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EVALUATION OF VARIATION OF PORTAL VEIN BRANCHING PATTERN ON MULTI-DETECTOR COMPUTED TOMOGRAPHY IN ADULT POPULATION

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ABSTRACT

Introduction:
The main aim of this study was to determine the prevalence of main and right portal vein variation in the study population and evaluate their branching patterns on abdominal CT

Methods:
A hospital-based cross-sectional study was carried out in the Department of Radiology, Bisheshwar Prasad Koirala Institute of Health Sciences (BPKIHS), over 6 months, after taking ethical approval from the institutional review committee. In total 375 cases, referred to our department, for abdominal CT for various indications, were included in the study.

Results:
The classic main portal vein branching pattern (Type 1) was identified in 305 (81.3%) cases. Similarly, main portal vein branching variations were identified in 70 (18.7 %) cases of which, the most common variation was a trifurcation pattern (Type 2) seen in 48 (12.8%) cases, followed by the right posterior portal vein as the first branch of the main portal vein (Type 3) seen in 21 (5.6%) cases. Out of 305 cases with Type 1 branching pattern, a classic branching pattern of the right portal vein was noted in 285 (93.4%) cases. The right portal vein variations were identified in 20 (6.5%) cases. Common variations of the right portal vein were present in the early origin of segment VII branch of the right portal vein, seen in 5 cases (1.6%), the early origin of segment VI branch from right portal vein seen in 4 (1.3%) cases, and a quadrifurcation pattern was seen in 3 (0.98%) cases.

Conclusion: Variations of MPV and its branches are a common occurrence on routine MDCT examinations. Trifurcation pattern of MPV and early origin of the segmental branch from RPV were the most frequent branching variation in this study.

Keywords: *Portal vein; Multidetector Computed Tomography; Variations*

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INTRODUCTION

The portal vein (PV) is one of the major vessels that drain blood from the intestine and spleen to the liver and is formed by the union of the superior mesenteric vein and the splenic vein. Variations of the main portal vein and right portal vein are quite common.[1,2] Previous studies have shown that the overall incidence of portal vein branching variation is ~25%.[3,4,5] Knowledge of the anatomy of the portal vein and its branching variations is important before performing various surgical procedures like hepatectomy, liver transplantation, and interventional procedures of the liver like portal vein embolization. A lack of knowledge of these variations increases the risk of unwanted liver injury during procedures.[1,6] A triple-phase Multidetector Computed tomography scan (MDCT) is the gold standard technique for visualizing the vascular anatomy and variations of the portal vein and has replaced the need for dissection of cadavers and other invasive conventional portal vein angiography.[7,8] It also aids in preoperative planning for hepatic surgery and other radiological hepatic interventions.

The main aim of this study was to determine the prevalence of the main and the right portal vein variations in the study population and to analyze the spectrum of their branching patterns on MDCT.

METHODS

A hospital-based cross-sectional study was carried out in the Department of Radiodiagnosis and Imaging at B. P. Koirala Institute of Health Sciences, Dharan, Nepal for 6 months, from July 2020 to January 2021, after taking the ethical approval from our local institutional review committee. In total, 375 adult cases referred to our department, for a triple-phase abdomen CT scan for various indications, were included in the study. Cases in which the portal vein anatomy was distorted due to portal vein thrombosis, presence of a large hepatic mass, and/or patients with a history of previous hepatic surgery were excluded from the study. MDCT was done on a multi-slice CT scanner – ECLOS 16; HITACHI, Japan after excluding contraindications to contrast CT. Non-contrast CT with oral contrast followed by contrast CT was done in a supine position. Volumetric acquisition of abdomen and pelvis was obtained by taking 10x10 and 7.5x7.5 mm axial sections before and after administration of intravenous contrast respectively. A contrast-enhanced CT was obtained after administration of 1.5 ml/kg of nonionic iodinated contrast agent (Iohexol 350 mg/ml) intravenously. Arterial, portal-venous and delayed-phase images were acquired at 20 sec, 60 sec, and 5 min intervals respectively. A three-dimensional (3D) reconstruction of the biliary anatomy was performed using maximum intensity projection (MIP) and volume rendering techniques (VRT). Thin-slice MPR was performed in coronal and sagittal planes for a better depiction of portal branching. Demographic records of patients along with the various types of portal vein branching patterns on CT were noted in structured proforma, and data was analyzed using the latest version of SPSS.

