common type of biliary anatomy was type I, followed by type II (10.5%) and type III A (7.9%). The least common type was type III B (2.6%). There was a statistically significant difference between CT volumetry of the right lobe and post-hepatectomy volume with a p-value of 0.0005. There was no statistically significant difference between CT volumetry of the left lobe and post-hepatectomy volume. (p-value 0.532)

The comparison between the predicted volume of the right lobe on CT volumetry (778.8 ± 139.7) was significantly different from the actual right lobe (724.9±131.0) with P = 0.0005 with mean difference of 53.9 ±63.7. The comparison between the predicted volume of the left lobe on CT volumetry (292.8±53.2) was not statistically different from the actual left lobe (278.6±59.3) with P = 0.620 with a mean difference of 14.6±26.8.

There was no statistically significant difference between MRCP findings and intraoperative cholangiography findings (p-value 0.623).

Table 3:- Chi Square Tests of Comparison of MRCP and IOC.

	Value	df	AsymptoticSignificance(2-sided)
Pearson Chi-Square	77.647[a]	12	.623*
Likelihood Ratio	45.200	12	.000
N of Valid Cases	38		

a. 19 cells (95.0%) have expected count less than 5. The minimum expected count is.03.
*p value >0.05- statistically not significant

Discussion:-

Demography

The study population in our study comprised of ages varying from 20 years to 51 years of age. The majority of the study population were in the age group of 31 to 40 years (42%), followed by 20 to 30 years (29%). There were only 3 patients who were above the age of 50 years. In the present study, including 38 subjects, males were 15 (39.5%), and females were 23 (60.5%). Out of the 38 patients, right hepatectomy was done for 32 patients, whereas left hepatectomy was done for the other 6 patients. 10% of the study population had space-occupying lesions in the liver, like hemangioma, simple cyst, and calcified granuloma, in frequencies of 5%, 2%, and 2%, respectively. Hepatomegaly was found in another 2.6% of study subjects. 33 people (86.8%) had normal imaging findings.

Volumetry

The volume of the right lobe of the liver after hepatectomy was compared with the volume measured by CT volume. There was a significant difference with intraoperative volume and CT volumetry of the right lobe of the liver ($p = 0.0005$). There was no statistically significant difference between CT volumetry and post-hepatectomy volume of the left lobe of the liver ($p = 0.532$). A mean deviation of 53.9 ±63.7 (17.8% discrepancy) in measurement of the right lobe was noticed. In the case of the left lobe, it was found that a mean deviation of 14.6±26.8 grams (18% discrepancy) was present. Despite the slightly larger discrepancy, statistical correlation could not be done because of the lesser number of study subjects for whom left hepatectomy was done.

In a study performed by Li et al.,[4] a mean deviation in delta volume of 13.81±8.12% was observed. According to the literature, a deviation of 10% is to be expected in an automatically calculated preoperative volume assessment. Liver volume calculations in donors aged less than 36 years have been reported to be closer to intraoperative measurements. In a study conducted by Paolo R et al.,[5] a 20% discrepancy was demonstrated between estimated liver volume and intraoperative measurement of the extracted liver. Fredricks et al.,[6] emphasized an increased margin of error in living donor liver graft volumes weighing ≥500 g.

Hepatic Arterial Anatomy

The arterial system is classified according to the Michel classification[7] Arterial anatomy. Out of the total study population, 71% were found to be type I, of which 10.5% of patients were found to have immediate trifurcation of the proper hepatic artery into the right hepatic artery, left hepatic artery, and branch to the quadrate lobe. There are no previous studies that mention the blood supply of the quadrate lobe and immediate trifurcation of the proper hepatic artery. Type II arterial anatomy, replaced left hepatic artery was found in 7.9% of patients. Type III anatomy, replaced right hepatic artery was seen in 13.2% of patients. Accessory left hepatic artery from left gastric artery, right hepatic artery, and left hepatic artery (type V) anatomy was seen in 7.9% of the population.

In our study, the prevalence of anatomical types was type I > type III > type II = type V. In a similar study conducted by Hiatt et al.,[8] also similar results were observed.Type I anatomy was found in 75%, next common was type III (10.6%), followed by type II anatomy (9.7%), type IV (2.3%), and type V (1.5%). Gruttadauria et al.,[9] also observed similar results, with type III (14%) more common than type II (11%). Type I was the most common with a prevalence of 57%. Michel et al.,[7] observed an equal prevalence of type II and III anatomy (18%), type IV—4%, and type V—2.5%. In our study we did not find any incidence of type IV anatomy.

Blood supply to Quadrate Lobe

A novel feature of our study was the assessment of blood supply to the quadrate lobe. The quadrate lobe was supplied by LHA in 57.9% of patients. It was supplied by both LHA and RHA in 18.4% of patients. 13.2% had a blood supply with segment IV A supplied by RHA and segment IV B by LHA. In 2.6% of the population, it is supplied by LHA and a branch directly from CHA. It was supplied by LHA and accessory LHA in 2.6% of patients.

In 5.2% of patients, there was immediate trifurcation of the proper hepatic artery, and a larger branch from the proper hepatic artery was directly supplying the quadrate lobe. Quadrate lobe was supplied by RHA in 10.5% of patients.

