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Clinical Efficacy of Transjugular Intrahepatic Portosystemic Shunt Created with Expanded Polytetrafluoroethylene-Covered Stent-Grafts: 8-mm Versus 10-mm

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Abstract

Purpose Conflicting data exist regarding the appropriate shunt diameter for transjugular intrahepatic portosystemic shunt (TIPS) creation in cirrhotic patients. This study was designed to compare the clinical efficacy of TIPS using stent-grafts with 8- and 10-mm diameters.

Methods In this retrospective study, cirrhotic patients who underwent TIPS technical successfully for the prevention of variceal rebleeding from December 2011 to June 2015 were included. Thirty-four patients with 8-mm TIPS and 380 patients with 10-mm TIPS were identified. Propensity score matching method produced 32 patients in each group for comparison.

Results Baseline characteristics between two groups were comparable. There was no significant difference in variceal rebleeding rate between the two groups. The cumulative incidence of variceal rebleeding after 1 and 3 years was 6.4% and 35.5% in the 8-mm group, respectively, and 14.2% and 24.9% in the 10-mm group, respectively ($P = 0.663$). 8-mm TIPS conferred a significant decrease in hepatic encephalopathy (HE) rate compared with the 10-mm TIPS (16.1 vs. 32.6% at 1 year, 27.8 vs. 53.2% at 3 years, $P = 0.034$). The cumulative survival rates were similar between the two groups: 93.3% and 79.6% at 1 and 3 years, respectively, in the 8-mm TIPS group vs. 87.3% and 72.1% at 1 and 3 years, respectively, in the 10-mm TIPS group ($P = 0.451$).

Conclusion The placement of 8-mm TIPS was sufficient to decompress the portal hypertension and prevent variceal rebleeding. The use of the 8-mm stent-graft can decrease HE rates compared with 10-mm stent-graft, although no survival benefit was observed.

Keywords Transjugular intrahepatic portosystemic shunt · Expanded polytetrafluoroethylene-covered · 8-mm stent-grafts · Variceal bleeding

Abbreviations

TIPS	Transjugular intrahepatic portosystemic shunt
PSG	Portosystemic gradient
HE	Hepatic encephalopathy
ePTFE	Expanded polytetrafluoroethylene
SD	Standard deviation
PSM	Propensity score matching
MELD	Model for end-stage liver disease
PVT	Portal vein thrombosis
PT	Prothrombin time
INR	International normalized ratio
TB	Total bilirubin
HCC	Hepatocellular carcinoma

Introduction

Transjugular intrahepatic portosystemic shunt (TIPS) has been widely used for the treatment of complications of portal hypertension by reducing the portosystemic gradient

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(PSG) [1–3]. The hemodynamic success of TIPS creation was defined as the successful reduction of the PSG below a target threshold [4]. Generally, the target PSG for the control or prevention of variceal hemorrhage is less than 12 mmHg. Regarding control of refractory ascites, limited data have shown that a post-TIPS PSG of 8 mmHg may be a more suitable target threshold [3].

The reduction of PSG largely depends on the diameter of TIPS. Over-shunting may dramatically decrease hepatic perfusion, leading to an increased risk of post-TIPS hepatic encephalopathy (HE) and hepatic insufficiency. The choice of the diameter of the shunt should balance the requirement of the decompression of the portal venous system and the maintenance of hepatic function. In the last decade, 10-mm-diameter stent-grafts were used most frequently during the TIPS procedure. Additionally, Riggio and his colleagues found that the application of 8-mm TIPS could not control the complications of portal hypertension effectively compared with a 10-mm shunt [5].

To date, both 8-mm and 10-mm stent-grafts are frequently used in China. The purpose of the present study was to compare the clinical efficacy of TIPS using stent-grafts with 8- and 10-mm diameters.

Materials and Methods

Patient Population

Between December 2011 and June 2015, patients with liver cirrhosis who underwent technically successful TIPS creation for the prevention of variceal rebleeding in our institution were identified by means of a search in the computerized hospital registration system. Thirty-four patients with 8-mm shunts and 380 patients with 10-mm shunts were identified. Propensity score matching (PSM) method produced 32 patients in each group for comparison. Liver cirrhosis was diagnosed by liver biopsy and/or clinical and imaging findings. This retrospective study was approved by the Institutional Review Board of West China Hospital. All methods were performed in accordance with the relevant guidelines and regulations. Informed consent was obtained from all subjects.

