Ultrasound-guided intraoperative inferior vena cava stent implantation for treatment of acute hypotension during orthotopic liver transplantation

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ABSTRACT

Severe obstruction of inferior vena cava (IVC) outflow after orthotopic liver transplantation can result in persistent hypotension, leading to transplantation failure and intraoperative circulatory instability and can even threaten the patient's life. IVC stent implantation is a therapeutic approach to relieve the obstruction of IVC outflow. In the present report, we describe two cases of IVC stent implantation assisted by color Doppler ultrasound during orthotopic liver transplantation to manage the persistent hypotension caused by acute obstruction of IVC outflow. At 1 and 3 months of follow-up, the stent position was optimal, and the stent and IVC patency were satisfactory without thrombosis. (J Vasc Surg Cases Innov Tech 2023;9:1-4.)

Keywords: Color Doppler ultrasound; Endovascular; Inferior vena cava obstruction; Orthotopic liver transplantation; Stent implantation

Orthotopic liver transplantation involves two anastomoses to the inferior vena cava (IVC). Twisting or stenosis at the superior IVC anastomosis site can result in IVC obstruction. Severe obstruction can cause a sharp decrease in cardiac output and acute, persistent hypotension shortly after donor liver transplantation.[1,2] In such cases, IVC stent implantation is required to restore blood flow.[3,4]

We successfully implanted IVC stents with the assistance of color Doppler ultrasound (DUS). Although several cases of stent implantation for hepatic vein occlusion under DUS guidance for patients with Budd-Chia syndrome have been reported,[5,6] to the best of our knowledge, our case report is the first to describe the application of DUS-assisted implantation of an IVC stent during orthotopic liver transplantation to manage intraoperative persistent hypotension caused by acute obstruction of IVC. Both patients provided written informed consent for the report of their case details and imaging studies.

CASE REPORT

Patient 1. A 49-year-old male patient had been diagnosed with giant hepatocellular carcinoma 11 months previously. Imaging studies revealed cirrhosis and a giant hepatocellular carcinoma in the lower part of the right posterior lobe of the liver, involving the right hepatic vein, posterior branch of the portal vein, and the IVC with tumor thrombus (Fig 1, *A*). During surgery, owing to the proximity of the superior end of the tumor thrombus to the hepatic vein outflow into the superior liver segment of the IVC, more of the superior liver segment of the IVC was removed to allow for complete tumor resection, resulting in a shorter remaining segment of the IVC inferior to the diaphragm. After orthotopic liver transplantation, the patient experienced mild liver congestion and swelling and persistent hypotension that was difficult to correct with vasopressors. Two Wallstents (Boston Scientific, Marlborough, MA) with an 18-mm diameter and 90-mm length were implanted under DUS guidance and placed into each anastomosis site. After stent placement, the hepatic congestion resolved, the IVC and hepatic vein outflow were restored, and arterial pressure showed a steady increase. On the second day after surgery, computed tomography venography (CTV) revealed an ideal position for both stents, satisfactory IVC outflow, and no evidence of thrombosis or stenosis (Fig 1, *B* and C). Rivaroxaban was used for long-term anticoagulation therapy postoperatively.

