ISSN: 0975-833X

Available online at http://www.journalcra.com

International Journal of Current Research
Vol. 11, Issue, 04, pp.2830-2833, April, 2019

DOI: https://doi.org/10.24941/ijcr.33250.04.2019

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

RESEARCH ARTICLE

ACOUSTIC RADIATION FORCE IMPULSE ELASTOGRAPHY OF SPLEEN – A NEW TOOL TO ASSESS THE SEVERITY OF PORTAL HYPERTENSION

[1]Shivu Jayadev, [2,*]Bhushita Lakhkar, [3]Bhushan N Lakhkar, [4]Ramesh C Pattanshetti and [5]Adiraju Karthik

[1]Third year Resident, Department of Radiodiagnosis and Imaging, Shri Bm Patil Medical College, Blde (Deemed to be University, Vijayapura

[2]Assistant Professor, Department of Radiodiagnosis and Imaging, Shri BM Patil Medical College,Blde (Deemed to be University, Vijayapura

[3]Professor & Head of Department, Radiodiagnosis and Imaging, Shri Bm Patil Medical College, Blde(Deemed to be University, Vijayapura

[4]Professor Department of Radiodiagnosis and Imaging, Shri Bm Patil Medical College, Blde(Deemed to be University, Vijayapura

[5]Third year Resident, Department of Radiodiagnosis and Imaging, Shri Bm Patil Medical College, Blde (Deemed to be University, Vijayapura

ARTICLE INFO

Article History:
Received 28th January, 2019
Received in revised form
22nd February, 2019
Accepted 20th March, 2019
Published online 29th April, 2019

Key Words:

Modified Asphalt, Plastic Waste, Polyethylene, Durability index, Curve index.

Corresponding author:

ABSTRACT

Background: The gold standard method considered to assess the severity of portal hypertension is the hepatic venous pressure gradient (HVPG). Patients with severe portal hypertension (HVPG ≥ 12 mm Hg) are at risk for variceal bleeding, with mortality rates ranging from 20% to 35%. However, due to its invasiveness, it is gradually getting replaced by Doppler ultrasound where, Damping index (DI) reflects portal pressure and liver dysfunction. Spleen stiffness measurements by acoustic radiation force impulse (ARFI) elastography have been proposed as a new, non-invasive parameter for assessment of portal hypertension. **Objectives:** To assess value of spleen stiffness measurements by acoustic radiation force impulse (ARFI) elastography in predicting the severity of portal hypertension. **Materials and Methods:** 130 clinically diagnosed cases of portal hypertension were included in the study. Spleen Elastography was performed by ARFI method to calculate the median shear wave velocity of the spleen. **Results:** In our series of 130 cases, the Spleen stiffness (SS) as measured by ARFI shear wave velocity ranged between 2.54 – 4.1 m/s with mean SSM of 3.14 ± 0.28 m/s. In our study, the Spleen stiffness cut-off value of 3.11 m/sec was considered as the better indicator to rule out the presence of severe portal hypertension with a sensitivity of 93.3% and specificity of 80% ($p<0.05$). **Conclusion:** Increased value of Spleen stiffness measurement by ARFI elastography has shown a strong association with the severity of portal hypertension.

***Citation: Shivu Jayadev, Bhushita Lakhkar, Bhushan N Lakhkar, Ramesh C Pattanshetti and Adiraju Karthik*, 2019.** "Acoustic radiation force impulse elastography of spleen – a new tool to assess the severity of portal hypertension", *International Journal of Current Research*, 11, (04), 2830-2833.

INTRODUCTION

Portal hypertension (PH) is defined as an increase in portal pressure above the normal range of 6-10 mmHg or an increased hepatic venous pressure gradient (HVPG) of more than 5 mmHg (Ravaioli *et al.,* 2018). The severity of portal hypertension is determined by the portal pressure. Patients with severe portal hypertension (HVPG ≥ 12 mm Hg) are at risk for variceal bleeding, with mortality rates ranging from 20% to 35% (Jensen, 2002). Hence, there is a need for a simple method to predict the progression of PH toward severe portal hypertension (SPH).

