

Doppler Ultrasound of Hepatic Vessels in the Diagnosis of Cirrhosis of the Liver in Togo

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Abstract

The aim of this work is to evaluate the role of Ultrasound-Doppler in the hemodynamic study of hepatic vessels during the liver cirrhosis in Togo. **Method:** This was an analytic cross-sectional study that measured the velocimetric parameters of hepatic vessels in cirrhotic patients and in non-cirrhotic patients. **Results:** The velocimetric parameters of the hepatic artery, the portal vein, and the hepatic veins were measured in 50 cirrhotic patients and 50 non-cirrhotic. The caliber of the portal vein was significantly increased in cirrhotic patients compared to non-cirrhotic patients with 13.11 ± 2.16 mm versus 11.45 ± 1.02 ($p < 0.00006$). The systolic velocity and the hepatic artery resistance index were significantly raised in the cirrhotic patients compared to the non-cirrhotic with 67.32 ± 22.77 versus 49.97 ± 17.24 (p -value < 0.00004) respectively, and 0.78 ± 0.07 against 0.72 ± 0.08 ($p < 0.00006$). The caliber of the hepatic veins was significantly decreased in the cirrhotic patients compared to the non-cirrhotic patients ($p < 0.0003$). There was no correlation between the gender of the patients and the change in the hemodynamics of the hepatic vessels. **Conclusion:** The hemodynamic study of the hepatic vessels can and must rightly be a diagnostic argument for liver cirrhosis.

Keywords

Doppler, Hepatic Vessels, Diagnosis, Cirrhosis, Togo

1. Introduction

Cirrhosis is defined as a diffuse disorganization of the liver architecture, with

annular fibrosis delineating hepatocyte nodules in clusters that are called regeneration nodules [1].

The standard diagnosis of cirrhosis is still histology [2]. However, this technique suffers from a false negative rate of up to 24% [2]. Also, because of the lack of technical means and the limitations in the histology method within our regions, this diagnosis is based on a bundle of clinical, biological, and radiological arguments [3]. The main radiological method is the Doppler ultrasound.

Several studies have been conducted around the world to determine the contribution of ultrasound coupled or not to Doppler in the diagnosis of cirrhosis [4] [5] [6]. However, in Togo, no study has been conducted on the use of Doppler in the diagnosis of hepatic cirrhosis, despite the frequency of the pathology [3].

We conducted this study to evaluate the Ultrasound-Doppler's hemodynamic variations of the hepatic vessels during the liver cirrhosis in Togo.

2. Method

This was an analytic cross-sectional study that measured the velocimetric parameters of hepatic vessels of the patients treated in the Hepato-gastroenterology department of the Lomé University Hospital Center for the liver's cirrhosis and of volunteers, non-cirrhotic, not having any known liver pathology and having a normal liver function.

We excluded the patients who had a high blood pressure or who got a liver mass, hepatocellular carcinoma, a heart failure, a kidney failure or an abundant ascites.

We utilized the *ESAOTE My lab* mark of ultrasound provided with multi-frequency probes, a color Doppler module, a pulsed Doppler with its different modes: duplex, triplex, and alternate, with the patients on least six hours of fasting.

All examinations were performed by the same operator, a radiologist with at least five years of experience in the visceral Doppler exam.

The examination began with a study of the hepatic morphology per subcostal, intercostal transverse and sagittal sections.

The filter was set between 50 and 100 Hz. The pulse repetition frequency (PRF) was manually set to operate according to the quality of the resulting plot and the observed velocities. The firing angle was between 30 and 60. The Doppler gate was as possible as possible in the center of the vessel to be surveyed.

All the recordings were made in the subject being in apnea in the middle of breathing. The exploration was done for each of the hepatic vessels.

We identified the portal vein, including the segment between the spleno-portal junction and the intrahepatic bifurcation that was shaped as an anechoic tube within which we measured the largest diameter, as a caliber.

The color Doppler enabled us to detect the blood flow.

The design obtained using pulsed Doppler was secondarily analyzed to deter-

mine the speeds and the different indexes.

We identified the hepatic artery by using a costal or intercostal approach. This artery visualization was difficult for some patients, but in most cases, the hepatic artery was anterior and slightly medial to the portal vein.

The pulsed Doppler mode was used to obtain the plot of at least three consecutive pulses that we examined and on which we measured the velocimetry parameters (velocities and indices).

