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DOPPLER ULTRASOUND IN LIVER CIRRHOSIS: CORRELATION OF HEPATIC ARTERY AND PORTAL VEIN MEASUREMENTS WITH MODEL FOR END-STAGE LIVER DISEASE SCORE

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Abstract

OBJECTIVE: *To evaluate the correlation between Doppler ultrasound measurements of the hepatic artery and portal vein with the Model for End-Stage Liver Disease (MELD) score in patients with liver cirrhosis.*

METHODOLOGY: *This cross-sectional investigation was executed at the Department of Radiology, Sindh Police Hospital, Karachi, encompassing a cohort of 103 cirrhotic patients who were recruited through a non-probability consecutive sampling methodology. Doppler ultrasonography was employed to quantify the velocities of the hepatic artery and portal vein, in addition to the computation of the hepatic arterial resistive index. The Model for End-Stage Liver Disease (MELD) scores were derived from serum bilirubin, creatinine, and International Normalized Ratio (INR) values. A Pearson correlation analysis was conducted utilizing SPSS version 26 to evaluate the interrelationship between the Doppler parameters and the MELD scores.*

RESULTS: *There were 103 participants having a mean age of 50.51 ± 12.35 years with 66% males and 34% females. The mean hepatic artery velocity was 84.93 ± 56.80, showing a strong positive correlation ($r = 0.933$, $p = 0.000$) with the MELD score. Similarly, the portal vein velocity had a mean of 17.84 ± 5.76 and also showed a strong positive correlation ($r=0.883$, $p=0.000$) with the MELD score.*

CONCLUSION: *This investigation elucidated a robust positive correlation between Doppler ultrasound measurements of the hepatic artery and portal vein with the Model for End-Stage Liver Disease (MELD) score in individuals afflicted with liver cirrhosis. The amalgamation of Doppler parameters alongside MELD scoring has the potential to enhance risk stratification, enable prompt clinical interventions, and aid in the prioritization of candidates for liver transplantation. Future multicenter studies with larger sample size are necessary to validate these results and to formulate standardized protocols for Doppler-based monitoring.*

INTRODUCTION

Liver cirrhosis, due to various factors such as alcohol, viral and metabolic diseases has now become established as one of the most important global health problems causing morbidity and mortality [1].

Portal hypertension due to the causes is highly relevant for how to approach these patients, as progressive cirrhosis induce rapid changes [2]. Various scoring systems are used in clinical practice, Designation Disease severity and death risk (Model for End-Stage Liver Disease scale [3]).

With its better objectivity and accuracy compared to traditional models such as the Child- Turcotte-Pugh (CTP) score, the MELD score, based on serum creatinine, international normalized ratio (INR), and bilirubin concentrations, has been the new standard [4,5]. Doppler ultrasonography is an integral part of non-invasive assessment of hepatic function and an important tool for diagnostics of CIRRHOSIS complications. In contrast, Doppler derived parameters, including hepatic arterial resistive index (HARI), hepatic arterial velocity (HAv) provide important insights regarding the haemodynamic changes that occur as liver disease progresses [6]. In the setting of cirrhosis, hepatic arterial flow increases even more as it attempts to compensate for reduced portal venous flow, which is referred to as the "hepatic arterial buffer response" [7]. Although the relevance of HARI in liver diseases has been previously studied but HAv assessment is more dependable with relatively recent advancement technology of ultrasound [8,9]. Doppler ultrasonography plays a crucial role in evaluating complications like ascites and splenomegaly which are commonly seen in patients with cirrhosis. This imaging technique is more commonly employed in order to give a more complete assessment of patients on the transplant waiting list [10,11] In addition, real-world evidence indicates that the amalgamation of Doppler ultrasound imaging results with Model for End-Stage Liver Disease (MELD) scores has the power to provide a non-invasive substitute to the invasive liver biopsy, which carries risks including bleeding and false negatives [12,13]. Earlier studies have shown that early detection of cirrhosis using non-invasive techniques like Doppler ultrasonography improves patient outcome significantly [14,15] hence the combination of MELD scores and Doppler ultrasound parameters potentially provides a more useful tool to survey the progress of liver disease and assist the management of patients with cirrhosis, especially those at great risk of hepatic decompensation or awaiting for liver transplantation [16,17]. Although MELD score will still be a reference tool for prognostic analysis, Doppler ultrasonography may offer more factual information on changes in liver perfusion and therefore improve the quality of disease staging and treatment. In this study, we try to identify a more optimum and less invasive modality for evaluating/monitoring the cirrhotic patients requiring liver transplant by correlating the MELD scores and Doppler parameters.

