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# Hepatic Venous Outflow Stenosis After Auxiliary Left Hemiliver Transplantation Diagnosed by Ultrasonic Shear Wave Elastography Combined With Doppler Ultrasonography

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**Abstract:** Hepatic vein stenosis after liver transplantation is a relatively rare complication that could even result in graft loss. However, it is difficult to arrive at a definite diagnosis at the early stage of postoperation, and there are few researches on ultrasonic shear wave elastography in the diagnosis of hepatic vein stenosis. We report the case of an 11-year-old male patient with cirrhosis due to hepatolenticular degeneration who received an auxiliary left hemiliver graft from his uncle. Massive ascites developed in 4 days after the operation. Stenosis was suspected at the site of anastomosis by Doppler ultrasonography when elevating the velocity of the left hepatic vein. Meanwhile, increased stiffness of the graft was revealed by ultrasonic shear wave elastography. The stenosis was confirmed by subsequent digital subtraction angiography. Ascites decreased gradually after the stent implantation. Our case indicates that ultrasonic shear wave elastography combined with Doppler ultrasonography is a promising method for noninvasive diagnosis of hepatic venous outflow stenosis following liver transplantation.

**Key Words:** Doppler ultrasonography, hepatic vein stenosis, liver transplantation, ultrasonic shear wave elastography

**Abbreviations:** DSA = digital subtraction angiography, ElastPQ = elastography point quantification, POD = postoperative day

(*Ultrasound Quarterly* 2017;33: 289–292)

Vascular relevant complications after liver transplantation are relatively rare, especially the hepatic venous outflow obstruction or anastomotic stenosis, which has an incidence rate of 0.5% to 3.2%.<sup>1,2</sup> Graft loss may be induced by hepatic venous outflow stenosis, if it is not timely diagnosed and properly

managed.<sup>3</sup> Early diagnosis of hepatic venous outflow stenosis and routine postoperative monitoring are extremely important for timely treatment to avoid graft dysfunction or even graft loss.<sup>3,4</sup> However, because of lack of specific clinical symptoms and biologic manifestations, the early diagnosis of hepatic venous outflow stenosis is often challenging.

Doppler ultrasonography has been regarded as the primary method to evaluate the vasculature of grafts after liver transplantation by analyzing velocity and waveform of the hepatic vein.<sup>5–7</sup> However, these features are not specific enough in making a diagnosis. Except for the change in hemodynamics, hepatic vein stenosis also leads to liver congestion, which is associated with increased liver stiffness. In theory, graft stiffness might be a useful indicator for outflow obstruction. Very recently, ultrasound shear wave elastography<sup>8–10</sup> made the liver stiffness measurement more convenient and simple.

We report a case of early hepatic vein stenosis diagnosed by ultrasonic shear wave elastography combined with Doppler ultrasonography.

## Case Presentation

An 11-year-old male patient with cirrhosis received a left lateral lobe liver graft from his uncle because of hepatolenticular degeneration. The right lobe of the recipient was preserved in original location. The patient recovered well in the first 3 days after surgery. On routine bedside ultrasound examinations, the cirrhotic right lobe of the liver was unremarkable. Increased echogenicity of the transplanted left hepatic lobe indicated mild hepatic steatosis. The portal vein and hepatic artery were unremarkable. The 2-dimensional ultrasound showed the anastomosis of the left hepatic vein was obscure; however, moderately increased velocity of the left hepatic vein was detected. On the fourth postoperative day (POD), ascites increased dramatically to 3000 mL, and massive ascites persisted for the following week. Therefore, specific ultrasound examination was ordered and performed using an iU22 ultrasound system (Royal Philips, Amsterdam, the Netherlands) equipped with C5-1 (1–5 MHz) transducer and an elastography point quantification (ElastPQ) feature, which is a kind of ultrasonic shear wave elastography to assess the stiffness of the graft. Besides the increased echogenicity, a significantly higher stiffness value of the graft was detected (Fig. 1) with measurement of 24 kPa as compared with the normal liver (approximately 5–6 kPa). Doppler ultrasonography displayed monophasic waveform of the left hepatic vein proximal to the anastomosis with a decreased velocity of

Received for publication April 15, 2017; accepted May 3, 2017.

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The authors declare no conflict of interest.

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J.L. drafted the article. Y.L. and Q.L. revised the article critically for important intellectual content.

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DOI: 10.1097/RUQ.0000000000000306



**FIGURE 1.** A 11-year-old male patient with cirrhosis due to hepatolenticular degeneration received a left lateral lobe liver graft from his uncle. Liver stiffness of the liver graft was measured with ultrasound equipped with ElastPQ feature. The ElastPQ measurement was expressed in Young modulus (in kilopascals).

