Association between Portal Vein Colored Doppler Ultrasound Findings and Severity of Liver Disease in Cirrhotic Patients with Portal Hypertension

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ABSTRACT

Background: Chronic liver disease is a heterogeneous and dynamic condition. So, noninvasive estimations of the condition and changes in portal hypertension and hepatic fibrosis are important in the management of this disease.

Aim of the Work: to correlate between color Doppler ultrasound findings of portal vein and severity of liver disease in cirrhotic patients with portal hypertension in the prediction of the future clinical outcomes and prognosis.

Patient and Methods: This study was conducted on 50 patients attending to Al-Hussein University hospital and Damanhur Fever hospital during the time of the study who were divided into groups: Control and Child (A, B, and C).

Results: The study showed an increase in the mean PV diam. with P value (0.02), marked decrease in PVV with P value (0.01) and increase PV congestive index with p-value (0.002). From child A to child B through child C compared with control and the difference was statistically significant.

Conclusion: Doppler ultrasound has a high diagnostic value of cirrhosis. Alterations of liver hemodynamics resulting from liver cirrhosis at the tissue level are detectable on Doppler sonography. Doppler findings of direction flow and velocity of the main PV and congestive index correlate with clinical parameters using the Child Pugh score.

Keywords: Portal Vein; Colored Doppler Ultrasound; Child-Pugh; Cirrhotic Patients; Portal Hypertension

INTRODUCTION

Liver cirrhosis is a progressive liver fibrosis caused by chronic liver disease. It is a prevalent problem in all over the world and leads to significant morbidity and mortality by liver cancer and liver failure.1 Early diagnosis can inhibit the associated detrimental signs, including variceal bleeding, hepatic encephalopathy, and portal vein thrombosis. Staging of liver cirrhosis helps with prognostic information and directs appropriate therapy.2 Severity of liver disease and cirrhosis can be graded by Child-Pugh (CP) score. Where the parameters of bilirubin, prothrombin time, serum albumin, presence of ascites and hepatic encephalopathy are accorded individual numerical points (ranging from 1 to 3) which are summed up to give the CP score. This scoring is useful in determining the short-term mortality rate and predicting the waiting list mortality of patients listed for liver transplantation.3 Ultrasonography is the worldwide best imaging modality for diagnosis and follows up of cirrhotic patients. The diagnosis usually depends on late findings of liver surface irregularity and secondary findings of portal hypertension. However, B mode sonography is unable to examine patients with cirrhosis without this late findings.4 Doppler sonography is a non-invasive modality based on hemodynamic parameters which might have developed even in patients with normal findings on B-mode sonography.5 Therefore evaluation of these alterations has a big value for
early diagnosis and for close follow up of previously diagnosed cases. This study aimed to correlate between color Doppler ultrasound findings of PV and severity of liver disease in cirrhotic patients with PHT in the prediction of the future clinical outcomes and prognosis.

**PATIENT AND METHODS**

This study was conducted between January and September 2019, on 50 patients attending to Al-Hussein University hospital and Damanhur Fever hospital during the time of the study. The study included patients with hepatitis and cirrhosis with portal hypertension diagnosis was based on a combination of the following: clinical data such as ascites, jaundice, muscle wasting, palmar erythema, cutaneous spider angiomas, flapping tremors, and ecchymosis. Laboratory data including liver synthetic functions such as decreased serum albumin, prolonged prothrombin time and INR, investigations that determine the etiology of the chronic liver disease (HBs Ag, HBe Ab, HCV Ab), US findings such as irregular liver surface and coarsened echo-texture, splenomegaly, as well as presence of collaterals, portal vein thrombosis and portal cavernomas and patient with HCC. Endoscopy and liver biopsy were not performed in all patients. Non-cirrhotic portal hypertension, pregnant women with cirrhosis, patients with grade III and IV encephalopathy, previous endoscopic treatment of varices (sclerotherapy or endoscopic band ligation) and patients who were subjected to previous surgical Porto-systemic shunts or TIPS were excluded from the study.