The classic portal vein branching anatomy categorized as type 1 in this study was the main portal vein (MPV) bifurcating into the right portal vein (RPV) and the left portal vein (LPV). Any deviation from this pattern was considered a variation of MPV in our study. A trifurcation of the MPV into the LPV, the right anterior portal vein (RAPV), and the right posterior portal vein (RPPV) were categorized as type 2; and early origin of the RPPV from the MPV followed by a bifurcation into the LPV and the RAPV from a common trunk was considered as type 3. Any other variations apart from these types were categorized as miscellaneous types.

In addition to the MPV variation, the right PV variations in patients with Type 1 MVP patterns were also noted in our study. Normally RPV after its origin from MPV further divides into the RAPV and the RPPV. The RAPV then gives off V and VIII segmental branches while the RPPV gives off VI and VII segmental branches. This pattern was considered a normal classic branching pattern of the RPV. Any deviation not following this pattern was considered a variant of the RPV in our study. Common variations of the RPV in our

study were categorized as a trifurcation of RPV, a quadrifurcation of the RPV, and early segmental branches from the RPV. Any other variations not fitting into these categories were classified as miscellaneous types.

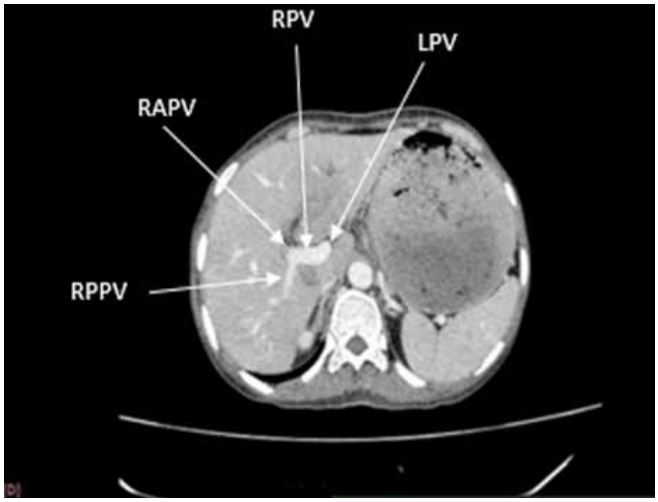
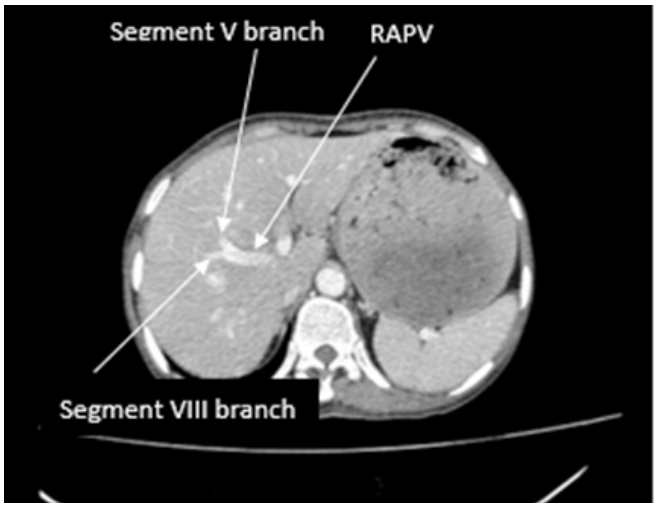


Figure:1A



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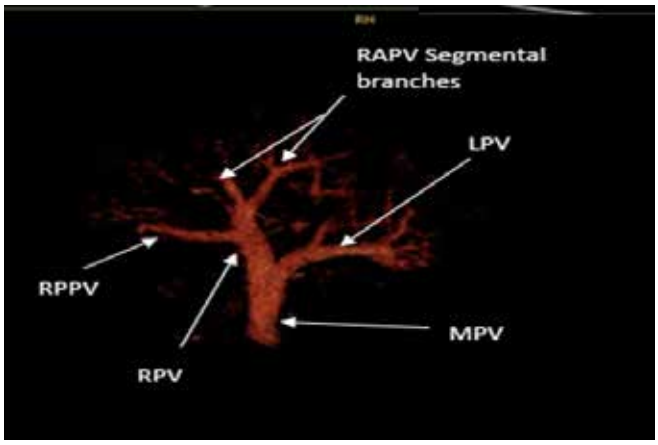

Figure:1C

Figure 1: A, B. Axial CECT abdomen showing classic portal vein branching pattern. **C**. Volume rendered image showing bifurcation of the main portal vein (MPV) into the right (RPV)and left portal vein (LPV)and right portal vein branching into the right anterior portal vein (RAPV) and right posterior portal vein (RPPV).

