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A simple new technique for creating an hourglass reducing stent-graft by means of targeted balloon expansion of each end of a commercially available device is presented. A 67-year-old man with progressive hepatic failure after TIPS creation was treated. A 48-mm-long Jostent stent-graft was placed inside the TIPS through a 10-F introducer and fully expanded only at the proximal and distal ends, resulting in an hourglass shape. Immediate increase of portal pressure was achieved, followed by complete clinical recovery. Advantages of covered versus bare reducing stents are discussed.

Index terms: Endovascular stent-grafts • Hypertension, portal • Liver • Shunts, portosystemic

THE transjugular intrahepatic portosystemic shunt (TIPS) has an important role in the treatment of complications of portal hypertension (1,2). However, the pressure decrease in the portal vein system after portosystemic shunt creation can sometimes result in hypoperfusion of hepatocytes, contributing to impaired liver function (3). The incidence of severe liver failure and/or disabling portosystemic encephalopathy after TIPS creation ranges from 1% to 3%, including patients with Class B or C cirrhosis, who are without surgical prospects (1,2). TIPS-flow–related complications may not respond to medical therapy and can be treated only by removing the cause or by liver transplantation. Shunt occlusion or placement of a reducing stent is therefore mandatory if severe liver failure and/or severe encephalopathy occur soon after a TIPS procedure (4–11).

We present a new technique for creation of a reducing stent-graft. A case of severe liver failure that occurred after TIPS insertion was successfully treated by positioning, within the TIPS, a commercially available balloon-expandable stent-graft (12), which was given an hourglass shape by means of a balloon angioplasty catheter. The advantages of this technique compared with those previously reported are discussed.

CASE REPORT

A 67-year-old man with hepatitis-C–related cirrhosis of Child class B (prothrombin activity rate, 68%; total bilirubin, 1.4 mg/dL; albumin, 3.2 g/L; no portosystemic encephalopathy; mild to moderate ascites) underwent TIPS creation for recurrent episodes of esophageal bleeding after endoscopic sclerotherapy procedures. Other pertinent laboratory examinations yielded a platelet count of 70 × 10^9/L and a fibrinogen level of 115 mg/mL. Preoperative ultrasonography (US) and dynamic computed tomography (CT) showed patency of the portal vein, reduction in size of the right hepatic lobe, and hypertrophy of the left hepatic lobe.

The TIPS was created with use of a standardized technique (2). The right jugular vein was accessed under US guidance, whereas the subsequent steps of the procedure were performed under digital fluoroscopy. The portal vein was reached with use of a Rösch-Uchida set (Cook, Bloomington, IN) and the shunt between the portal vein and the right hepatic vein was created by releasing a 12-mm covered stent (Passager; Boston Scientific/Medi-tech, Watertown, MA). Residual stenosis at the portal vein entry site was corrected with a Palmaz stent.

Control portography showed a high flow through the shunt with disappearance of esophageal varices but failed to detect antegrade flow into intrahepatic branches of the portal vein. The portosystemic pressure gradient at the end of the procedure was 12 cm H₂O.

After TIPS creation, the patient developed progressive liver failure and, 1 week later, his prothrombin rate fell to 24% and his bilirubin level rose to 23 mg/dL. Neither intrahepatic nor abdominal fluid collection, nor damage to the biliary system, were detected by US examination, dynamic CT, and selective hepatic angiography. Doppler US examination showed a shunt velocity of 130
cm/sec with a flow of 2.6 L/min through the shunt. Hepatofugal flow toward the TIPS was noted in the left portal vein with a high hepatic artery flow. Because the hepatic failure was attributed to shunt flow, reduction of the TIPS lumen was planned.

**Technique**

The right jugular vein was accessed as previously described. A 45-cm-long 10-F sheath (Arrow International, Reading, PA) was advanced in the portal vein through the TIPS with use of a shaped catheter. Preliminary portography and measurement of portosystemic pressure gradients were performed. Then, in anticipation of a possible rapid rise in portal pressure, gastroesophageal varices were embolized with metal coils and 3% diluted polidocanol. A 48-mm-long stent-graft (Jostent; Jomed, Rangendingen, Germany), which is a balloon-expandable endograft with three 60-μm-thick layers of extended polytetrafluoroethylene (PTFE) sandwiched between two flexible, tubular, slotted Stainless-steel stent bodies expandable from 6 to 12 mm in diameter, was mounted tightly on the proximal end of a 4.0-cm-long 12-mm balloon catheter (Opta; Cordis, Roden, The Netherlands). The stent-graft (Fig 1) mounted on the balloon catheter was carefully advanced inside the sheath until the desired position was reached at the distal end of the TIPS. Because the TIPS was curved, this position reduced the risk of stent-graft displacement (11). The sheath was then pulled back and the balloon was inflated to 10 atm so that only the distal end of the stent-graft was expanded, making it trumpet-shaped. The tip of sheath was then advanced to the nondilated proximal end of the stent-graft to hold the system in place while the deflated balloon was positioned at the trailing end of the stent-graft held in place by the sheath (Fig 2). Although the portal branches were not visualized, the portosystemic gradient immediately increased from 10 to 25 cm H₂O.