The work included 2 Groups: Control Group (I) (10 patients), Study Group (II) (40 patients) which subdivided according to the Child-Pugh criteria: Child (A) Subgroup: included 21 patients who were presented by common diffuse forms of liver disease, Child (B) Subgroup included 13 patients with cirrhotic liver and Child (C) Subgroup included 6 cirrhotic patients. Patients included in the study were subjected to the following: Full medical history with focusing on risk factors especially for viral hepatitis as blood transfusion, dental procedures. Also, the history of symptoms of CLD was checked for. Laboratory investigations: Blood sampling was performed for measuring serum bilirubin, albumin, International Normalized Ratio (INR). Clinical judgments were performed to assess hepatic encephalopathy. Investigations to determine the etiology of chronic liver disease(HBs Ag, HBe Ab, HCV Ab). Abdominal Ultrasonography: All patients fasted for 6 hours before the examination. All measurements were obtained during a short time breath-holding avoiding deep respiration. And all the following were obtained:- Liver size and echo-pattern, Portal vein diameter, Presence of PVT or Portal cavernoma, Spleen span and splenic vein diameter, Presence of ascites, Presence of collateral, GB cavernoma. Assessment patency of PV and blood flow: PV anatomy is evaluated using B-mode imaging which identified by the splenic vein to the right until its junction with the SMV. However, when the PV is difficult to see in the supine position, the patient is examined in the left lateral position. Portal vein diameter and cross-sectional area: Perpendicular to the long axis of the vein, the cross-sectional area was calculated by (A × B)/4Π, where A is the long axis of the vein, B is the short axis of the vein and (Π)=3.14. If they were equal, the cross-sectional area was calculated by (r² ×Π), where r is half of the vein diameter. Portal vein flow velocity: The position of the scanner was optimized until a Doppler angle of less than 60 degrees was achieved. The velocity of the PV was calculated from the Doppler tracings. The normal velocity of the PV blood flow was 15–30 cm/sec. Portal hypertension was associated with an increase in blood flow and congestion, but with a decrease in blood velocity in the PV. Doppler ultrasound was used to show blood flow within PV and its main tributaries and abnormal collaterals. Congestion index: The congestion index (CI) is the ratio between the cross-sectional area (cm²) and the blood flow velocity (cm/s) of the PV. Doppler data were obtained while scanning the PV along its axis and with the sample volume in the mid-portal vein trunk. Just after the Doppler signals were recorded, the PV cross-sectional area was measured from the B-mode image while scanning perpendicular to the long axis of the PV. Image analysis Normal PV diameter is less than 13 mm, with a greater than 20–30% increase with food and respiration. In portal hypertension, the PV is dilated (>13 mm), with absent or less than 20% variation with respiration. The direction of blood flow can be determined by the color flow pattern. Normal blood flow is toward the liver and is of low velocity, undulating with respiration.

SPSS statistical software package (V. 20, Echosoft Corp., USA) was used for data analysis. Data were expressed as Mean±SD for quantitative measures and both number and percentage for categorized data. The following tests were done: Comparison between two independent mean groups for parametric data using Student T-test. Ranked Sperman correlation test to study the possible association between each two variables among each group for non-parametric data. Chi-square test to study the association between every 2 variables or comparison between 2 independent groups as regards the categorized data. The probability of error at 0.05 was considered significant, while at 0.01 and 0.001 are highly significant. Multi Regression analysis was used to
search for a panel (independent parameters) that can predict the target parameter (dependent variable). By using stepwise multi regression analysis, parameters among these panels can be sorted according to their sensitivity to discriminate.

