

Determining the optimal portal pressure gradient after small-diameter TIPS for ascites: a retrospective study

Guofeng Liu*, Songchi Xiao*, Xiaoze Wang, Yi Shen, Yuping He, Li Yang and Xuefeng Luo

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Abstract

Background: The optimal hemodynamic threshold for portal pressure gradient (PPG) following transjugular intrahepatic portosystemic shunt (TIPS) for ascites remains uncertain.

Objective: This study aimed to elucidate the relationship between post-TIPS PPG and clinical outcomes in patients undergoing small-diameter (8-mm) TIPS for ascites.

Design: Single-center retrospective study.

Methods: From June 2015 to June 2023, consecutive patients receiving small-diameter (8-mm) TIPS for refractory or recurrent ascites were considered for inclusion retrospectively. The impact of PPG on clinical outcomes—including ascites response, overt hepatic encephalopathy (OHE), further decompensation, and mortality—was evaluated using Fine and Gray competing risk regression models, both unadjusted and adjusted for potential confounders.

Results: A total of 143 patients were included in the analysis, of whom 65.7% had refractory ascites, with a median Child-Pugh score of 9. Receiver operating characteristic (ROC) curve analysis identified post-TIPS PPG as a reliable predictor of ascites response (cutoff: 10.5 mmHg, area under curves (AUC): 0.733, $p < 0.001$) and OHE (cutoff: 7.5 mmHg, AUC: 0.716, $p < 0.001$). Univariate and multivariate Fine and Gray competing risk regression analyses further revealed that patients with PPG between 8 and 10 mmHg had favorable outcomes, including a lower incidence of ascites (>10 vs 8–10 mmHg: hazard ratio (HR) = 5.74, 95% confidence interval (CI) 2.11–15.58, $p < 0.001$), a reduced risk of OHE (<8 vs 8–10 mmHg: HR = 2.87, 95% CI 1.29–6.35, $p = 0.010$), and a decreased risk of further decompensation (>10 vs 8–10 mmHg: HR = 2.78, 95% CI 1.43–5.41, $p = 0.003$; <8 vs 8–10 mmHg: HR = 2.42, 95% CI 1.20–4.90, $p = 0.014$) after TIPS placement.

Conclusion: This study revealed that post-TIPS PPG was associated with clinical outcomes in patients with refractory or recurrent ascites undergoing small-diameter TIPS. A post-TIPS PPG of 8–10 mmHg seems to be the optimal range, effectively controlling ascites without significantly increasing the risk of shunt-related hepatic encephalopathy, while also reducing the risk of further decompensation.

Correspondence to:

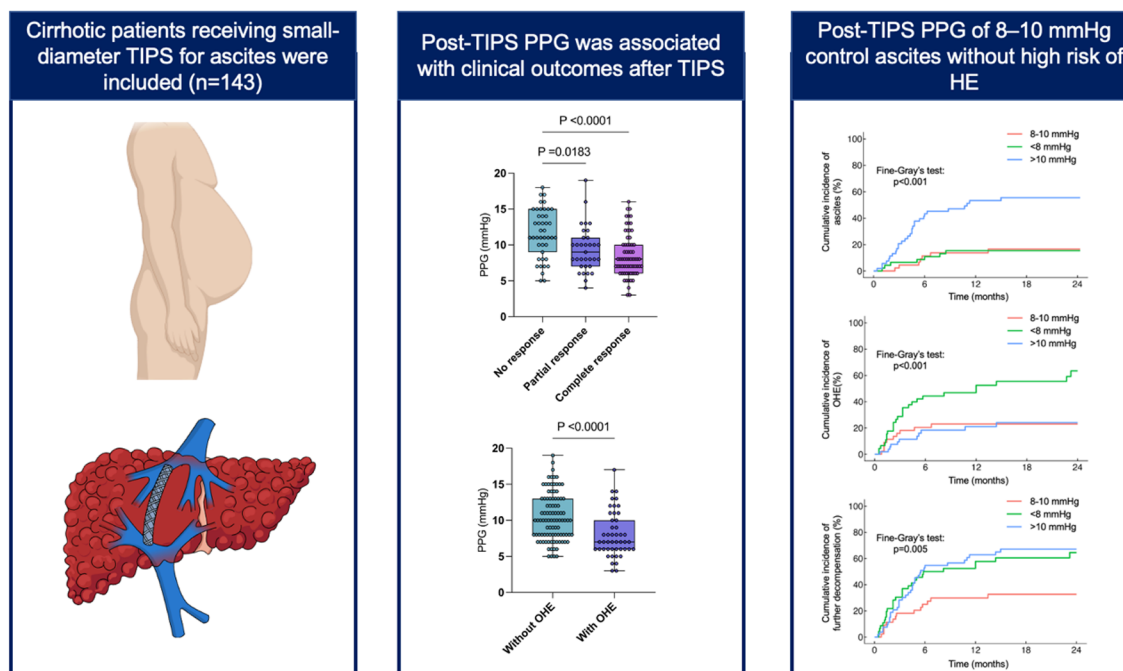
Xuefeng Luo
Li Yang
Department of
Gastroenterology and
Hepatology, Sichuan
University—University
of Oxford Huaxi Joint
Centre for Gastrointestinal
Cancer, West China
Hospital, Sichuan
University, 37 Guoxue
Lane, Chengdu, Sichuan
610041, People's Republic
of China
luo_xuefeng@wchscu.cn
yangli_hx@scu.edu.cn

