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Multidetector-Row Computed Tomography and Colour Doppler Imaging in the Evaluation of Patients with Extrahepatic Portal Hypertension: A Prospective Study

Asim Rather, Gh Mohammad Wani*, Irfan Robbani

[a] *Department of Radiology, Sher-i-Kashmir Institute of Medical Sciences, Soura, India*

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ABSTRACT

Background and aims: Evaluating patients of extrahepatic portal hypertension with Colour Doppler and MDCT to study the morphology of splenoportal axis, determining the site of obstruction, the anatomy of portosystemic collaterals, any associated vascular aneurysms, and features of portal biliopathy.

Materials and methods: We studied 45 patients (aged 6-55 years) with clinical features of portal hypertension with no identifiable hepatic cause or extrahepatic portal venous occlusion on sonography. All cases underwent Doppler ultrasound and MDCT. The data was compiled and analyzed. A comparative evaluation of Doppler imaging and MDCT was performed with the help of Cohen's kappa test to assess the agreement between the two modalities.

Results: MDCT provides better details about the morphology of the splenoportal axis, the site, and cause of block, as well as the extent and distribution of collateral groups. Colour Doppler has an advantage over MDCT in determining the direction and pattern of blood flow within the splenoportal axis, various collaterals, and spontaneous shunts, along with a better depiction of features of portal biliopathy. Colour Doppler is inadequate in the visualization of gastroesophageal and retroperitoneal varices. Identification of spontaneous spleno-adreno-renal and gastrorenal shunts is achieved with the high agreement between Colour Doppler and MDCT.

Conclusion: MDCT should be preferred for preoperative evaluation of patients being contemplated for shunt surgery. Colour Doppler imaging of portal biliopathy is sufficiently characteristic to avoid other invasive modalities. The two modalities provide complementary information in the evaluation of patients with extrahepatic portal hypertension.

1. Introduction

EHPVO (Extrahepatic Portal Venous Obstruction) is a common cause of portal hypertension in developing countries. It constitutes up to 40% of all portal hypertension patients.[1, 2] Studies from India have indicated that about 54% of portal hypertension in children is due to EHPVO.[3] The reported common causes of portal vein thrombosis in children are umbilical sepsis, neonatal systemic sepsis, umbilical catheterization, and developmental anomalies.[4-7] Dehydration and multiple exchange transfusions are two other causes.[8] Infections, neoplastic diseases, five pancreatitis, myeloproliferative disorders, and hypercoagulable states are common causes in adults.[9, 10] Portal vein thrombosis may also occur secondary to direct invasion of the portal vein by tumor;[11] it may also be seen in the setting of blunt abdominal trauma or surgery.5 Splenectomy carries a risk of developing portal vein thrombosis in 0.7-8% of patients.[12-15] However, up to 90% of cases are categorized as idiopathic in India, probably due to want for a detailed etiological workup.[16]

Radiological Evaluation

Colour Doppler imaging and MDCT have revolutionized the methodology of evaluation of portal hypertension. The cause of portal hypertension, vascular patency, collaterals, and portal flow can be assessed non-invasively. Usually, color Doppler ultrasonography (CDUS) is the first imaging modality used and is accurate in assessing the portal venous system. However, in patients who are potential candidates for portosystemic shunt procedures, a more detailed diagnostic method that covers the whole portal venous system is required to choose the type of shunt surgery to be performed.[17] The creation of vascular maps is possible using MDCT in combination with post-processing of the imaging data using a variety of three-dimensional reformatting techniques such as maximum intensity projection (MIP), shaded surface display (SSD), and volume-rendered technique (VRT). Variceal mapping is of paramount importance, especially when interventional procedures or surgery is contemplated.[18]

* *Corresponding author. Gh Mohammad Wani*
E-mail address: mohammadwani86@gmail.com
Department of Radiology, Sher-i-Kashmir Institute of Medical Sciences, Soura, India
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Aims and Objectives

Assessment of Colour Doppler Imaging and Multidetector row Computed tomography in evaluating patients of extrahepatic portal hypertension with emphasis on:

1. Defining the complete morphology of the portosplenic venous axis.
2. Determining the site of obstruction & cause of obstruction
3. Defining the distribution and extent of portosystemic collaterals and varices and presence of any venous or arterial aneurysms.
4. Defining any associated features of portal biliopathy.
5. Comparing the utility of Color Doppler Imaging vis-à-vis MDCT in managing patients with extrahepatic portal hypertension.