**RESULTS**

Analysis of the results of Child’s A, B, and C patients included in the study showed an increase in the PV mean diam. with P value (0.02), marked decrease in PVV with P value (0.01), and increase in portal vein CI with p-value (0.002), marked increased in spleen span with P value (0.003) as well as splenic vein diam. With P value (0.003) from child A to child B through child C compared with control. And there was a statistically significant difference. (Table 1)

In addition to PVV in the presence of varices =13.5 cm/sec (16 patients) and PVV in the absence of varices =14.04 cm/sec (24 patients) which showed statistically significant between portal vein velocity in the presence and absence of varices P value=0.002. (Table 2)

Also results of PVV in the absence of ascites =18.2 cm/sec (29 patients), PVV in the presence of mild ascites =14.31 cm/sec (6 patients) and PVV in the presence of moderate ascites=11.06 cm/sec (5 patients) showed statistically significant between portal vein velocity in the presence and absence of ascites (p value=0.001). (Table 3)

### Tables

<table>
<thead>
<tr>
<th>VALUE BY GROUP</th>
<th>Control (n=10)</th>
<th>Child A (n=21)</th>
<th>Child B (n=13)</th>
<th>Child C (n=6)</th>
<th>T-TEST</th>
</tr>
</thead>
<tbody>
<tr>
<td>P.V diam.</td>
<td>11±1.1</td>
<td>13.67±0.952</td>
<td>15.46±1.25</td>
<td>15.8±0.75</td>
<td>2.637</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.02*</td>
</tr>
<tr>
<td>P.V velocity</td>
<td>24.7±5.77</td>
<td>19.4±5.08</td>
<td>14.97±2.112</td>
<td>11.2±1.24</td>
<td>2.934</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.01*</td>
</tr>
<tr>
<td>P.V congestive index</td>
<td>0.0536±0.02</td>
<td>0.10±0.023</td>
<td>0.139±0.025</td>
<td>0.2±0.03</td>
<td>4.337</td>
</tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.002*</td>
</tr>
<tr>
<td>Spleen span(cm)</td>
<td>10.37 ±1.17</td>
<td>12.67±1.80</td>
<td>14±0</td>
<td>17±3.57</td>
<td>14.592</td>
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<td></td>
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<td>0.003*</td>
</tr>
<tr>
<td>Splenic vein diam.(mm)</td>
<td>5.2±1.90</td>
<td>7.23±1.27</td>
<td>8.96±1.8</td>
<td>10.066±0.92</td>
<td>14.592</td>
</tr>
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<td></td>
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<td>0.003*</td>
</tr>
</tbody>
</table>

Table 1: Portal vein diam., PVV, CI of the portal vein, spleen span and splenic vein diameter in the studied groups.

<table>
<thead>
<tr>
<th>VALUE BY GROUP</th>
<th>Presence of varices n=16</th>
<th>absence of varices n=24</th>
<th>T-TEST</th>
</tr>
</thead>
<tbody>
<tr>
<td>P.V. velocity</td>
<td>13.5 cm/sec</td>
<td>14.04 cm/sec</td>
<td>18.467</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.002*</td>
</tr>
</tbody>
</table>

Table 2: Relation between portal vein velocity in the presence and absence of varices in the group (II).

<table>
<thead>
<tr>
<th>VALUE BY GROUP</th>
<th>Presence of ascites n=29</th>
<th>absence of ascites n=29</th>
<th>T-TEST</th>
</tr>
</thead>
<tbody>
<tr>
<td>P.VV</td>
<td>14.31 cm/sec</td>
<td>11.06 cm/sec</td>
<td>18.034</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.001*</td>
</tr>
</tbody>
</table>

Table 3: Relation between portal vein velocity in the presence and absence of ascites in the group (II).
Liver biopsy and hepatic venous pressure measurement are the best methods for the assessment of hepatic fibrosis and PHT, respectively, and they have diagnostic and prognostic value. But they are invasive and cannot be used repeatedly in clinical practice. The ideal noninvasive test must be inexpensive, easy to perform, safe and reproducible as well as to give accurate results in real-time. It should be predictive of long term outcomes related to cirrhosis and PHT to allow prognostic stratification.