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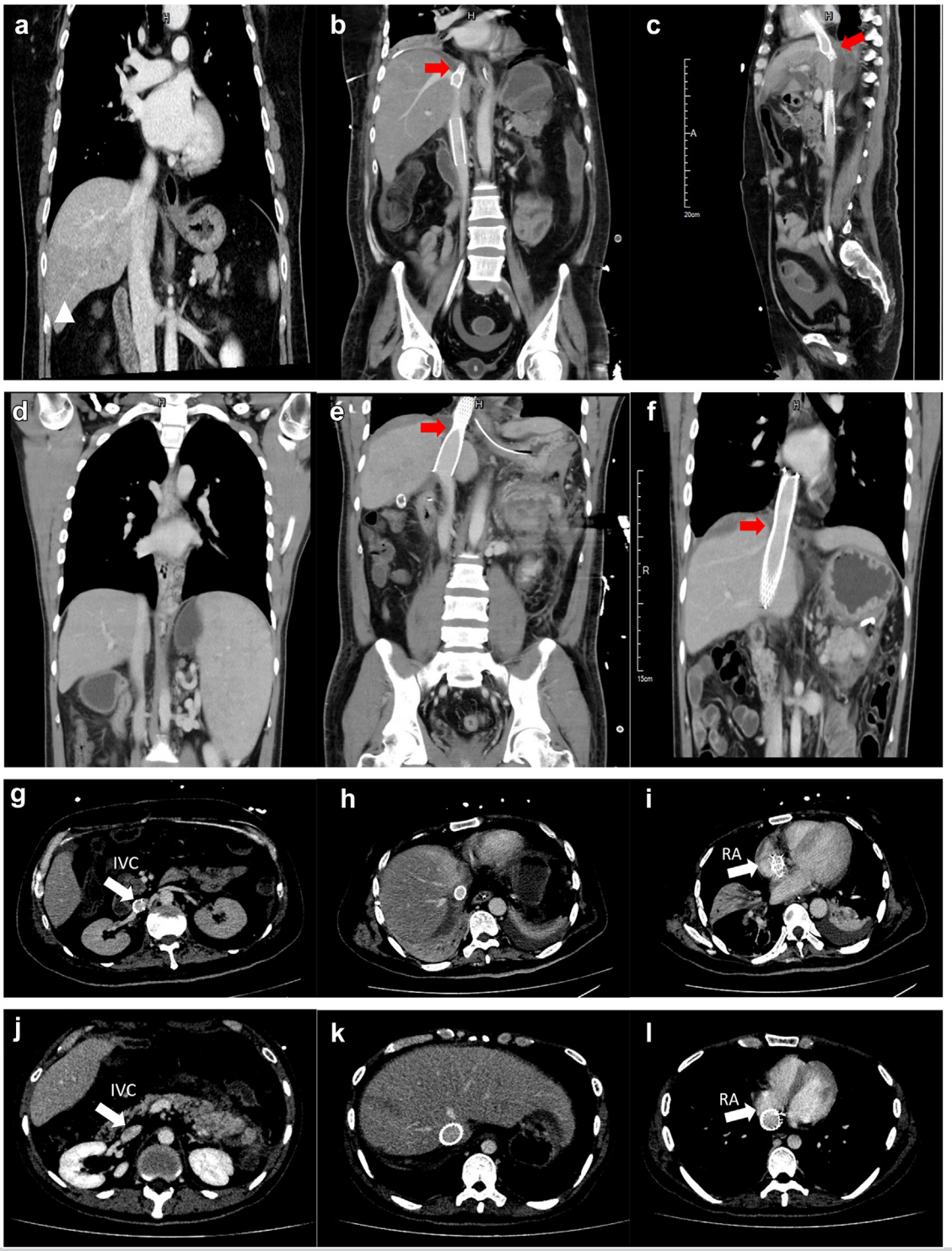

Fig 1. Preoperative and postoperative computed tomography venography (CTV). **A,** Preoperative CTV of patient 1 in the coronal plane. *White arrowhead* indicates the hepatic tumor. **B** and **C,** Postoperative (1 day after transplantation) CTV of patient 1 showing the inferior vena cava (IVC) stenosis of the anastomosis corrected by the stent. *Red arrows* indicate stenosis sites. **D,** Preoperative CTV of patient 2 in the coronal plane. **E** and **F,** Postoperative (1 day after transplantation) CTV of patient 2 showing the IVC stenosis of the anastomosis corrected by the stent. *Red arrows* indicate stenosis sites. **G-I,** Postoperative CTV for patient 1 at 1 month postoperatively. **J-L,** Postoperative CTV for patient 2 at 3 months postoperatively. *RA,* Right atrium.