METHODOLOGY

This was a cross-sectional study conducted at Department of Radiology, Sindh Police Hospital Karachi with objective to describe the association of Doppler ultrasound measurement of hepatic artery and portal vein with Model for End-Stage Liver Disease (MELD) score in patients with liver cirrhosis. Non-probability consecutive sampling was applied to enroll 103 patients. Patients aged 18 years and above with liver cirrhosis confirmed through clinical history and sonographic features—such as coarsened liver echotexture, nodular surface, and widened fissure were included in the study. Patients with hepatocellular carcinoma, metastatic liver disease, focal liver masses, congenital hepatic vascular anomalies, or those with poor acoustic windows were excluded. All participants fasted for at least six hours prior to the ultrasound examination. Gray- scale ultrasound was performed using GE Logiq E9 or ACUSON S2000 machines with a 2–5 MHz curvilinear transducer to assess liver morphology, splenomegaly (defined as spleen length ≥13 cm), and ascites. A Doppler ultrasound was subsequently performed using a right lateral intercostal approach and an insonation angle of ≤ 60° to obtain peak systolic velocity (PSV) and end-diastolic velocity (EDV) of the hepatic artery and to calculate the hepatic arterial resistive index (HARI = [PSV − EDV]/PSV). Portal vein velocity (PVv) was meticulously measured at the porta hepatis. All Doppler assessments were computed as averages over three distinct cardiac cycles MELD scores were calculated using available serum bilirubin, creatinine, and INR values from all patients. The data was subjected to analysis utilizing SPSS version 26.0. Demographic characteristics were presented as mean ± standard deviation, and frequency

represented in percentage. The Pearson correlation coefficient was used in determining the correlation of Doppler ultrasound measurements and scores of MELD, and $p \leq 0.05$ was considered statistically significant.

RESULTS

The investigation encompassed a cohort of 103 individuals, with an average age of 50.51 ± 12.35 years. A significant proportion of the subjects (56.3%) exceeded the age of 50 years, whereas 43.7% fell within the age range of 28 to 50 years. In terms of gender representation, 66.0% were identified as male, while 34.0% were classified as female. Pertaining to the etiology of liver disease, the predominant causative factor was identified as fatty liver disease (86.4%), succeeded by Hepatitis B (7.8%) and Hepatitis C (5.8%). The Model for End-Stage Liver Disease (MELD) score, utilized to evaluate the severity of liver impairment, yielded a mean value of 16.20 ± 5.73. A substantial majority of the patients (83.5%) presented with a MELD score of less than 19, in contrast to 16.5% who had a MELD score of 19 or higher. (Table I).

The research assessed the relationship between Doppler ultrasonography outcomes and the MELD score in 103 individuals. The mean hepatic artery velocity was recorded at 84.93 ± 56.80, demonstrating a robust positive correlation ($r = 0.933$, $p = 0.000$) with the MELD score, signifying that an increase in hepatic artery velocity corresponded with an escalation in the severity of liver disease. In a similar vein, the portal vein velocity was observed to have a mean of 17.84 ± 5.76 and also exhibited a strong positive correlation ($r=0.883$, $p=0.000$) with the MELD score. (Table II) The investigation explored the association between Doppler ultrasonography findings and the MELD score in 103 subjects, taking into account variables such as age, gender, and disease etiology. Patients over the age of 50 demonstrated significantly elevated hepatic artery velocity (100.60±70.01) and portal vein velocity (18.84±6.16) in comparison to their younger counterparts aged 28-50 years (64.73±19.75 and 16.55±4.98, respectively). The correlation between Doppler ultrasonography findings and MELD score was moderate among younger patients ($r=0.446$, $p=0.002$) but exhibited a strong association in older patients ($r=0.875$, $p=0.000$). Likewise, male subjects presented with higher hepatic artery (93.63±64.73) and portal vein velocities (18.66±6.37) than female subjects (68.02±31.24 and 16.25±3.96, respectively), with a strong correlation evident in both genders ($p=0.000$). Among the various etiologies, fatty liver disease was identified as the most prevalent and demonstrated a significant correlation with hepatic artery (69.75±37.12, $r=0.695$, $p=0.000$) and portal vein velocity (16.82±5.05). Patients diagnosed with hepatitis B exhibited higher velocities (169.87±83.66 and 23.00±6.84, $r=0.813$, $p=0.014$), while those with hepatitis C presented the apex values (196.83±33.19 and 26.16±4.30); however, their correlation was weak and not statistically significant ($r=0.442$, $p=0.380$). (Table III)

