Thieme

Portal vein velocity and its dynamics: a potentially useful tool for detecting clinically silent transjugular intrahepatic porto-systemic shunt dysfunction using Doppler ultrasonography

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ABSTRACT

Background Ultrasound (US) surveillance for transjugular intrahepatic portosystemic shunt (TIPS) dysfunction has yet to be standardized, as clear-cut criteria have not been conventionally defined. This study evaluated the role of US-based parameters in detecting hemodynamic TIPS dysfunction (HD).

Methods We included consecutive patients treated with TIPS. All patients were scheduled within the first six weeks after the procedure for TIPS revision, comprised of a Doppler US exam and invasive hemodynamic reassessment. Clinical TIPS dysfunction (CD) was defined as symptom recurrence, while HD was defined by a portal pressure gradient (PPG) ≥ 12 mmHg. The predictive capabilities of Doppler US for predicting TIPS dysfunction were tested against the hemodynamic gold standard.

Results 86 patients were included. Secondary prophylaxis of variceal bleeding was the main indication for TIPS in 72 patients (83.7 %), while 27 (31.4 %) had refractory ascites. HD occurred in 37 cases (43 %), of which 25 patients (67.5 %) had no CD. Patients with HD had a significantly lower portal vein velocity (PVV): 35 (20–45) cm/s vs. 40.5 (35–50) cm/s, p = 0.02. Compared to the immediate post-TIPS assessment, the patients without HD had a ΔPVV of 6.08 ± 19.8 cm/s vs. a decrease of − 8.2 ± 20.2 cm/s in HD (p = 0.04). Using a cut-off value of 40.5 cm/s, PVV had an AUROC of 0.705 for predicting HD, while the addition of ΔPVV (cut-off 9.5 cm/s) improved the AUROC to 0.78.

Conclusion Despite adequate symptom control, a considerable percentage of patients have a post-TIPS PPG ≥ 12 mmHg. The dynamic assessment of PVV and its temporal dynamics can reliably predict TIPS dysfunction.

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Introduction

Transjugular intrahepatic portosystemic shunts (TIPS) have gained traction as a mainstay in the therapeutic approach to portal hypertension (PHT) [1, 2]. Probably the most significant turning point in the TIPS era was the replacement of bare metal (BM) with covered expandable polytetrafluoroethylene (ePTFE) stents [3]. This innovation has dramatically decreased the rate of shunt dysfunction, from up to 80 % at two years for BM to a more manageable 10–30 % for ePTFE stents [3–10], with primary stent patency exceeding 75 % at five years according to multiple reports [6–8].

The Baveno VII consensus on the management of PHT has refined recommendations regarding TIPS and the target portal pressure gradient (PPG) [11]. Immediate post-TIPS PPG might be influenced by various factors, such as general anesthesia, vasoactive medication, and hemodynamic instability. Consequently, to obtain an unbiased PPG, Baveno VII recommends systematic measurement in an elective manner in stable and non-sedated patients. However, most research designs in the past have only assessed stent functionality based primarily on symptom relapse or inadequate clinical control, which only then prompted hemodynamic reevaluation. Therefore, the only hemodynamic assessment was obtained during the TIPS placement procedure for many patients with adequate symptom control, with no subsequent measurements if stent dysfunction was not suspected on clinical or ultrasonographic grounds.

Given the invasive character of hepatic catheterization, there have been multiple attempts to establish ultrasound-based criteria to evaluate TIPS dysfunction, using variables such as portal vein velocity (PVV), intrahepatic portal branch flow directionality, and in-stent peak velocity, with varying degrees of success [6, 12–14]. Detecting TIPS dysfunction defined by a suboptimal PPG appears to be challenging, with an AUROC of only 0.77, with sub-par pooled sensitivity (82 %) and specificity (58 %) [15]. A significant caveat was that most of the studies only performed a hemodynamic assessment if dysfunction was suspected on clinical or ultrasonographic grounds, rendering the US-angiography comparison pairings subject to a selection bias towards dysfunction [6, 13, 16–18].

The aim of the current study was to evaluate the discrimination capabilities of Doppler ultrasonography for TIPS dysfunction in the setting of scheduled hepatic catheterization at four to six weeks following TIPS placement, performed systematically regardless of any indication of stent dysfunction. As a secondary aim, the study evaluated the role of systematic hemodynamic TIPS revision for evaluating changes in PPG in a standardized condition not affected by general anesthesia, vasoactive medication, or hemodynamic instability.