We identified the hepatic veins by using intercostal and recurrent subcostal cuts. We preferably chose the right hepatic vein. The Doppler window was placed in the center of the vein, two centimeters from its meeting with the inferior vena cava.

The size of the portal vein, the direction of its flow, its spectrum, its average velocity (V_m), its maximum systolic velocity (V_{smax}), and its diastolic velocity (V_{dias}) were studied. The vein pulse index of the portal vein (VPI) corresponds to the ratio of the difference between the maximum systolic speed and the diastolic rate on the systolic maximum speed.

The maximum systolic velocity, the average velocity, the diastolic velocity, the resistance index (RI), and the pulse index (PI) were the variables analyzed on the hepatic artery.

The studied parameters of the hepatic veins were the caliber, the spectrum, and the flow.

The hepatic vascular index (HVI) is the ratio of the average velocity of the portal vein to the pulse index (PI).

The arterio-portal ratio (APR) is the ratio of the systolic velocity of the hepatic artery to the maximum systolic velocity of the portal vein.

The *Chi-2* statistical test was applied after crossing to determine the interdependence of the qualitative variables with values greater than 2.5. For the variables with values less than 2.5, the *Fisher* test was used. For the numerical averages, the *Student's* test was used. The relationship between the continuous values was analyzed using the *Pearson* correlation test. These tests were significant when the *p*-value (random part) was less than 0.05.

3. Results

The caliber of the portal vein was abnormal in 52% of cirrhotic patients and in 6% of the case of non-cirrhotic patients. The difference was statistically significant (p -value = 4.75×10^{-7}).

The averages of the velocimetry variables of cirrhotic and non-cirrhotic patients are shown in **Table 1**.

The V_{smax} , V_m , RI, hepatic artery PI, as well as the portal vein caliber, had a statistically significant increase in values in the cirrhotic patients versus non-cirrhotic patients (**Figure 1** & **Figure 2**).

The sensitivity and the specificity of the resistance index for a value of 0.77 were respectively 54% and 68%.

Hepatic veins were normal in all the non-cirrhotic patients compared to 36% in the cirrhotic patients. (P -value = 3.01×10^{-11}). The Sensitivity and specificity were 64% and 100%, respectively.

A demodulation of the hepatic vein spectrum was found in 52% of the cirrhotic patients (**Figure 3**) whereas there was no change in the spectrum in the non-cirrhotic patients (p -value = 1.202×10^{-8}).

The blood flow in the hepatic veins was hepatofugal in both cirrhotic and non-cirrhotic patients.

The relationship between age and the speed parameters assessed by the Pearson correlation test noted a linear and positive correlation between age and RI (p -value = 0.02) and age and PI (p -value = 0.021).

There was no correlation between sex and the statistically significant variations observed between the speed parameters in cirrhotic and non-cirrhotic patients.

4. Discussion

4.1. Portal Vein

We found a statistically significant (p -value = 0.00006) increase in the portal vein average caliber in cirrhotic versus non-cirrhotic patients.

The increase of the caliber is secondary to the increase of the pressure in the

Table 1. Comparison of the Doppler averages for Cirrhotic patients and Non-Cirrhotic Patients.

	Cirrhotic patients	Non cirrhotic patients	<i>P</i> value
Portal vein			
Caliber (mm)	13.11 ± 2.16	11.45 ± 1.02	0.000066
Average speed (cm/s)	15.50 ± 5.46	15.85 ± 4.18	0.71
Maximum systolic speed (cm/s)	19.30 ± 6.68	19.58 ± 5.03	0.81
Diastolic speed (cm/s)	13.11 ± 6.64	13.88 ± 8.34	0.4
VPI	0.30 ± 0.12	0.27 ± 0.11	0.2
Hepatic artery			
Average speed (cm/s)	30.20 ± 10.94	25.75 ± 13.16	0.06
Maximum systolic speed (cm/s)	67.32 ± 22.77	49.97 ± 17.24	4.09×10^{-5}
Diastolic speed (cm/s)	13.99 ± 6.64	14.28 ± 8.34	0.84
RI	0.78 ± 0.07	0.72 ± 0.08	6.54×10^{-5}
PI	1.82 ± 0.51	1.49 ± 0.40	0.00056
HVI	09.09 ± 4.05	11.52 ± 4.55	0.005
APR	3.80 ± 1.55	2.71 ± 1.16	0.00015

VPI: venous pulse index, RI: resistance index, PI: pulse index, HVI: hepatic vascular index, APR: arterio-portal ratio.