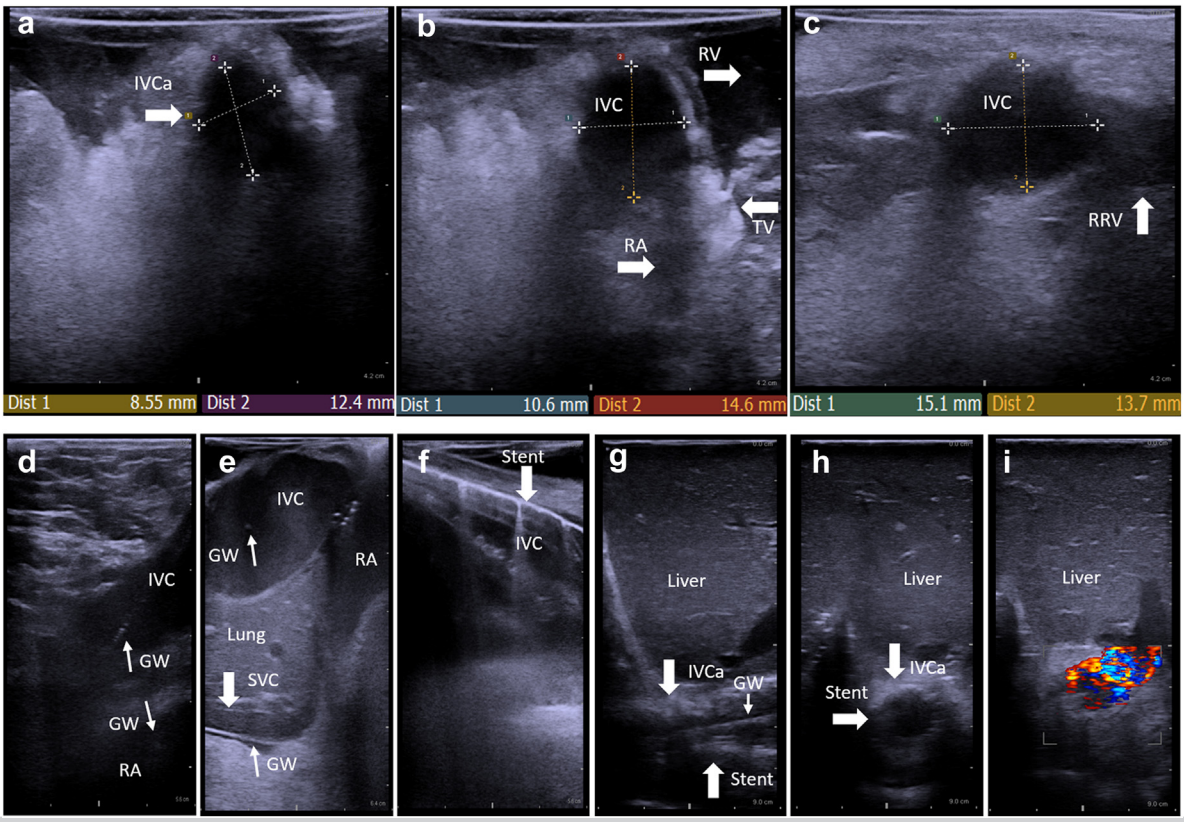

Fig 2. Procedural details of ultrasound-guided intraoperative inferior vena cava (IVC) stent implantation for patient 2. **A,** Diameter of the IVC at the anastomosis of the superior liver segment in the IVC. **B,** Diameter of the IVC at the entrance of the right atrium (*RA*). **C,** Diameter of the IVC at the opening of the right renal vein (*RRV*). **D,** Introduction of the guidewire through the anastomosis. **E,** Determination that the guidewire or catheter is located at the superior vena cava (SVC). **F,** Introduction of the stent into the IVC. **G,** Deployed stent in the transverse section plane located at the anastomosis. **H,** Deployed stent in the longitudinal section plane located at the anastomosis. **I,** In-stent blood flow. *GW,* Guidewire; *IVCa,* inferior vena cava anastomosis; *RV,* right ventricle; *TV,* tricuspid valve.