Materials and Methods

Study population

All patients who benefited from TIPS placement between 2013 and 2020 in a tertiary care facility were prospectively registered and considered potentially eligible for inclusion in this retrospective descriptive analysis. Patients with symptom recurrence (bleeding) or liver disease decompensation leading to death during the initial hospital stay were excluded, as well as patients who continued their follow-up in other centers or were lost to follow-up.

All patients signed the informed written consent before TIPS. The study was conducted according to the modified Declaration of Helsinki, and the institutional ethics committee approved the study design.

Data regarding liver disease staging were collected on the index admission. The indication for TIPS placement was determined according to the most recent Baveno consensus recommendation (Baveno V Field [19] and VI [2]).

TIPS placement procedure

All patients included in the study benefited from a TIPS procedure with ePTFE-covered graft stents using the standard procedure, as previously described [14]. Given that dedicated ePTFE stents were commercially unavailable in our country, our protocol consisted of creating a double-stent hybrid using a BM stent (Wallstent Endoprosthesis, Boston Scientific, Marlborough, MA, USA) and an ePTFE-covered stent (Fluency, Bard, Murray Hill, NJ, USA) to cover the intrahepatic trajectory of the shunt. The shunt was dilated to 8 mm, and the final PPG was measured. In the case of an insufficient PPG decrease (PPG ≥ 12 mmHg, or PPG decrease < 50 % of the initial PPG), the shunt was further dilated to 10 mm. All procedures were performed under general anesthesia.

Ultrasonography

All US examinations were performed using the same equipment throughout the study (Aixplorer, SuperSonic Imagine, Aix-en-Provence, France). The two US evaluations were scheduled within 48 hours following TIPS placement and at the first follow-up visit before hepatic catheterization. Velocities were measured in blocked inspiration. The following variables were recorded: shunt patency, portal vein velocity (PVV, cm/s), right and left portal branch flow directionality, and peak velocities (cm/s) (▶ **Fig. 1**). Ascites was graded according to the International Ascites Club classification [20]. ΔPVV was calculated by subtracting the post-TIPS PVV from the PVV at the time of the first revision.

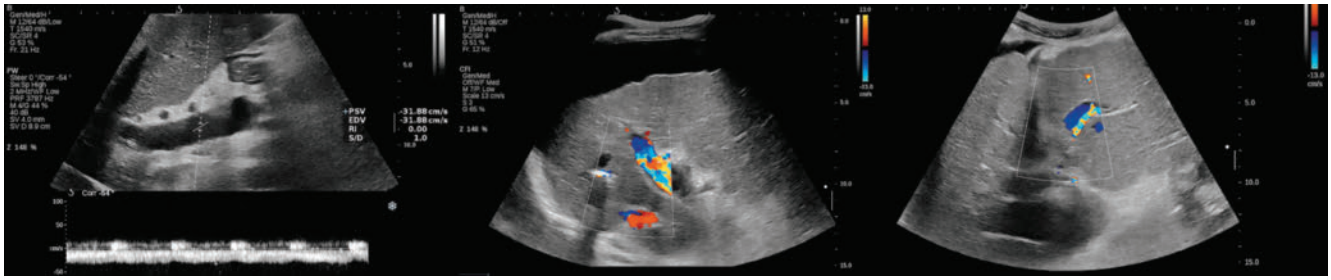
TIPS Revision

Our protocol for scheduled follow-up consists of a systematic ultrasonographic and hemodynamic reevaluation at six weeks post-TIPS (▶ **Fig. 2**). The hemodynamic protocol included standard venography evaluating shunt patency and PPG measurements. If the venography revealed significant shunt stenosis or thrombosis, or if the PPG exceeded 12 mmHg, the shunt was deemed dysfunctional, and further angioplasty was performed.