Measuring the Spleen stiffness by ARFI Elastography have opened new doors for predicting the severity of portal hypertension in a non-invasive way (Lechowicz *et al.,* 2015). Parenchymal remodeling of the spleen occurs in patients of PH, which is due to factors like, high arterial inflow, passive congestion, hyperactive splenic lymphoid tissue, increased angiogenesis and fibrogenesis (Mejias *et al.,* 2010). Stiffness and haemodynamics of the spleen can be considered as sensitive markers of portal pressure and portal vein resistance. Therefore, it has been stated that SSM by Ultrasound Elastography can be effectively used as an accurate non-invasive alternative method for assessing the PH (Rizzo *et al.,* 2014).ARFI Elastography using Virtual Touch Tissue Quantification (VTTQ) software is emerging as a significant

tool to predict severity of PH (Lucchina *et al.,* 2018). The present study is targeted to assess the role of Spleen stiffness measurement (SSM) using ARFI Elastography for predicting the severity of portal hypertension.

MATERIALS AND METHODS

130 clinically diagnosed cases of portal hypertension were included in the study. Spleen Elastography was performed by ARFI elastography (with VTTQ software) method to calculate the median share wave velocity of the spleen by intercostal approach**.** The patients were fasting for 12 hours. They were examined by ARFI elastography in right lateral decubitus position. The transducer was placed perpendicular to the longitudinal axis of the spleen, the line of the VTTQ ROI aligned with the transducer axis. The VTTQ ROI, measuring 5 x 10 mm in width and depth respectively, was placed in 10 di□erent sites from the superior to the inferior splenic pole and calculated the median value of the 10 measurements (Kim *et al.,* 2015) (Figure 1). Doppler Ultrasonography of abdomen was also performed to look for waveform pattern of the hepatic vein and Damping Index (DI) (Baik, 2006). The hepatic vein (HV) was depicted intercostally along its longitudinal axis with colour Doppler following which, spectral Doppler waveforms were obtained in the right HV at a distance of 3–6 cm from the union of the HV and the inferior vena cava by curvilinear probe. The maximum and minimum velocities of downward HV flow were measured and The DI was calculated by measuring the minimum and maximum velocities of downward HV flow and their ratio (Kim *et al.,* 2007).

Statistical Analysis: Data were analyzed using SPSS software v.23.0. and Microsoft office 2007. ROC analysis for Sensitivity- specificity was done to check relative efficiency. If the p-value was < 0.05, then the results were considered to be statistically significant otherwise it was considered as not statistically significant.

RESULTS

Among 130 cases in our study group aged between 30 to 70 years with male predominance, cirrhosis was the most common etiology encountered. Hepatic veins showed biphasic waveform in 58 (44.6%) cases followed by triphasic in 40 (30.8%) cases and monophasic in 32 (24.6%) cases. DI was between 0.36-0.92 (0.65± 0.15). Majority of the cases (69.2 %) showed DI>0.6 suggesting severe portal hypertension. The median shear wave velocity (Vs) of spleen stiffness as measured by ARFI method ranged between 2.54 - 4.1 m/s with a mean value of 3.14 ± 0.28 m/s. Due to non-availability of invasive techniques like HVPG measurement and Endoscopy, diagnosis of severe portal hypertension was determined on the basis of the Damping index of hepatic vein as studied by Antil N et al[10] in 2016 and Kim MY et al. (2007) who found that by linear correlations with HVPG, DI>0.6 was significantly associated with severe portal hypertension. Among 130 patients in our study group, we tried to analyze the correlation between ARFI shear wave velocity of spleen with the severity of portal hypertension by considering DI>0.6 as the reference value (Table1, Fig.2). We observed a statistically significant difference between spleen stiffness (SS) in subjects with DI<0.6 and those with DI>0.6 (p<0.001). The best SSM cut-off value for predicting severe portal hypertension was 3.11 m/s (AUROC 0.877, p<0.001, with 93.3% Se, 80% Sp, 91.30% PPV, 84.21% NPV and 89.23% accuracy) (Table2, Fig.3).