Length of RHA and Relationship with Arterial Anatomical Variant

The average length of RHA in type I anatomy was 31.9 mm, type II anatomy 31.7 mm, type III anatomy 47.4 mm, and type V anatomy 11 mm. It was found that in type III, where there was replaced RHA, the length of RHA was longer. In type V anatomy, where there was an accessory LHA from LGA, the length of RHA was found to be smaller, with an average length of 11 mm. The mean length of RHA when compared with different anatomical variation groups showed that there was a significant difference in mean length of RHA in a patient having type I arterial anatomy and with patients of type III and type V arterial variation. Type III was longer compared to type I, whereas type V was shorter compared to type I. There was a significant difference in mean length of RHA of patients with type III and type V variation. This was also novel to our study. There are no previous studies available that studied the relationship of RHA length and type of anatomical variation.

Hepatic Venous Anatomy and Variations

57% of the middle and left hepatic veins drained into the IVC, uniting as a single orifice; the left and middle hepatic veins drained into the IVC individually in 42%. The presence of two MHVs was found in 5.3% of the population. 36% of the study population had accessory hepatic veins draining segment VI, and 34% had accessory hepatic veins draining segment VII. 7% were not having any accessory hepatic veins. Out of these, 1.7% were having a pattern in which the middle and left hepatic veins join together and drain into the IVC. In the remaining 5.3%, the right, middle, and left hepatic veins were joining separately into the IVC. 60% were having two accessory hepatic veins, 28% were having a single accessory hepatic vein, 2.6% of patients were having three accessory hepatic veins, and 7% of the patients were having no accessory hepatic veins.

Out of the patients who were having MHV and LHV joining together and draining into IVC, 7.9% of patients were having accessory hepatic vein draining segment VII, and 5.3% of patients were having accessory hepatic vein draining segment VI. 6% of patients had an accessory hepatic vein draining segment VI and segment II, and 2.6% of patients had an accessory hepatic vein draining segment VI and another vein from segment IV A directly into the IVC. 2.6% of patients had an accessory hepatic vein draining segment VII along with the presence of two middle hepatic veins. Out of the 26% of the population who had a normal ramification pattern, 2.6% of patients had accessory hepatic vein draining. Segment VIII, 15.8% were having accessory hepatic vein draining segment VIII, 10.5% had accessory hepatic vein draining segment VI, and 2.6% had accessory hepatic vein draining both segment II and segment VII. Another 2.6% of the population had two middle hepatic veins, an accessory hepatic vein draining segment VII and segment VI. Accessory hepatic veins draining segments VI and VIII were seen in another 2.6%. Few of the findings of our study were different from the study of Taha et al. According to Taha et al.,[10] standard hepatic venous anatomy (a triplet of hepatic veins draining separately into the IVC (Inferior Vena Cava)) was found in 65.6%. Another 34.4% presented hepatic venous drainage variants. 25% had a single significant accessory hepatic vein. 9.4% had two or more significant accessory hepatic veins. An accessory inferior right hepatic vein was the commonest accessory hepatic vein detected, 21.9%. In our study, the percentage of patients with two accessory veins was more than that of a single accessory vein.

In Soyer et al.,[11] study, drainage of the middle hepatic vein into IVC as two separate hepatic veins was not described. According to Ozosy et al.,[12] 61 donors had this type of variant. Normal anatomy was described as the drainage of the hepatic veins into the IVC as three main trunks appearing in the letter “W”. Soyer et al.,[11] reported the ratio of normal anatomy to be 68%; Lafortune et al.,[13] reported the same ratio to be 70%. In our series, normal anatomy (drainage into IVC like W) was observed in 42% of subjects; this ratio is different from the ratios reported in the literature.

The prevalence of accessory hepatic veins was considerably higher in our series compared to other studies. i.e., 28% of single accessory hepatic veins, 60% of 2 or more accessory hepatic veins. The reason may be that our study was done in a 128-slice CT scanner with a minimum slice thickness and no slice gap, which helped in better visualization and detection of all the accessory veins.

Portal Anatomical Variation

The majority of the patients (81.7%) were having type I anatomy, the usual bifurcation type (normal branching pattern). Type II is a trifurcation pattern without the trunk of RPV, which was seen in 13.2%. 5.3% were having type III anatomy, wherein the right anterior sectorial branch arises separately from the proximal or extra-parenchymal part of LPV. In the case of trifurcation, surgical planning must be modified because of the lack of a portal segment to clamp during surgery. There are increased chances of bleeding in the donor and difficult anastomosis in the recipient. The frequency of portal vein variations was consistent with a previous study done by Soyer et al.,[11] in which type II anatomy was more common than type III anatomy. The results of our study were different from those of Covey et al.,[14] and Atasoy et al.[15] The frequency of type II and type III anatomy was 9% and 13% for Covey et al.,[14] and 9.5% and 23.5% for Atasoy et al.,[15] respectively.

Biliary Anatomy and Variations

Biliary anatomy on imaging was studied using MRCP. 68.4% of the study subjects were having normal biliary configuration. Variant anatomy was found in 31.6% of the remaining patients. 10.5% were having type II anatomy. 13.2% of patients were having type III A anatomy, and 5.3% type III B anatomy. Type VI anatomy was found in 2.6% of patients. Type IV and type V anatomy were not found in any of the patients.

The imaging findings, when compared with intraoperative findings, showed that 2.6% of patients who had type III B anatomy on imaging were found to have type III A anatomy in intraoperative cholangiography. A single patient was having type VI biliary anatomy on imaging but was found to have normal anatomy on IOC. The comparison study of imaging features of biliary anatomy and intra-operative cholangiography findings was done, and the p-value was 0.62, showing there is no statistically significant difference between MRCP and intra-operative cholangiography findings.

Ozsoy et al.,[12] the second most common variation was RPHD joining LHD, then comes trifurcation. Radha Sarwagi et al.,[16] also had similar conclusions. 27% of variation was RPHD draining to LHD, then trifurcation with a percentage of 29.3%. Huang et al.,[17] found that 60% have normal anatomy, 6% have a pattern of trifurcation, and 30% of the RPHD population is joining LHD. The finding of our study was consistent with other studies.