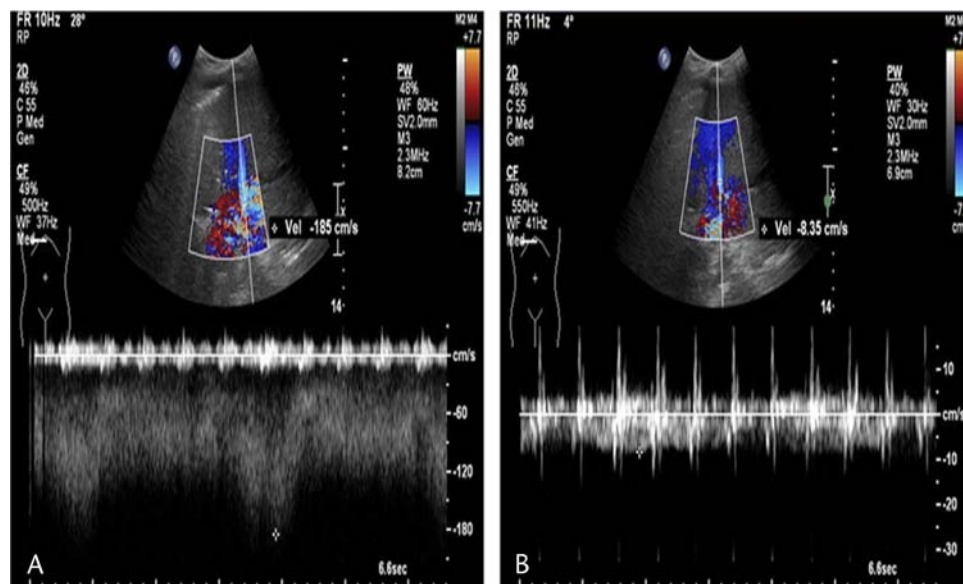
8.35 cm/s (Fig. 2A), whereas the velocity at the site of anastomosis was as high as 185 cm/s (Fig. 2B). For the right lobe, vasculature was normal, whereas the coarse echotexture and high stiffness value of 40 kPa indicated cirrhosis. With the above findings, severe stenosis of the left hepatic vein was suspected, and digital subtraction angiography (DSA) was then performed. After DSA, a beaklike severe stenosis at the anastomosis of the left hepatic vein was verified (Fig. 3A) followed by the implant of a stent (Fig. 3B). In the follow-up Doppler studies, the stent remained patent (Fig. 4), and the

ascites decreased gradually. On the 30th POD, the patient was discharged from the hospital with a full recovery.

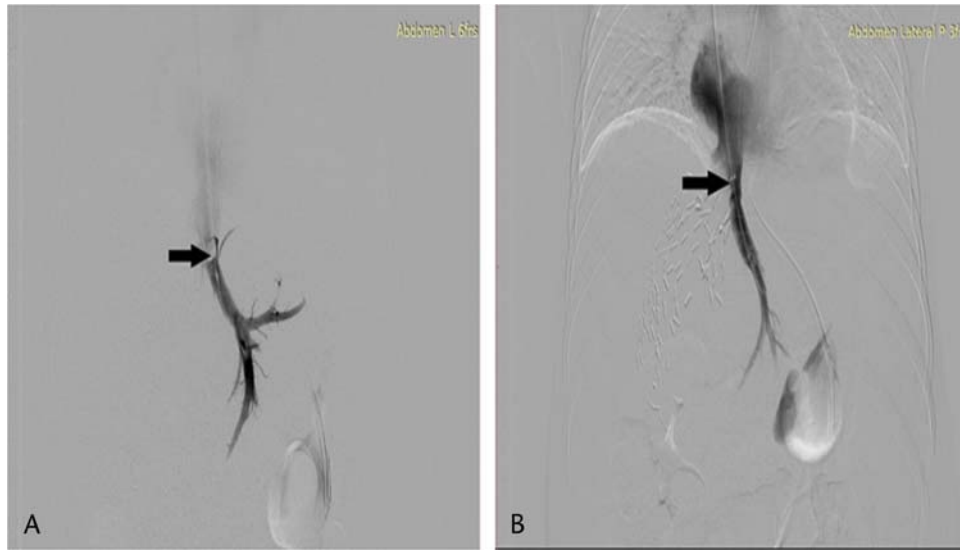
## DISCUSSION

Liver transplantation is regarded as the most effective therapeutic method for patients with end-stage liver diseases.<sup>11</sup> The improvement of surgical techniques and development of immunosuppressive therapies have significantly increased the survival of both graft and recipient. However, postoperative complications after liver transplantation still have an important impact on the survival of the graft and recipient.<sup>12,13</sup> Hepatic vein stenosis is one of the severe complications after liver transplantation, which may result in loss of the graft.<sup>3</sup> Early diagnosis and timely treatment of the adverse event are crucial to improve the prognosis of the grafts and recipients.

