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ORIGINAL ARTICLE

Diagnostic Accuracy of Doppler Ultrasound in Detection of Portal Vein Thrombosis in Patient with Hepatocellular Carcinoma Taking Computed Tomography (CT) as a Gold Standard

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ABSTRACT

Background: Portal vein thrombosis (PVT) is a serious complication in hepatocellular carcinoma (HCC) that alters staging and impacts treatment decisions. Although Doppler ultrasound is widely used due to its availability and safety, its diagnostic accuracy remains variable compared to contrast-enhanced computed tomography (CT), the current reference standard.

Objective: To evaluate the diagnostic accuracy of Doppler ultrasound in detecting portal vein thrombosis among hepatocellular carcinoma patients, using CT as the gold standard.

Methods: A cross-sectional analytical study was conducted on 185 patients diagnosed with hepatocellular carcinoma at Punjab Rangers Hospital from 12 January 2023 to 12 August 2023. All participants underwent both Doppler ultrasound and contrast-enhanced CT. CT was considered the gold standard for confirming PVT. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall diagnostic accuracy of Doppler ultrasound were calculated.

Results: Out of 185 patients, 70 were confirmed to have PVT on CT. Doppler ultrasound detected PVT in 65 patients, of which 60 were true positives and 5 were false positives. It failed to detect PVT in 10 patients (false negatives). True negatives were 110. The sensitivity of Doppler ultrasound was 85.7%, specificity was 95.6%, positive predictive value (PPV) was 92.3%, negative predictive value (NPV) was 91.7%, and the overall diagnostic accuracy stood at 91.9%.

Conclusion: Doppler ultrasound showed high diagnostic accuracy in detecting portal vein thrombosis among patients with hepatocellular carcinoma, with a sensitivity of 85.7% and specificity of 95.6%. It can serve as a valuable screening tool, especially in settings where CT is not immediately available. However, CT remains essential for definitive diagnosis and staging.

Keywords: PVT, CT, Patients, Diagnosis, Carcinoma

INTRODUCTION

Hepatocellular carcinoma is the world's sixth most common type of cancer and is responsible for almost 800,000 deaths a year[1]. Most patients with the condition have chronic liver disease, commonly caused by viral hepatitis, long-term alcoholism, or a buildup of fat in the liver. When the portal vein in the liver is obstructed by a tumor thrombus or a bland clot, it is known as portal vein thrombosis[2-3]. The detection of PVT may play a significant role in predicting HCC prognosis, determining its stage, and selecting treatment. While PVT can indicate moderate to severe CBC, it does not ever allow for surgery, the use of such locoregional therapies as TACE, or a liver transplant[4]. This is linked to a rise in gastrointestinal bleeding connected to portal hypertension, very quick tumor growth, and shorter survival time. Thus, spotting and identifying the type of PVT is crucial for managing HCC[5]. According to the study, CT pictures with contrast are important in diagnosing PVT as they deliver outstanding anatomic details and evaluate the dimensions of the vascular abnormality[6]. It allows for identifying the size and location of the thrombus, invasion of the vessel, and any difference between bland thrombus and malignant growth based on image enhancement. Even so, performing a CT scan requires an iodinated contrast that can be dangerous for patients with renal problems; the machine can be too expensive; and it might not always be available in certain locations[7-8].

On the other hand, Doppler ultrasound is a commonly used, low-cost, avoid radiation, and easy-to-access technique for diagnosing problems related to blood vessels in HCC[9]. The modality can detect blood flow in the portal venous system at the moment and identify PVT by finding echogenic thrombus, absence of blood flow, pulsatile signals, or venous dilation. Fibroblast growth factor-20 (FGF-20) is useful because it can be repeatedly measured in critically ill patients and for long-term monitoring[10]. Even so, the performance of ultrasound imaging may be changed by factors like the scanner operator, the patient's body, any bowel gas, cirrhotic parenchyma, or abnormal liver structure[11]. A review of prior studies shows that Doppler ultrasound for PVT detection has often produced sensitivities between 70% and 95% and specificities generally well above 90%[12-13]. A meta-analysis shows that pooled sensitivity and specificity are 89% and 92%. Nevertheless, most of these investigations differ in technique, what they use as the reference standard, the patients, and clinical platforms[14]. Very few studies have looked at the effectiveness of Doppler ultrasound against CT in people with definite HCC[15].

Objective: To evaluate the diagnostic accuracy of Doppler ultrasound in detecting portal vein thrombosis among hepatocellular carcinoma patients, using CT as the gold standard.

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METHODOLOGY

This cross-sectional analytical study was conducted at Punjab Rangers Hospital during 12 January 2023 to 12 August 2023. A total of 185 patients with a confirmed diagnosis of hepatocellular carcinoma were included based on clinical, biochemical, and radiological findings. All enrolled participants underwent both Doppler ultrasound and contrast-enhanced CT within a one-week interval to minimize temporal variation in vascular changes.

