

# Color Doppler Evaluation of Portal Venous System in Liver Diseases

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## Abstract

**Introduction:** Color Doppler sonography is an important non-invasive procedure for detecting abnormalities in hepatic vasculature in various liver diseases. Not only portal hypertension (HTN) but also various other liver diseases are associated with abnormalities noted in hepatic vasculature. An abnormal liver texture and ascites are also commonly seen and are usually related to accompanying cirrhosis. Helical flow may be seen in the portal vein and is more common in patients with severe liver disease. Color Doppler is a key tool, since the hepatic veins may be difficult to visualize with B-mode imaging alone when the liver is enlarged or cirrhotic. The right, left, and middle hepatic veins are imperceptible wall and show a triphasic pattern similar to inferior vena cava, and flow pattern is phasic in response to both cardiac and respiratory cycles. The hepatic veins have two periods of forward flow during the cardiac cycle, corresponding to the two phases of right atrial filling.

**Aims and Objectives:** The aims and objectives of this study were to evaluate the abnormalities of portal vein in various liver diseases and the role of color Doppler in portal veins in various liver diseases with histopathological correlation.

**Materials and Methods:** This is a prospective study and is conducted in the Department of Radiodiagnosis, Netaji Subhash Chandra Bose, Medical College, Jabalpur, Madhya Pradesh, over a period of 1 year (2011–2012). On color Doppler assessment, flow pattern, velocity, and direction, along with its diameter, were studied. A study of collaterals if present was also done (portal venous system detail examination was done only if portal vein diameter >15 mm at hilum), and a statistical analysis was performed according to data collection.

**Results:** In the present study, of 45 cases, on ultrasonography, 15 (33.33%) cases were detected as having liver metastasis, 15 (33.33) had cirrhosis with portal HTN, 5 (11.1%) patient had hepatocellular carcinoma, 3 (6.6) patients had liver hydatid cyst, and 3 (6.6%) other had abscess, while 1 (2.2%) had liver hemangioma and 1 (2.2%) had fatty infiltration in liver. Final diagnosis was confirmed by histopathology in all these patients.

**Conclusion:** Color Doppler study in liver hemangioma has not any added advantages over two-dimensional sonography. Color Doppler study in intrahepatic liver cyst has not yield any extra information, and vascular changes were seen in large size liver cyst due to compression of adjacent vessels.

**Key words:** Color Doppler, Liver hemangioma, Sonography

## INTRODUCTION

Color Doppler sonography is an important non-invasive procedure for detecting abnormalities in hepatic vasculature in various liver diseases. Ultrasound findings associated with

portal hypertension (HTN) include enlarged diameter of the portal vein, lack of respiratory variation in the portal vein or its tributaries, hepatofugal portal flow direction, decreased portal velocity or volume, and the presence of collaterals or varices.<sup>[1,2]</sup> Not only portal HTN but also various other liver diseases are associated with abnormalities noted in hepatic vasculature. An abnormal liver texture and ascites are also commonly seen and are usually related to accompanying cirrhosis.<sup>[3]</sup> Helical flow may be seen in the portal vein and is more common in patients with severe liver disease.<sup>[4]</sup>

In normal individual, gray scale and Doppler characteristic of various vessels are as follows: Portal vein is seen in

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**Month of Submission :** 10-2018  
**Month of Peer Review :** 11-2018  
**Month of Acceptance :** 12-2018  
**Month of Publishing :** 12-2018

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about 97% of normal patients; failure to visualize it can suggest the presence of pathology, such as thrombosis.<sup>[5]</sup> On Doppler assessment, it shows low-velocity signal with respiratory variation and smooth color fill in vessel. A sudden onset of ascites should prompt careful examination of the portal vein for thrombosis.<sup>[6]</sup> With deep inspiration, the normal diameter may increase to about 16 mm, resulting in an overestimation of portal vein diameter.<sup>[2]</sup> As pressure increases, portal blood flow may become pulsatile.<sup>[7]</sup> Color Doppler sonography is superior to gray scale and spectral Doppler imaging in diagnosing partially occluded vessels. Clot detection by gray scale imaging is difficult when the thrombus is hypoechoic.<sup>[8]</sup>

Color Doppler is a key tool, since the hepatic veins may be difficult to visualize with B-mode imaging alone when the liver is enlarged or cirrhotic.<sup>[9]</sup> Theright, left, and middle hepatic veins are veins with imperceptible wall and show triphasic pattern similar to inferior vena cava (IVC) and flow pattern is phasic in response to both cardiac and respiratory cycles. The hepatic veins have two periods of forward flow during the cardiac cycle, corresponding to the two phases of the right atrial filling.<sup>[10]</sup>

### Aims and Objectives

The aims and objectives of this study were to evaluate the abnormalities of portal vein in various liver diseases and to evaluate the role of color Doppler in portal vein in various liver diseases with histopathological correlation.