Table I: Demographic Characteristics of Study Participants (n=103)	
Variable	**n** (%)
Age (Mean ± SD) = 50.51 ± 12.35 years	
28 - 50 years	45 (43.7)
>50 years	58 (56.3)
Gender	
Male	68 (66.0)
Female	35 (34.0)
Etiology	
Fatty Liver Disease	89 (86.4)
Hepatitis B	8 (7.8)
Hepatitis C	6 (5.8)
MELD Score (Mean ± SD) = 16.20 ± 5.73	

<19	86 (83.5)
≥19	17 (16.5)

Table II: Correlation between Doppler Ultrasonography Findings and MELD Score (n=103)

Correlation	Mean	±SD	(r)	P-Value
Hepatic Artery	84.93	±56.80	0.933	0.000
MELD Score	16.20	±5.73		
Portal Vein	17.84	±5.76	0.883	0.000
MELD Score	16.20	±5.73		

Table III: Comparison of Patients characteristics with Doppler Ultrasonography Findings (n=103)

Variables		Hepatic Artery Mean±SD	Portal Vein Mean±SD	(r)	P-Value
Age Group	28 - 50 years	64.73±19.75	16.55±4.98	0.446	0.002
	>50 years	100.60±70.01	18.84±6.16	0.875	0.000
Gender	Male	93.63±64.73	18.66±6.37	0.735	0.000
	Female	68.02±31.24	16.25±3.96	0.898	0.000
Etiology	Fatty Liver Disease	69.75±37.12	16.82±5.05	0.695	0.000
	Hepatitis B	169.87±83.66	23.00±6.84	0.813	0.014
	Hepatitis C	196.83±33.19	26.16±4.30	0.442	0.380

DISCUSSION

Doppler ultrasonography is a non-invasive imaging technique that is an essential part of hepatic hemodynamic assessment in patients with liver cirrhosis. Cirrhosis to provoke the change of hepatic artery as well as portal vein blood flow and these are the traditional indicators of liver disease severity that can be evaluated with Doppler ultrasound. The correlation between Doppler assessments and the MELD (Model for End-Stage Liver Disease) score, a widely used scoring system for the determination of liver function impairment, is essential for determining disease progression and for outcome prediction. The hepatic artery and portal vein are two key components of the hepatic vascular supply, and hemodynamic changes in these vessels are biomarkers of liver functional state changes [18]. A cirrhosis that brings with it the most frequent complication linked to portal hypertension, related to the good vascularization of the liver. This functional adaptation might stimulate a reduction in portal venous flow, paralleled by a rise in hepatic arterial flow due to compensating mechanisms. Doppler ultrasound has the potential to quantitatively assess these hemodynamic changes, thus delivering key information regarding portal hypertension severity and hepatic vascular resistance. The data from the MELD empirical investigations further confirmed that double of the Doppler ultrasound parameters of the hepatic artery and portal vein had a significant association with MELD score[10,11]. The MELD score progressivity increases as hepatic function deteriorates in cirrhotic patients, whilst Doppler ultrasound findings, such as increases in hepatic artery resistances and changes in flow patterns in the portal vein, become clinically evident with advancing stages of the disease. The MELD score represents a comprehensive assessment of hepatic failure, including contributions from serum bilirubin, creatinine, and international normalized ratio (INR). Additionally, Doppler ultrasound provides a functional evaluation of hepatic blood flow in real time, which may allow for the confirmation or even prediction of changes in laboratory variables that comprise the MELD score. Doppler ultrasound may not only show diagnosis, but it has great application especially in case of liver cirrhosis. And it is also useful for following the progression of the disease, which can guide clinicians on when liver transplantation should be performed [19]. Elevation of MELD will often indicate an increased transplant urgency and Doppler

ultrasound is helpful in determining the presence of complications such as variceal bleeding, ascites and hepatic encephalopathy [20]. It can also be used to evaluate the impact of treatment and therapy of portal hypertension and its complications.