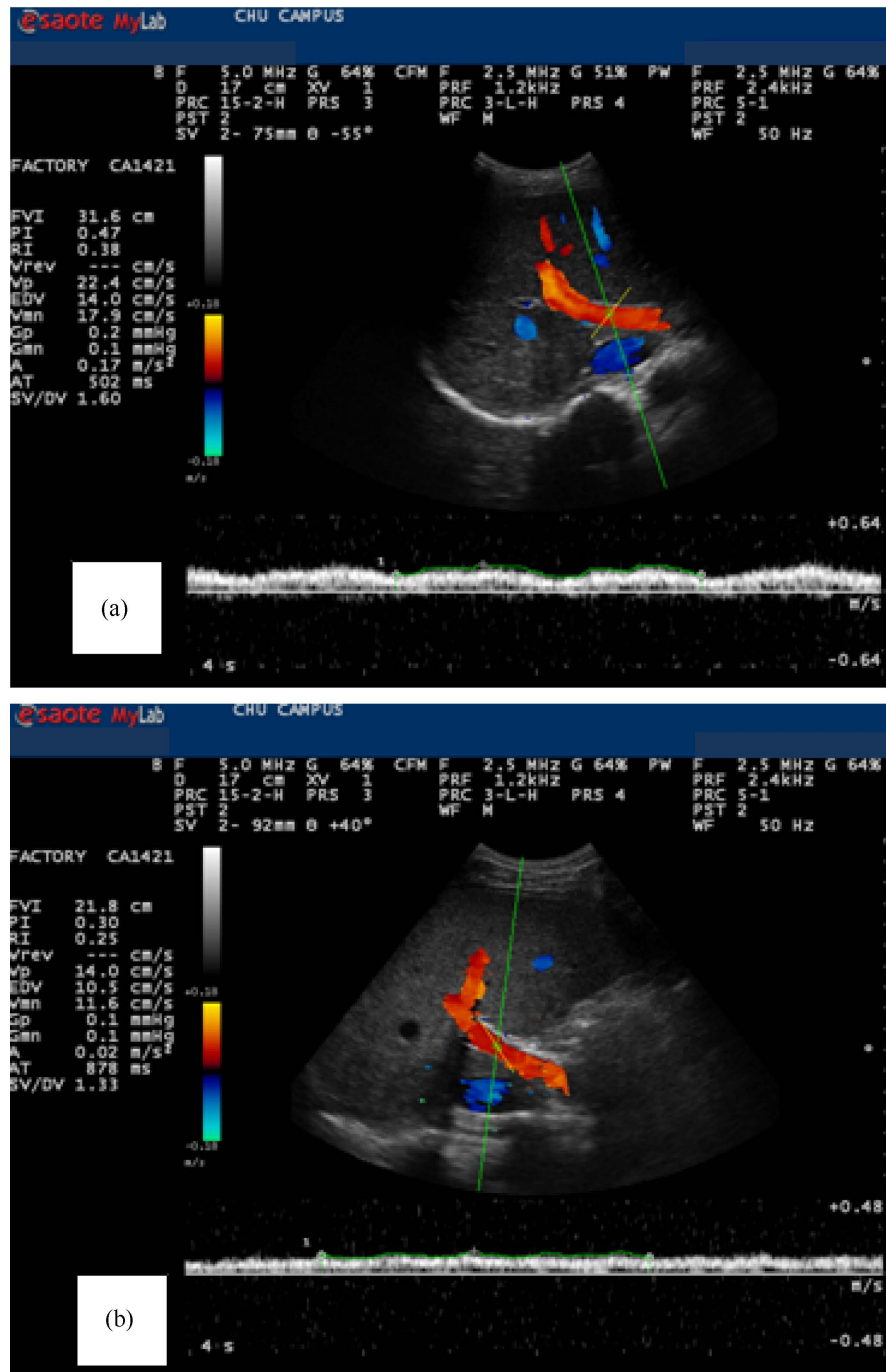


Figure 1. Flow and spectrum of portal vein. (a) In a non cirrhotic patient, hepatopetal flow and normal mean velocity (17, 9 cm/s); (b) in a cirrhotic patient, hepatopetal flow and decreased mean velocity (11.6 cm/s).

portal system. Thus, an increased caliber of the portal vein should be given special attention in the search for other signs of cirrhosis. However, the diameter of the portal vein decrease and become normal again in case of portosystemic diversion. And when these diversion paths are important, the flow reverses and the caliber generally becomes normal or inferior to normal [7].