2. Materials and methods

PATIENTS

This prospective study was carried out over two years in a group of 45 patients evaluated with Colour Doppler Ultrasound (CDUS) and Multidetector row CT (MDCT) for assessment in clinically suspected cases of portal hypertension.

INCLUSION CRITERIA

Clinical and endoscopic features of portal hypertension with no evident hepatic cause. Greyscale ultrasound identification of extrahepatic portal venous occlusion.

EXCLUSION CRITERIA

Patients are having evidence of chronic liver disease.

Patients who have already undergone any shunt surgery.

Iodine hypersensitivity and deranged renal functions.

The study group comprised 28 female patients and 17 male patients with ages ranging from 6 to 65 years, with 30.4 years. All patients were first subjected to Colour Doppler ultrasound followed by MDCT splenoportovenography later after proper planning and preparation. Interpretation of the two imaging modalities was made in a blinded manner.

COLOUR DOPPLER ULTRASOUND IMAGING

Ultrasonographic examination and colour flow imaging was performed with a CDUS unit (Aloka pro sound SSD-3500SX, Hitachi Aloka Medical, Ltd, Japan) using a 3.5–5 MHz curvilinear transducer and high frequency 7.5 MHz linear array transducer. Using Doppler sonography portosplenic venous axis was assessed. Collaterals were sought around the gall bladder, liver hilum, gastrohepatic ligament, gastric & perigastric area, periumbilical region, and around the renal and splenic hila. An attempt was made to identify mesenteric and retroperitoneal varices. The formation of any spontaneous gastrorenal or splenorenal shunts was noted, and flow direction across shunts was determined.

MDCT PORTAL VENOGRAPHY

All patients underwent CT splenoportovenography on Siemens Somatom Sensation 64-slice Multidetector row CT scanner. The patient was given approximately 750 ml of water per oral before the scan to observe small varices in the gastric walls and gastro-esophageal junction. Detector collimation of 64 x 0.625 mm was used. 100 ml of non-ionic iodinated contrast material (Iohexol 300) was injected through an 18 or 20G angiocath, preferably into the antecubital vein via a pressure injector at a rate of 3-4 ml/sec. Bolus tracking was performed to obtain first-pass arterial phase images. Portal venous phase images were then acquired after a scan delay of 10-15 sec, after the arterial phase, depending upon the heart rate and spleen size (as determined on sonography or preceding CT images). Additional delayed phase images were acquired if the need was so felt. For patients belonging to the pediatric age group, adjustments were made in contrast administration and reduced exposure factors with resultant appreciable dose reductions. Post-processing of volumetric data obtained on Syngo multi-modality work station and 3-D reconstruction was done using maximum intensity projection (MIP) and volume rendering (VRT) algorithms for variceal mapping.

Statistical Analysis

The data obtained were compiled and subjected to analysis, and a comparative evaluation of Colour Doppler Imaging and MDCT was performed. Since the observations were in a categorical variable, we analyzed our data with the help of Cohen's Kappa test to assess the agreement between the two modalities, i.e., Multidetector row CT (MDCT) and Colour Doppler Ultrasound (CDUS). The kappa value was discussed with the 5% significance level, i.e., p-value < 0.05 considered statistically significant. Also, cross-tabulation was utilized to compare the detection of the variables on Colour Doppler and MDCT.

3. Results

The study group comprised 28 female patients (62.2%) and 17 male patients (37.7%) with an age range of 6-65 years, the mean age being 30.4 years. The majority of the patients were found to be in the age group of 11-30 years (62.2%).

COLOUR DOPPLER FINDINGS

Out of 45 patients, the cavernous transformation of the portal vein was seen in 41 patients (91%). These included eight patients (17.7%) in whom portal vein thrombosis was seen in combination with occlusion of the portal confluence and varying portions of the adjacent segments of the superior mesenteric vein and splenic vein. Intrahepatic extension of the cavernomatous transformation was seen in 28 patients (62.2 %) and involved one or more intrahepatic portal venous branches. Isolated splenic vein thrombosis was seen in 2 patients (4.4%). Colour Doppler could identify blockade of the total spleno-portal axis in 3 patients (6.6%). Spectral analysis of the vessels forming the cavernoma revealed a low velocity, steady flow pattern without phasicity directed towards the liver (hepatopetal flow).