Non-probability consecutive sampling is a major limitation of this study, which is likewise easier but might introduce selection bias. The study participants were not only referred for screening of hepatocellular carcinoma, but also patients who were requiring medical consultation at the Hepatology Department over the same period of time, which causes a selection bias that does not reflect the real prevalence of liver cirrhosis.

And indeed this limitation reduces the generalizability of study results to the population. The fact that patients with metastatic disease, hepatocellular carcinoma or other focal liver lesions were excluded also limits the generalizability of the results, since these pathological conditions can importantly influence the Doppler measurements and the MELD score.

Another considerable limitation resides in the operator-dependency inherent to Doppler ultrasound, which can compromise the precision of the measurements obtained. Notwithstanding the utilization of advanced ultrasound apparatus (GE Logiq E9 and ACUSON S2000), Doppler measurements, particularly those concerning the hepatic artery and portal vein, may exhibit slight discrepancies influenced by the operator's proficiency and the anatomical characteristics of the patient. The investigation utilized a right lateral intercostal approach, a technique that is traditionally employed within clinical environments; however, it may not be the most suitable method for all patients, particularly those who exhibit ascites or significant liver distortion resulting from cirrhosis. These factors could insert random noise for the measurements leading to possible fluctuations in the outcomes of the study. Regardless of these drawbacks, the result of the study emphasizes the strong correlation between Doppler ultrasound variables (consist of peak systolic velocity and hepatic arterial resistive index) and MELD score. As hepatic function deteriorates in the context of cirrhosis, these Doppler evaluations exhibit alterations that are aligned with the severity of portal hypertension and hepatic vascular resistance, which are subsequently linked to the MELD score. These elements of this association indicate that Doppler ultrasound might support the MELD score as a dynamic, real-time assessment of hepatic hemodynamics that has the potential to impact clinical decision-making, particularly in determining the need for liver transplantation or monitoring disease progression. Future research efforts should aim to narrow these limitations by using random sampling methods that would better represent the population under study. A larger multicenter study that recruits patients with a wider range of serious liver diseases like hepatocellular carcinoma and metastasis could yield a more comprehensive view of the relationship between Doppler ultrasound parameters and liver function. Additionally, the uniformity of Doppler ultrasound techniques in addition to the broader hemodynamic parameters including portal venous pressure can greatly enhance the quality and quantity of data.

CONCLUSION

This investigation elucidated a robust positive correlation between Doppler ultrasound measurements of the hepatic artery and portal vein with the Model for End-Stage Liver Disease (MELD) score in individuals aflicted with liver cirrhosis. The amalgamation of Doppler parameters alongside MELD scoring has the potential to enhance risk stratification, enable prompt clinical interventions, and aid in the prioritization of candidates for liver transplantation. Future multicenter studies with larger sample size are necessary to validate these results and to formulate standardized protocols for Doppler-based monitoring.

REFERENCES

Asrani SK, Devarbhavi H, Eaton J, Kamath PS. Burden of liver diseases in the world. J Hepatol. 2019;70(1):151-71.

Berzigotti A. Advances and challenges in cirrhosis and portal hypertension. BMC Med. 2017; 15:1-8.

D'Amico G, Maruzzelli L, Airoldi A, Petridis I, Tosetti G, Rampoldi A, et al. Performance of the model for end-stage liver disease score for mortality prediction and the potential role of etiology. J Hepatol. 2021;75(6):1355-66.

Acharya G, Kaushik RM, Gupta R, Kaushik R. Child-Turcotte-Pugh score, MELD score and MELD-Na score as predictors of short-term mortality among patients with end-stage liver disease in Northern India. Inflamm Intest Dis. 2020;5(1):1-0.