Guofeng Liu
Songchi Xiao
Xiaoze Wang
Yi Shen
Yuping He
Department of
Gastroenterology and
Hepatology, Sichuan
University—University
of Oxford Huaxi Joint
Centre for Gastrointestinal
Cancer, West China
Hospital, Sichuan
University, Chengdu,
Sichuan, People's Republic
of China

*These authors are
co-first authors.

Graphical abstract

Determining the Optimal Portal Pressure Gradient After Small-Diameter TIPS for Ascites: A Retrospective Study



Keywords: ascites, liver cirrhosis, portal hypertension, transjugular intrahepatic portosystemic shunt

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Introduction

Refractory/recurrent ascites are the hallmarks of complicated ascites in patients with end-stage liver disease and are strongly associated with poor prognosis, with a 1-year mortality rate of 20%–50%.^{1,2} Transjugular intrahepatic portosystemic shunt (TIPS) creation significantly reduces portal pressure and has been proposed as an effective treatment for ascites.³ Compared to large-volume paracentesis (LVP) combined with intravenous albumin infusion, TIPS offers superior ascites control and improved transplant-free survival.^{4,5}

The portal pressure gradient (PPG) represents the difference between the pressures in the portal vein and the inferior vena cava (IVC) and is routinely assessed during the TIPS procedure.⁶ Post-TIPS PPG was associated with portal hypertension

complications in patients receiving TIPS for variceal bleeding.^{7,8} Thus, the target of a post-TIPS PPG <12 mmHg or a 50% relative reduction from the pre-TIPS baseline was recommended by current guidelines.⁹ However, there is no established consensus on the target post-TIPS PPG for ascites. A recent study indicated that greater PPG reduction after TIPS was associated with improved ascites control.¹⁰ However, the majority of patients in that study received 10-mm bare stents, which are linked to a higher risk of shunt stenosis, overt hepatic encephalopathy (OHE), and mortality.^{11,12} Given that small-diameter covered stents are now more commonly used, the relationship between post-TIPS PPG and clinical outcomes in patients receiving small-diameter covered TIPS stents for ascites remains unclear.

This study aims to investigate the relationship between post-TIPS PPG and clinical outcomes and to determine the optimal PPG range in patients undergoing small-diameter (8-mm) covered TIPS for ascites.

Patients and methods

Patients

We retrospectively screened all consecutive patients undergoing TIPS procedures at the West China Hospital of Sichuan University between June 2015 and June 2023. Patients who received TIPS for refractory or recurrent ascites were eligible for inclusion in this study. Refractory ascites (RA) is defined as ascites that cannot be mobilized or the early recurrence (within 4 weeks) of which (after the LVP) cannot be prevented by medical therapy.¹³ Recurrent ascites was regarded as a requirement of >3 LVPs within 1 year.⁹

Exclusion criteria included non-cirrhotic portal hypertension, previous TIPS or liver transplantation (LT), advanced hepatocellular carcinoma or extra-hepatic malignancy, end-stage renal disease, or insufficient medical records. Clinical and laboratory variables were obtained from electronic medical records. This study was approved by the institutional review board of West China Hospital. Written informed consent was waived because of the retrospective nature of this study. This study conforms to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement.¹⁴

TIPS procedure

All TIPS procedures were performed under general anesthesia by experienced interventional hepatologists on our team using standardized techniques previously described.¹⁵ An 8-mm expanded polytetrafluoroethylene (PTFE)-covered stent with Viatorr Endoprosthesis (Gore and Associates, Flagstaff, AZ, USA) or Fluency stent (Bard, Inc., Tempe, AZ, USA) was deployed and dilated to its full diameter. Viatorr stents became available at our center in 2019; prior to that, Fluency covered stents were routinely used. The PPG was defined as the difference between the pressure measured in the main stem of the portal vein and the pressure measured in the IVC and determined before (pre-TIPS PPG) and at the end of the stent implantation (post-TIPS

PPG) by a pressure transducer system (SCW Medicath Ltd., Shenzhen, Guangdong, China) and a multichannel monitor (Mindray, Shenzhen, Guangdong, China).