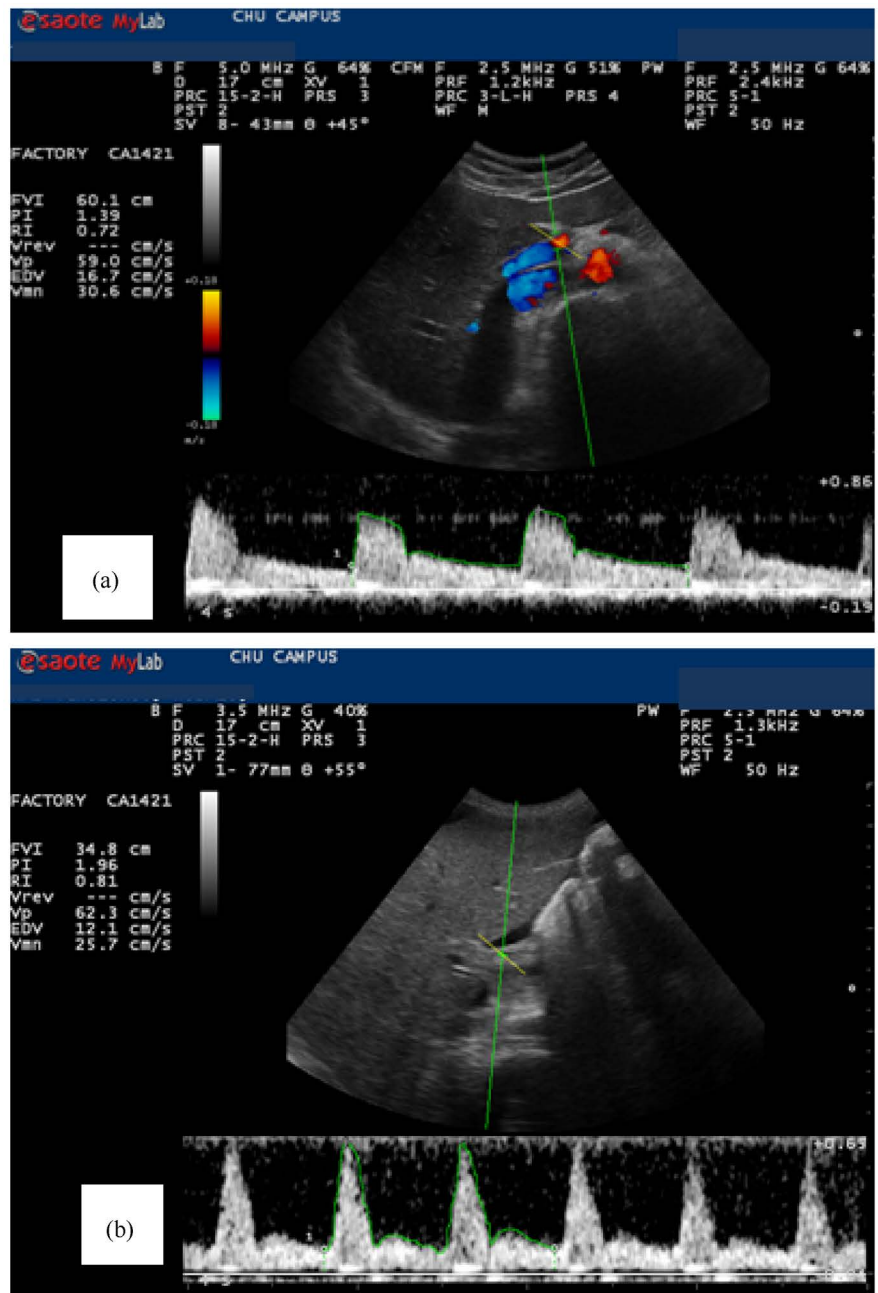


Figure 2. Hepatic artery spectrum. (a) in a non cirrhotic patient, the RI is 0.72; (b) in a cirrhotic patient, the RI is 0.81.