Patient 2. A 30-year-old man with cirrhosis of >5 years' duration was diagnosed with decompensation stage of hepatitis B cirrhosis, with repeated esophageal and gastric varice ruptures and bleeding (Fig 1, *D*). After transplantation, the liver texture was stiff, and the arterial blood pressure remained persistently decreased. The vasopressor was unable to maintain the blood pressure, and the stroke volume variation was also low. Consequently, a 22-mm × 100-mm Sinus-XL stent (Optimed, Ettlingen, Germany) was implanted at the anastomosis of the superior liver segment of the IVC under DUS guidance. After the stent was implanted, the liver congestion resolved, and the IVC and hepatic vein outflow became patent. Peripheral arterial manometry showed a steady increase in blood pressure, and the stroke volume variation increased. CTV performed on the second day after surgery showed an ideal stent position, satisfactory IVC outflow, and the absence of thrombosis or stenosis (Fig 1, *E* and *F*). The second patient also received rivaroxaban for long-term anticoagulation therapy after surgery.

Both patients underwent CTV at 1 and 3 months after surgery, which showed ideal stent positions and no significant thrombosis present in the stents or IVC lumen (Fig 1, *G-L*).

Procedural details of DUS-guided intraoperative IVC stent implantation. The procedure for patient 2 was standardized using the experience from the patient 1. Under color DUS (Flex Focus 800; probe 8811; BK Medical, Burlington, MA) guidance, a 12F sheath (Cook Medical Inc, Bloomington, IN) was inserted into the right femoral vein. The diameter of the IVC was measured (Fig 2, *A-C*; Supplementary Video 1, online only). A 4F multipurpose catheter (Terumo Corp, Tokyo, Japan) and a 0.035-in. soft Radifocus Guidewire (Terumo) were introduced intravenously. Once the guidewire catheter had been inserted to the appropriate length, the DUS probe was placed in the superior liver segment at the IVC to the previously determined locations of the guidewire and catheter (Fig 2, *D*). The DUS probe was then placed at the superior liver segment of the IVC and diaphragm angle to confirm that the guidewire was located at the superior vena cava (SVC; Fig 2, *E*). If the guidewire was in the SVC, the stent was slowly introduced through the stiff wire until the head of the stent in the IVC cava was palpated by fingers near the diaphragm, indicating that the tip of the stent had reached the diaphragm level. Once the stent had been pushed forward ~2 to 3 cm, the proximal end of the stent could

be positioned where the IVC enters the right atrium. The DUS probe was then placed at the stenosis to observe whether the stent covered the superior segment of the IVC anastomosis (Fig 2, *F*). Finally, the stent was detected at the superior liver segment of the IVC. DUS was performed on the surface of the liver to evaluate the transverse section of the IVC (Fig 2, *G*; Supplementary Video 2, online only), longitudinal section of the IVC (Fig 2, *H*; Supplementary Video 3, online only), and blood flow (Fig 2, *I*).

DISCUSSION

Stent placement can be a life-saving procedure for patients who experience intraoperative circulatory instability after liver transplantation and also avoids the risk of secondary injury and operative area infection associated with transferring patients to interventional or hybrid operating rooms. This technology can be particularly beneficial for hospitals or operating rooms without mobile interventional devices, because it can effectively address fatal hypotension occurring during surgery. The appropriate stent size should be selected according to the diameter of the IVC. Braided stents are often a suitable option; however, for larger IVC diameters, Sinus-XL stents (Optimed) might be preferred. A retrospective study comparing Sinus-XL stents and nonvenous stents in the treatment of SVC stenosis found no significant advantage for venous stents.[7] Another study examining the treatment of IVC obstruction caused by malignant tumors with Sinus-XL stents reported a primary patency rate of 93% and an assisted primary patency rate of 100% in 21 patients after stenting.[8] Additionally, Sinus-XL is a stent with a closed cell design and high radial strength and will be more effective in overcoming the stenosis. Also, the range of sizes from ∅ 16 mm to 34 mm seems more suitable for the vena cava. In summary, ultrasound-guided IVC stent implantation is a feasible option for patients with persistent hypotension during orthotopic liver transplantation.

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