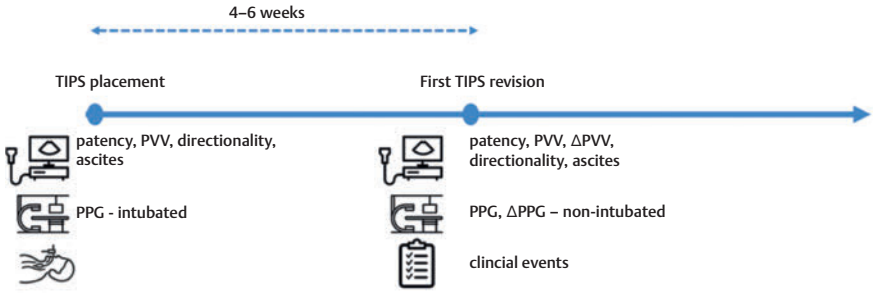
Clinical dysfunction (CD) was defined as the recurrence of PHT-related bleeding or inadequate control of ascites. Given the relatively short timeframe from TIPS placement to revision, adequate control of ascites was defined by US-proven improvement of ascites or a decrease in the need for large-volume paracenteses by at least one-third. Hemodynamic dysfunction (HD) was defined as a PPG ≥ 12 mmHg.

Statistical Analysis

Descriptive statistics were used for normality testing and demographic variables. Scale variables were described using the



▶ **Fig. 1** Doppler ultrasonographic assessment of portal vein velocity (left), right intrahepatic portal branch flow directionality (middle), and left intrahepatic portal branch directionality (right).



▶ **Fig. 2** TIPS revision timeline and study protocol. PVV – portal vein velocity, PPG – portal pressure gradient.

mean ± standard deviation (SD) for normally distributed variables or the median (interquartile range – IQR) for non-normal distributions. Two-tailed T-tests were used for mean comparison and the Mann-Whitney U tests for median comparison. Nominal and ordinal variables were described in absolute values and relative frequencies (%). Either Pearson's Chi-squared or Fisher's Exact Test was used for non-scale variables, according to sample sizes. Correlations were analyzed using the Pearson correlation coefficient. The receiver operating characteristic (ROC) curves were used to assess the diagnostic prowess of the DU variables for TIPS dysfunction and to identify an optimal cut-off value to maximize the sum between sensitivity and specificity. The diagnostic performance of the cut-off values obtained from our study population were compared with previously reported values [10, 12] using the McNemar test. The threshold for statistical significance was set at $p \leq 0.05$. Statistical analysis was performed using IBM SPSS Statistics 28.0.0.0 (SPSS Inc., Chicago, IL, USA).

Results

A total of 137 TIPS procedures were performed, with 86 meeting the inclusion criteria for the study. The baseline characteristics are depicted in ▶ **Table 1**. Most of the procedures were performed for PHT-related bleeding (n = 71, 82.5 %), and the most common clinical scenario was secondary prophylaxis of variceal bleeding (n = 55, 63.9 %). Technical success, defined as a post-procedural PPG below 12 mmHg, was obtained in 97.6 % of the cases (n = 84), while a PPG reduction exceeding 50 % was obtained in 74.4 % of the cases (n = 64).

The median interval to the first revision was 40.5 days. Data obtained from the first hemodynamic revision is summarized in ▶ **Table 2**. At six weeks, the rate of clinical dysfunction was 18.6 % (n = 16). Two patients (2.7 %) presented with recurrence of portal hypertension-related bleeding. One of the patients had a revision PPG of 16 mmHg, presenting with a second episode of severe alcoholic hepatitis, which progressed to grade III acute-on-chronic liver failure and ultimately led to the patient's demise. The second patient had a bleeding recurrence from gastric varices despite a PPG of 5 mmHg.

Overall, there was a significant increase in PPG at the first revision. The median increase in PPG was 3 (0–6.5) mmHg, and 43 % of the patients (n = 37) had a revision PPG ≥ 12 mmHg. The median PPG increase was significantly higher in patients with HD – 7 mmHg (5–9.75) vs. 3 mmHg (0–5) in patients without HD (p = 0.01). There were no significant differences regarding TIPS indication and the rate of HD. Notably, the patients with HD had more advanced liver disease at the time of TIPS placement expressed by the Child-Pugh (8.8 ± 2 vs. 7.8 ± 1.9, p = 0.02) and MELD scores (16.4 ± 6 vs. 14.6 ± 6, p = 0.05).

The differences in Doppler US-based variables in different subgroup scenarios were comparatively analyzed and summarized in ▶ **Table 3**. At a PPG cut-off value of 10 mmHg, there were no significant differences between groups regarding PVV and intrahepatic portal flow directionality, although the median PVV was higher in patients with a PPG below the cut-off and there was a higher proportion of patients with hepatofugal flow in both the left and right portal vein branches. The only statistically significant difference

▶ **Table 1** Baseline characteristics and initial presentation.