Table 1. Association Between Suggested cut offs for Shear wave Velocity of Spleen and Damping Index

Damping Index	Spleen Stiffness (Median Vs (m/s))				p value
	<3.11		≥3.11		
	N	%	N	%	
<0.6	32	80.0	6	6.7	<0.001
≥0.6	8	20.0	84	93.3	*
Total	40	100.0	90	100.0	

Table 2. Diagnostic Ability of SSM For Identifying Severe Portal Hypertension

Cut-off value for severe PH Median Vs (m/s)	Sensitivity	Specificity
2.75	100.0%	30.0%
3.11	93.3%	80.0%
3.15	86.7%	80.0%
3.20	60.0%	85.0%
3.28	26.7%	90.0%

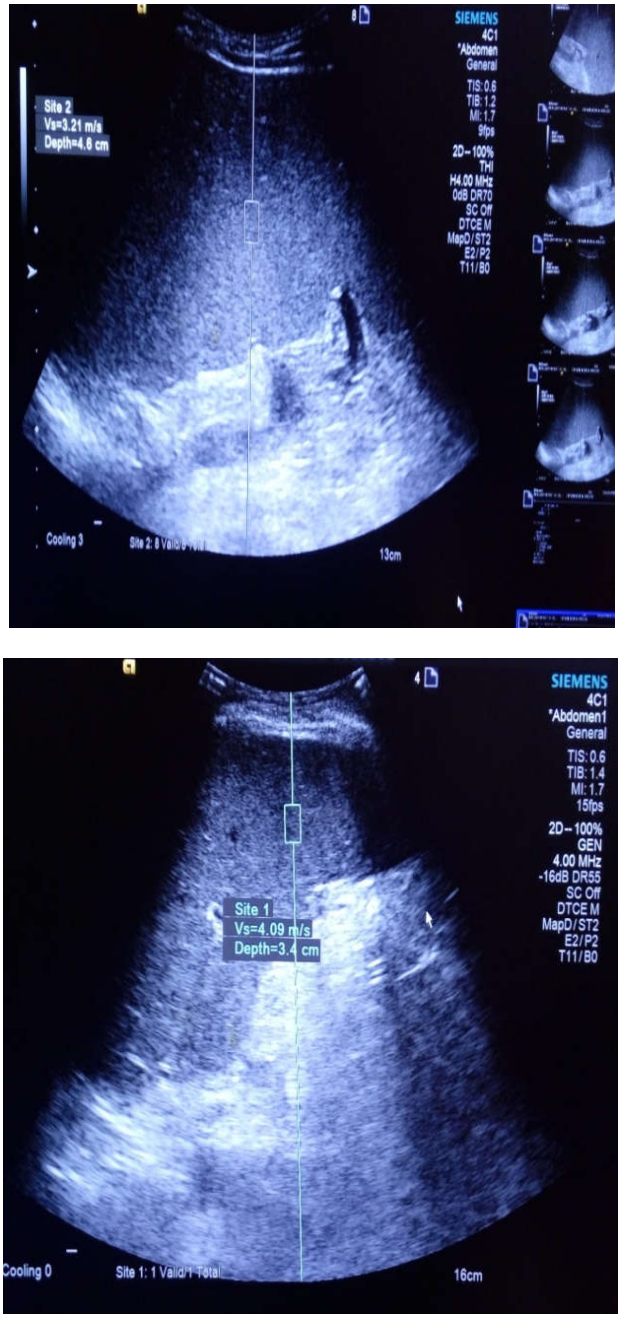

Figure 1. Spleen stiffness measured through shear wave velocity by ARFI method

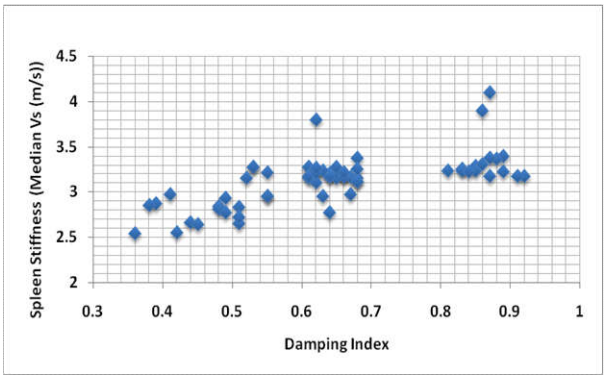

Figure 2. Correlation Of Shear Wave Velocity Of Spleen With Damping Index

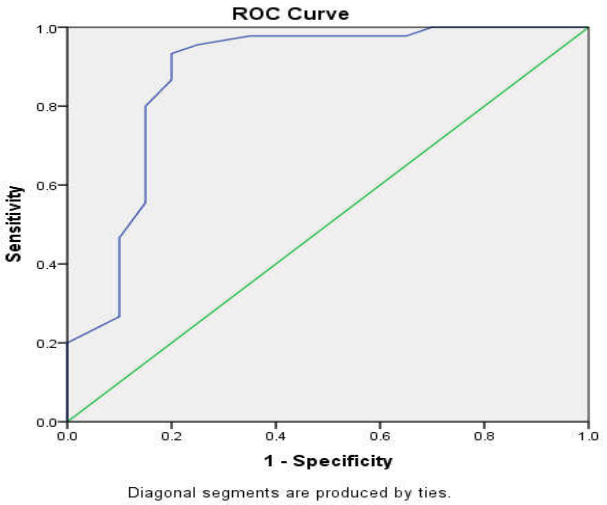

Figure 3. Area under the receiver operating curve (AUROC) analyses of spleen stiffness measurement (SSM) and Damping Index (DI) was plotted to predict the presence of severe portal hypertension (AUROC: 0.877)

DISCUSSION

Portal hypertension is a common clinical syndrome, characterized by an increase in portal venous pressure due to increased flow resistance in the hepatic sinusoids as well as an increase in total amount of blood flowing through the portal system (Lechowicz, 2015). The standard investigation for evaluation of portal hypertension are HVPG measurement and upper gastrointestinal endoscopy, however, they are invasive and require a specialized clinical setting (de Franchis, 2010; Bosch, 2009). Among the various possible evaluations, in clinical practice, Ultrasonography (US) is a mainstay in the assessment of patients with portal hypertension; a noninvasive, widely available, and inexpensive technique that allows the evaluation of liver and spleen morphology as well as of functional parameters with Doppler US (Ravaioli *et al.,* 2018). ARFI elastography has recently gained a great attention in measuring the spleen stiffness. It is an ultrasound-based technique to evaluate the speed of propagation of wave in the targeted tissue to study its viscoelastic properties. The region of interest in the targeted organ (ROI) is excited mechanically by an acoustic pulse which generates localised displacement of the targeted tissue. The tissue shear wave speed can be estimated at each lateral location of the ROI by measuring the time to peak displacement. The SWV is proportional to the square root of the tissue elasticity (Hirooka, 2011).