Some of the limitations of the study were that the total number of patients included was less compared to other similar studies. Also, we did not find some portal variations at all, possibly because of the lower number of cases. Intrahepatic arterial variation was not studied in our study; literature shows that the intrahepatic arterial system proceeds in parallel to the biliary system. We focused on extra-hepatic arterial variation, which is more important for the surgical planning. We did not study the variations of the cystic artery as well, as it was less relevant for our study. Intraoperative correlation of vascular anatomy was not done. The study involved only a specific group of subjects that is liver donors. This particular group was limited and specific. We couldn’t assess the intrahepatic variations occurring due to liver lesions. In our study, cases with left hepatectomy were relatively less, which resulted in an insignificant correlation when CT volumetry was compared with post-hepatectomy volume.

REPRESENTATIVE IMAGES OF THE STUDY

Arterial anatomy and variations

Case 1

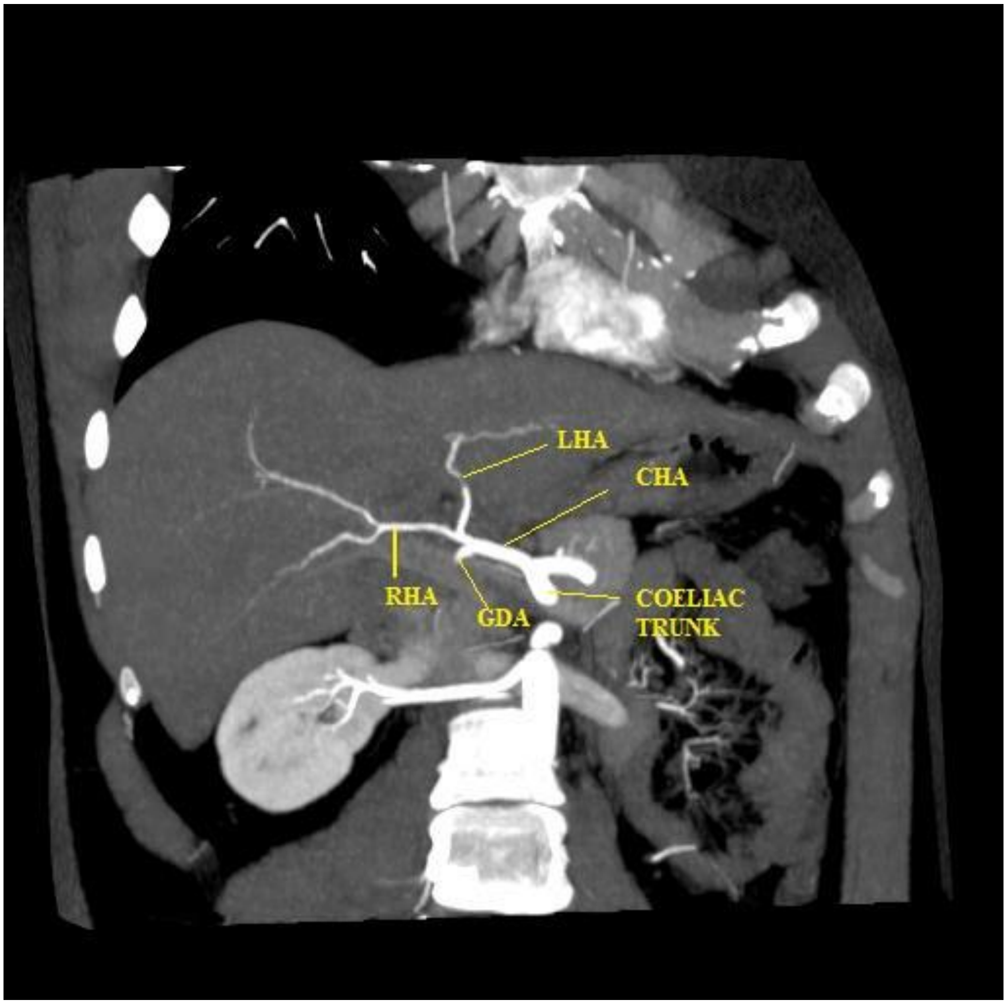

Figure 1: Type I arterial anatomy (RHA& LHA arising from proper hepatic artery)
RHA- Right hepatic artery, LHA- Left hepatic artery,
CHA-Common Hepatic artery, GDA- Gastro duodenal artery

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Case 2.

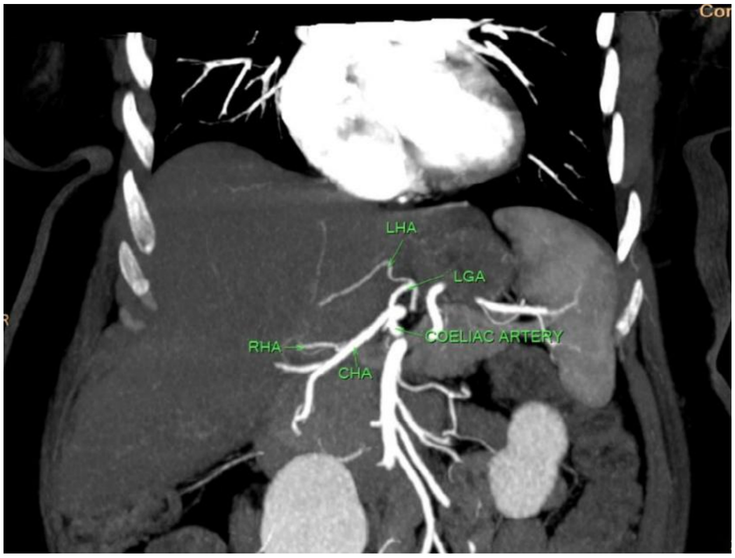


Figure 2. Type II arterial anatomy (LHA arising from LGA)

RHA- Right hepatic artery, LHA- Left hepatic artery, LGA- Left gastric artery

CHA-Common Hepatic artery

Case 3.

