ORIGINAL ARTICLE

HEPATIC AND PORTAL VEINS ANATOMICAL VARIANTS: PREVALENCE AND CLINICAL IMPLICATIONS ON ROUTINE ABDOMINAL MDCT

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ABSTRACT

This study reviewed the types, prevalence rate and implications of anatomical variants of the hepatic and portal veins by using routine abdominal multidetactor computed tomography (MDCT). These aberrant increase the risk of catastrophic liver injury and must be diagnosed for interventional radiologist's and vascular surgeons before complex hepatectomy, living donor transplantation or hepatic venous embolization. **MATERIAL AND METHOD:** This is a prospective study of 7 months from May to November 2017, included 100 patients referred to radiology department. **RESULTS:** In total, 66 patients out of 100 had at least one abdominal vein variant and anomalies. The hepatic vein variants had high frequency 45% (n=45), while hepatic veins were identified in 41% (n=41). And 20% (n=20) had both variations. Inferior right hepatic IRHV was more common in 46.6% (n=21). The surgically significant mean diameter of hepatic vein was >5mm in 13.3% (n=06). The Variations of the PV system were observed in 41% (n=41) while 59% (n=59) had the normal or classic pattern of the PVs anatomy. The commonest was trifurcation PV (Type 2) in 58.5% followed by right posterior PV as a first branch of main PV (Type 3) in 19.5% (n=08) patients. The branch of segment VII and VI was identifies as a separate branch of RPV in 4.2% (n=02) and 14.6% (n=06) respectively. **CONCLUSION:** The aberrant portal veins in 66% patients indicate vulnerability to inadvertent complications during surgery and radiological interventions. This emphasizes for diligence CT reporting by radiologists to reduce injury and complications in liver procedures and transplant.

Keywords: Aberrant hepatic artery; Portal vein, liver transplantation, variations, Multidetector computed tomography

Introduction

The portal vein anomalies are usually asymptomatic and mostly identified incidentally during surgeries and diagnostic angiographies but impose risk to patients undergoing surgical interventions, transplantation and interventional procedures of liver.[1] The advancements in liver surgery, living donor transplantation, complex liver resection, and interventional radiological procedures like portal vein embolization (PVE) demand precise and reliable preoperative imaging of vascular anatomy to avoid potential catastrophic complications.[2]

The preoperative knowledge of formation, termination and tributaries of portal vein, superior mesenteric vein and splenic vein variants are very important for vascular and transplant surgeons for planning intervention and managing surgeries of liver, pancreas and spleen. It enables interventional radiologists for better radiological procedures.[3,4]

In Living Donor Liver Transplants (LDLT), the hepatic venous variants anatomy imposes the risk of hepatic

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venous complications.[5] Hence, preoperative evaluation of hepatic venous anatomy minimizes surgical complications for the donor and recipient.[6,7] The preoperative anatomical detection of the hepatic vascular pattern helps to reduce iatrogenic complications and leads to better outcomes.[8]

The routine Multidetector CT (MDCT) is considered as gold standard for visualization of hepatic arteries and veins supplying the hepatic parenchyma in living subjects.[9] In MDCT the multiple slices are acquired at higher rate with enhanced CT image acquisition. Thus, the MDCT angiography is valuable in evaluation of portal vein patency and preoperative planning for hepatic resection.[10]

The study aims to highlight the hepatic and portal veins anatomy, variations and their implications for liver surgery and radiological interventions using routine abdominal MDCT.

LIVER ANATOMY

The liver being the largest vascular viscera weighs about 2% of body weight in the adult.[11] The Couinaud classification of liver anatomy divides the liver into eight functionally independent segments with a branch of the portal vein, hepatic artery and bile duct. These self-contained units can be resected without damaging those remaining. For the liver to remain viable, resections must proceed along the vessels that define the peripheries of these segments.

The two distinct blood supply sources to the liver are hepatic artery and portal vein. All blood exits the liver via the hepatic vein. The liver holds about one pint (13%) of the body's blood supply at any given moment.[12]

NORMAL PORTAL VEINS:

The normal portal vein is formed by union of superior mesenteric and splenic veins behind the neck of pancreas in front of inferior vena cava and at the level of L2 vertebra.[13] The portal trunk divides into left and right portal veins. The right portal vein branch divides secondarily into two branches: the right anterior portal vein feeding segments V and VIII and the right posterior vein feeding segments VI and VII (Type 1). Any deviation from this anatomy is considered an anatomical variant.