Damping Index was calculated to assess the severity of portal hypertension. In our study DI was between 0.36-0.92 (0.65± 0.15). Majority of the cases (69.2 %) showed DI>0.6 suggesting severe portal hypertension. Kim MY et al[9] conducted a study on cirrhotic patients to evaluate the correlation between the extent of abnormal Doppler HV waveforms expressed as DI and the HVPG. 86.8% patients showed abnormal HV waveforms with a significant correlation between the DI and the grade of HVPG, i.e. with higher HVPG increased DI was observed (P<0.01). By logistic regression analysis, DI>0.6 was significantly associated with severe portal hypertension (odds ratio: 14.19, 95% confidence interval: 4.07-49.55). It was concluded that DI of the HV waveform by Doppler ultrasonography can be a supplementary tool in evaluating the severity of portal hypertension. In 2016, Antil N et al[10] conducted a Colour Doppler ultrasound study on patients of chronic liver disease to evaluate hepatic venous waveform and DI in predicting the presence of oesophageal varices and severity of portal hypertension. The hepatic veins showed monophasic waveform in 73.3% patients, followed by biphasic and triphasic waveforms in 13.3% cases. There was a statistically significant correlation between the hepatic vein waveform/DI and the Child Pugh's class (r=0.614; p<0.05). 66.7% cases had value of Damping index more than >0.6 where majority of patients belonged to class C. It was concluded that DI >0.6 with change in hepatic vein waveform from triphasic to monophasic suggests severe liver disorder and is strongly associated with severe portal hypertension. Portal hypertension causes congestion of the spleen thereby increasing the spleen stiffness. In addition, portal hypertension results in architectural changes of the splenic arteries and veins and induces splenic fibrosis (Colecchia *et al.,* 2012; Hirooka *et al.,* 2011).