Demographic variables	
Age (years)	53.85 ± 9.63
Male gender (n, %)	57 (66.3)
Liver disease etiology	
Alcoholic liver disease (n, %)	47 (54.7)
Viral – HBV, HCV (n, %)	17 (19.8)
Alcoholic + viral (n, %)	9 (10.5)
Other (n, %)	13 (15.1)
Liver disease staging	
MELD score	14 (11–18)
Child-Pugh class A (n, %)	21 (24.4)
Child-Pugh class B (n, %)	39 (45.3)
Child-Pugh class C (n, %)	26 (30.3)
Ascites prior to TIPS placement (n, %)	62 (72.1)
Indication for TIPS placement	
Portal hypertension-related bleeding (n, %)	58 (67.4)
Refractory ascites (n, %)	14 (16.3)
Combined – bleeding and refractory ascites (n, %)	13 (15.1)
Refractory hepatic hydrothorax and ascites (n, %)	1 (1.2)
Portal hypertension-related bleeding clinical scenario	
Secondary prophylaxis (n, %)	55 (77.4)
Rescue TIPS (n, %)	14 (19.7)
Preemptive TIPS (n, %)	2 (2.8)
Hemodynamics	
Initial PPG (mmHg)	16 (14–19)
Post-TIPS PPG (mmHg)	7 (5.5–8)
Technical success	
Post-TIPS PPG ≤ 10 mmHg (n, %)	81 (94.1)
Post-TIPS PPG ≤ 12 mmHg (n, %)	84 (97.6)
50 % decrease of PPG (n, %)	64 (74.4)

▶ **Table 2** Clinical and hemodynamic dysfunction at the first revision.

TIPS revision data	
Median interval to first revision (days)	40.5 (23)
Clinical dysfunction (n, %)	16/86 (18.6)
(n, %) of which had a PPG ≥ 10 mmHg	13/16 (81.2)
(n, %) of which had a PPG ≥ 12 mmHg	13/16 (81.2)
Portal hypertension-related bleeding recurrence (n, %)	2/71 (2.7)
(n, %) of which had a PPG ≥ 10 mmHg	1/2 (50)
(n, %) of which had a PPG ≥ 12 mmHg	1/2 (50)
Inadequate control of ascites (n, %)	14/62 (22.5)
(n, %) of which had a PPG ≥ 10 mmHg	12/14 (85.7)
(n, %) of which had a PPG ≥ 12 mmHg	12/14 (85.7)
Revision PPG ≥ 10 mmHg (n, %)	44/86 (51.2)
(n, %) of which had no clinical recurrence	31/44 (70.4)
Revision PPG ≥ 12 mmHg	37/86 (43)
(n, %) of which had no clinical recurrence	25/37 (67.5)
PPG at first revision (mmHg)	10 (7–14)
Post-TIPS – first revision PPG variation (mmHg)	+ 3 (0–6.5)
50 % PPG decrease at first revision vs. pre-TIPS PPG (n, %)	27 (31.4)
Clinical scenarios	
Portal hypertension-related bleeding	
PPG ≥ 10 mmHg	37/71 (52.1)
(n, %) of which had bleeding recurrence	1/37 (2.8)
PPG ≥ 12 mmHg	31/71 (43.6)
(n, %) of which had bleeding recurrence	1/31 (3.2)
50 % PPG decrease at first revision vs. pre-TIPS PPG (n, %)	21/71 (29.6)
(n, %) of which had bleeding recurrence	1/21 (4.7)
Refractory ascites	
PPG ≥ 10 mmHg	15/27 (55.5)
(n, %) of which had inadequate control of ascites	14/15 (93.3)
PPG ≥ 12 mmHg	14/27 (51.8)
(n, %) of which had inadequate control of ascites	14/14 (100)
50 % PPG decrease at first revision vs. pre-TIPS PPG (n, %)	7/27 (25.9)

was regarding ΔPVV, as patients with a PPG below 10 mmHg had an increase in PVV, as opposed to patients with a PPG ≥ 10 mmHg who had a decrease in PVV.

On the other hand, when a PPG cut-off of 12 mmHg was used, the differences in US variables increased, as patients with HD had a significantly higher median PVV ($p = 0.02$), ΔPVV ($p = 0.04$), and a higher prevalence of hepatofugal flow in the right portal vein branch ($p = 0.03$). There were no differences regarding the Doppler US-based variables between patients with or without clinical dysfunction.