Among the imaging modalities for the evaluation of complications after liver transplantation, ultrasound is the modality of choice both in the early postoperative period and in the longitudinal follow-up because of its noninvasiveness, accessibility, and relatively high accuracy. However, the definite diagnostic criteria for hepatic vein stenosis by ultrasonography are still missing, and different conclusions have been reported by different studies.<sup>6,8,14</sup> Huang<sup>5</sup> reported that monophasic hepatic vein waveforms with an average velocity lower than 10 cm/s indicated hepatic vein stenosis. Luo et al<sup>14</sup> reported that hepatic venous outflow stenosis should be suspected when the ratio of stenotic to prestenotic velocity is greater than 4:1 with a flat intrahepatic waveform at the stenosis proximal segment. The spectrum waveform of hepatic vein was also revealed as helpful for the diagnosis of hepatic vein stenosis, and the normal hepatic vein waveform is triphasic.<sup>15</sup> In a study of Lee et al,<sup>6</sup> by using monophasic wave pattern, accuracy of 66.2% was reported



**FIGURE 2.** The velocity of left hepatic vein anastomosis and left intrahepatic vein was detected by Doppler ultrasonography. A, Significantly elevated velocity of 185 cm/s at the site of left hepatic vein anastomosis was detected with Doppler ultrasonography. B, Doppler ultrasonography revealed waveform of the left intrahepatic vein with a decreased velocity of 8.35 cm/s.



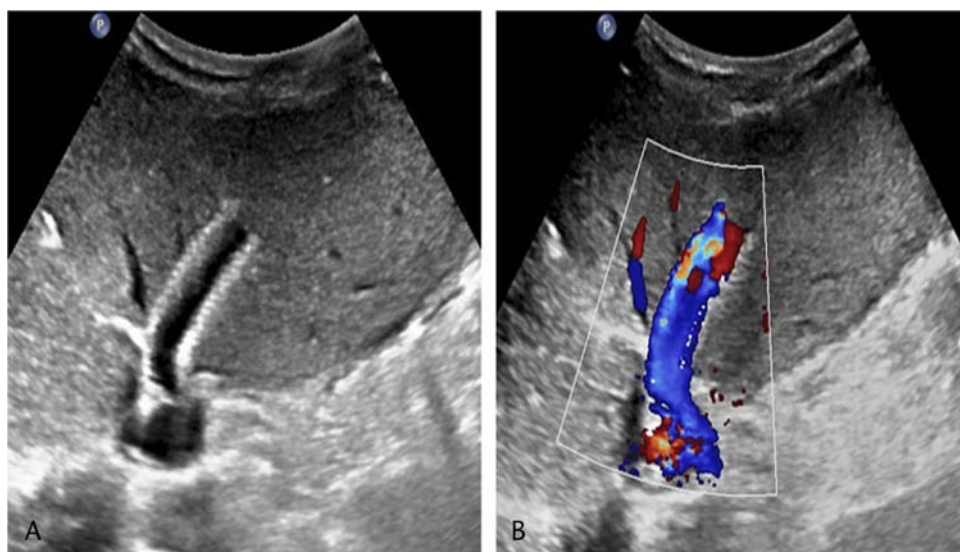
**FIGURE 3.** The left hepatic vein was explored by DSA examination. A, Severe stenosis (arrow) of the left hepatic vein was revealed by DSA. B, The stenosis was resolved by implantation of stent (arrow).

when hepatic vein stenosis was detected in 39 of 73 patients after living-donor liver transplantation. However, Ko et al<sup>7</sup> reported that the specificity of monophasic wave pattern for the diagnosis of hepatic vein stenosis was not high, but a continuous triphasic wave pattern can rule out the possibility of hepatic vein stenosis. In our case, the 2-dimensional ultrasound showed anastomosis of the left hepatic vein was obscure; however, the velocity ratio of anastomosis to preanastomosis blood flow reached 22 cm/s.

Moreover, significantly higher stiffness value on the left lobe was detected. The mean stiffness value of the graft was 24 kPa, which was significantly higher than that in normal liver ( $4.62 \pm 1.52$  kPa).<sup>9</sup> Fibrosis, inflammation, cholestasis, and

congestion are the most commonly reported factors that contribute to increase liver stiffness.<sup>10</sup> In this case, development of severe fibrosis in a few days in the graft liver was impossible. Mild elevated total bilirubin and liver enzyme also could not explain the high liver stiffness. The most reasonable explanation for the marked increase in liver stiffness is congestion induced by hepatic vein stenosis. As also reported by Ninomiya et al,<sup>16</sup> venous congestion after liver transplantation could increase liver stiffness. Therefore, increased liver stiffness may be taken as another important indicator for hepatic outflow obstruction after liver transplantation.

In conclusion, our case indicates that ultrasonic shear wave elastography combined with Doppler ultrasonography



**FIGURE 4.** The location and condition of stent displayed by ultrasonography. A, B-mode ultrasound displayed the stent within the left hepatic vein. B, Doppler ultrasonography showed the patency of stent was well.

might be a useful method for the noninvasive diagnosis of hepatic vein stenosis after liver transplantation.

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