**RESULTS**

Doppler US examination performed after 24 hours (Fig 3) showed a reduction in TIPS flow to 1.8 L/min. The peak flow velocity was 95 cm/sec with expected acceleration at the narrow part to 195 cm/sec. The flow in the left portal branch was no longer hepatofugal but stagnant.

Seven days later, the total bilirubin level was 3.5 mg/dL and prothrombin activity returned to the initial value. The
patient was discharged 10 days after the procedure. At 7-month follow-up, the patient was well, bleeding had not recommenced, the shunt was patent, and his bilirubin level was 1.5 mg/dL.

**DISCUSSION**

Several approaches have been advocated to control the portosystemic shunt overflow that occurs after TIPS creation. Although embolization with nonresorbable materials produces a definitive occlusion of portosystemic shunt, it leads to a high risk of variceal bleeding related to a rapid and irreversible increase of portal pressure (4,5). Besides, a death attributed to hemodynamic changes after this technique has been reported (5). Reversible complete thrombosis with use of an occlusion balloon catheter kept inflated for at least 12 hours within the TIPS has been proposed (6). However, thrombosis involving the portal vein (7) and variceal rebleeding has been reported with this technique (6,7). Also, the balloon can dislocate, leading to failure of the procedure (6,7), and infection can potentially occur as a result of the long duration of catheter insertion (6).

Stable reduction of the shunt flow by reducing the TIPS lumen appears more attractive than occlusion in that it allows reversal of TIPS-flow–related complications and control of portal hypertension.

The technique presented here for narrowing the TIPS lumen is simple and effective. We used the only manufactured stent-graft that combines PTFE with a balloon-expandable metal stent (12). The low-profile device, which is also available in 48- and 58-mm lengths, allows an hourglass reducing stent-graft with a narrowed middle segment to be created by the simple means of targeted balloon dilatation. Because the graft causes an immediate exclusion of flow outside the reducing stent, it is not necessary to wait for thrombus formation around the stenotic area. This permits an immediate improvement of liver perfusion and a reliable intraprocedural evaluation of the hemodynamic outcome. Excessively increased portal pressure can be treated by stepwise expansion of the narrowed segment. Of course, other ways of achieving the same result are possible: a hand-made stent-graft could be used in locations where manufactured balloon-expandable devices are not commercially available, or a self-expanding stent-graft could be modified to reach an hourglass shape. Therefore, the reducing stent-graft seems to be a valid alternative to emergency shunt occlusion (9) in situations such as TIPS-induced hepatic failure in which coagulopathy impedes thrombosis.

In our case, complete clinical recovery was achieved even though the flow in the prevalent branch of the portal tree did not become antegrade again, but rather became stagnant. The improvement of hepatocyte perfusion could be a result of the restored compensatory arterial supply. The arterioportal steal hypothesis postulates a short circuit of hepatic arterial flow from the periportal area upstream to a low-pressure outlet. The increase of portal pressure after shunt narrowing might thereby restore sinusoidal perfusion by reversing the stolen arterial flow toward the sinusoidal spaces (3).

Other effective reducing stents have been described. However, with use of the only available manufactured bare hourglass-shaped stent, which is a low-profile nitinol stent with a Dacron net outside the wall at its waist and prefixed diameters of the narrow part, the new portosystemic gradient can be evaluated only 1 week after the procedure or even later when thrombosis has occurred (10). A new procedure involving a Palmaz stent will be needed in the event of excessive portal pressure. Hauenstein et al (10) reported that treatment with a reducing stent was unsuccessful in three patients with liver failure, and lack of thrombosis around the stent leading to treatment failure has also been reported in a patient with severe coagulopathy (11).

Two other systems for reducing flow have been reported. A hand-made constraining stent can be made by placing in the TIPS a Wallstent in which a central...
segment is prevented from fully expanding by circular suture (13) or by a Palmaz stent mounted on the outside and sutured to the Wallstent during assembly (14). As with all bare reducing stents, it takes some time for thrombosis to develop outside the stent and for it to have its maximum efficacy on TIPS flow. If portal hypertension recurs, it may be controlled with use of an angioplasty balloon, which forces the suture in the former configuration or gradually dilates the Palmaz stent in the latter configuration. Relative drawbacks are that these devices require time-consuming procedures, great skill in preparation and release, and large-diameter introducers.

Experimental and clinical studies indicate that covered stents can improve primary and secondary patency of TIPS (15,16), although not yet firmly established in large clinical trials. Our findings suggest that reducing stent-grafts may achieve improvement of liver perfusion in TIPS-induced liver failure. The technique we described for creating an hourglass reducing stent-graft could prove to be a useful tool for treating life-threatening TIPS-flow–related complications.

References