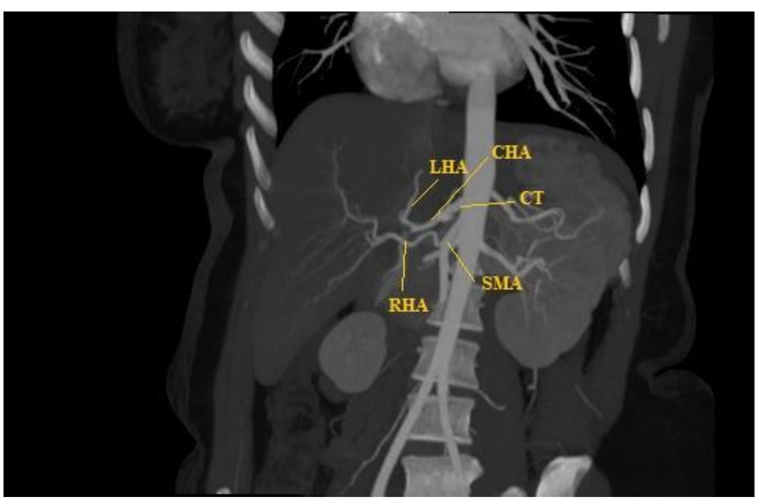


Figure 3. Type III arterial anatomy (Replaced Right hepatic artery)

RHA- Right hepatic artery, LHA- Left hepatic artery

CHA-Common Hepatic artery

CT- Coeliac trunk

SMA- Superior Mesenteric artery

Case 4.

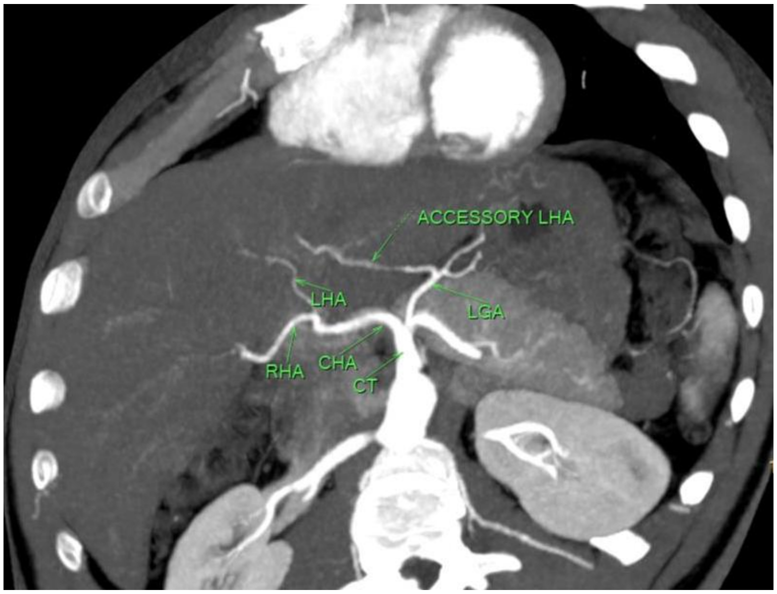


Figure 4 :Type V arterial anatomy . A left hepatic artery originating from the left gastric artery in addition to the left branch of the hepatic artery. RHA- Right hepatic artery, LHA- Left hepatic artery ,LGA – Left gastric artery .CHA-Common Hepatic artery

Case 5

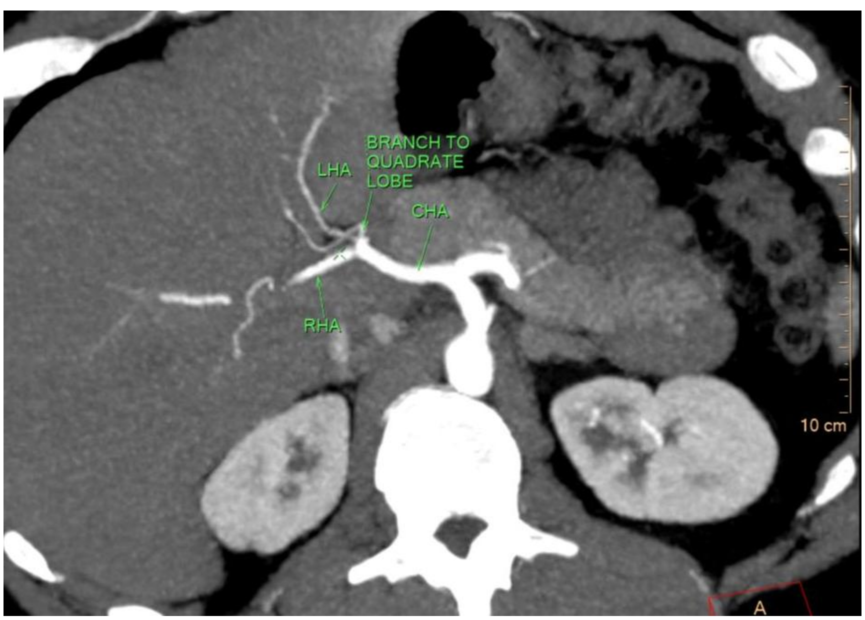


Figure 5: Type I arterial anatomy with immediate trifurcation of proper hepatic artery.