Left gastric vein dilatation and collateral vessels within the gastrohepatic ligament were seen in 10 patients (22.2%), with the majority of these showing hepatofugal flow. In 4 patients (8.8%), lower esophageal varices were visualized, while identification of gastric varices was possible in only two patients (4.4 %). Short gastric varices could be demonstrated in 4 patients (8.8 %). Venous collaterals present in the splenic and renal hila and the retrogastric area represented the spontaneous spleno-adreno-renal and gastrorenal shunts. These could be identified in 20 patients (44.4%). Flow within these shunts was directed towards the left renal vein, which appeared dilated in 16 patients (35%). Identification of mesenteric and retroperitoneal varices (other than splenorenal) was possible in 6 patients (13.3 %). We were able to demonstrate pericholecystic varices in 24 patients (53.3%) using Colour Doppler ultrasound. We could identify splenic arterial aneurysms in 3 patients (6.6%), showing a high-velocity arterial flow on spectral Doppler. Demonstration of venous aneurysms of the spleno-portal axis was possible in 2 patients (4.4%), both being visualized at the portal bifurcation. Portal biliopathy, characterized by features such as dilatation of intrahepatic biliary radicles (IHBR) and pericholecystic varices was noted in 34 patients (75.5%). Out of 45 patients,

pericholecystic varices could be visualized in 24 patients (53.3%), and dilatation of IHBR was seen in 24 patients (53.3%).

MDCT FINDINGS

Using multidetector-row CT, portal cavernoma formation was documented in 41 patients (91%) out of a total of 45 patients. Cavernomatous transformation involving the portal confluence in combination with the entire portal vein was noted in 8 patients (17.7%), while intrahepatic extension along portal vein branches was seen in 32 patients (71.1%). Four patients (8.8%) had thrombosis limited to splenic vein only. MDCT could identify total spleno-portal axis block in 6 patients (13.3%).

Left gastric vein dilatation and collaterals within the lesser omentum were identified in 31 patients (68%). Lower esophageal and paraesophageal varices were well depicted in 25 patients (55.5%), as was a visualization of gastric varices in 18 patients (40%). Short gastric varices located between the stomach and spleen were noted in 17 patients (37.7%). The presence of spontaneous gastrorenal and spleno-adreno-renal shunts was documented in 26 patients (57.7%). These shunts were seen to be draining into the left renal vein, with resultant dilatation seen in 22 patients (48%). Mesenteric and retroperitoneal varices being visualized in 24 patients (53.3%). Pericholecystic varices were seen in 25 patients (55.5%). Dilates azygous system could be demonstrated on MDCT in 19 patients (42.2%). As with Doppler studies, no paraumbilical varices were identified on CT. Assessment for the presence of portal biliopathy was attempted on MDCT using features such as gall bladder wall varices and intrahepatic biliary ductal abnormalities. Thirty-one patients (68.8 %) were seen to be having either or both of these features. We could document pericholecystic varices in 25 patients (55.5%) and dilatation of IHBR in 16 patients (35.5%).

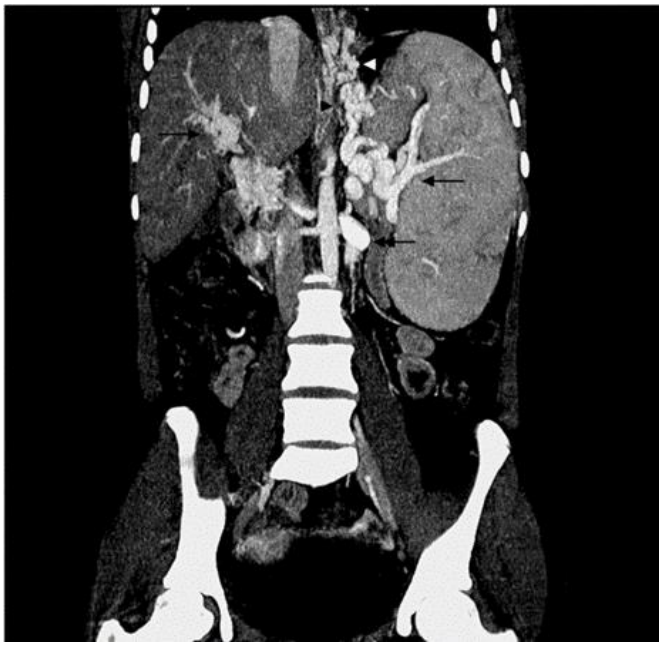


Fig. 1. Coronal maximum intensity projection (MIP) CT portal venogram in a patient with extrahepatic portal hypertension shows replacement of the main portal vein by cavernoma formation(→), splenic hilar collaterals(←), tortuous collaterals along gastrohepatic ligament(>) with prominent lower esophageal varices(<). Also noted is a dilated left renal vein(<←) and splenomegaly.