TIPS Procedure

A standardized TIPS technique has been detailed described elsewhere and is only briefly discussed here [6]. Under sedation, an intrahepatic tract was created between the right hepatic vein and an intrahepatic portion of the right portal vein in most cases. Pre-TIPS PSG was measured and recorded. The tract was then dilated with an angioplasty balloon (Powerflex: Cordis, Roden, the Netherlands) with a diameter of 8 mm and a length of 6 cm. The entire tract was covered with expanded polytetrafluoroethylene (ePTFE)-covered stent-grafts (Fluency: C.R. Bard, Murray Hill, NJ) with a diameter of either 8 or 10 mm. In patients who underwent 10-mm TIPS, if PSG was not reduced to be less than 12 mmHg, a post-dilatation with a 10-mm balloon was performed. The choice of the diameter of the stent-grafts, and the embolization of gastroesophageal varices was performed at the discretion of the primary operator. In general, persistent visualized varices on post-TIPS venography were embolized using metal coil (Cook, Bloomington, USA), glue (Baiyun, Guangzhou, China) or plug (Huayi shengjie, Beijing, China). Low molecular weight heparin (0.01 ml/kg) was prescribed twice a day for 3–5 days. Prophylactic antibiotics were not administered routinely.

Follow-Up

Follow-up time was measured in days from the date of the technically successful TIPS procedure until liver transplantation, death, or the most recent clinical examination. Patients lost to follow-up were included until the day they were last known to be alive. All patients were scheduled for a standardized post-TIPS surveillance program at 1, 3 and 6 months, followed by every 6 months, or whenever clinically necessary. Follow-up observation included clinical assessment, blood chemistry and color duplex ultrasound examination of the liver.

Clinical Outcomes

The primary outcome of the study was the incidence of variceal rebleeding after TIPS creation. Variceal rebleeding was defined as a single episode of clinically significant rebleeding (recurrent melena or hematemesis resulting in hospital admission, blood transfusion, 3 g drop in Hb or death) from portal hypertensive sources [7]. Secondary outcomes were the incidence of post-TIPS HE, mortality and TIPS dysfunction. The diagnosis and evaluation of the degree of HE was based on the alteration of the patient's mental state according to the West-Haven criteria [8]. Refractory HE was defined as persistence of altered mental state despite protein restriction and optimal treatment with lactulose and/or nonabsorbable antibiotics. TIPS dysfunction was defined as an intrastent stenosis $\geq 50\%$, reoccurrence of complications of portal hypertension or a PSG > 12 mmHg.

Statistical Analysis

The continuous variables are expressed as the mean $\pm$ standard deviation (SD). The comparisons among groups were performed for quantitative data by an analysis of variance or an unpaired Student's t test. The Chi-square test was used to determine the differences in proportions. The incidence of the first episode of variceal rebleeding after TIPS, as well as of the other outcomes of the study, including HE, mortality and TIPS dysfunction, was calculated using the Kaplan–Meier method and compared using the log-rank test. Statistically different variables determined by univariate analysis were included in the multivariate analysis using the Cox regression model. The differences were considered statistically significant at a P value of < 0.05. The SPSS 22.0 statistical package (SPSS Inc., Chicago, IL, USA) was used for data analysis. To minimize the probability of selection bias, PSM was performed by software package R, version 3.1.1 (R development core team, 2014). A PSM for 8-mm TIPS vs. 10-mm TIPS was generated by multiple logistic regression. This model included all variables with clinical relevance to outcomes, including age, gender, etiology, coexistent disease, hematological and biochemical values, previous hepatic encephalopathy, severity of ascites, Child–Pugh grade, Child–Pugh and model for end-stage liver disease (MELD) scores. The nearest available matching (1:1) on the estimated PSM method was used to construct the control group. The c-statistic for the propensity score model was 0.988, which indicates an excellent discrimination between the two groups.