Both PVV and ΔPVV were significantly correlated with the revision PPG, although the strength of the correlation was moderate for PVV (−0.38, $p < 0.001$) and modest for ΔPVV (−0.28, $p = 0.03$).

The discriminative capabilities of PVV and ΔPVV for HD were evaluated using the AUROC analysis (▶ **Fig. 3**). Both variables had acceptable predictive capability: PVV had an AUROC of 0.715 for a cut-off of 40.5 cm/s ($p < 0.001$), while ΔPVV had an AUROC of 0.705 for a cut-off of 9.5 cm/s ($p = 0.002$). Combining the two variables at these cut-off values led to a discrimination improvement up to an AUC of 0.78. When a composite variable was computed using PVV and right portal branch flow directionality, there were no substantial improvements in AUC (0.68). Since hemodynamic revision (gold standard) is an invasive procedure, a number-needed-to-harm (NNH) analysis was performed using US-based variables as the experimental procedure. The NNH, representing patients with US evidence of TIPS dysfunction without HD, was calculated for a PVV cut-off of 40.5 cm/s, ΔPVV of 9.5 cm/s, and a composite variable comprising both PVV and ΔPVV, with values of 4.31 (95 % confidence interval 3.1–17.8), 3.42 (1.9–23.23) and 5.26 (3.11–18.5), respectively.

The diagnostic test metrics for the PVV cut-off derived from our dataset were compared to previously reported cut-offs for TIPS dysfunction (▶ **Table 4**). While the diagnostic accuracy remained around 65 % regardless of the PVV value, the sensitivity decreased

proportionately with the cut-off from a moderately effective 83.8 % for 40.5 cm/s to 32.3 % for the lowest available cut-off of 28 cm/s, albeit with significant increases in specificity. However, the variable that appeared to be best suited as a screening test for TIPS dysfunction appeared to be ΔPVV, as an increase in PVV of less than 9.5 cm/s had a sensitivity of 96.7 %.

▶ **Table 3** Comparison of ultrasonographic predictors of TIPS dysfunction.

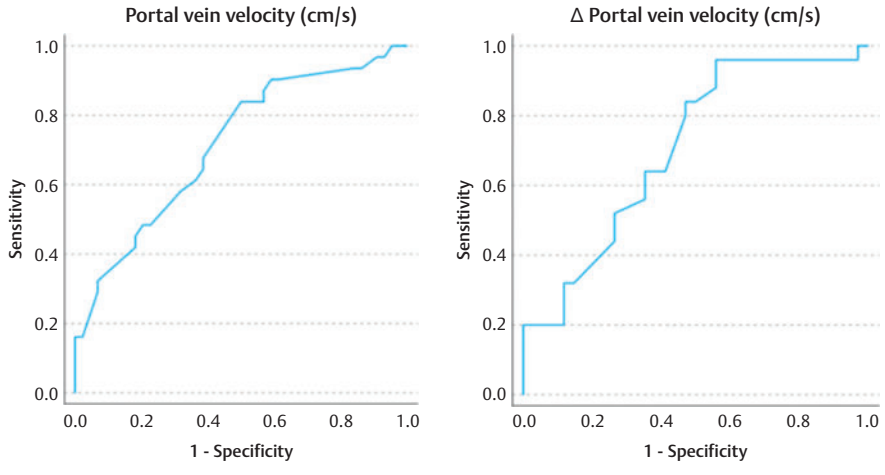
Portal pressure gradient ≥ 10 mmHg			
	No (n = 42)	Yes (n = 44)	p-value
Portal vein velocity (cm/s)	40 (34.5–50)	35 (26.5–42.25)	0.13
Δ Portal vein velocity (cm/s)	6.07 ± 20.9	−5.4 ± 20.1	0.01
Hepatofugal flow – right portal vein branch (n, %)	40 (95.2)	37 (84.1)	0.15
Hepatofugal flow – left portal vein branch (n, %)	39 (92.8)	37 (84.1)	0.29
Portal pressure gradient ≥ 12 mmHg			
	No (n = 59)	Yes (n = 37)	p-value
Portal vein velocity (cm/s)	40.5 (35–50)	35 (25–40)	0.02
Δ Portal vein velocity (cm/s)	6.08 ± 19.8	−8.2 ± 20.2	0.04
Hepatofugal flow – right portal vein branch (n, %)	56 (94.9)	30 (81.1)	0.03
Hepatofugal flow – left portal vein branch (n, %)	55 (93.2)	30 (81.1)	0.06
Clinical dysfunction			
	No (n = 70)	Yes (n = 16)	p-value
Portal vein velocity (cm/s)	40 (30–50)	35 (25–40.5)	0.24
Δ Portal vein velocity (cm/s)	1.5 ± 19.4	−5.3 ± 26.3	0.15
Hepatofugal flow – right portal vein branch (n, %)	64 (91.4)	13 (81.2)	0.23
Hepatofugal flow – left portal vein branch (n, %)	63 (90)	13 (81.2)	0.24