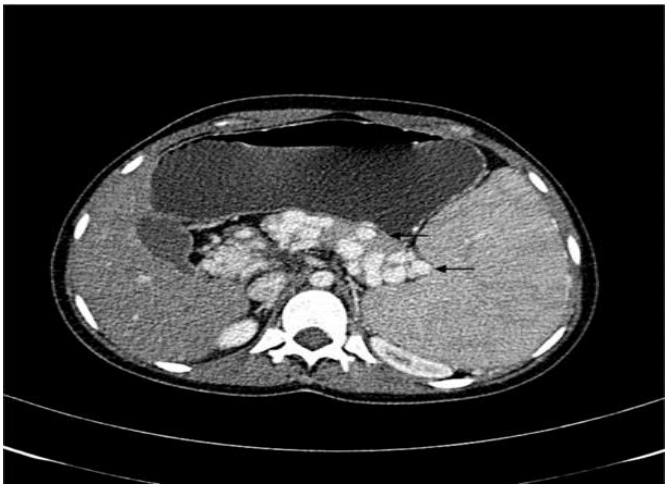


Fig. 2. Axial CT portal venogram scan in a patient with extrahepatic portal hypertension shows replacement of the entire portosplenic venous axis by multiple peripancreatic collaterals (←) and portal cavernoma formation.

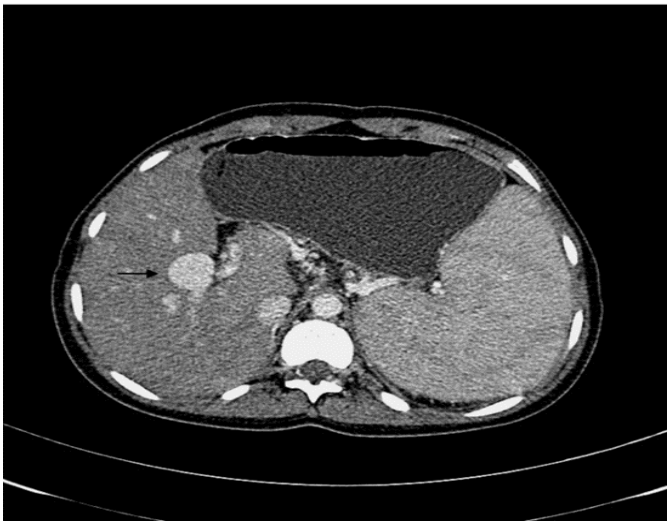


Fig. 3. Axial CT portal venogram image shows a venous aneurysm at portal bifurcation.

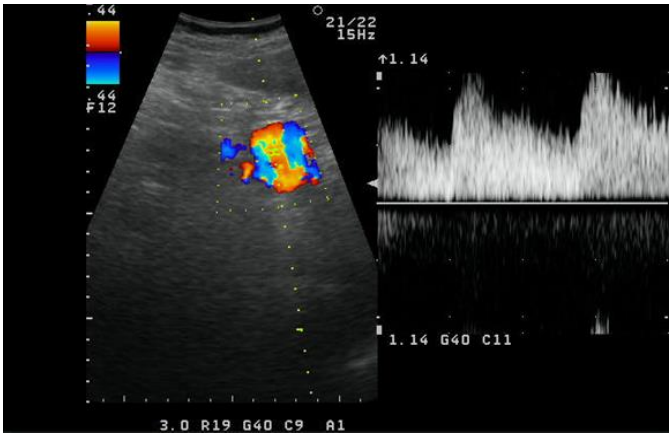


Fig. 4. Colour Doppler ultrasound image showing splenic artery aneurysm along with its spectral waveform.