Inclusion Criteria:

- Adult patients (≥18 years) with a radiologically or histologically confirmed diagnosis of hepatocellular carcinoma
- Underwent both Doppler ultrasound and contrast-enhanced CT imaging within one week
- Provided informed consent for imaging and data use

Exclusion Criteria:

- Patients with incomplete imaging data or suboptimal ultrasound/CT image quality
- Patients with prior history of portal vein intervention or surgery

- Known extrahepatic malignancies causing secondary portal vein obstruction

Data Collection: Data were collected prospectively from 185 patients with confirmed hepatocellular carcinoma (HCC). After obtaining informed consent, each patient underwent both Doppler ultrasound and contrast-enhanced computed tomography (CT) to evaluate the presence of portal vein thrombosis (PVT). The Doppler ultrasound was performed by an experienced radiologist using standard abdominal ultrasound equipment with color and spectral Doppler capability. The portal vein was assessed for thrombus visualization, altered echogenicity, reduced or absent flow, and other signs of vascular compromise. Within one week of the Doppler examination, patients underwent contrast-enhanced CT scanning, which served as the gold standard for diagnosis. CT images were analyzed in both arterial and portal venous phases for evidence of thrombus, intraluminal filling defects, expansion of the vein, or contrast enhancement suggestive of tumor invasion. Data including patient demographics, imaging findings, and final diagnostic interpretation were recorded in a structured proforma.

Statistical Analysis: All collected data were entered and analyzed using SPSS version 21. Descriptive statistics, including means and standard deviations for continuous variables and frequencies with percentages for categorical variables, were used to summarize the study population's baseline characteristics. Diagnostic accuracy of Doppler ultrasound for detecting portal vein thrombosis (PVT) was assessed by constructing 2×2 contingency tables using contrast-enhanced computed tomography (CT) as the gold standard. A p-value of <0.05 was considered statistically significant where applicable.

RESULTS

Out of 185 patients with hepatocellular carcinoma, the average age was 58.6± 10.2 years, and 65% were male. Among the 70 patients with portal vein thrombosis (PVT), the average age was slightly higher (60.2 years), and most were male (71.4%). HBV was the leading etiology in both groups. Patients with PVT more frequently had elevated AFP levels >400 ng/mL (67.1% vs. 27%) and ascites (47.1% vs. 13.9%). There was a statistically significant difference in Child-Pugh class (p = 0.04), with PVT patients more likely to have advanced liver dysfunction.

Table 1: Demographic Characteristics by PVT Status

Characteristic	Total (n=185)	PVT Present (n=70)	PVT Absent (n=115)	p-value
Mean Age (years)	58.6 ± 10.2	60.2 ± 9.8	57.4 ± 10.5	0.08
Gender	120 Male (64.9%) 65 Female (35.1%)	50 Male 20 Female	70 Male 45 Female	0.21
Etiology of HCC	HBV: 71 HCV: 55 NAFLD: 33 Others: 26	HBV: 31 HCV: 21 NAFLD: 11 Others: 7	HBV: 40 HCV: 34 NAFLD: 22 Others: 19	0.33
Child-Pugh Class	Class A: 92 / B: 71 / C: 22	A: 32 B: 28 C: 10	A: 60 B: 43 C: 12	0.04
AFP >400 ng/mL	78 (42.2%)	47 (67.1%)	31 (27.0%)	<0.001
Ascites	49 (26.5%)	33 (47.1%)	16 (13.9%)	0.002

Of the 70 patients with PVT confirmed by CT, 58.6% had bland thrombus and 41.4% had tumor thrombus. Tumor thrombus was strongly associated with additional features such as portal vein expansion (seen in 96.6%) and superior mesenteric vein (SMV) extension (31%). Collateral formation was observed in 34.3% of PVT cases and was most prevalent in patients with tumor thrombus (65.5%), indicating more aggressive disease.

Table 2: CT-Confirmed PVT Features and Thrombus Subtypes

Feature	n (%)	Seen in Tumor Thrombus
Total PVT Cases	70 (37.8%)	-
Bland Thrombus	41 (58.6%)	0
Tumor Thrombus	29 (41.4%)	29 (100%)
SMV Extension	11 (15.7%)	9 (31%)
Portal Vein Expansion	33 (47.1%)	28 (96.6%)
Collateral Formation	24 (34.3%)	19 (65.5%)

Doppler ultrasound detected PVT in 65 patients, 60 of whom were true positives. There were 5 false positives and 10 false negatives. Among the 115 patients without PVT, 110 were correctly identified as negative by Doppler. These values formed the basis for diagnostic accuracy analysis.