Venous anatomy and variations

Case 6.

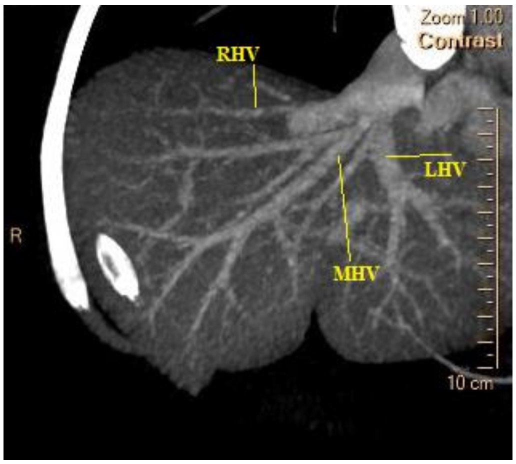


Figure : 6

Normal anatomy of hepatic veins.

RHV, MHV and LHV joins separately into IVC

RHV-Right hepatic vein

MHV-Middle hepatic vein

LHV- Left hepatic vein

Case 7

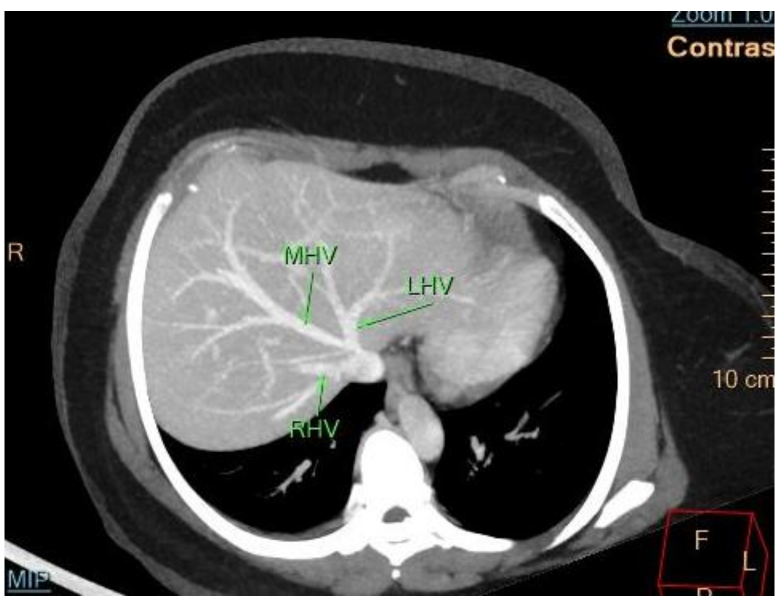


Figure 7: MHV and LHV joins to IVC as a single orifice.