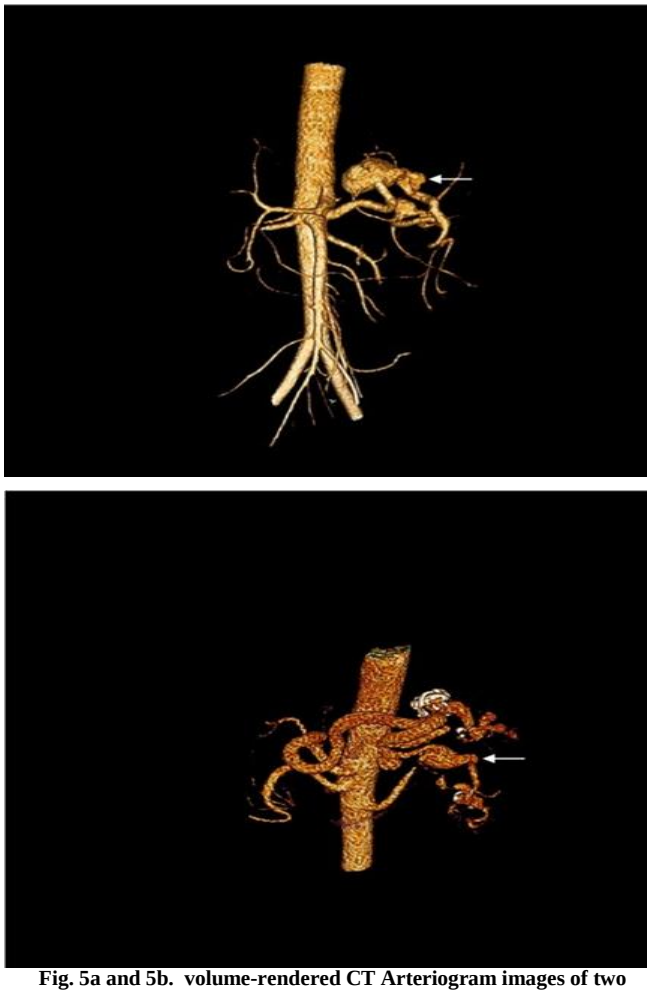


Fig. 5a and 5b. volume-rendered CT Arteriogram images of two patients with extrahepatic portal vein occlusion show tortuous Splenic artery with aneurysmal dilatations (←).

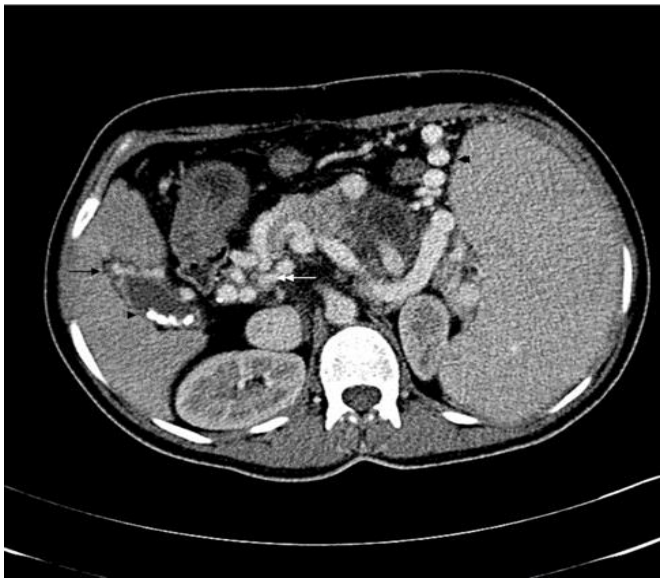


Fig. 6. Axial CT portal venogram image shows cavernomatous transformation of the portal vein(<←) with associated pericholecystic varices (→), peripancreatic collaterals, and mesenteric collaterals(<<). The note is also made of multiple GB calculi(>).