Results

Main clinical and biological baseline characteristics in the 8-mm and 10-mm groups are shown in Table 1. All further results are obtained after propensity score matching. The two groups were comparable with regards to etiology of liver cirrhosis ($P = 0.905$), total bilirubin ($P = 0.538$), severity of ascites ($P = 0.883$), Child–Pugh grade ($P = 0.861$), Child–Pugh score ($P = 1$), MELD score ($P = 0.796$), and presence of portal vein thrombosis (PVT) ($P = 0.777$). The mean ($\pm$ SD) follow-up time was 1161 $\pm$ 479 days in the 8-mm group and 675 $\pm$ 419 days in the 10-mm group ($P < 0.001$).

Post-TIPS PSG was decreased from 23.9 $\pm$ 6.3 to 9.2 $\pm$ 3.5 mmHg in the 8-mm group and from 24.6 $\pm$ 7.3 to 7.4 $\pm$ 3.7 mmHg in the 10-mm group. Four patients (12.5%) in the 8-mm group had a post-TIPS PSG higher than 12 mmHg, as did two patients (6.3%) in the 10-mm group after additional dilation. The most frequent early complication within one month after the TIPS procedure was encephalopathy in five of 64 cases (7.8%) in the cohort. Three patients experienced post-TIPS infection and required additional therapy and hospital stay. Intra-abdominal bleeding occurred in one patient during the procedure. One patient in the 10-mm group died four days later after TIPS procedure due to heart disease.

In the 8-mm group, variceal rebleeding occurred in 10 patients (31.3%) as a result of TIPS dysfunction in nine patients and insufficient variceal embolization of gastric varices in one patient. One patient died of acute upper gastrointestinal bleeding before further intervention could be performed. Four patients underwent shunt angioplasty and stent placement, one patient underwent parallel TIPS because the original shunt could not be recanalized and one patient received balloon-occluded retrograde transvenous obliteration of gastric varices. The remaining three patients refused interventional or endoscopic treatments. In the 10-mm group, five patients (15.46%) had failure to prevent variceal rebleeding. The causes of variceal bleeding were TIPS dysfunction in four patients and inadequate PSG reduction in one patient. Four patients underwent TIPS revision (stent placement in three patients and parallel TIPS in one patient). The other patient took propranolol (60 mg/d) for further reduction of the PSG and remained free of variceal bleeding during the follow-up time. The cumulative incidence of variceal rebleeding after 1 and 3 years were 6.4% and 35.5% in the 8-mm group, respectively, and 14.2% and 24.9% in the 10-mm group, respectively ($P = 0.663$; Fig. 1; Table 2). In the univariate Cox regression analysis, prothrombin time (PT) (HR, 1.247; 95% CI 1.031–1.508; $P = 0.023$), International normalized ratio (INR) (HR, 13.506; 95% CI 1.758–103.781; $P = 0.012$), Child–Pugh C (HR, 6.172; 95% CI 1.766–21.577; $P = 0.004$) and MELD score (HR, 1.248; 95% CI 1.065–1.462; $P = 0.006$) were significantly associated with variceal rebleeding. In the multivariate analysis, no predictor factor was found.

De novo HE occurred in eight patients (25%) in the 8-mm group and in 15 (46.9%) in the 10-mm group. There was no statistical difference in mean HE episodes between the two groups (1.3 $\pm$ 2.6 in the 8-mm group vs. 2.1 $\pm$ 3.6 in the 10-mm group; $P = 0.325$). Two patients (7.7%) in the 8-mm group and four (12.5%) in the 10-mm group experienced refractory HE ($P = 0.391$). The cumulative incidence of HE was 16.1% and 27.8% at 1 and 3 years, respectively, in the 8-mm group, and 32.6% and 53.2% at 1 and 3 years, respectively, in the 10-mm group. The probability of post-TIPS HE was higher in the 10-mm group ($P = 0.034$; Fig. 2; Table 2). In the univariate analysis, total bilirubin (TB) (HR, 1.028; 95% CI 1.008–1.048; $P = 0.005$), albumin (HR, 0.839; 95% CI 0.766–0.919; $P < 0.001$), alanine aminotransferase (HR, 1.011; 95% CI 1.000–1.021; $P = 0.044$), aspartate aminotransferase (HR, 1.012; 95% CI 1.003–1.022; $P = 0.012$), PT (HR, 1.258; 95% CI 1.099–1.441; $P = 0.001$), INR (HR, 13.965; 95% CI 3.196–61.022; $P < 0.001$) and Child–Pugh score (HR, 1.522; 95% CI 1.201–1.930; $P = 0.001$) were associated