PORTAL VEINS VARIANTS:

The most common variant is the so called “portal vein trifurcation” where the main portal vein divides into three branches: the left portal vein, the right anterior portal vein, and the right posterior portal vein (Type 2).[14] The second most common variant is a right posterior portal vein originating as the first branch of the portal vein (Type 3).

These two variants account for the majority of portal vein variation (Tab. 1).

Type	Description
COMMON	
1	Normal branching pattern
2	Trifurcation
3	Right posterior PV as the first branch of main PV
UNCOMMON	
4	Segment VII branch as separate branch of RPV
5	Segment VI branch as separate branch of RPV
6	Absence of PV bifurcation
PV: Portal vein, RPV: Right portal vein	

Table 1: Portal Vein Branching Pattern

NORMAL HEPATIC VEINS ANATOMY:

The hepatic veins (generally three in number) drain the liver and empty into the inferior vena cava near the diaphragm. The right hepatic vein drains segments V and VII, the middle hepatic vein drains segments IV, V, and VII and the left hepatic vein branch drains segments II and III.[15]

HEPATIC VEINS VARIANTS:

The most common and the most frequent hepatic vein variant were one or more. The inferior right hepatic veins (IRHV) classified in (Tab. 2).

Type	Hepatic vein variants
1	Segment VII branch as a branch of RHV
2	IRHV(one)
3	IRHV(two, same level)
4	IRHV(two, different level)
5	Tributary HV
6	LHV draining separately into IVC
HV: Hepatic vein, IRHV: Inferior right hepatic vein, IVC: Inferior vana cava, LHV: Left hepatic vein	

Table 2: Hepatic Vein Variations

Material and Methods

This is a prospective study of 7 months from May to November 2017, included 100 patients referred to radiology department for abdominal CT scan on routine preoperative transplant work-up to radiology department of a transplantation hospital. The study was approved by ethical committee. The patients with large hepatic masses, distorted intrahepatic portal venous anatomy and poor opacification of the vessels were excluded.

IMAGE ACQUISITION AND PROCESING:

Tri-phasic CT abdomen was performed on GE Single-source Dual Energy CT scanner (Discovery CT 750HD; GE Healthcare, Milwaukee, WI). 100ml of non-ionic iodinated contrast material (iodine concentration, 400 mg ml^{-1}) was injected at a rate of 4 ml s^{-1}. Scans were acquired in hepatic arterial, portal venous and hepatic venous phase using a Smart Prep Protocol with enhancement threshold set at 150 HU. Examination parameters were detector coverage 40 mm, 98.43 mm s^{-1} table speed, 0.5 s rotation time, pitch and speed of 0.984, 1.5 mm section thickness, 5-mm reconstruction interval, 120 kVp and 200-360 mA (auto). Additional images were reconstructed with 1.25 mm reconstruction intervals for detailed interpretation.

IMAGE INTERPRETATION AND DATA COLLECTION:

All CT images were analyzed post-processing technique including Maximum Intensity projection (MIP), multiplanar reconstruction (MPR) and volume rendering (VR). The presence, types and numbers of variants or anomalies of the hepatic and portal veins were recorded and excluded the inferior right hepatic veins smaller than 2 mm diameter.

Results

The distribution frequency showed 66 patients out of 100 exhibited at least one abdominal vein variant. The patients with hepatic vein variants had concomitantly significantly higher frequency of portal vein variants than those with normal hepatic veins. The 45% (n=45) patients had hepatic vein variation, 41% (n=41) exhibited portal vein variants while 20% (n=20) had both hepatic and portal variants concomitantly. The graphic presentation of percentage of normal and variants of hepatic and portal veins is shown in (Fig. 1):

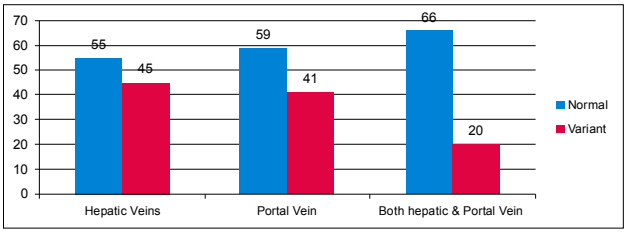

Figure 1: The percentage of normal and variants of Hepatic and Portal veins

HEPATIC VEINS:

The 55 (55%) of patients had normal Hepatic veins while 45 (45%) patients had variants, which composed of three main veins: Right, Left and Middle hepatic vein. Only 46.6% (n=21) patients had one or more IRHVs defined as caudal HVs draining into IVC. The (Tab. 3) explains the frequency distribution of Hepatic vein distribution in study population:

Type	Hepatic vein variants	#	%
1	Normal branching pattern	55	55
2	Segment VII branch as a separate branch of RPV	15	33.3
3	IRHV(one)	21	46.6
4	IRHV(two, same level)	2	4.4
5	IRHV(two, different level)	1	2.2
6	Tributary HV	6	13.3
7	LHV draining separately into IVC	1	2.2
HV: Hepatic vein, IRHV: Inferior right hepatic vein, IVC: Inferior Vana Cava, LHV: Left hepatic vein			

Table 3: Hepatic Vein Variations

In 37 patients the mean diameter measured was 4.9 mm and 08 patients had ≥ 5mm diameter which has significant surgical implication. Only 06 (13.3%) patients out of 45 had early tributary HVs.

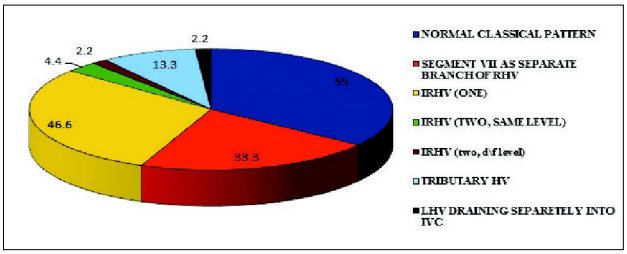

Figure 2: The frequency distribution of Hepatic vein variants

PORTAL VEINS:

The Portal vein variants were observed in 41 (41%) patients while 59 (59%) patients had normal or classic pattern of the PVs anatomy which comprises of division of Main PV at the hilus of liver into Right PV and Left PV. The Right PV further divides into anterior and posterior trunks. The common variant we observed was the trifurcation of the PV (Type 2) found in 24 (58.5%) patients. The second common PV variant was right posterior PV as a first branch of main PV (Type 3) was detected in 08 (19.5%) patients. While the branch of segment VII and VI as a separate branch of RPV was seen in 4.8% (n=2) and 14.6% (n=6) respectively. The frequency of PV variants is described (Tab. 4).

Type	Description	#	%
1	Normal branching pattern	59	59
2	Trifurcation	24	58.5
3	Right posterior PV as the first branch of main PV	8	19.5
4	Segment VII branch as separate branch of RPV	2	4.8
5	Segment VI branch as separate branch of RPV	6	14.6
6	Absence of PV bifurcation	1	2.4
PV: Portal vein, RPV: Right portal vein			

Table 4: The Portal vein variants

The frequency distribution of the portal vein variants is explained in (Fig. 3):

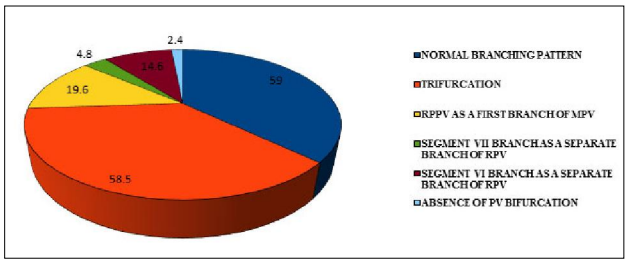

Figure 3: The frequency distribution of Portal vein variants

Discussion

In our study, we found the HVs variants in 45% of the cases and this rate is quite similar to others that have been in previous studies. The rate of inferior right HV variant is about 53.2%, it seems to be the most common variant and 13% of them were surgically significant. Different studies with different methods of investigation have reported the prevalence rate of IRHV up to 86%. We detected one or more tributary HV in 13.3% of our patients and 25% of them were surgically significant.