RHV- Right hepatic vein, MHV –Middle hepatic vein ,LHV- Left hepatic vein

Case 8

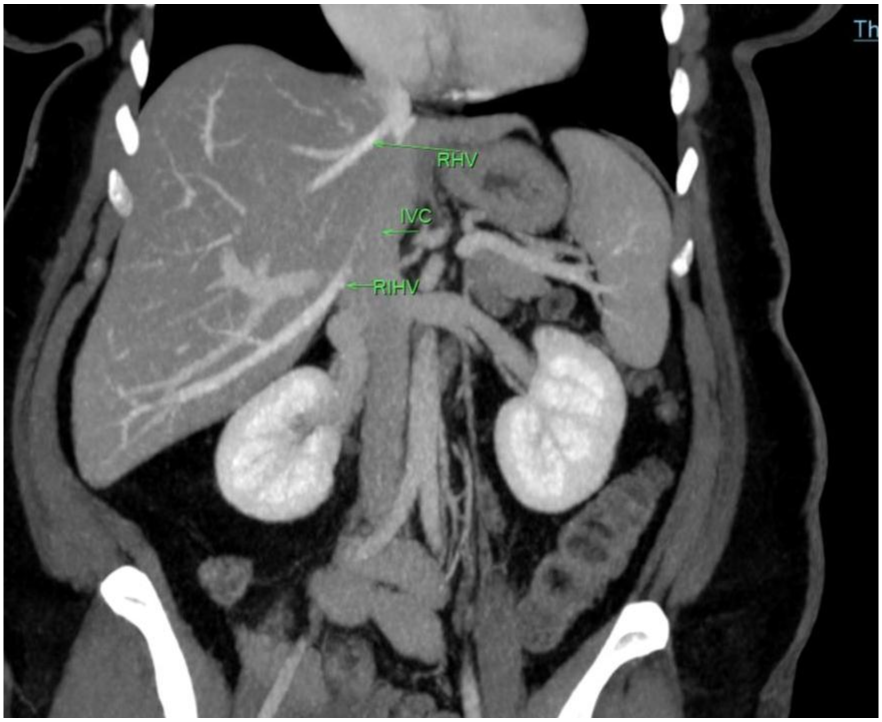


Figure 8. Right inferior hepatic vein draining segment VI and VII to IVC

RIHV- Right inferior hepatic vein , IVC- Inferior venacava

RHV –Right Hepatic vein

Case 9

Figure 9: Small accessory hepatic vein from segment VI

Portal Anatomy and variations

Case 10

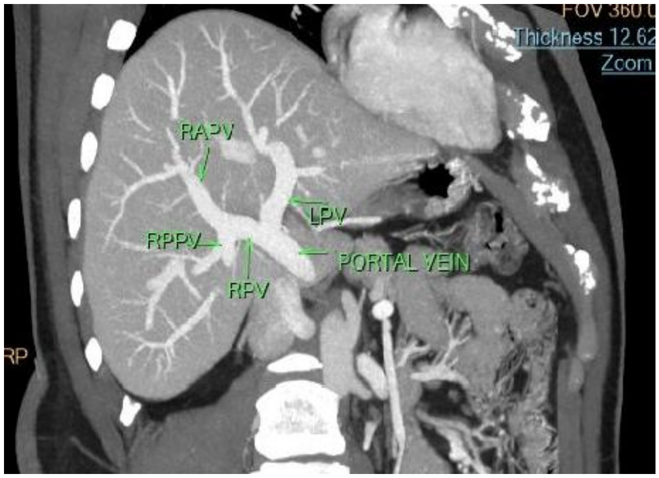


Figure 9. Normal portal vein anatomy.Portal vein branching into right and left branches, Right portal vein dividing secondarily into two branches- Anterior(supplying segment V and VIII) and Posterior (supplying segments VI and VII)RPV-Right Portal vein, LPV- Left portal vein, RAPV-Right anterior portal vein, RPPV-Right posterior portal vein.

Case 11.

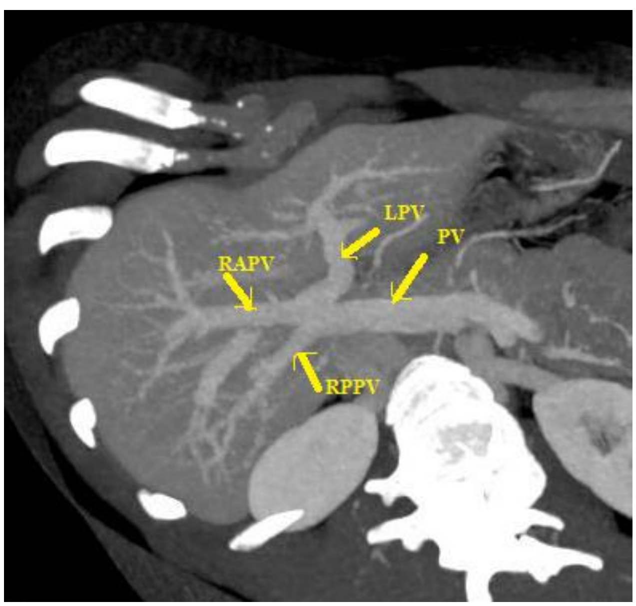


Figure 11 Portal trifurcation with division of the main portal vein into the left, right anterior, and posterior branches. RPV-Right Portal vein, LPV- Left portal vein, RAPV-Right anterior portal vein, RPPV-Right posterior portal vein.

Case 12.

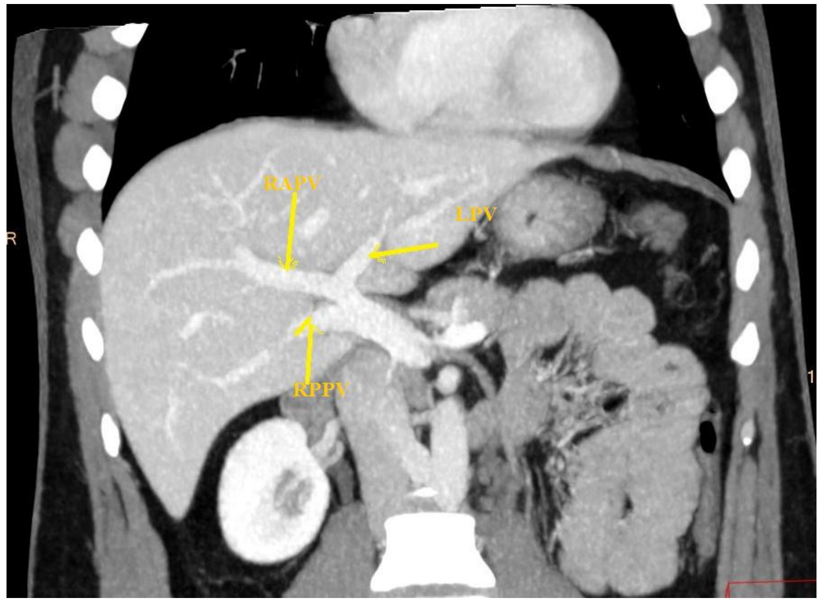


Figure 12: Type III portal variation

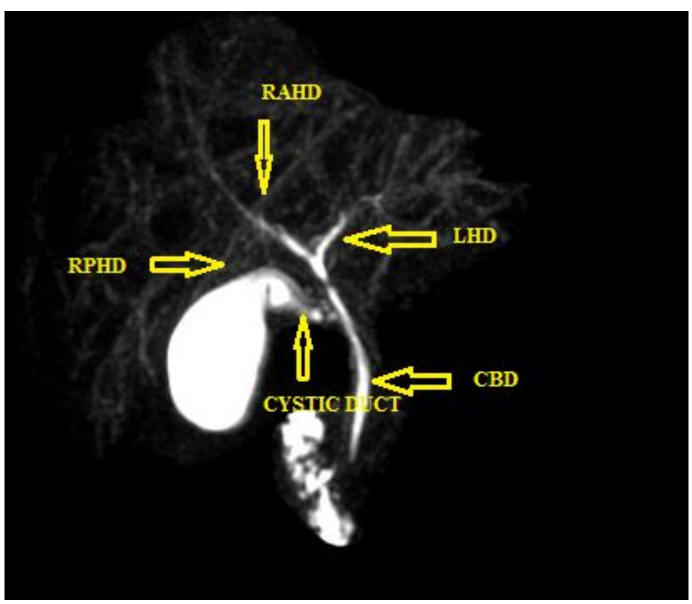
RAPV is coming from LPV.