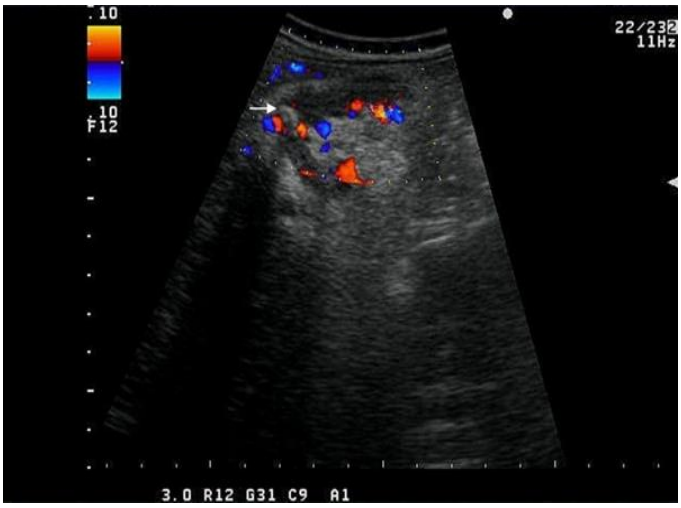
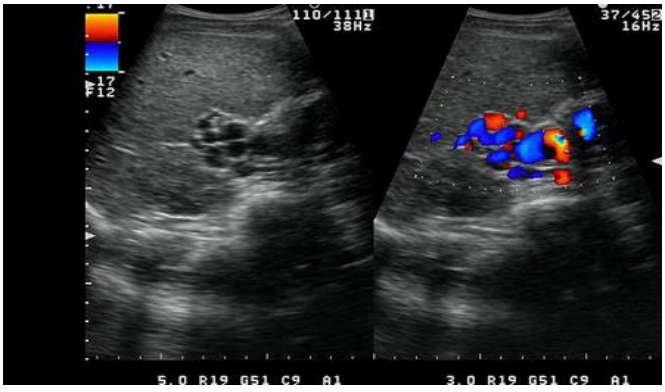


Fig. 7. Colour Doppler ultrasound image shows multiple GB wall varices in a patient having chronic portal vein thrombosis. Solitary GB calculus is also seen(→).



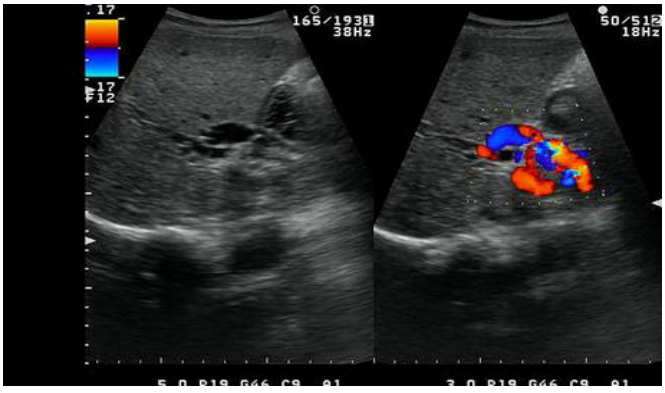


Fig. 8a and 8b. Colour Doppler ultrasound images of two patients show the absence of the main portal vein replacement by multiple serpigenous collaterals suggestive of cavernoma formation. Corresponding greyscale ultrasound images are also given.

COMPARISON OF MDCT AND COLOUR DOPPLER

Both Colour Doppler and MDCT were in complete agreement to detect cavernomatous transformation of the main portal vein and its extension into portal confluence. Identification of intrahepatic extension was also comparable between the two. However, MDCT proved to be better for visualization of isolated splenic vein block and total spleno-portal axis block. On MDCT, we could determine the cause of splenic vein thrombosis in three

patients. two patients had features of chronic calcifying pancreatitis, and one patient had a cystic mass lesion of the pancreas. Doppler ultrasound could visualize the cause in only two patients, one with CCP and the other with the pancreatic mass lesion. There was no evident cause of obstruction seen on either imaging modality in the rest of the patients. Splenomegaly was identified in 38 patients on both Doppler and MDCT. However, splenic infarcts were better seen on CT; 8 patients on MDCT compared to five patients on sonography.

Table 1. Comparison of Colour Doppler and MDCT in evaluation of various collaterals.