Table 1 Demographics and clinical characteristics at admission

Clinical characteristic	Pre-match		*P* value	Post-match		*P* value
	8-mm group (n = 34)	10-mm group (n = 380)		8-mm group (n = 32)	10-mm group (n = 32)	
Age, years	51 ± 12	52 ± 11	0.900	52 ± 12	51 ± 11	0.996
Male, sex	22 (64.7)	260 (68.4)	0.656	20 (62.5)	20 (62.5)	1
Cause of liver disease, n			0.712			0.905
Chronic HBV infection	26 (76.6)	233 (61.3)		24 (75)	23 (72)	
Chronic HCV infection	1 (2.9)	15 (3.9)		1 (3.1)	0	
Alcohol	5 (14.7)	74 (19.5)		5 (15.7)	5 (15.7)	
PBC	1 (2.9)	24 (6.3)		1 (3.1)	1 (3.1)	
AIH	1 (2.9)	11 (2.9)		1 (3.1)	3 (9.4)	
Others	0	23 (6.1)		0	0	
Hemoglobin, g/L	81.8 ± 22.1	82.2 ± 22.2	0.747	82.6 ± 22.5	82.6 ± 20.6	0.352
Platelet, 10^9/L	68.7 ± 47.2	79.8 ± 62.5	0.598	69.2 ± 48.6	63.1 ± 38.7	0.315
WBC, 10^9/L	3.7 ± 2.4	3.7 ± 2.4	0.882	3.8 ± 2.4	3.4 ± 1.8	0.262
Bilirubin, μmol/L	20.3 ± 13.1	22.9 ± 13.5	0.562	20.1 ± 13.0	22.3 ± 17.3	0.538
Albumin, g/L	32.2 ± 4.9	32.5 ± 5.3	0.428	32.2 ± 5.1	32.3 ± 5.9	0.325
BUN, μmol/L	5.8 ± 3.9	29.7 ± 462.3	0.562	5.9 ± 4.1	5.1 ± 2.5	0.207
Creatinine, μmol/L	74.2 ± 21.4	72.7 ± 58.2	0.976	72.9 ± 18.3	69.3 ± 21.7	0.773
ALT	54 ± 104	32 ± 36	0.000	38 ± 50	30 ± 23	0.404
AST	55 ± 63	44 ± 39	0.027	49 ± 52	43 ± 25	0.343
ALP	87 ± 46	107 ± 88	0.044	87 ± 47	90 ± 72	0.403
GGT	48 ± 47	68 ± 89	0.046	46 ± 48	46 ± 49	0.814
Prothrombin time, s	15.2 ± 2.6	14.6 ± 2.2	0.528	15.3 ± 2.7	14.9 ± 2.6	0.724
INR	1.36 ± 0.24	1.30 ± 0.19	0.500	1.36 ± 0.25	1.35 ± 0.23	0.534
Encephalopathy	0	7 (1.8)	0.425	0	0	
Ascites (no/small/medium/large)	11/9/9/5	144/126/58/52	0.372	11/8/9/4	11/10/7/3	0.883
Child–Pugh grade			0.394			0.861
A	10 (29.4)	144 (37.9)		10 (31.2)	12 (37.5)	
B	20 (58.8)	211 (55.5)		18 (56.3)	16 (50)	
C	4 (11.8)	25 (6.6)		4 (12.5)	4 (12.5)	
Child–Pugh score	7.4 ± 1.6	7.2 ± 1.6	0.588	7.4 ± 1.6	7.3 ± 1.8	1
MELD score	10.5 ± 2.9	10.5 ± 2.7	0.804	10.8 ± 2.9	10.9 ± 3.0	0.796
PVT	10 (29.4)	82 (21.6)	0.293	9 (28.1)	8 (25)	0.777
HCC	2 (5.9)	16 (4.2)	0.647	1 (3.1)	2 (6.3)	0.554
DM	5 (14.7)	35 (9.2)	0.299	4 (12.5)	3 (9.4)	0.689