RPV-Right Portal vein, LPV- Left portal vein,RAPV-Right anterior portal vein, RPPV-Right posterior portal vein

BILIARY ANATOMY AND VARIATIONS

Case 13. Figure 13: Normal biliary anatomy MRCP

Figure 13: The left and right hepatic ducts unite to form the **common hepatic duct (CHD)**.segments VI and VII: **right posterior duct (RPHD)**, coursing more horizontally, segments V and VIII: **right anterior duct (RAHD)**, coursing more vertically ,right posterior and anterior ducts unite to from the **right hepatic duct (RHD)**,segmental bile ducts from II-to-IV unite to form the **left hepatic duct (LHD)**



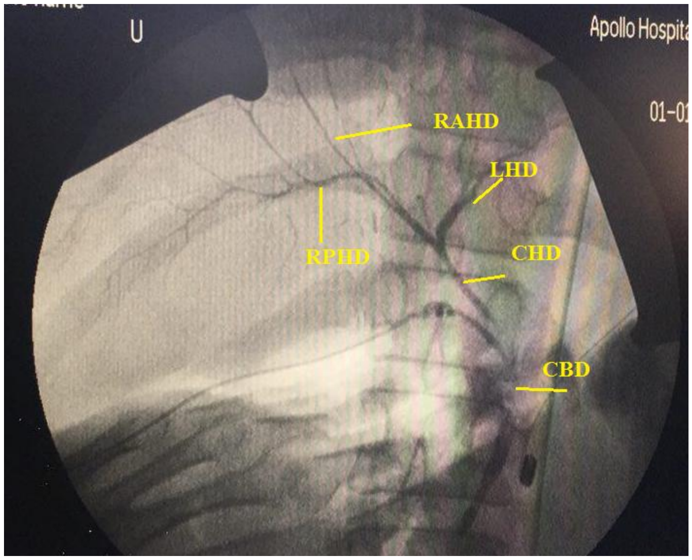


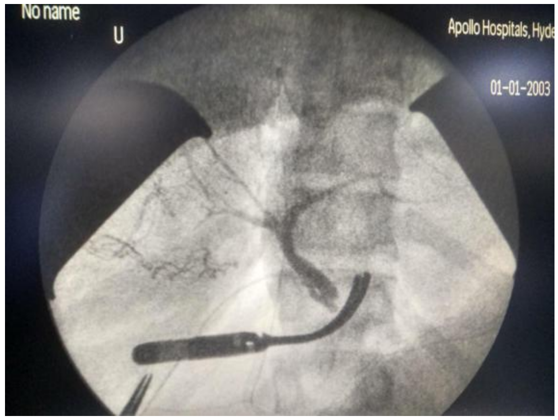
Figure 13.1: Normal biliary anatomy intraoperative cholangiography

Case 14

Figure 14: Type II biliary anatomy MRCP

Figure 14,14.1: Type II biliary anatomy
Trifurcation,
RAHP ,RPHD and LHD simultaneously emptying into CHD
right posterior duct (RPHD)
right anterior duct (RAHD),
left hepatic duct (LHD)
common hepatic duct (CHD)

Figure 14.1 : Type II biliary anatomy intraoperative cholangiography



Case 15

Figure 15: Type III A Biliary Anatomy (MRCP)

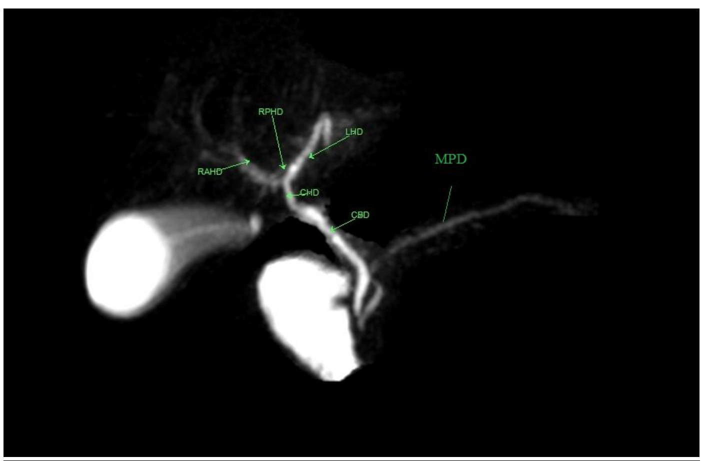


Figure 15.1: Type III A anatomy intraoperative cholangiography

Figure 15 ,15.1 : Type III A biliary anatomy. Right posterior hepatic duct opening into the left hepatic duct . Coronal MRCP image showing right posterior hepatic duct opening into the left hepatic duct . Primary confluence is formed by the right anterior sectoral duct and the left hepatic duct

right posterior duct (RPHD)

right anterior duct (RAHD),

left hepatic duct (LHD)

common hepatic duct (CHD)

Case 16.