RESULT

Out of the 375 cases in the study group, 153(40.8%) were male and 222 (59.2%) were female, with a mean age of 49.86 ± 19.71 years. Most of the cases were in the age group of 40-49 years (69, 18.4%). A normal classic MPV branching pattern was identified in 305 (81.3%) cases (Figure 1). MPV branching variations were identified in 70 (18.7 %) patients. The most common MPV variation was trifurcation of the main portal vein into the RAPV, the RPPV, and the LPV (type 2). The second most common variation was the RPPV branch as the first branch of the main PV (type 3). In one case of the MPV variation, a completely different pattern was appreciated, in which there was an absence of PV bifurcation and all the segmental branches originated from the MPV. The frequency of the various branching patterns of the MPV in our study is shown in Table 1.

Table 1: Main portal vein variations and their frequency (n=375)

Type	Description	No. of patients	Percentage (%)
1.	Classic Branching pattern	305	81.3
2.	Trifurcation of MVP	49	12.8
3.	RPPV** as first branch of MVP*	21	5.6
4.	Miscellaneous pattern	1	0.3
	Total	375	100

*MPV=Main portal vein, **RAPV=Right anterior portal vein

Out of the 305 cases with the type 1 MPV anatomy, the classic branching pattern of the RPV was noted in 285 (93.4%) cases, while, the RPV variations were identified in 20 (6.5%) patients. The most

common RPV variation was the early origin of the segment VII branch from the RPV. The second most variation of the RPV in our study was the early origin of the segment VI branches from the RPV. Other variations that were noted in our study were the quadrifurcation pattern (in which the right portal vein directly branched into V, VI, VII, and VIII segmental branches); and the trifurcation pattern (in which the RPV branched into the RAPV and segment VI, and VII branches). A few miscellaneous branching patterns of the RPV were also seen in our study, out of which, the most common pattern was the separate origin of segment VI and VII branches from the RPV. The frequency of various branching patterns of the RPV is shown in Table 2.

Table 2: Right portal vein variations and their frequency (n=305)

Description	No. of patients	Percentages (%)
Classic branching pattern	285	81.3
Trifurcation of RPV^	2	0.65
Quadrifurcation of RPV	3	0.98
Early segmental branch of VII from RPV	5	1.6
Early segmental branch of VI from RPV	4	1.3
Miscellaneous	6	1.9
Separate branch of VI and VII segments from RPV	3	0.98
Segment VII branch from RAPV	1	0.32
Segment VI branch from RAPV**	1	0.32
Separate branch of V and VIII from LPV ^^	1	0.32
Total	305	100

^RPV=Right portal vein, ^^LPV= Left portal vein, **RAPV=Right anterior portal vein

DISCUSSION

The variations of the main portal vein and its branches are quite common. Therefore, proper knowledge of the portal vein and its variations is important, especially for planning hepatic surgeries, and before carrying out various interventional procedures.[3,4,5] Any unusual variation can complicate such surgical and interventional procedures resulting in unwanted morbidity and mortality. Nowadays, modern imaging methods like the MDCT, with its various reconstruction techniques, enable us to accurately determine the portal vein anatomy and its variations, which can be used as a roadmap for carrying out various surgical and interventional procedures.[7]

The overall incidence of the portal vein variation in different studies ranged from 15 to 40%. It was 35.5% in a study by Atasoy et al.[2]; 20.1% in a study by Sureka et al.,[3] 15.2% in a study by Lal et al.[10]; 27.4% in a study by Koç et al.[11]; 29% in a study by Sharma et al.[12]; 32% in a study by Kumar et al.[13]; and 41% in a study by Mehmood et al.[14] In our study portal vein variation was noted in 18.7% of cases, which falls within the range of variations as were present in previous studies. The most common variation of the MPV in our study was Type II, (trifurcation of the PV into the LPV, the RAPV, and the RPPV) which was observed in 12.8% of cases. The prevalence of Type II PV variation ranged from 6% to 58% in previous studies. A trifurcation of the PV was observed as the most common variant in different studies; Sureka et al.[3] (6.8%), Koç et al.[11] (11.1%), Sharma et al.[12] (12%) and Mehmood et al.[14] (58.5%). It was the second most common variant in a study by; Atasoy et al.[2] (9.5%), Lal et al.[10] (6.6%), and Kumar et al.[13](11%). The prevalence of Type III PV variation ranged from 5.6% to 23.5% in previous studies. In our study, type III PV variation was the second most common variant which was observed in 5.6% of cases similar to studies by Sureka et al.[3] (4.9%), Koç et al.[11] (9.7%), and Mehmood et al.[14]