HBV hepatitis B virus, *HCV* hepatitis C virus, *PBC* primary biliary cholangitis, *AIH* autoimmune hepatitis, *WBC* white blood cell, *BUN* blood urea nitrogen, *INR* international normalized ratio, *MELD* model for end-stage liver disease, *TIPS* transjugular intrahepatic portosystemic shunt

with post-TIPS encephalopathy. In the multivariate analysis, only albumin was a significant predictor of HE (HR, 0.859; 95% CI 0.759–0.973; $P = 0.016$).

A total of 14 (21.9%) patients died at a median time of 437 days (range 4–1268 days). The main causes of death were hepatic failure ($n = 3$), hepatocellular carcinoma (HCC) ($n = 3$), gastrointestinal bleeding ($n = 2$), sepsis (2), heart disease ($n = 1$) and unknown($n = 3$) (Table 3). The cumulative survival rates at 1 and 3 years were 93.3% and 79.6%, respectively, in the 8-mm TIPS group and 87.3% and 72.1%, respectively, in the 10-mm TIPS group. The survival rates were similar in these two groups ($P = 0.451$; Fig. 3; Table 2). In the univariate analysis, TB (HR, 1.029; 95% CI 1.010–1.049; $P = 0.003$), albumin (HR, 0.910; 95% CI 0.834–0.994; $P = 0.036$), PT (HR, 1.319; 95% CI 1.116–1.558; $P = 0.001$), INR (HR, 20.146; 95% CI 3.158–128.505; $P = 0.001$), hepatocellular carcinoma (HCC) (HR, 5.258; 95% CI 1.132–24.425; $P = 0.034$), Child–Pugh score (HR, 1.720; 95% CI 1.281–2.309; $P < 0.001$), Child–Pugh C (HR, 9.284; 95% CI

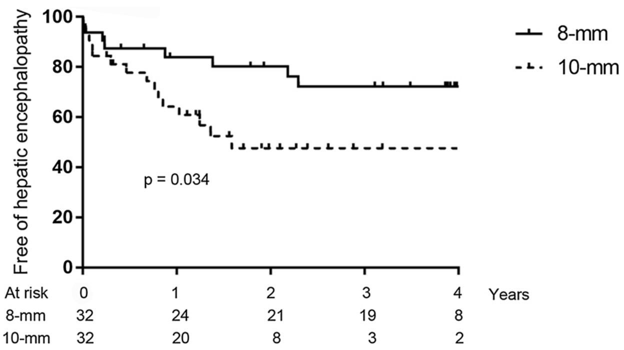

Fig. 1 The probability of free of variceal rebleeding in the two groups

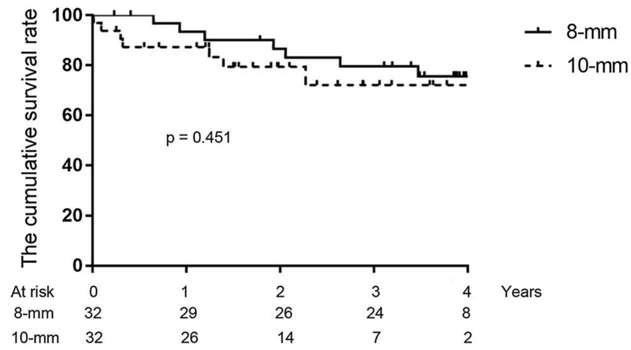

Fig. 3 The cumulative survival rate in the two groups

Table 2 Clinical outcomes in two groups

	8-mm group (%)	10-mm group (%)	*P* value
Variceal rebleeding			0.663
1-year	6.4	14.2	
3-year	35.5	24.9	
Hepatic encephalopathy			0.034
1-year	16.1	32.6	
3-year	27.8	53.2	
Survival			0.451
1-year	93.3	87.3	
3-year	79.6	72.1	
TIPS patency			0.895
1-year	96.9	85.6	
3-year	62.8	65.2	