Follow-up

Patients were followed at the outpatient clinic every 3–6 months after TIPS. Patients were followed until LT, death, or last follow-up. The outcomes regarding ascites response, OHE, variceal bleeding, liver transplant, and death were collected. Complete response of ascites was defined as the absence of ascites after TIPS. Partial response was defined as improved ascites with no further need for LVP. No response referred to the persistence or recurrence of ascites necessitating LVP after TIPS.^{10,16} OHE was defined as hepatic encephalopathy grades ≥ 2 according to West-Haven criteria.¹⁷ Based on a previous study, further decompensation after TIPS was defined as persistent/recurrent ascites requiring paracentesis, OHE, or variceal bleeding after TIPS.¹⁸

Statistical analysis

Data are presented as medians and ranges or as the number of patients and percentages. Comparisons of two or more groups with continuous variables were performed using the Mann–Whitney *U* test and the Kruskal–Wallis *H* test. Receiver operating characteristic (ROC) curves and area under curves (AUC) were used to analyze the predictive power of PPG for OHE and ascites after TIPS, with the AUC used as a measure of performance. Clinical outcomes (OHE, ascites, variceal bleeding, mortality) were analyzed as time-to-event variables. The effects of PPG on these outcomes were estimated by a competing risk regression model using the Fine and Gray test. Both unadjusted and adjusted analyses were performed to account for potential confounders. Death and LT were regarded as competing events when investigating the risk of OHE, ascites, and further decompensation. For death, LT was considered the competing risk. Subdistribution hazard ratios (sHR) and 95% confidence interval (CI) were estimated. The differences were considered statistically significant at a *p* value of <0.05. Statistical analyses were performed using R, Version 4.1.2 (<http://www.R-project.org/>) and GraphPad Prism, Version 10 (GraphPad Software Inc., San Diego, CA, USA).

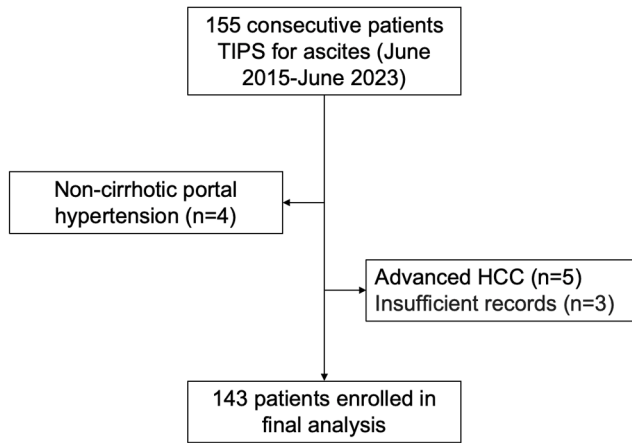


Figure 1. Flowchart of patient enrollment.
HCC, hepatocellular carcinoma; TIPS, transjugular intrahepatic portosystemic shunt.

Result

Patient selection and characteristics

From June 2015 to June 2023, 155 consecutive patients undergoing TIPS for ascites in our hospital were screened. Twelve patients were excluded because of acute Budd-Chiari syndrome ($n=4$), advanced hepatocellular carcinoma ($n=5$), and insufficient records ($n=3$). Ultimately, 143 patients were included in the final study cohort (Figure 1). Baseline characteristics are shown in Table 1. Briefly, the median age was 55 years, and 67.1% of the patients were male. Chronic Viral hepatitis (52.4%) was the most common etiology of cirrhosis, followed by alcohol-related liver disease (19.6%). Portal vein thrombosis was present in 42 patients (29.4%). The median Child-Pugh score and model for end-stage liver disease (MELD) scores were 9 and 12, respectively. Among the cohort, 94 patients (65.7%) received TIPS for RA, while 49 (34.3%) for recurrent ascites. Additionally, 76 patients (53.1%) received Viatorr stents, while the remaining patients (46.9%) were treated with Fluency stents.