## MATERIALS AND METHODS

This is a prospective study and is conducted in the Department of Radiodiagnosis, Netaji Subhash Chandra Bose (N.S.C.B.) Medical College, Jabalpur, Madhya Pradesh, over a period of 1 year (2011–2012). All patients (male/female of all age groups) having liver diseases (medical or surgical) as diagnosed on various investigations are included in the study. Sonography and color Doppler study were conducted in the Department of Radiodiagnosis using curvilinear and linear probe of machine Wipro GE (Logic 3 Expert - Ay 15 CUK) and Siemens (Sonoline G-50). First, two-dimensional (2D) sonography was conducted, and then, color Doppler assessment of portal vein was done. On color Doppler assessment, flow pattern, velocity, direction, RI, and its diameter were studied. A study of collaterals if present was also done (portal venous system detail examination was done only if portal vein diameter >15 mm at hilum), and a statistical analysis was performed according to data collection.

## RESULTS

Table 1 shows that maximum number of patients with liver disease were in the age group of 51–60 years and it was 26%. The second largest group was in the age group of 41–50 years and it was 24.4%. Liver disease was found more in male gender as compared to female and male gender involvement was 57.7%. In addition it was observed that the number of cases involved in addiction 24.4%.

Table 2 shows distribution of cases according to presenting complaint, and in the present study, most common presenting complaint was abdominal pain (75.6%). Table 3 shows distribution of studied cases according to diseases of liver., It was observed that the most frequent liver disease was liver mets (33.3%) and cirrhosis with portal HTN (33%), while 11.1% of cases of primary liver tumor hepatocellular carcinoma (HCC), 6.6% cases of liver abscess, 6.6% cases of liver cyst, 2.2% cases of hemangioma of liver, and fatty infiltration of liver constituted rest of the disease.

The distribution of studied cases according to portal vein diameter in liver pathologies shown in Table 4. It

**Table 1: Distribution of cases according to age (n=45)**

| Age group (years) | Number of patients | % age |
|-------------------|--------------------|-------|
| 0–10              | 3                  | 6.6   |
| 11–20             | 6                  | 13.3  |
| 21–30             | 4                  | 8.8   |
| 31–40             | 6                  | 13.3  |
| 41–50             | 11                 | 24.4  |
| 51–60             | 12                 | 26.6  |
| >61               | 3                  | 6.6   |
| Gender            |                    |       |
| Male              | 26                 | 57.7  |
| Female            | 19                 | 42.2  |
| Locality          |                    |       |
| Rural             | 29                 | 64.4  |
| Urban             | 16                 | 35.6  |
| Addiction         |                    |       |
| Present           | 11                 | 24.4  |
| Absent            | 34                 | 75.5  |

**Table 2: Distribution of cases according to presenting complaint**

| Presenting complaint      | Frequency | % age |
|---------------------------|-----------|-------|
| Abdominal pain            | 34        | 75.6  |
| Breast lump               | 1         | 2.2   |
| Vomiting mixed with blood | 2         | 4.4   |
| Abdominal distension      | 3         | 6.7   |
| Swelling                  | 2         | 4.4   |
| Fever                     | 1         | 2.2   |
| Bleeding PR               | 1         | 2.2   |
| Total                     | 45        | 100.0 |

was observed that we found 13.3% of cases of increased diameter of portal vein in liver metastasis, 33.3 of cases of abnormal flow pattern, 33.3% of cases of abnormal flow velocity, and 33.3% of cases of abnormal direction in liver wets. In cirrhosis with portal HTN, we found 66.6% of cases of increased diameter and abnormal flow pattern, abnormal flow velocity, and abnormal direction of flow in portal vein. In primary liver tumor (HCC), we found that there was no change in portal vein diameter, but in 40% of cases, we found abnormal flow pattern, flow velocity, and direction of flow in portal vein.