Discussion

Our findings suggest that PVV and its dynamics might be useful screening tools for detecting hemodynamic TIPS dysfunction in the absence of clinical relapse and might be sufficient to prompt a TIPS revision. While the discriminative capabilities of both PVV and ΔPVV are moderate taken separately, discrimination substantially improves by combining both variables, thus providing good diagnostic metrics for TIPS dysfunction screening. Moreover, our results suggest that hemodynamic dysfunction defined by a revision PPG > 12 mmHg is relatively frequent (43 %) if revision is performed systematically, regardless of clinical or US evidence of dysfunction and despite an adequate intraprocedural PPG.

The AUC of 0.78 for combining PVV and ΔPVV is in line with data presented in the only available meta-analysis on the performance of US in detecting TIPS dysfunction, which reported a pooled AUC of 0.77 [15]. However, the criteria for dysfunction in the studies included in the meta-analysis are highly inhomogeneous, with many studies including composite criteria combining variables such as peak in-stent velocity, PVV, or flow directionality [6, 13, 16, 17]. Moreover, many studies performed in the bare-metal stent era had a significantly higher dysfunction rate and might have generated additional bias.

To date, two key studies have assessed the role of portal vein velocity (PVV) in detecting TIPS dysfunction during systematic TIPS revision. A 2007 randomized controlled trial by Christophe Bureau et al., comparing ePTFE-covered and BM stents, explored Doppler US performance in predicting shunt dysfunction [10]. Their findings indicated that patients with a PPG > 12 mmHg had a PVV of 30.7 ± 11.8 cm/s, contrasting with 40.3 ± 19.1 cm/s for optimal PPG ($p < 0.05$), mirroring our dataset but with a notably lower PVV for dysfunctional stents. However, the overall discrimination was modest, with an AUC of 0.65 for a cut-off value of 31 cm/s. Another study with a similar design, albeit on a smaller scale (34 patients and 117 US-venography pairs), was published in 2005 by Juan Abraldes et al., focusing on PVV and intrahepatic portal branch directionality. Although the model was derived from the BM era, it



▶ **Fig. 3** AUROC analysis for portal vein velocity (left) and portal vein velocity (right) for predicting hemodynamic TIPS dysfunction.

▶ **Table 4** Diagnostic test evaluation for portal vein velocity cut-off values.

Cut-off value	PVV – 40.5 cm/s	PVV – 39 cm/s + hepatopetal flow[14]	PVV – 31 cm/s [12]	PVV – 28 cm/s + hepatofugal flow [14]	ΔPVV – 9.5 cm/s	PVV + ΔPVV*
Sensitivity (%, 95% C.I.)	83.8 (66.2–94.5)	67.7 (46.7–83.3)	48.3 (30.1–66.9)	32.3 (16.6–51.3)	96.7 (83.3–99.9)	87.1 (70.1–96.3)
Specificity (%, 95% C.I.)	50 (34.5–65.4)	61.3 (45.5–75.6)	79.5 (64.7–90.2)	93.1 (81.3–98.5)	35 (20.6–51.6)	60 (43.3–75.1)
Positive predictive value (%, 95% C.I.)	52.8% (44.5–60.9)	53.8 (42.8–64.5)	62.5 (45.6–76.8)	76.9 (49.9–91.7)	53.5 (47.6–59.3)	62.7 (53–71.6)
Negative Predictive Value (%, 95% C.I.)	82.3 (66.4–91.6)	74 (61.9–83.3)	68.6 (60.1–76)	66.1 (60.1–71.6)	93.3 (66–99)	85.7 (63.9–93.9)
Accuracy	63.5 (51.6–74.3)	63.9 (52–74.6)	66.6 (54.8–77.1)	68 (56.2–78.3)	61.9 (49.6–73.2)	71.8 (59.9–81.8)
p-value (McNemar Test)	–	<0.01	<0.01	<0.01	0.02	<0.01

*Using a cut-off value of 40.5 cm/s for PVV and 9.5 cm/s for ΔPVV; PVV – portal vein velocity; C.I. – confidence interval.

was prospectively validated on covered stents. Their criteria for TIPS dysfunction were a PVV of 39 cm/s for hepatofugal flow and 28 cm/s for hepatopetal flow, achieving a sensitivity of 87% and specificity of 57% [12]. In our dataset, both these criteria exhibited relatively high specificity but inadequate sensitivity (<70%) for effective screening, thus failing as an effective screening tool.