Median portal pressure decreased from 31 to 23 mmHg after TIPS ($p<0.001$), while median IVC pressure increased from 8 to 13 mmHg ($p<0.001$). Median PPG dropped significantly from 23 to 9 mmHg after TIPS ($p<0.001$), representing a 60% reduction, as illustrated in Table 2.

Clinical outcomes after TIPS

The median follow-up period was 20.4 months after the TIPS procedure. As shown in Table 3,

67 patients (46.8%) had no ascites after TIPS, achieving a complete response. Improved ascites with no need for LVP was observed in 33 patients (23.1%), while 43 patients (30.1%) remained persistent or recurrent ascites requiring further LVP after TIPS. Forty-seven patients (32.9%) experienced OHE, of which 12 patients required hospitalization. A total of 78 patients (54.5%) developed further decompensation, including persistent or recurrent ascites in 33 patients, OHE in 43 patients, and variceal bleeding in 2 patients. TIPS dysfunction occurred in 11 patients (7.7%).

Fifty-one patients died during follow-up, and liver failure was the main cause ($n=19$, 13.3%). Only three patients (2.1%) received LT.

The impact of post-TIPS PPG on ascites and OHE after TIPS implantation

Patients who showed no response, with ascites showed higher post-TIPS PPG values compared with those with partial response or complete response (Figure 2(a)). A lower PPG was observed in patients with OHE after TIPS insertion, compared with those without (Figure 2(b)). ROC analysis revealed the post-TIPS PPG had a favorable prediction for ascites (AUC: 0.733; $p<0.001$) and OHE (AUC: 0.716; $p<0.001$). The Youden index identified 10.5 mmHg as the optimal cutoff value for predicting persistent or recurrent ascites and 7.5 mmHg for predicting OHE following TIPS implantation (Figure 2(c) and (d)).

Post-TIPS PPG of 8–10 mmHg associated with favorable prognosis after TIPS

Based on the analysis of the Youden index, patients were classified into three groups according to post-TIPS PPG: <8 , 8–10, and >10 mmHg. Patients with PPG >10 and <8 mmHg were observed to have a higher risk of no response for ascites and OHE after TIPS, respectively (Figure 3(a) and (c)). Patients with a post-TIPS PPG of 8–10 mmHg exhibited a lower risk of further decompensation compared to those with PPG <8 or >10 mmHg (Figure 3(e)). After adjusting for potential confounders, multivariable competing risk regression analysis identified higher PPG (>10 vs 8–10 mmHg: HR=5.74, 95% CI 2.11–15.58, $p<0.001$) and creatinine (HR=1.00, 95% CI 1.00–1.01, $p=0.035$) as independent risk factors for ascites persistence or recurrence (Figure 3(b)). Lower

Table 1. Baseline characteristics.

Baseline	N = 143
Age (year)	55 (49–64)
Male, <i>n</i> (%)	96 (67.1)
Etiology, <i>n</i> (%)	
Viral	75 (52.4)
Alcohol	28 (19.6)
Autoimmune	15 (10.5)
Other	25 (17.5)
Ascites types, <i>n</i> (%)	
Refractory ascites	94 (65.7)
Recurrent ascites	49 (34.3)
Stent types, <i>n</i> (%)	
Viatorr	76 (53.1)
Fluency	67 (46.9)
PVT, <i>n</i> (%)	42 (29.4)
MELD score (points)	12 (10–14)
Child-Pugh score (points)	9 (8–9)
Child-Pugh class, <i>n</i> (%)	
B	112 (78.3)
C	31 (21.7)
Hemoglobin (g/L)	85 (72–104)
White blood cell (G/L)	3.39 (2.32–5.00)
Platelet count (G/L)	69 (44–97)
Bilirubin (μmol/L)	22.5 (15.5–31.1)
Albumin (g/L)	32.0 (29.0–34.8)
Creatinine (μmol/L)	76 (60–98)
Prothrombin time (s)	15.9 (13.9–17.6)
INR	1.31 (1.20–1.48)
Sodium (mmol/L)	137.4 (134.2–139.7)
Data are presented as median (interquartile range) or number (%).	
INR, international normalized ratio; MELD, model for end-stage liver disease; PVT, portal vein thrombosis.	

Table 2. Hemodynamics before and after TIPS insertion.