Studies have shown excellent correlation between hepatic venous pressure gradient and SSM in the evaluation of portal hypertension (Singh *et al.,* 2014). In our study we assessed the efficacy of SS measurement by ARFI elastography in detecting the severity of portal hypertension. The median shear wave velocity (Vs) of spleen stiffness as measured by ARFI method ranged from 2.54 - 4.1 m/s with a mean value of 3.14 ± 0.28 m/s. Due to non-availability of invasive techniques like HVPG measurement and Endoscopy, diagnosis of severe portal hypertension was determined on the basis of the Damping index of hepatic vein as studied by Antil N et al. (2016) in 2016 and Kim MY et al[9] who found that by linear correlations with HVPG, DI>0.6 was significantly associated with severe portal hypertension (odds ratio: 14.19, 95% confidence interval: 4.07-49.55). Among 130 patients in our study group, we tried to analyze the correlation between ARFI shear wave velocity of spleen with the severity of portal hypertension by considering DI>0.6 as the reference value. We observed a statistically significant difference between SS in subjects with DI<0.6 and those with DI>0.6 (p<0.001). In our study, among 90 cases who has been considered as severe portal hypertension based on DI>0.6, 78 cases (93.3 %) showed a median Vs of SS >3.11m/s. The SS cutoff value of 3.11 m/sec was selected to rule out the presence of severe portal hypertension with a highest sensitivity of 93.3% and specificity of 80% (p<0.05) compared to other cut off velocities in the study group. Hence, SS was the most accurate diagnostic factor for severe portal hypertension (AUC, 0.877; 95% CI: 0.767, 0.988). In a study by Y. Takuma et al. (2015) in 2013, SSM of 3.15 m/s had a higher sensitivity and specificity of 96.6% and 77.8% respectively to rule out severe

portal hypertension. He observed a significant correlation coefficient between SS and HVPG ($r = 0.876$) better than that between liver stiffness (LS) and HVPG ($r = 0.609$, $P < .0001$). The areas under the ROC curve of SSM were significantly higher for the identification of clinically important portal hypertension (HVPG ≥ 10 mm Hg), severe portal hypertension (HVPG ≥ 12 mm Hg), esophageal varices (EVs), and high-risk EVs (0.943, 0.963, 0.937, and 0.955, respectively).

Conclusion

The development of simple, non-invasive technique like ARFI Elastography of Spleen has enabled the rapid and accurate diagnosis of patients with a high risk of severe portal hypertension and varices requiring further testing such as screening endoscopy or prophylactic treatment for decompensation thereby minimizing the further complications and better management. If the present results can be confirmed in further studies with large patient population, this completely non-invasive method might prove to be a readily available and popular alternative to invasive methods such as measurement of HVPG in patients with cirrhosis and portal hypertension.

Conflict of Interest Statement: nil

Funding Statement: NIL

REFERENCES

Ravaioli F, Montagnani M, Lisotti A, Festi D, Mazzella G, Azzaroli F. 2018. Noninvasive Assessment of Portal Hypertension in Advanced Chronic Liver Disease: An Update. *Gastroenterology Research and Practice*. 2018;2018.