The distribution of studied cases according to IVC diameter in liver pathology is presented; it was observed that there were no change in diameter in above-mentioned liver diseases. We found only in IVC flow pattern changes. In 13.3% cases abnormal flow pattern in liver metastasis, in 26.6% cases abnormal flow pattern in cirrhosis with portal HTN, in 20% cases abnormal flow pattern in primary liver tumor (HCC) and rest of liver abscess, liver cyst, haemangioma, fatty infiltration there were no change seen in IVC.

**DISCUSSION**

The present study was conducted in 45 cases, of which majority of cases were in decade age group. In this study, 26 (57.7%) cases were male and rest of 19 (42.2%) cases was female. Of these 45 cases, 29 (64.4%) cases were from rural area and rest of 16 (35.5%) cases belonged to

urban area. In our study, 11 (24.4%) cases had a positive history of various types of addiction. Most commonly presenting complaint was abdominal pain which is found in 35 (76%) cases.

In the present study, of 45 cases, on ultrasonography (USG), 15 (33.33%) cases were detected as having liver mets, 15 (33.33) had cirrhosis with portal HTN, 5 (11.1%) patients had HCC, 3 (6.6) patients had liver hydatid cyst, and 3 (6.6%) other had abscess, while 1 (2.2%) had liver hemangioma and 1 (2.2%) had fatty infiltration in the liver. Final diagnosis was confirmed by histopathology in all these patients.

**Hepatic Vein Changes in Liver Pathology**

In 15 cases of cirrhosis with portal HTN, in 10 (66.6%) cases, we found decreased diameter and loss of respirophasic pattern in the hepatic vein. While rest of our cases showed Colli *et al.* and Bolondi *et al.* found that Liver parenchymal disease impairs the compliance of a hepatic decreasing and flattening phasic oscillations. Flattening of phasic oscillations within the hepatic venous system is seen in 50–75% of patients with cirrhosis.<sup>[11,12]</sup>

Kane and Eustace found that color Doppler is key tool, since the hepatic veins may be difficult to visualize with Bmode imaging alone when the liver is enlarged or cirrhotic.<sup>[9]</sup>

Of 5 cases of HCC, in 3 (60%) cases, we found loss of respirophasic pattern in hepatic vein, and in 1 (20%) case, we found decreased (compressed) diameter of the hepatic vein.

Becker and Cooperberg described that hepatic vein obstruction<sup>[13]</sup> is the presence of echogenic intraluminal material (thrombus or tumor) accompanied by the absence of hepatic vein flow.

If the hepatic vein is narrowed but not completely blocked, focal elevated velocity and post stenotic turbulence may be seen.<sup>[13]</sup>

**Table 3: Distribution of cases according to diseases of the liver**

| Liver pathology                 | Number of patients | % age |
|---------------------------------|--------------------|-------|
| Mets                            | 15                 | 33.33 |
| Cirrhosis with portal HTN       | 15                 | 33.33 |
| Primary liver tumor (HCC)       | 5                  | 11.11 |
| Liver abscess                   | 3                  | 6.6   |
| Liver cyst                      | 3                  | 6.6   |
| Hemangioma of the liver         | 1                  | 2.2   |
| Fatty infiltration of the liver | 1                  | 2.2   |

HTN: Hypertension, HCC: Hepatocellular carcinoma

**Table 4: Distribution of cases according to portal vein parameter in liver pathology**

| Diagnosis                       | Portal vein parameter |       |                       |       |                        |       |                            |       |
|---------------------------------|-----------------------|-------|-----------------------|-------|------------------------|-------|----------------------------|-------|
|                                 | Increased diameter    | % age | Abnormal flow pattern | % age | Abnormal flow velocity | % age | Abnormal direction of flow | % age |
| Mets                            | 2                     | 13.3  | 5                     | 33.3  | 5                      | 33.3  | 5                          | 33.3  |
| Cirrhosis with portal HTN       | 10                    | 66.6  | 10                    | 66.6  | 10                     | 66.6  | 10                         | 66.6  |
| Primary liver tumor (HCC)       | 0                     | 0     | 2                     | 40    | 2                      | 40    | 2                          | 40    |
| Liver abscess                   | 0                     | 0     | 0                     | 0     | 0                      | 0     | 0                          | 0     |
| Liver cyst                      | 0                     | 0     | 0                     | 0     | 0                      | 0     | 0                          | 0     |
| Hemangioma of the liver         | 0                     | 0     | 0                     | 0     | 0                      | 0     | 0                          | 0     |
| Fatty infiltration of the liver | 0                     | 0     | 0                     | 0     | 0                      | 0     | 0                          | 0     |

HTN: Hypertension, HCC: Hepatocellular carcinoma

We found no change in the hepatic vein in case of hemangioma of the liver and fatty infiltration of the liver.