We noticed in this study that a non-statistically significant decrease in the portal average velocity (p-value = 0.71) of systolic and diastolic velocity in cirrhotic versus non-cirrhotic patients. The decrease in these speeds is explained by the loss of the flexibility of the hepatic parenchyma which becomes more difficult to irrigate and behaves as an obstacle to the normal flow of the blood. As a result, the blood flow slows down. This decrease in the velocity of the portal vein has been found by several authors. Iwao *et al.* [8] and Zironi *al* [7] respectively found an average of 11.0 ± 2.4 cm/s speed in cirrhotic patients versus 15.9 ± 2.8

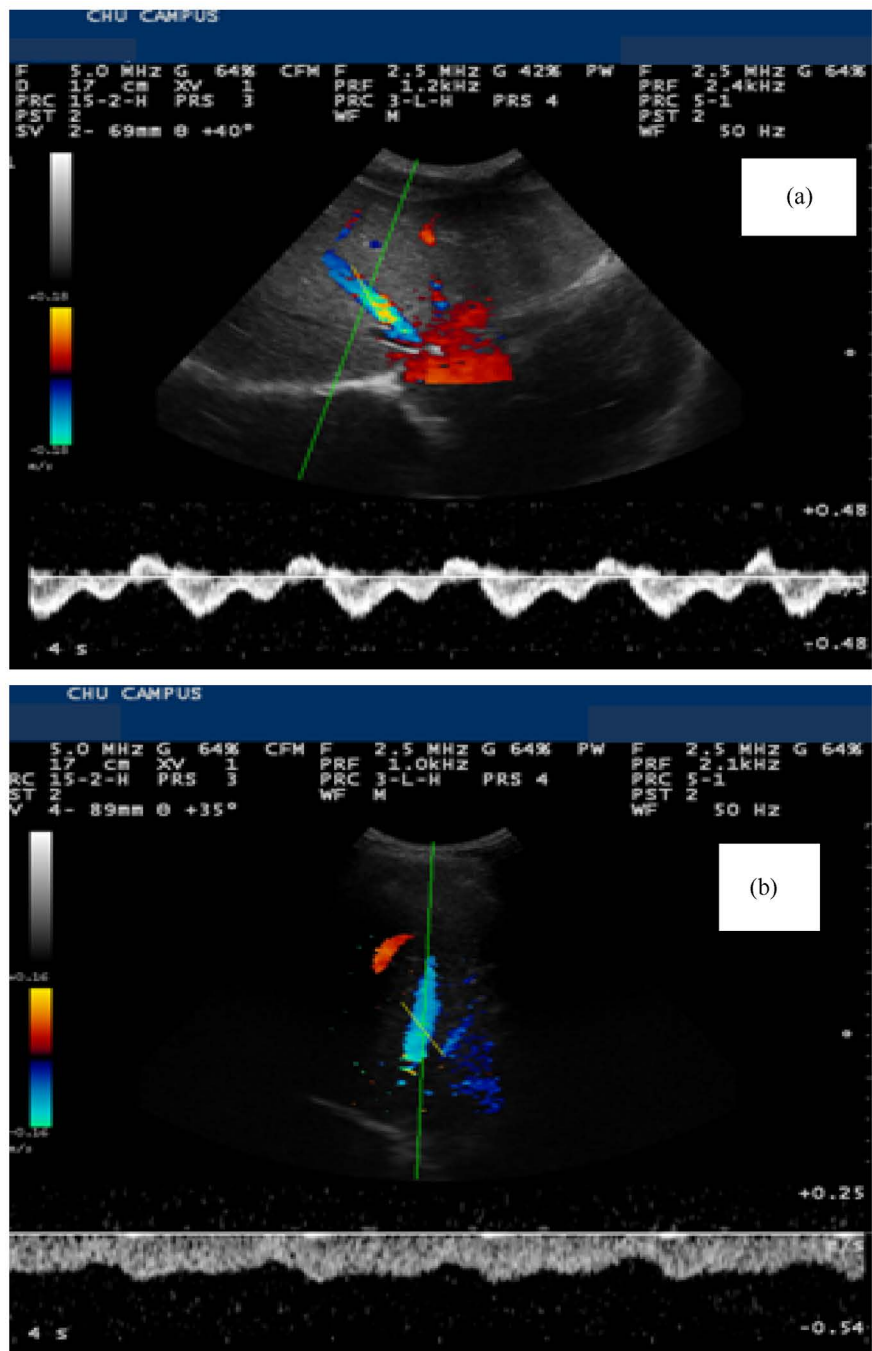


Figure 3. Hepatic vein spectrum. (a) normal waveform in a non cirrhotic patient characterized by a triphasic flow; (b) abnormal hepatic flow pattern in a cirrhotic patient characterized by a flat flow pattern.

cm/s in controls and (13.0 ± 3.2 cm/s against 19.6 ± 2.6 cm/s, $p < 0.001$) with however a statistically significant difference.