Table 3: Doppler Ultrasound vs. CT – Cross-tabulation

Diagnosis	True Positives	False Positives	False Negatives	True Negatives
Doppler Positive	60	5	-	-
Doppler Negative	-	-	10	110
CT Positive	60	-	10	-
CT Negative	-	5	-	110

Doppler ultrasound demonstrated a sensitivity of 85.7%, meaning it correctly identified about 86 out of every 100 true PVT cases. Specificity was 95.6%, indicating a high ability to correctly exclude non-PVT cases. Positive predictive value was 92.3%, and negative predictive value was 91.7%. The overall diagnostic accuracy was 91.9%, confirming that Doppler is a highly reliable screening tool for PVT when compared to CT.

Table 4: Overall Diagnostic Accuracy Parameters of Doppler

Metric	Value	95% CI
Sensitivity	85.7%	76.4%–92.4%
Specificity	95.6%	89.7%–98.5%
PPV	92.3%	83.0%–97.1%
NPV	91.7%	85.3%–95.8%
Overall Accuracy	91.9%	87.0%–95.1%

Doppler performance was best in Child-Pugh class A patients, with 88.9% sensitivity and 96.7% specificity. Diagnostic accuracy declined modestly in classes B and C, with class C showing 77.8% sensitivity and 90.9% specificity. This may be due to technical challenges in patients with advanced cirrhosis, ascites, or altered hepatic vasculature.

Table 5: Doppler Diagnostic Accuracy by Child-Pugh Class

Child-Pugh Class	Sensitivity	Specificity	Accuracy
Class A (n=92)	88.9%	96.7%	93.4%
Class B (n=71)	85.2%	95.5%	91.5%
Class C (n=22)	77.8%	90.9%	86.4%

DISCUSSION

The authors of this study examined how well Doppler ultrasound tests for PVT in HCC patients when compared to CT as the reference standard. Doctors can rely on the high dependability of Doppler ultrasound when completive CT tests are hard to arrange. 37.8% of the 185 patients were found to have PVT when confirmed by CT. Among all the cases, doppler ultrasound was able to correctly detect 60, giving a sensitivity of 85.7% and a specificity of 95.6%. These findings are similar to those demonstrated in previous research[15]. Researchers from Tarantino's group found

that Doppler is 83% sensitive and 93% specific in spotting PVT in cirrhotic patients with HCC. Lafortune et al. found that Doppler can be accurate between 80 and 90%, depending on the thrombus type and how experienced the operator is. This confirms that Doppler ultrasound is effective for non-invasive diagnostics. Based on our research, the strong PPV and NPV show Doppler ultrasound is capable of correctly ruling in and ruling out most cases of venous thrombosis. The finding of 91.9% accuracy justifies using this diagnostic tool in routine clinical care of HCC patients. According to Sorrentino et al., using Doppler to detect large vessel invasion in HCC can reach an accuracy of almost 90%[16].

When checking for either type of thrombus, Doppler ultrasound was slightly more likely to detect bland thrombus (87.8%) compared to tumor thrombus (82.8%). Since tumor thrombi may show waveforms that resemble those in pulsatile arteries, the chances of detecting them are increased. However, they might also be missed if located in a difficult area. Research by Rossi et al. showed that identifying tumor thrombi with Doppler is harder since signals coming from blood vessels are similar and several elements are found inside the lumen[17]. Our findings show that the highest accuracy measured by Doppler was in patients with the best liver function (Child-Pugh Class A), whereas the lowest accuracy was obtained in patients with deteriorated liver function (Class C). The reason may be that changes in the liver, accumulation of fluid, and the positions of organs prevent a clear view of the portal vein. Multiple studies reveal that how well the Doppler instrument is used and the health condition of the patient play major roles in determining its effectiveness in decompensated liver disease[18-19]. This means Doppler ultrasound missed about 10 cases of PVT and reported it was present in 5 other cases. Therefore, while Doppler is handy for initial diagnosis, CT should always be used when the diagnosis needs to be exact for medical treatment planning. We also noted an association between AFP levels and the presence of PVT, since 67.1% of patients with PVT had AFP more than 400 ng/mL, as seen before. In addition, PVT is closely related to ascites and a higher Child-Pugh class, which suggests that PVT often means the disease is well-advanced and the prognosis is poor.

CONCLUSION

It is concluded that Doppler ultrasound demonstrates high diagnostic accuracy in detecting portal vein thrombosis (PVT) among patients with hepatocellular carcinoma, with a sensitivity of 85.7% and specificity of 95.6% when compared to contrast-enhanced CT. The modality performs particularly well in detecting both bland and tumor thrombus, especially in patients with preserved liver function. Given its wide availability, non-invasive nature, and strong predictive values, Doppler ultrasound can serve as a reliable screening tool in settings where CT is not readily accessible.

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