TIPS transjugular intrahepatic portosystemic shunt

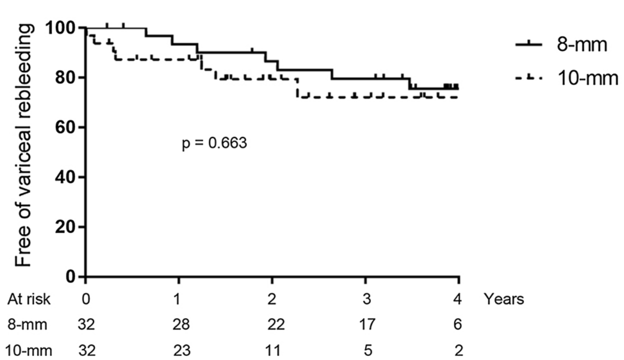

Fig. 2 The probability of free of hepatic encephalopathy in the two groups

3.121–27.614; $P < 0.001$) and MELD score (HR, 1.357; 95% CI 1.717–1.573; $P < 0.001$) were associated with mortality. In the multivariate analysis, PT (HR, 117.813; 95% CI 3.411–4068.658; $P = 0.008$), HCC (HR, 94.572; 95% CI 5.337–1675.718; $P = 0.002$) and MELD score (HR, 1.6104; 95% CI 1.067–2.430; $P = 0.023$) were predictors of mortality.

During the follow-up, 10 subjects in the 8-mm TIPS group and six in the 10-mm TIPS group experienced shunt dysfunction. The probability of shunt patency after 1 and 3 years was 96.9% and 62.8%, respectively, in the 8-mm group and 85.6% and 65.2%, respectively, in the 10-mm group ($P = 0.895$; Table 2). Ten out of 13 patients who had variceal rebleeding underwent shunt angiography. Shunt angiography showed four complete shunt occlusions, three hepatic vein stenoses, one intrastent stenoses, and one portal vein stenosis. One patient had continually visualized gastric varices and a PSG of 8 mmHg. In the meanwhile, angiography confirmed shunt dysfunction in three of five patients with compromised intrastent flow on ultrasound.

Discussion

In the study by Riggio et al., 8-mm TIPS was associated with less efficient control of complications of portal hypertension in cirrhotic patients in an Italian population compared with 10-mm TIPS [5]. It is even more disappointing that small-diameter TIPS did not decrease the incidence of HE or improve the survival rate [5]. However, this study was limited by the following—its small sample size, with a total of 45 patients enrolled; the diversity of TIPS indications, with variceal bleeding in 21 cases and refractory ascites in 24 cases; and the relatively early termination. The present study retrospectively compared the clinical efficacy of TIPS created with 8-mm stent-grafts with 10-mm stent-grafts in patients with cirrhosis and variceal bleeding. We found that, in patients treated with 8-mm TIPS, the clinical efficiency to prevent variceal rebleeding was not impaired. More importantly, 8-mm TIPS was associated with a reduction in post-TIPS HE risk.

TIPS is used to decompress the portal venous system and, therefore, prevent bleeding from gastroesophageal varices or reduce the formation of ascites. The diameter of the shunt is crucial for the effects and adverse side-effects. A large-diameter shunt may relieve complications of portal hypertension highly effectively, but at the cost of an increased risk of HE and severe deterioration of liver function. It has been demonstrated that large TIPS with a diameter of $>$ 10 mm or a low PSG of $<$ 12 mmHg lead to thorough deprivation of portal hepatic perfusion in more than 80% of patients [9]. The optimal reduction of the post-TIPS PSG varies depending on the indication being treated. For varices, it is widely accepted that, if post-TIPS PSG could be reduced to less than 12 mmHg, then the risk of variceal bleeding will fall considerably [2, 3, 10]. Therefore, to avoid excessive portosystemic shunting related complications such as overt HE, stent grafts with 10-mm diameters have been widely considered the most appropriate choice and are commonly used in US and European countries.