Parameter	Median (interquartile range)
Pre-TIPS PV (mmHg)	31 (28–36)
Pre-TIPS IVC (mmHg)	8 (5–10)
Pre-TIPS PPG (mmHg)	23 (19–27)
Post-TIPS PV (mmHg)	23 (20–27)
Post-TIPS IVC (mmHg)	13 (10–16)
Post-TIPS PPG (mmHg)	9 (7–12)
PPG reduction (%)	60 (48–68)
IVC, inferior vena cava; PPG, portal pressure gradient; PV, portal vein; TIPS, transjugular intrahepatic portosystemic shunt.	

PPG (<8 vs 8–10 mmHg: HR=2.87, 95% CI 1.29–6.35, $p=0.010$) and MELD score (HR=1.12, 95% CI 1.02–1.24, $p=0.017$) were found to be key determinants for OHE (Figure 3(d)). Furthermore, both higher PPG (>10 vs 8–10 mmHg: HR=2.78, 95% CI 1.43–5.41, $p=0.003$) and lower PPG (<8 vs 8–10 mmHg: HR=2.42, 95% CI 1.20–4.90, $p=0.014$) were independently associated with further decompensation after TIPS (Figure 3(f)). Regarding mortality, no significant difference was observed in the competing risk regression (Figure 3(g)). Only Child-Pugh score (HR=1.37, 95% CI 1.02–1.84, $p=0.036$) and creatinine levels (HR=1.01, 95% CI 1.00–1.01, $p=0.001$) were recognized as major contributors to death in the multivariable competing risk regression analysis (Figure 3(h)). Similarly, subgroup analyses of patients stratified by stent type (Viatorr and Fluency) revealed that those with a post-TIPS PPG of 8–10 mmHg consistently exhibited better ascites response and lower risks of OHE and further decompensation (Supplemental Figures 1 and 2).

Discussion

The current retrospective study included patients receiving small-diameter TIPS for ascites and demonstrated that post-TIPS PPG was a critical determinant of clinical outcomes. Excessive PPG reduction (<8 mmHg) or insufficient reduction (>10 mmHg) was associated with unfavorable

Table 3. Clinical outcomes after TIPS.

Outcomes	N (%)
Ascites, n (%)	
Persistent or recurrent ascites needing LVP	43 (30.1)
Ascites without LVP	33 (23.1)
No Ascites	67 (46.8)
Gastrointestinal bleeding, n (%)	18 (12.6)
Variceal bleeding	7 (4.9)
Peptic ulcer bleeding	2 (1.4)
Unknown	9 (6.3)
OHE, n (%)	47 (32.9)
Grade of first episode of OHE, n (%)	
Grade 2	28 (19.6)
Grade 3	11 (7.7)
Grade 4	8 (5.6)
Further decompensation, n (%)	78 (54.5)
First episode of further decompensation, n (%)	
Persistent or worsening ascites	33 (23.1)
OHE	43 (30.0)
Variceal bleeding	2 (1.4)
Death, n (%)	51 (35.7)
Cause of death, n (%)	
Liver failure	19 (13.3)
Gastrointestinal bleeding	8 (5.6)
HCC	4 (2.8)
Pulmonary infection	6 (4.2)
Others	5 (3.5)
Unknown	9 (6.3)
Liver transplantation, n (%)	3 (2.1)
Data presented as the number of patients (percentage). HCC, hepatocellular carcinoma; LVP, Large-volume paracentesis; OHE, overt hepatic encephalopathy; TIPS, transjugular intrahepatic portosystemic shunt.	

outcomes, and 8–10 mmHg might be an optimal range of post-TIPS PPG with a lower risk of further decompensation. However, no clear

relationship between PPG and mortality was observed in our cohort.

More than two-thirds of the patients achieved an ascites response in our research, with 67% achieving complete resolution, which is comparable to previous studies.^{19–21} Theoretically, lower post-TIPS PPG values could reduce portal pressure more effectively and improve ascites control, but the relationship between PPG reduction and ascites outcomes remains controversial. Several previous studies found no clear correlation between PPG reduction and recurrence of ascites.^{22,23} By contrast, a recent study by Queck et al.¹⁰ revealed that patients with higher PPG reduction had improved ascites. It should be further highlighted that most of these studies included patients who received bare stents, with a higher rate of shunt stenosis, which may lead to a gradual increase in the post-TIPS PPG.¹¹ Additionally, the lack of standardized definitions and measurement protocols for PPG across centers during earlier studies might contribute to inconsistent findings. In our study, PPG was calculated according to current guidelines by measuring the main portal vein pressure and IVC pressure before and after TIPS placement.^{9,24} Furthermore, at variance with these studies, a competing risk regression model was performed to eliminate the impact of death or LT on evaluating ascites outcomes in our study. Both univariate and multivariate regression analyses confirmed that patients with PPG >10 mmHg had a higher risk of ascites progression. In addition to PPG, serum creatinine levels were identified as a risk factor, consistent with findings reported in previous studies.^{19,25}