S.N	Variable			Doppler		Kappa Value	P-value	Percentage agreement
				n	y			
1	PORTAL CAVERNOMA	CT	N	4	0	1.000	0.001	100
			Y	0	41			
2	ESOPHAGEAL & PARAESOP. VARICES	CT	N	20	0	0.145	0.061	53.33
			Y	21	4			
3	GASTRIC VARICES	CT	N	27	0	0.130	0.076	64.44
			Y	16	2			
4	LEFT GASTRIC VEIN DILATATION	CT	N	13	1	0.155	0.102	48.88
			Y	22	9			
5	SHORT GASTRIC VARICES	CT	N	28	0	0.277	0.007	71.11
			Y	13	4			
6	PERICHOLECYSTIC VARICES	CT	N	16	4	0.597	0.001	80
			Y	5	20			
7	IHBR DILATATION	CT	N	20	9	0.564	0.001	77.77
			Y	1	15			
8	SPLENO-ADRENO-RENAL & GASTRORENAL VARICES	CT	N	19	0	0.738	0.001	86.66
			Y	6	20			
9	MESENTRIC & RETROPERITONEAL VARICES	CT	N	21	0	0.237	0.014	60.00
			Y	18	6			
10	VENOUS ANEURYSM	CT	N	42	0	0.789	0.001	97.77
			Y	1	2			
11	ARTERIAL ANEURYSM	CT	N	40	0	0.727	0.001	95.55
			Y	2	3			
12	DILATED AZYGOUS SYSTEM	CT	N	26	0	-----	-----	-----
			Y	19	0			

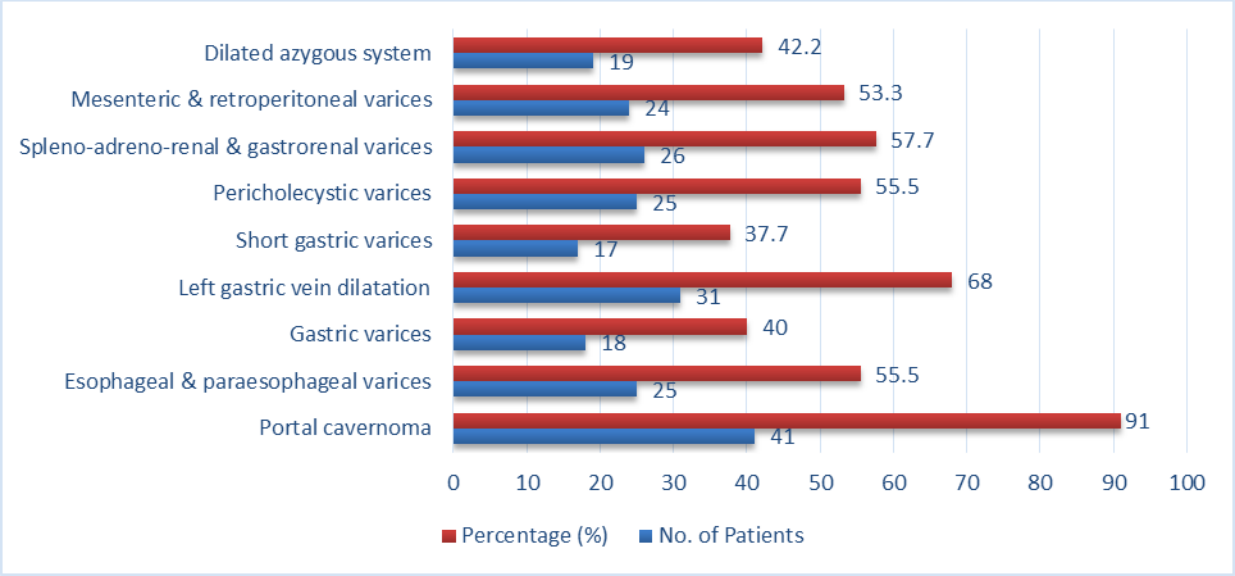


Fig. 9. The collateral distribution on MDCT.

For detection of portal cavernoma, MDCT and Colour Doppler had 100% agreement (k=1, p< 0.05). Good agreement was noted in identifying spleno-adreno-renal and gastrorenal varices (k=0.73, p<0.05) as well as visualizing associated arterial (k=0.72, p<0.05) and venous (k=0.78, p<0.05) aneurysms. For evaluation of portal biliopathy, the two modalities were found to be in moderate agreement and fair agreement for detection of short gastric varices. Detection of Gastro-esophageal varices and coronary vein dilatation had a poor agreement between the comparing modalities with MDCT providing much better visualization of these varices than Colour Doppler.