Chen PC, Chen BH, Huang CH, Jeng WJ, Hsieh YC, Teng W, et al. Integrated model for end-stage liver disease maybe superior to some other model for end-stage liver disease-based systems in addition to Child-Turcotte-Pugh and albumin-bilirubin scores in patients with hepatitis B virus-related liver cirrhosis and spontaneous bacterial peritonitis. Eur J Gastroenterol Hepatol. 2019;31(10):1256-63.

Gaspari R, Teofili L, Mignani V, Franco A, Valentini CG, Cutuli SL, et al. Duplex Doppler evidence of high hepatic artery resistive index after liver transplantation: role of portal hypertension and clinical impact. Digest Liver Dis. 2020;52(3):301-7.

Spaggiari M, Martinino A, Ray Jr CE, Bencini G, Petrochenkov E, Di Cocco P, et al. Hepatic arterial buffer response in liver transplant recipients: implications and treatment options. Semin Intervent Radiol. 2023;40(01):106-12.

Park HS, Desser TS, Jeffrey RB, Kamaya A. Doppler ultrasound in liver cirrhosis: correlation of hepatic artery and portal vein measurements with Model for End-Stage Liver Disease score. J Ultrasound Med. 2017;36(4):725-30.

Wang Z, Ma Y, Wu X, Lu Y, She Q. Advances in diagnostic ultrasound techniques for assessing liver steatosis in nonalcoholic fatty liver disease. iLIVER. 2023;2(4):214-8.

Baz AA, Mohamed RM, El-kaffas KH. Doppler ultrasound in liver cirrhosis: correlation of hepatic artery and portal vein measurements with model for end-stage liver disease score in Egypt. Egypt J Radiol Nucl Med. 2020;51:1-0.

Tuladhar S, Katwal S, Gurung G, Khanal U. Hepatic arterial hemodynamics and model for end-stage liver disease (MELD) scores in chronic liver disease: insights from Doppler ultrasonography. Egypt J Radiol Nucl Med. 2024;55(1):65.

Aranzana EM, Coppini AZ, Ribeiro MA, Massarollo PC, Szutan LA, Ferreira FG. Model for end-stage liver disease, model for liver transplantation survival and donor risk index as predictive models of survival after liver transplantation in 1,006 patients. Clinics. 2015;70:413-8.

Elzawawy MS, El Nomrosy RM, Hassanein SA. The role of fibroscan in assessment of liver cirrhosis in patients with chronic liver disease. Menoufia Med J. 2018;31(2):520-4.

Topal NB, Sarkut P, Dündar HZ, Sahin AU, Ercan I, Ayyldiz T. The correlation between Doppler US measurement of hepatic arterial flow and the MELD score in patients with chronic liver disease. Eur Rev Med Pharmacol Sci. 2016;20(2):291.

Glišić TM, Perišić MD, Dimitrijevic S, Jurišić V. Doppler assessment of splanchnic arterial flow in patients with liver cirrhosis: correlation with ammonia plasma levels and MELD score. J Clin Ultrasound. 2014;42(5):264-9.

Khammas AS, Mahmud R. Ultrasonographic measurements of the liver, gallbladder wall thickness, inferior vena cava, portal vein and pancreas in an Urban Region, Malaysia. J Med Ultrasound. 2021;29(1):26-31.

Fayad L, Narciso-Schiavon JL, Lazzarotto C, Ronsoni MF, Wildner LM, Bazzo ML, et al. The performance of prognostic models as predictors of mortality in patients with acute decompensation of cirrhosis. Ann Hepatol. 2015;14(1):83-92.

Møller S, Bendtsen F. The pathophysiology of arterial vasodilatation and hyperdynamic circulation in cirrhosis. Liver Int. 2018;38(4):570-80.

Wazir H, Abid M, Essani B, Saeed H, Khan MA, Nasrullah FN, et al. Diagnosis and treatment of liver disease: current trends and future directions. Cureus. 2023;15(12).

Artru F, Samuel D. Approaches for patients with very high MELD scores. JHEP Rep. 2019;1(1): 53-65.