(19.5%). Type III was the most common variant in previous studies by; Kumar et al.[13] (18%), Atasoy et al.[2] (23.5%), and Lal et al.[10] (7.6%). The differences seen in the most common variant of the MPV in studies may be due to the difficulty in differentiating between Type II and Type III portal vein variations, especially if the common LPV and the RAPV trunk are small. Differentiation between Type I and Type II portal vein can be made based on the shape of the gap between the RAPV and the RPPV as suggested by Huang et al.[15] where, if the gap was rectangular, it was considered Type II, and if the gap was triangular, it was considered Type III.

Rare variants of the MPV, like the absence of portal bifurcation, have been described in limited studies. Only one case of absence of portal vein bifurcation with total ramification was noted in our study. Similar to our study, Mehmood et al.[14] and Sureka et al.[3] also noted a single case of absence of portal bifurcation in their studies. Two cases of absence of portal vein bifurcation were noted in a study by Koç et al.[11] The right portal vein variations ranged from 4 to 18% in various previous studies; it was 17.8% in a study by Lal et al.[10], 16.8% in a study by Atasoy et al.[2], 14.8% in a study by Kumar et al.,[13] and 3.9% in a study by Koç et al.[11] In our study the RPV variations were seen in 20 cases (6.5%) in patients with Type 1 portal vein anatomy. Among various RPV variations, the early origin of segment VII branch from the RPV was the most common variation which was observed in 5 cases (1.6%) in the present study. However, in the study by Atasoy et al.[2], Koç et al., [11,] and Sureka et al., [3] this variation pattern was the second most common variation of the RPV reported in 3.8%, 0.6%, and 2.69% of cases respectively. The segment VI branch as a separate branch of the RPV was the second most common variant of the RPV observed in 4 cases (1.3%) in this study, in contrast, to study by Koç et al.[11]and Sureka et al.,[3] where such branching pattern was the most common variant of the RPV reported in 2.4% and 1.34% of cases respectively. The less common variations like a quadrifurcation of the RPV into the RAPV and three right segmental branches were seen in only 3 cases (0.98%) and a trifurcation of the RPV into the RAPV and the segment VI and VII branches, was seen in only 2 cases (0.65%) in our study. Similar to our study, in the study by Kumar et al.[13], such variations were also present in a smaller number of cases with a quadrifurcation of the RPV seen in 1(1.4%) case, and a trifurcation of the RPV seen in 6 (8.6%) cases. In contrast, a higher number of cases were observed in a study by Munguti et al.,[16] where trifurcation and quadrifurcation of RPV were seen in 11 (20.8%) and 9 (18.2%) cases respectively.
Several miscellaneous patterns of the RPV have been described in previous studies. Six cases (1.9%) with miscellaneous types of the RPV variations were seen in our study. A separate origin of the Segment VI and VII branches from the RPV was the most common miscellaneous variant present in our study, seen in 3 (0.95%) cases. Similar variants were also observed in 3 cases (0.31%) in a study by Sureka et al.[3] Another uncommon variant noted in our study was the segmental branch of V and VIII from the LPV, seen in one (0.3%) of the cases. A separate origin of segment VII from the LPV was seen in one (0.1%) case in a study by Koç et al.[11] and origin of segment VIII from the LPV was seen in two (0.2%) cases in a study by Sureka et al.[3]

There are some limitations of our study. Variation of portal vein detected on the MDCT was not confirmed using conventional portal vein angiography. Also, as the observation was done by a single radiologist, there is a potential for bias in the findings. In case of rare findings, discussion with another radiologist would have increased the reliability of the findings. In addition to this, our study was limited to studying the variations of the MPV and the RPV. However, the LPV and the hepatic veins variations are also important before performing hepatic surgeries.

CONCLUSION

Variations of the MPV and its branches are a common occurrence on routine MDCT examinations. The MPV branching variations are more prevalent than the RPV branching. A trifurcation pattern of the MPV and the early origin of the segmental branch from the RPV were the most frequent branching variation seen in this study.

CONFLICT OF INTEREST

None

SOURCES OF FUNDING

None

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