Figure 16: Type VI biliary anatomy

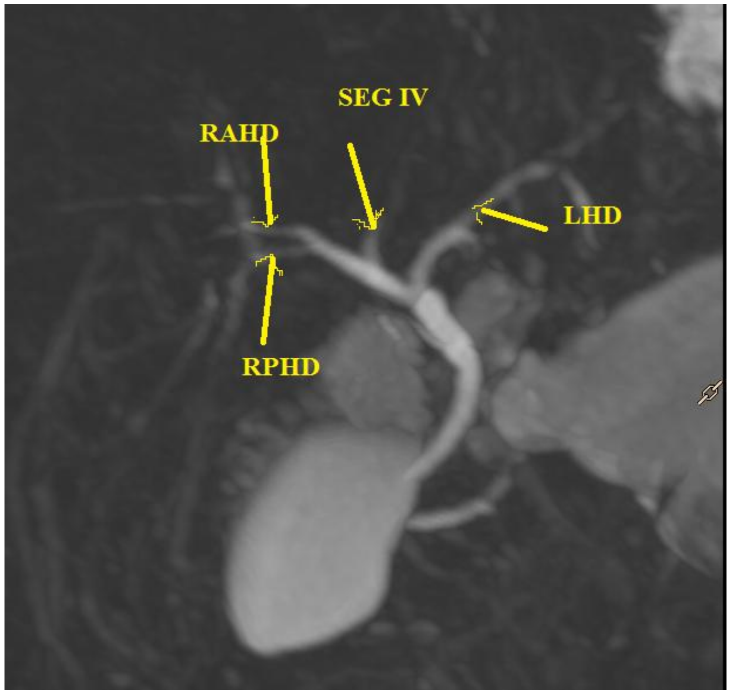


Figure 16: Type VI biliary anatomy. Segment II/ III/IV ducts draining into RHD or CHD

right posterior duct (RPHD) ,right anterior duct (RAHD), left hepatic duct (LHD),common hepatic duct (CHD)

Conclusion:-

The present study was conducted to identify, describe and estimate the prevalence of anatomical variants of the hepatic arterial, portal, venous, and biliary systems by imaging and their comparison with intraoperative findings. Anatomical variants in the vascular and biliary systems are common in living liver donors and can pose challenges for the transplant. It's important to recognize and manage these variants to ensure the safety of the donor and reduce complications for the recipient.

References:-

[1] Strong RW, Lynch SV, Ong TH, Matsunami H, Koido Y, Glenda A,et al. Successful liver transplantation from a living donor to her son. N Engl J Med 1990;322:1505-7.

[2] Sun Z, Yu Z, Yu S, Chen J, Wang J, Yang C, et al. Post-operative complications in living liver donors: a single-center experience in China. PloS One 2015;10(8):e0135557.

[3] Choi JW, Kim TK, Kim KW, Kim AY, Kim PN, Ha HK, Lee MG. Anatomic variation in intrahepatic bile ducts: an analysis of intraoperative cholangiograms in 300 consecutive donors for living donor liver transplantation. Korean Journal of Radiology 2003;4(2):85-90.

[4] Li YC, Hu Y, Zhang MM, Jin XQ, Fan X, Pu CL, et al. Usage of 64-detector-row spiralcomputed tomography volumetry in preoperative volume prediction in living donor livertransplantation in children. Pediatr Surg Int2011;27:445–9.

[5] Salvalaggio PR, Baker TB, Koffron AJ, Fryer JP, Clark L, Superina RA, et al. Liver graftvolume estimation in 100 living donors: measure twice, cutonce. Transplantation 2005;80(9):1181-5.

[6] Frericks BB, Caldarone FC, Nashan B, Savellano DH, Stamm G, Kirchhoff TD, et al. 3D CT modeling of hepatic vessel architecture and volume calculation in living donated livertransplantation.EurRadiol2004;14:326-33.
[7] Michels NA Am J.Newer anatomy of the liver and its variant blood supply and collateral circulation. Surg 1966;112(3):337-47.
[8] Hiatt JR, Gabbay J, Busuttil RW. Surgical anatomy of the hepatic arteries in 1000 cases. Ann Surg 1994;220(1):50-52.
[9] Gruttadauria S, Scotti Foglieni C, Doria C, Luca A, Lauro A, Marino IR. The hepatic artery in liver transplantation and surgery: vascular anomalies in 701 cases. Clinical Transplantation 2001;15(5):359-63.
[10] Ali TF, Tawab MA, EL-Hariri MA, Abdel-Fattah ES. Pre-operative hepatic vascular mapping of living donor for liver transplantation using 64-MDCT. The Egyptian Journal of Radiology and Nuclear Medicine 2012;43(3):325-36.
[11] Soyer P, Bluemke DA, Choti MA, Fishman EK. Variations in the intrahepatic portions of the hepatic and portal veins: findings on helical CT scans during arterial portography. Am J Roentgenol 1995;164(1):103-8.
[12] Ozsoy M, Zeytunlu M, Kilic M, Alper M, Sozbilen M. The results of vascular and biliary variations in Turks liver donors: comparison with others. International Scholarly Research Notices 2011;2011(1):367083.
[13] Lafortune M, Madore F, Patriquin H, Breton G. Segmental anatomy of the liver: a sonographic approach to the Couinaud nomenclature. Radiology 1991;181(2):443-8.
[14] Covey AM, Brody LA, Getrajdman GI, Sofocleous CT, Brown KT. Incidence, patterns, and clinical relevance of variant portal vein anatomy. Am J Roentgenol 2004;183(4):1055-64.
[15] Atasoy C, Özyürek E.Prevalence and types of main and right portal vein branching variations on MDCT. Am J Roentgenol 2006;187(3):676-81.
[16] Sarawagi R, Sundar S, Raghuvanshi S, Gupta SK, Jayaraman G. Common and uncommon anatomical variants of intrahepatic bile ducts in magnetic resonance cholangiopancreatography and its clinical implication. Pol J Radiol2016;81:250-5.
[17] Hwang S, Lee SG, Sung KB, Park KM, Kim KH, Ahn CS, et al. Long-term incidence, risk factors, and management of biliary complications after adult living donor liver transplantation.Liver Transpl 2006;12(5):831-8.