Among the noninvasive methods for diagnosis of early liver cirrhosis, ultrasonography has become the most common and valuable method because of its low cost, easy performance, and high acceptability.
comparison with child (B) & (A) subgroups and the difference was statistically significant. As well as there is also decreased in mean serum albumin (2.69±0.29) in the child (C) in comparison with child (B)( 3.19±0.34) & (A) (3.84±0.23) subgroups as well as control (4.051±0.18) and the difference was statistically significant P value = 0.003.

In our study, splenic varices were seen in 40% while 60% of the patients have no splenic hilar varices. And none of the patients had gall bladder varices. The mean PVV (13.5 cm/s) was significantly lower in patients with splenic varices in comparison to those without splenic varices PVV (14.04 cm/s) (P < 0.05). This presentation is logical and can be explained fact that splenic varices provide an alternate route for drainage of the portal venous flow, thereby diminishing the hepatic flow and thereby the portal velocity. With progression, this may lead to hepatofugal flow.

The portal vein CI shows significantly increased as the disease progress from child A subgroup (0.10±0.023) to child B subgroup (0.139±0.025) through child C subgroup (0.24±0.04), this difference was statistically significant (P value=0.002). The portal vein CI shows evidence of higher sensitivity (71%) in detecting cirrhosis than PVV (23%). By using this index, the PVV was significantly reduced, while the cross-sectional area of the PV was increased in cirrhotic patients.

The mean PVD shows significantly increased as the disease progress from child A subgroup (13.67±0.952 mm) to child B subgroup (15.46±1.25 mm) through child C subgroup (15.8±0.75 mm) (P value=0.02). It is noted that mean PVD shows a significant correlation with CTP score in agreements with a study done by Macias et al.

On the other hand, other studies mentioned that no significant difference in PVD between cirrhotic patients and control patients, or between the compensated and decompensated cirrhosis groups, or among various CTP grades suggesting that PVD does not correlate with the high portal pressure and the severity of cirrhosis.

Measurement of PVV is an easy, noninvasive procedure and quick. Therefore, a finding of a decrease in PVV below the threshold of 15 cm/s may be alone or combined with other factors, an important parameter in the assessment of the risk of PVT (portal vein thrombosis) in cirrhotic patients.

In our study one patient had PVT without a tumor represented about 2.5% Of cases in group II (PVV=12.1 cm/sec); In agreements with Zocco et al. said that patients with a PVV below 15 cm/s, may benefit from prophylactic anticoagulation to prevent PVT.

One patient in our study had Hepatocellular Carcinoma with extension to the Main PV (Main Portal Vein Tumor Thrombus) The accurate frequency of PVT is not known but may occur in as many as 30% of patients with HCC. Other studies mentioned that the incidence of PVT in HCC varies about 20 - 30% in small HCC (< 3 cm), up to 50 - 75% in HCC > 5 cm.

Using multiple regression analysis the PVV, congestive index, splenic span, splenic vein diam., splenic varices as well as portal vein diam. and ascites shows significant correlation with Child’s score, thereby highlighting the importance of PVV, as well as the congestive index in predicting the severity of the disease. However, hemodynamics of PHT is quite complex and PVV alone does not always reflect the degree of hepatic damage and hepatic encephalopathy.

CONCLUSION

Doppler sonography is a noninvasive technique and helps in the assessment of the degree of liver cirrhosis and the stage of fibrosis, and it should be used to follow the progression of CLD in relation to Child classification. Colour Doppler is an excellent modality for delineating the complex hemodynamics of PHT in cirrhotic patients. Doppler findings of direction, PVV, and CI of PV correlate with clinical parameters using Child-Pugh score.

Limitations of our study include that diagnosis of cirrhosis and PHT was based on the combination of clinical, laboratory and US findings. This could lead to excluding patients with early disease and those with atypical findings. In addition, no follow up has been done.

REFERENCES