4. Discussion

A common cause of portal hypertension in developing countries is extrahepatic portal vein obstruction (EHPVO) which constitutes up to 40 % of all patients with portal hypertension.[1, 2] This condition assumes importance because of the significant morbidity associated with its complications such as recurrent variceal bleeds, effects of hypersplenism, portal gastropathy, and colopathy, as well as portal biliopathy. Radiological evaluation of these patients is undertaken to confirm the diagnosis, define the vascular anatomy of the portosplenic axis and collateral mapping in surgical candidates, and evaluate disease-associated complications and sequelae. Noninvasive modalities like Ultrasonography, Colour Doppler, Multidetector row CT (MDCT), and MRI have replaced the older techniques of conventional splenoportovenography, arterial portography, and percutaneous transplenic portography.[19-22] This prospective study was carried out to assess and compare the role of Multidetector row CT and Colour Doppler ultrasound in the evaluation of patients having extrahepatic portal hypertension with emphasis on defining the morphology, site, and cause of obstruction of the spleno-portal axis, demonstrating the collateral distribution and other vascular malformations and defining any associated features of portal biliopathy. Colour Doppler and MDCT had complete agreement (k=1; p<0.001) to identify portal cavernoma in 91%. MDCT Features of portal biliopathy were noted in 75.5% of patients on CDUS and 68.8% patients on MDCT with colour Doppler proving better at demonstrating changes of biliary radicles. MDCT provides better details about the morphology of the spleno-portal axis, the site and cause of the block, and the extent and distribution of collateral groups. Colour Doppler ultrasound has an advantage over MDCT in determining the direction and pattern of blood flow within the spleno-portal axis, various collaterals and spontaneous shunts, and better depiction of biliopathy portal features. Our findings agree with Adaletli I et al., who determined in their study that while MDCT and CDUS were equally sensitive in detecting cavernous transformation, MDCT was superior in detecting abnormal collateral circulation, especially esophageal varices. At the same time, CDUS was superior to MDCT in identifying hepatic parenchymal changes and hemodynamic parameters. Combining these two modalities provides more comprehensive information than either alone in diagnosing and follow-up of portal hypertension.[23] MDCT being a highly sensitive modality for detecting gastro-esophageal varices was also demonstrated in a study by El-Assaly, H. et al. They determined that MDCT is better at detecting gastro-esophageal, paraesophageal, and retrogastric varices than MDCT with endoscopy.[24] Isolated splenic vein thrombosis was demonstrated in 8.8% of patients on MDCT and only 4.4% of patients on CDUS. Pancreatic pathology was detected as the cause of splenic vein block in 3 patients on MDCT and only two patients on CDUS. Associated vascular aneurysms were detected by both CDUS and MDCT with the high agreement. This study, therefore, highlights the potential advantage of combining these two modalities in the workup of patients with EHPVO with a similar conclusion obtained by Nićiforović, D et al. who also stated the possibility of early and more accurate diagnosis was achieved when combining the two radiological techniques (CDU and contrast CT scan), which is not the case when these methods are used separately.[25]

5. Conclusion

MDCT provides exquisite details about the morphology of the spleno-portal axis and its abnormalities associated with extrahepatic portal hypertension. Its multiplanar reconstruction and 3-D capabilities make it more advantageous than Colour Doppler in depicting and evaluating the venous axis. In patients considered for surgery, pre-surgical evaluation with MDCT is invaluable for variceal mapping and determining the status of vessels such as a left renal vein, superior mesenteric vein, and IVC to decide about the type of shunt surgery to be performed. Both are comparable in depicting the site

of obstruction and extension of cavernomatous transformation of the portal vein. However, MDCT is better at a demonstration of isolated splenic vein block. Colour Doppler is inadequate in the visualization of gastro-esophageal and retroperitoneal varices due to its various limitations. It has an advantage in the determination of direction and pattern of blood flow. Identification of spontaneous spleno-adreno-renal and gastrorenal shunts is achieved with the high agreement between the two modalities. Both can detect various vascular aneurysms associated with extrahepatic portal hypertension. Their spatial relationship and anatomical details are better demonstrated on 3-D rendered MDCT images. For evaluation of portal biliopathy, comparable results are achieved between the two modalities in displaying pericholecystic varices. However, morphological changes in biliary radicles are better demonstrated on Colour Doppler ultrasound. Finally, Colour Doppler ultrasound and MDCT appear to be complementary rather than competing modalities in evaluating patients with extrahepatic portal hypertension.

Conflict of Interest

The authors declared that there is no conflict of interest.

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