Colli *et al.* demonstrated that hepatic vein changes in the form of dampening of spectral waveform seen in chronic liver disease.<sup>[11]</sup>

Oguzkurt *et al.* observed that dampening of hepatic vein waveform was associated with fatty infiltration, cirrhosis, metastatic liver disease, and veno-occlusive disease.<sup>[14]</sup>

### IVC Changes in Liver Pathology

Of 15 cases of liver mets, in 2 (13.3%) cases, we found a loss of variation in diameter on inspiration in IVC.

Of 15 cases of cirrhosis with portal HTN, in 4 (26.6%) cases, we found a loss of variation in diameter on inspiration in IVC.

Kitamura *et al.* found that, in the normal liver group, the maximal diameter of the vena cava was  $2.35 \pm 0.34$  cm (mean  $\pm$  standard deviation), and this was reduced by  $1.30 \pm 0.67$  cm (range, 0.4–2.85 cm) during deep inspiration. In the cirrhotic patient group, the maximal diameter was  $1.74 \pm 0.35$  cm, and this was reduced by  $0.03 \pm 0.09$  cm (range, 0.0–0.4 cm) ( $P < 0.0001$ ) (60) in 5 cases of HCC, and in 1 (20%) case, we found a loss of variation in diameter on inspiration in IVC.

In 3 cases of liver abscesses, hemangioma, liver cyst, and fatty infiltration, we found no change in IVC.

Rajagopal and Bishwas found and published a case of 15 cm  $\times$  14 cm cystic mass involving the medial segment of the left hepatic lobe and the anterior segment of the right hepatic lobe and was compressing IVC.<sup>[15]</sup>

### SUMMARY

The present study was carried out in the Department of Radiodiagnosis, N.S.C.B. Medical College and Hospital, Jabalpur, Madhya Pradesh, to evaluate the color Doppler of hepatic vessels and portal venous system in liver disease with pathological correlation.

A total of 45 cases of various liver pathology attending the various surgical, medicine, and pediatric outpatient departments were referred to us with a brief history, physical examination, and a provisional clinical diagnosis.

Liver pathology was evaluated by 5–10 MHz electronically focused curvilinear and linear transducer with a patient in supine position with direct contact method.

In our study group, age ranges from 8 to 73 years. Most common age group affected was between 50 and 60 years.

In this study, 26 (57.7%) cases were male and rest of 19 (42.2%) cases were female. Of these 45 cases, 29 (64.4%) cases were from the rural area and rest of 16 (35.5%) cases belonged to the urban area. In our study, 11 (24.4%) cases had a positive history of various types of addiction. Most common presenting complaint was abdominal pain which is found in 35 (76%) cases.

In the present study, of 45 cases, on USG, 15 (33.33%) cases were detected as having liver mets, 15 (33.33) had cirrhosis with portal HTN, 5 (11.1%) patient had HCC, 3 (6.6) patients had liver hydatid cyst, and 3 (6.6%) other had abscess, while 1 (2.2%) had liver hemangioma and 1 (2.2%) had fatty infiltration in liver. Final diagnosis was confirmed by histopathology in all these patients. In liver abscess, liver fatty infiltration, and hemangioma cases, no changes were detected in any of the vessels.

In portal HTN, portal vein changes seen in maximum patients.

### CONCLUSION

Color Doppler study in liver hemangioma has not any added advantages over 2D sonography. Color Doppler study in intrahepatic liver cyst has not yield any extra information and vascular changes were seen in large size liver cyst due to compression of adjacent vessels.

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**How to cite this article:** Sharma P, Sharma S. Color Doppler Evaluation of Portal Venous System in Liver Diseases. *Int J Sci Stud* 2018;6(9):1-73.

**Source of Support:** Nil, **Conflict of Interest:** None declared.