Hepatic encephalopathy (HE) remains a significant problem after TIPS insertion.²⁶ In our cohort, the rate of OHE was 32.9%, which was lower than reported in previous studies of patients undergoing TIPS for ascites.^{20,21} This might be partly attributable to the use of small-diameter stents in our study. Excessive reduction of PPG by TIPS is associated with a higher risk of shunt-related HE.^{27,28} In our cohort, in line with these findings, our study found that patients with PPG <8 mmHg had a higher risk of OHE after TIPS. Mechanistically, the lower PPG allows a greater volume of portal venous blood to bypass hepatic detoxification and flow directly to the IVC via the stent, thereby increasing the risk of post-TIPS hepatic encephalopathy.²⁹ Therefore, based on our findings, maintaining a post-TIPS PPG of

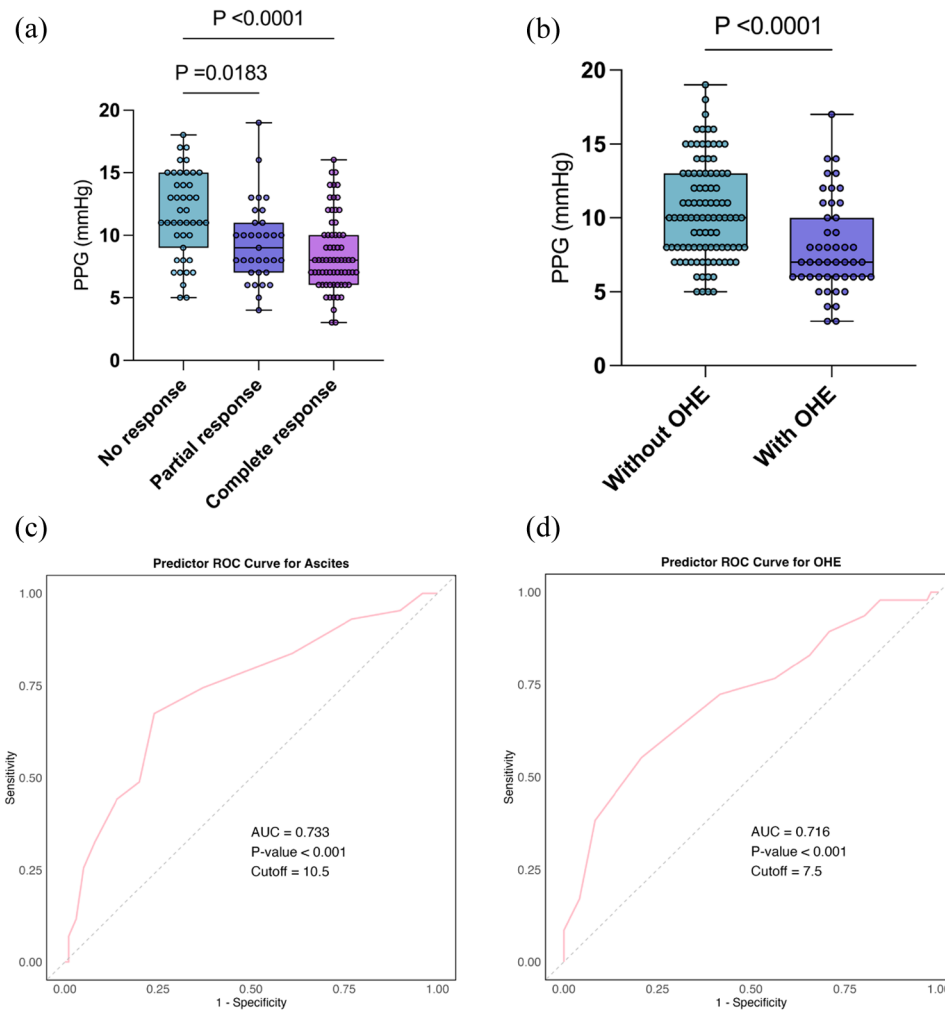


Figure 2. The impact of post-TIPS PPG on ascites and OHE after TIPS implantation. Mann-Whitney test was used to analyze ascites response (a) and OHE (b) after TIPS, dependent on post-TIPS PPG value. Receiver operating characteristic analyses demonstrated the strong predictive value of post-TIPS PPG value for ascites response (c) and OHE (d). OHE, overt hepatic encephalopathy; PPG, portal pressure gradient; TIPS, transjugular intrahepatic portosystemic shunt.