The target PSG $\leq$ 12 mmHg is the standardized definition of hemodynamic success of TIPS creation, although reduction of PSG is a comprehensive outcome of the shunt diameter, type of stent, pre-TIPS portal hemodynamic and liver volume. Because small liver volume usually indicates impaired reserve liver function, a small-diameter shunt may be more suitable in these instances. The ideal way to determine the diameter of the shunt may be to quantitatively determine the post-TIPS PSG on the basis of portal hemodynamics, liver volume and other relative parameters quantitatively. Finally, due to the differences in the average heights and weights between Chinese and Western populations, whether the 10-mm stent-graft is the best choice in a Chinese population must to be validated.

In our institution, according to the consensus and guidelines, we also chose 12 mmHg as the target threshold during TIPS creation in patients who suffered from variceal bleeding. In this study, hemodynamic success of TIPS creation was achieved in 87.5% of patients in the 8-mm group, and it was comparable with previous reports [11, 12]. The hemodynamic response after TIPS creation confirmed that the 8-mm shunt is wide enough to decompress the portal venous system in subjects from the Chinese population. During the follow-up, no statistical difference in variceal rebleeding was observed between the 8-mm group and 10-mm group. In addition, a recent study showed that the 2-year variceal rebleeding rate was only 7% in patients with 8-mm stent-grafts [11]. These findings demonstrated that 8-mm TIPS is effective to lower PSG and prevent variceal rebleeding.

It is well known that HE is one of the most challenging complications of the TIPS procedure. Previous studies have reported that liver disease with etiologies other than alcohol, female gender, increasing age, serum creatinine level, hypoalbuminemia, higher Child–Pugh class and past history of encephalopathy was predictive of post-TIPS HE [13–16]. The present study found that 8-mm TIPS could significantly decrease the risk of post-TIPS HE, compared with 10-mm TIPS. This finding corroborated the recent study that reported a low overt encephalopathy rate (18% at 2 years) using an 8-mm shunt, which was lower than the average proportion (20–31%) [3, 11]. The diameter of the shunt could greatly influence the portal hepatic perfusion. More importantly, neither hemodynamic success rate of TIPS nor the clinical efficacy of preventing variceal rebleeding was impaired by 8-mm TIPS in Chinese population.

Some authors recommended that covered stents with a diameter of 10 mm should be initially dilated only to 8 mm during TIPS creation [2, 10]. It has also been suggested that a 10-mm stent could be dilated to only 6–8 mm; therefore, further dilatation can be performed in cases of insufficient

Table 3 Causes of death in two groups

	8-mm group (n = 7)	10-mm group (n = 7)
Hepatic failure	1	2
HCC	1	2
Sepsis	2	0
Gastrointestinal bleeding	2	0
Heart disease	0	1
Unknown	1	2

HCC hepatocellular carcinoma

clinical response [17]. This is based on the hypothesis that an underdilated stent may maintain an initial small caliber, thereby possibly reducing the risk of HE. However, Gaba and his colleagues found that an underdilated stent would eventually expand to a nominal caliber, and the shunt underdilation strategy could not limit HE or occurrence of worsened liver function compared with nominal dilation [18].

The limitations of the present study include the retrospective design, a single center and small sample size. PSM method was conducted to control for the baseline confounders. Only the patients who underwent the TIPS procedure for the secondary prophylaxis of variceal bleeding were included. Whether our findings could be generalized for other TIPS indications, such as refractory ascites, is still doubtful.

In conclusion, our study demonstrated that 8-mm TIPS was sufficient to decompress portal hypertension and prevent variceal rebleeding in a Chinese population. The use of an 8-mm ePTFE-covered stent-graft could decrease HE rates compared with 10-mm ePTFE-covered stent-graft, although no survival benefit was observed. Future well-designed prospective studies are required to evaluate the clinical efficacy of 8-mm TIPS in other populations and for other indications.

Compliance with Ethical Standards

Conflict of interest On behalf of all authors, the corresponding author states that there is no conflict of interest.

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