Jensen DM. 2002. Endoscopic screening for varices in cirrhosis: findings, implications and outcomes. Gastroenterology 122(6):1620–1630.

Lechowicz R., Elwertowski M. 2015. Standards of the Polish Ultrasound Society. Ultrasound examination of the portal system and hepatic vessels. Journal of ultrasonography. Jun;15(61):208-226.

Mejias M., Garcia-Pras E., Gallego J., Mendez R., Bosch J., Fernandez M. 2010. Relevance of the mTOR signaling pathway in the pathophysiology of splenomegaly in rats with chronic portal hypertension. *Journal of hepatology*. Apr 1;52(4):529-39.

Rizzo L., Attanasio M., Pinzone MR., Berretta M., Malaguarnera M., Morra A., L'Abbate L., Balestreri L., Nunnari G., Cacopardo B. 2014. A new sampling method for spleen stiffness measurement based on quantitative acoustic radiation force impulse elastography for noninvasive assessment of esophageal varices in newly diagnosed HCV-related cirrhosis. *BioMed research international*. 2014.

Lucchina N., Recaldini C., Macchi M., Molinelli V., Montanari M., Segato S., Novario R., Fugazzola C. 2018. Point Shear Wave Elastography of the Spleen: Its Role in Patients with Portal Hypertension. Ultrasound in medicine & biology. 1;44(4):771-8.

Kim HY., Jin EH., Kim W., Lee JY., Woo H., Oh S., Seo JY., Oh HS., Chung KH., Jung YJ., Kim D. 2015. The role of spleen stiffness in determining the severity and bleeding risk of esophageal varices in cirrhotic patients. Medicine. Jun;94(24).

Baik SK., Kim JW., Kim HS., Kwon SO., Kim YJ., Park JW., et al. 2006. Recent variceal bleeding: Doppler US hepatic vein waveform in assessment of severity of portal hypertension and vasoactive drug response. Radiology 2006;240:574–80.

Kim MY., Baik SK., Park DH., Lim DW., Kim JW., Kim HS., *et al.,* 2007. Damping index of Doppler hepatic vein waveform to assess the severity of portal hypertension and response to propranolol in liver cirrhosis: a prospective nonrandomized study. *Liver Int.,* 27:1103–10.

Antil N., Sureka B., Mittal MK., Malik A., Gupta B., Thukral BB. 2016. Hepatic Venous Waveform, Splenoportal and Damping Index in Liver Cirrhosis: Correlation with Child Pugh's Score and Oesophageal Varices. Journal of clinical and diagnostic research: JCDR. 2016 Feb;10(2):TC01.

de Franchis R. Baveno V Faculty. Revising consensus in portal hypertension: report of the Baveno V consensus workshop on methodology of diagnosis and therapy in portal hypertension. J Hepatol. 2010;53:762–768.

Bosch J, Abraldes JG, Berzigotti A, et al. The clinical use of HVPG measurements in chronic liver disease. Nat Rev Gastroenterol Hepatol. 2009;6:573–582.

Colecchia A, Montrone L, Scaioli E, et al. Measurement of spleen stiffness to evaluate portal hypertension and the presence of esophageal varices in patients with HCV-related cirrhosis. Gastroenterology 2012;143:646–654.

Hirooka M, Ochi H, Koizumi Y, et al. Splenic elasticity measured with real-time tissue elastography is a marker of portal hypertension. Radiology 2011;261:960–968.

Singh S, Eaton JE, Murad MH, Tanaka H, Iijima H, Talwalkar JA. Accuracy of spleen stiffness measurement in detection of esophageal varices in patients with chronic liver disease: systematic review and meta-analysis. Clinical Gastroenterology and Hepatology. 2014 Jun 1;12(6):935-45.

Takuma Y, Nouso K, Morimoto Y, Tomokuni J, Sahara A, Takabatake H, Matsueda K, Yamamoto H. Portal hypertension in patients with liver cirrhosis: diagnostic accuracy of spleen stiffness. Radiology. 2015 Nov 20;279(2):609-19.

****