Ultrasound in Med. & Biol., Vol. ■, No. ■, pp. 1–9, 2016

0301-5629/$ - see front matter

http://dx.doi.org/10.1016/j.ultrasmedbio.2016.01.026

● *Original Contribution*

DIAGNOSIS OF CLINICALLY SIGNIFICANT PORTAL HYPERTENSION IN PATIENTS WITH CIRRHOSIS: SPLENIC ARTERIAL RESISTIVE INDEX VERSUS LIVER STIFFNESS MEASUREMENT

Chul-min Lee,* Woo Kyoung Jeong,† Sanghyeok Lim,* Yongsoo Kim,* Jinoo Kim,‡ Tae Yeob Kim,§ and Joo Hyun Sohn§

*Department of Radiology, Hanyang University Guri Hospital, Hanyang University College of Medicine, Guri-si, Gyeonggi-do, Korea; †Department of Radiology and Center for Imaging Science, Samsung Medical Center, Sungkyunkwan University, School of Medicine, Gangnam-gu, Seoul, Korea; ‡Department of Radiology, Ajou University Hospital, Ajou University College of Medicine, Yeongtong-gu, Suwon, Korea; and §Department of Internal Medicine, Hanyang University Guri Hospital, Hanyang University College of Medicine, Guri-si, Gyeonggi-do, Korea

(*Received* 21 *July* 2015; *revised* 28 *January* 2016; *in final form* 30 *January* 2016)

Abstract—The purpose of the present study is to compare the diagnostic accuracy of the splenic arterial resistive index (SARI) with that of liver stiffness measurement (LSM) for identifying patients with clinically significant portal hypertension (CSPH). We included 47 patients (M:F = 37:10) who underwent Doppler ultrasonography, LSM and hepatic venous pressure gradient (HVPG) on the same day. We investigated whether the SARI and LSM were correlated with the HVPG, and compared area under the curve (AUC) values for the abilities of SARI and LSM to diagnose CSPH. We also performed a sub-group analysis. The SARI and LSM were all moderately correlated with HVPG overall in patients. The AUC of SARI and LSM were 0.873 and 0.745, respectively. In patients without splenomegaly, SARI was strongly correlated with HVPG (r = 0.830), but LSM was moderately correlated with HVPG (r = 0.601). The AUC was also higher for SARI than for LSM. Therefore, SARI is potentially an excellent non-invasive measurement method for diagnosing CSPH, especially those without splenomegaly. (E-mail: jeongwk@gmail.com) © **2016 World Federation for Ultrasound in Medicine & Biology.**

Key Words: **Portal hypertension, Doppler ultrasonography, Liver stiffness, Splenomegaly, Resistive index.**

INTRODUCTION

Cirrhosis is accompanied by a profound disarrangement of the intra-hepatic circulation, which leads to portal hypertension. Portal hypertension can result from increased resistance due to architectural derangements of the liver such as fibrosis, sinusoidal collapse and development of a basement membrane in the space of Disse; however, it can also result from increased vascular tone by vasoconstrictor affecting the hepatic sinusoid (Zipprich 2007). The hormonal and sympathetic nervous systems can also increase the splanchnic blood volume, which can overload the portal venous system (La Villa and Gentilini 2008). To non-invasively estimate the severity of portal hypertension in cirrhosis, portal hemodynamic changes have been assessed using imaging techniques such as Doppler ultrasonography and elastography.

Splenic hemodynamics is particularly important in portal hypertension because it plays a pivotal role in the pathogenesis and maintenance of portal hypertension. In patients with portal hypertension, splenomegaly and splenic congestion develop due to the splanchnic hyperdynamic state (Bolognesi et al. 1996). Splenomegaly is a possible consequence of portal hypertension. Contrary to other ultrasound (US) signs, splenomegaly is a highly sensitive parameter for the diagnosis of portal hypertension. It is observed by US in 65%–80% of all patients with cirrhosis, and is more frequent in patients with cirrhosis due to viral hepatitis and primary biliary cirrhosis than in patients with alcoholic cirrhosis (Berzigotti and Piscaglia 2011). However, splenomegaly is not a specific sign of portal hypertension in patients with cirrhosis, nor can it predict the existence of esophageal varices (Sort et al. 2014). To overcome this

Address correspondence to: Woo Kyoung Jeong, Department of Radiology and Center for Imaging Science, Samsung Medical Center, Sungkyunkwan University, School of Medicine, 81 Irwon-ro, Gangnam-gu, Seoul, 135-710, Republic of Korea. E-mail: jeongwk@gmail.com

limitation, the splenic arterial resistive index (SARI) was introduced as a hemodynamic parameter by which portal hypertension can be estimated. SARI is a simple measurement by which alterations in splenic hemodynamics can be assessed (Bolognesi et al. 2001), and is believed to measure the sum of downstream resistances, including splenic and portal venous resistances.