For a portal vein average velocity of 15 cm/s, Zironi [7] also found a sensitivity and a specificity of 88% and 96% respectively, not for the diagnosis of cirrhosis but for the detection of portal high blood pressure. This is still important because portal high blood pressure is a major complication of the cirrhosis of the

liver.

Then, the lowering of the average speed can be an indirect sign of the diagnosis of hepatic cirrhosis.

Most studies [7] [8] found a decrease in portal vein velocimetry values in cirrhotic patients compared with non-cirrhotic subjects, but with different values.

This variation in values may be related to the difference in the material used, the test conditions and the measurement methods as reported in the literature [7] [9] [10] [11]. It can also be related to the variations in the position of the cursor and the Doppler window [12].

4.2. Hepatic Artery

The maximum systolic rate, as well as the average speed, had a statistically significant increase in cirrhotic patients compared to non-cirrhotic subjects.

The diastolic rate, meanwhile, experienced a non-statistically significant decrease in cirrhotic patients compared to controls.

The increase in the systolic velocity and the decrease in the diastolic velocity might be explained by the increase in the flow of the hepatic artery, which might attempt to curb the decrease the flow of the portal vein. This increased flow leads to the increase of the resistance in the arterial lair and, consequently, lead to the rise of the resistance and the pulse indices [13].

We also found in our study a statistically significant increase of the resistance index (IR) and the pulse index (PI).

This rise of the indices was found by Iwao [8] (PI 1.28 ± 0.18 against 0.95 ± 0.17) Sacerdoti [14] (PI 1.3 ± 0.29 against 0.89 ± 0.09 and RI 0.71 ± 0.07 vs. 0.59 ± 0.04).

Taking into account the normal averages of the RI (0.55 - 0.81) proposed by the literature [15] [16] [17], we found in our study 46% pathological IR and 86% pathological IP. This reflects the sensitivity of these indices to cirrhosis corresponding to the data proposed by Pierce [18] who noted a sensitivity and specificity of 68% and 70% from an IR value of 0.77. However, it should be noted that the increase in the indices is not specific to cirrhosis. Indeed, increased indices are also noted in the chronic diseases of the liver [19], after the meal and with age [20] [21]. It should also be noted that there are significant inter- and intra-observer variations that might affect the measurement of these indices [22].

4.3. Hepatic Veins

The decreased size of the hepatic veins and the demodulation (decrease in pulse) of the hepatic vein spectrum in cirrhotic patients can be explained by the decrease of the hepatic parenchyma compliance due to fibrosis and the decrease of hepatic vein diameter. resulting from cirrhosis. [23] [24] [25].

Bolondi & al [26] and Colli & al [23] found respectively 50% and 75% abnormal spectrum in the cirrhotic patients.

The decrease of the calibers and the demodulation of the spectrum of the hepatic veins is a sensitive sign of the cirrhosis but nonspecific because the Budd Chiari syndrome, the diffuse hepatic metastases as well as the deep inspiration, obesity, and ascites are the factors that can influence the spectrum of hepatic veins [26] [23] [27] [28] [29] [30].

4.4. Limitations

None of our patients received a liver biopsy puncture which is the gold standard for the diagnosis of cirrhosis [2]. The diagnosis of cirrhosis in the hepato-gastroenterology department was based on a combination of clinical, biological and radiological arguments [3].

5. Conclusions

We found a statistically significant change in hemodynamic parameters of liver vessels in the cirrhotic patient compared with the non-cirrhotic subject. The size of the portal vein; the hepatic artery average and systolic velocities, the resistance and the pulse index had increased in the cirrhotic. The systolic and diastolic average velocities of the portal vein and the caliber of the hepatic veins, on the other hand, had decreased in cirrhotic patients.

The measurement of hemodynamic parameters of hepatic vessels is a sensitive and specific argument for the diagnosis of cirrhosis. It can and must rightly be part of the diagnosis arsenal of cirrhosis.

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