If a donor has large tributary HV than drains into MHV from the adjacent segment (V or VIII) of the right lobe can change the hepatectomy plane or site of anastomosis can increase postoperative complications.[16] As the living related liver donor's have increased, it is crucial for the surgeons and radiologist to know the accurate depiction and definition of the hepatic vessels anatomy.[17] A surgeon and radiologist must be familiar with both common and rare hepatic and portal vein variants to avoid accidental injury to any vessel and catastrophic surgical complications.[18]

The variations in portal anatomy also may have surgical implications. Variations in intrahepatic portal anatomy have been described by Fraser-Hill et al.[19] In a retrospective analysis of 18,550 sonographic examination of the liver, they found variation in the right and left main portal branches for seven (0.04%) and (0.05%) patients, respectively. Although the prevalence of variation (41%) was high in our study, we found fewer types of variations, but we believe our figures reflect the prevalence evaluated on thin axial sections and reformatted images. Several studies in which MDCT was used showed more frequent portal vein variants, ranging from 20% to 24%.[20]

The most common variant we observed in our study is trifurcation of the portal vein (58.5%) as in majority of previous studies showed the same result.[21] The 19.6% cases of our study population had variations in RPV branching patterns. The preoperative awareness of variants RPV branching may be beneficial in right posterior segment harvesting and in segmental resection involving the right lobe. The (Fig. 4) demons-

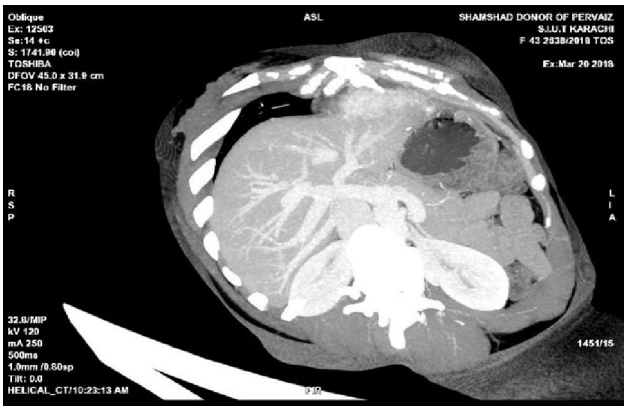

Figure 4: An axial oblique maximum intensity projection (MIP) CT image shows Right Portal Vein trifurcation arrow is demonstrated.

trates the trifurcation of portal vein while (Fig. 5) shows the 3D image of the trifurcation.

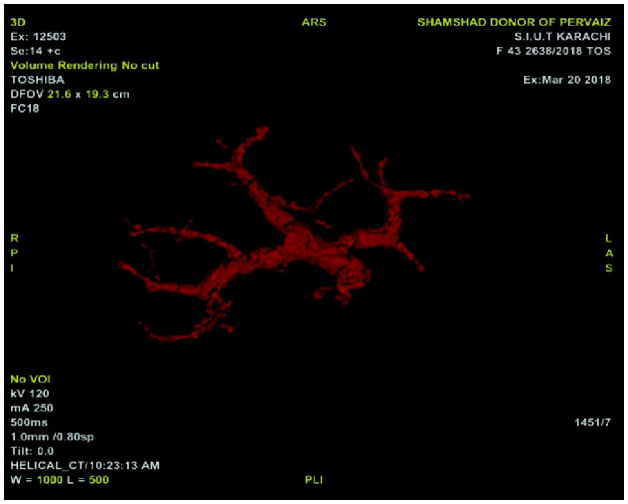

Figure 5: 3D reconstructed image shows Right Portal Vein trifurcation

With respect to linkage between categories of variants, we found a correlation between PV and hepatic vein variants. The patients with HV variants had a significantly higher frequency of PV variants than those with normal HV anatomy (P<0.002). This relationship is also been reported previously. In this way, with MDCT detection and characterization of minor venous variants and anomalies is possible preoperatively with very high sensitivity and accuracy.

The identification of vascular anatomy of hepatic and portal vein is pivotal in navigating the anatomical delineating liver segments. The living right lobe transplantation requires the removal of right lobe and this should not compromise the blood supply and metabolic functioning of rest of the left lobe. Hence, the portal vein variants occur in 20-35% of population.[22] Thus, the preoperative precision of liver blood vessels becomes mandatory for patient selection and surgery. It provides the vascular road map for surgical planning.

Conclusion

The aberrant portal veins in 66% patients indicate vulnerability to inadvertent complications during surgery and radiological interventions. This emphasizes for diligence CT reporting by radiologists to reduce injury and complications in liver procedures and transplant.

Conflict of Interest: None

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