≥ 8 mmHg might be beneficial in mitigating the incidence of HE following TIPS.

Further decompensation is associated with poor outcomes in patients with cirrhosis.^{18,30} Our study found that patients with a post-TIPS PPG between 8 and 10 mmHg had a lower risk of further decompensation, largely due to better ascites response and a reduced incidence of OHE. However, the lower risk of further decompensation did not result in a survival benefit in our cohort, possibly due to the proportions of decompensation events. OHE was the most common further decompensation event in our cohort, accounting for over 30%. This aligned with recent evidence indicating that

episodic OHE following TIPS was not significantly associated with mortality in patients treated for ascites or variceal bleeding.³¹ Consequently, we did not find an appropriate PPG range to reduce post-TIPS mortality. Furthermore, beyond portal hypertension, the progressive deterioration of liver function, as demonstrated in our multivariate analysis, and systemic inflammation play critical roles in the development of end-stage liver disease.³² A reduction in portal pressure alone is insufficient to reverse the progression of cirrhosis.³³

Several factors may influence the accuracy of PPG measurements during TIPS procedures, including timing of measurement, catheter position, and

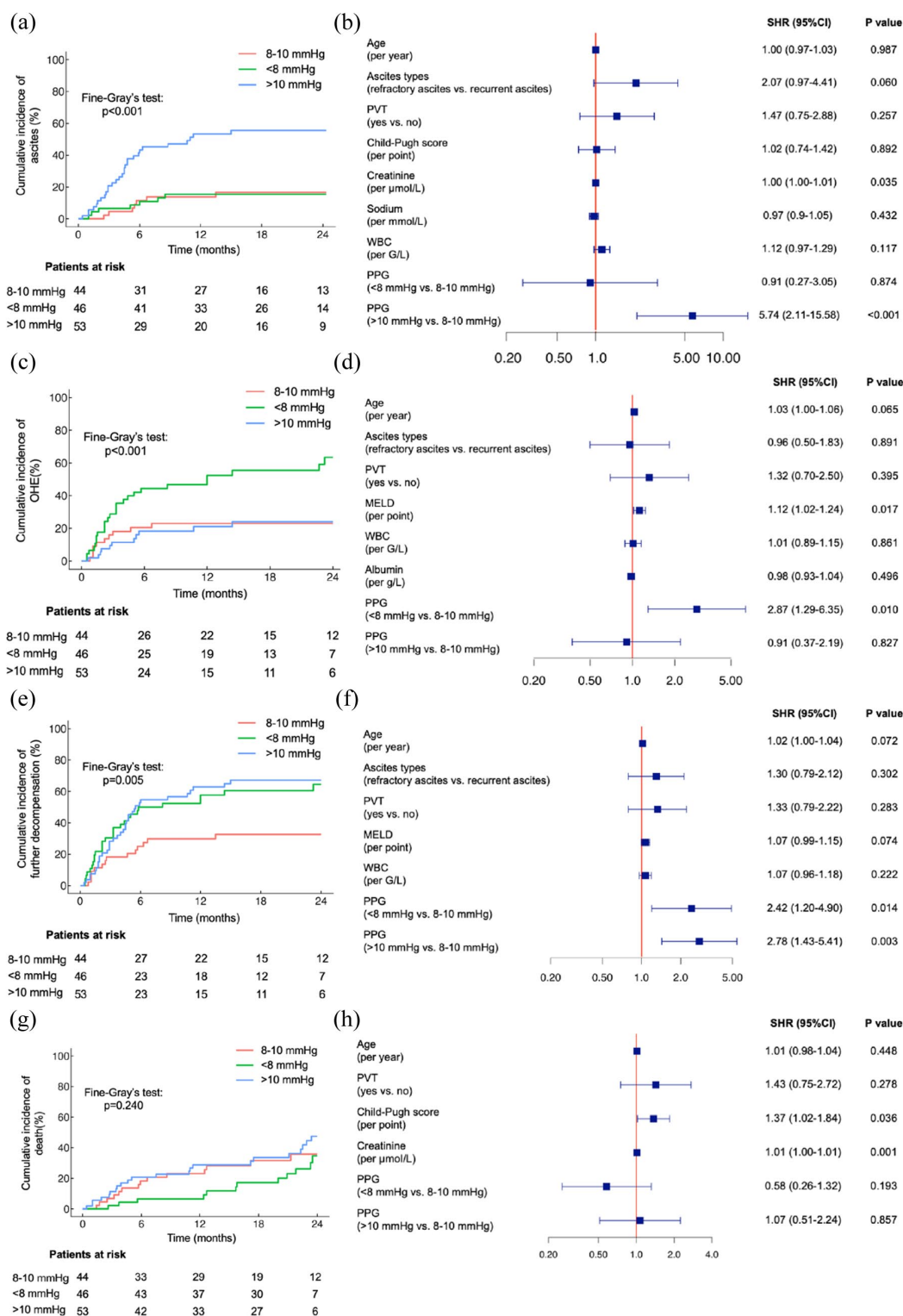


Figure 3. Impact of the post-TIPS PPG values on clinical outcomes. Cumulative incidence curves of (a) ascites, (c) OHE, (e) further decompensation, and (g) death according to the threshold of 8 and 10 mmHg of post-TIPS PPG. Forest plot showing the adjusted effect of post-TIPS PPG on (b) ascites, (d) OHE, (f) further decompensation, and (h) death in multivariate analysis. OHE, overt hepatic encephalopathy; PPG, portal pressure gradient; TIPS, transjugular intrahepatic portosystemic shunt; WBC, white blood cell.

anesthesia method.^{34,35} A recent prospective study by Lv *et al.*³⁶ demonstrated that the early PPG (1–3 days after the TIPS procedure) is a better reflection of long-term PPG and was significantly associated with clinical outcomes. Consistent with the retrospective study by Silva-Junior *et al.*,³⁵ the early PPG avoids the confounding effects of anesthesia and hemodynamic instability, thereby allowing a more accurate assessment of true portal pressure. These key findings provide valuable evidence for optimizing post-TIPS pressure targets and management. Importantly, whether these findings can be extended to patients with ascites remains to be further investigated.

Our study has several limitations. First, this was a single-center retrospective analysis, inherently susceptible to selection and outcome-reporting biases. However, the inclusion of consecutive patients was intended to mitigate these biases.