At the same time, congestion caused by portal hypertension can increase organ viscoelasticity, meaning that increased liver and splenic stiffness is measured by ultrasonographic elastography (Jeong et al. 2014). Many studies have found that stiffness measurements are useful for estimating the severity of portal hypertension (Castera et al. 2012; Choi et al. 2014; Elkrief et al. 2015; Kim et al. 2015). However, the diagnostic accuracies of SARI and liver stiffness measurement (LSM) to predict clinically significant portal hypertension (CSPH) have not yet been compared.

The purposes of this study were i) to compare the diagnostic accuracy of SARI versus that of LSM in patients with liver cirrhosis and ii) to evaluate whether these non-invasive parameters could play an added role for identifying patients with CSPH.

MATERIALS AND METHODS

Patients

Our institutional review board approved this retrospective study, and the requirements for patient approval and informed consent for the retrospective analysis were waived. For patient selection, we searched our portal hypertension database, which included all patients with clinical findings of portal hypertension who were referred to the radiology department for Doppler US, LSM and hepatic venous pressure gradient (HVPG) evaluation of portal hypertension between March 2012 and February 2013.

The underlying liver diseases were as follows: 27 patients had alcoholic liver cirrhosis, 14 patients had liver cirrhosis due to hepatitis B virus infection, two patients had liver cirrhosis due to hepatitis C virus infection and four patients had liver cirrhosis due to other miscellaneous causes.

Seventeen patients had a history of variceal bleeding, and 24 patients had taken a beta-blockade medication to reduce their portal hypertension. The mean Child-Pugh score was 6.75 points and the mean model for end-stage liver disease (MELD) score was 10.14 points (MELD-Na 11.31). Of the 47 patients, 28 were Child A, 13 were Child B and 6 were Child C.

Liver and spleen ultrasonography

All hepatic and splenic Doppler US scans were performed by an abdominal radiologist (W.K.J) who had 11 y of clinical experience of hepatic and abdominal Doppler study. US was performed with the IU-22 system (Philips Healthcare, Bothell, WA, USA) and a 3.5 MHz phased array transducer. All patients underwent Doppler US measurements just before the HVPG measurements and had fasted from midnight of the d before the measurements. Grayscale and Doppler US scans of the liver and spleen were performed. The presence of ascites was also evaluated on the gray-scale US scan.

To measure the splenic dimensions, the spleen (including the splenic hilum) was observed on the intercostal and cranio-caudal planes. The larger measurement was selected as the maximum dimension. SARI was measured at the level of the splenic hilum as follows: the splenic artery was imaged longitudinally, and then the sample Doppler volume was set to the midpoint of the spectral Doppler image. The sample point was then adjusted to the center of the splenic artery. Then, the maximum systolic velocity and end-diastolic velocity were measured and the SARI was calculated using the following formula: resistive index = (peak systolic velocity − end-diastolic velocity)/peak systolic velocity.

Liver stiffness measurement

Following splenic Doppler, LSM was performed using shear wave elastography (SWE) function of a dedicated US machine (Aixplorer US System, version 3; SuperSonic Imagine, Aix-en-Provence, France). LSM was performed after SARI measurement by a separate abdominal radiologist (Y.K.) who had measured liver stiffness in more than 100 patients. The radiologist was also blinded to all of the previous Doppler results. Scanning parameters were set to their defaults.

The US transducer was moved to show the parenchyma of the right anterior portion of the liver *via* the right intercostal window, and the patients were asked to hold their breath after unforced exhalation during the examination. The SWE region of interest was acquired at a location deeper than 2 cm from the hepatic capsule to avoid reverberation artifacts; the region was also kept away from large vessels. Sequential frames were recalled from the cine loops obtained from the US images, which included a color map of the SWE data, until the saturated and stabilized color map showed reliable elasticity. The round Q-box was then positioned in the homogeneous center of the stabilized color map to enable measurement of the mean elasticity and its standard deviation. The Q-box was initially fixed to 20 mm; however, its size was decreased in situations such as limited measureable parenchyma due to the locations of blood vessels and the hepatic capsule. LSM values (in kilopascals) of a patient are shown as median value of five repetitions.