Second, only self-expanding PTFE-covered stents were used due to the unavailability of controlled-expansion stents during the study period. Third, only approximately 30% of patients in our cohort achieved a post-TIPS PPG of 8–10 mmHg. Hence, our findings remain to be confirmed in larger prospective studies. Lastly, as most patients had viral liver disease, no definitive conclusion can be drawn for patients with other chronic liver diseases.

In conclusion, the current study revealed that the post-TIPS PPG was associated with clinical outcomes following small-diameter TIPS implantation in patients with ascites. Patients with PPG ≤ 10 mmHg had better ascites control; meanwhile, patients with PPG ≥ 8 mmHg had a lower risk for OHE. Hence, a post-TIPS PPG range of 8–10 mmHg may represent an optimal target for reducing further decompensation, despite no survival benefit. Further large-scale prospective studies, particularly involving controlled-expansion stents, are needed to establish the optimal post-TIPS PPG range for ascites.

Declarations

Ethics approval and consent to participate

The study was approved by the Biomedical Research Ethics Committee of West China Hospital, Sichuan University (no. 2023-1446). Written informed consent was waived because of the retrospective nature of this study.

Consent for publication

Not applicable.

Author contributions

Guofeng Liu: Data curation; Formal analysis; Methodology; Writing – original draft.

Songchi Xiao: Methodology; Resources.

Xiaoze Wang: Data curation; Formal analysis.

Yi Shen: Formal analysis; Investigation; Software.

Yuping He: Data curation.

Li Yang: Supervision; Writing – review & editing.

Xuefeng Luo: Supervision; Writing – review & editing.

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Competing interests

The authors declare that there is no conflict of interest.

Availability of data and materials

The data and materials of this article could be available by contacting the corresponding author.

ORCID iDs

Guofeng Liu  <https://orcid.org/0000-0002-2835-9547>

Li Yang  <https://orcid.org/0000-0003-3821-9342>

Supplemental material

Supplemental material for this article is available online.

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Appendix

Abbreviations

AUC	area under curves
HCC	hepatocellular carcinoma
INR	international normalized ratio
IVC	inferior vena cava
LT	liver transplantation
OHE	overt hepatic encephalopathy
PPG	portal pressure gradient
PV	portal vein
PVT	portal vein thrombosis
RA	refractory ascites
ROC	receiver operating characteristic
sHR	subdistribution hazard ratios
TIPS	transjugular intrahepatic portosystemic shunt
WBC	white blood cell

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