TIPS occlusion, thrombosis, and stenosis are relatively straightforward to identify, with AUROCs of 0.95 and 0.86, respectively [15]. Yet, if gross patency is confirmed, evidence of dysfunction becomes more subtle, as criteria are less firm and cannot confidently replace hemodynamic revision. Therefore, based on the available data, it appears that the discriminative capabilities of Doppler US for detecting TIPS dysfunction are satisfactory but do not provide sufficient strength to firmly ascertain the diagnosis of dysfunction, especially during adequate clinical control.

In response to the secondary aim, we noted a higher proportion (43%) of patients with a PPG > 12 mmHg during the first revision, conducted 6 weeks post-TIPS placement, despite achieving the target PPG in 97.6% of cases during the initial procedure. These findings align with the recommendations of Baveno VII, emphasizing the influence of immediate post-TIPS conditions on PPG readings and advocating for remeasurement in stable conditions [11]. Notably, the Barcelona Group's 2017 study supported this, comparing immediate (post-TIPS), early (non-intubated), and late (one month) PPG values [21]. For intubated patients, immediate PPG was poorly correlated with early PPG, with 30.5% crossing the threshold during early revision. Discrepancies persisted even when immediate PPG was recorded post-anesthesia, with 24.5% potentially misclassified as having an adequate post-TIPS PPG. Similar discordance persisted between early and late PPG, suggesting the need for periodic or late systematic TIPS revision. This raises the possibility that long-term PPG may stabilize later due to slow-developing hemodynamic changes or factors associated with liver disease or environment.

Therefore, if PPG is systematically assessed, values exceeding the recommended threshold of 12 mmHg appear to be more frequently encountered. While the Baveno VII consensus clearly states that a PPG of 12 can provide near-complete protection from PHT-related bleeding events [11], it is unclear whether a single measurement during TIPS placement followed by clinical monitoring provides sufficient confidence in adequate PPG control. Previously published data has shown that only 50.3% (n = 68) of patients had a PPG < 12 mmHg during the entire follow-up (median of 23 months) [21]. These figures contrast sharply with those reported in protocols that only performed hemodynamic revision in the case of clinical or US suspicion, boasting 5-year primary patency rates of 79.9% [6]. Moreover, as most of the available data regarding target PPG in patients with TIPS come from such protocols, an evident source of bias arises, as patients with adequate clinical control often have fewer hemodynamic reassessments and, therefore, higher primary patency rates are reported.

Another problematic issue resides in adequate ascites control. To this point, in contrast to PHT-related bleeding, there are no clear-cut values of target PPG for ascites [11]. The poor control of ascites was also encountered in our dataset, as 87.5% (n = 14/16) of patients with clinical dysfunction had no significant improvement in this regard. Young et al. have reported that clinical relapse was a significantly better predictor of a PPG > 12 mmHg compared to Doppler US on a cohort of a similar scale, which included 78 US/venogram pairings [13]. On the other hand, the causal agent for an inadequate response might be influenced by numerous factors, including non-compliance to salt restriction or a lack of etiological cure (i. e., continued alcohol consumption), as proven by a small proportion of patients in our study with no improvement in ascites, yet still within the target PPG. Also, the time of assessment could influence the results since six weeks could be too early to assess ascites response to TIPS insertion.

A cautious approach to our results is warranted. The patients were retrospectively analyzed, and no long-term data is currently available regarding their complete history of decompensation and overall outcomes. However, analyzing the long-term outcomes of patients with TIPS was beyond the scope of the current design. Another potential caveat might be that due to the lack of available dedicated ePTFE-covered TIPS stents in our country, patients in our

study had a custom dual assembly of bare-metal and ePTFE-covered stents closely resembling the dedicated stent. This was the rationale for not including in-stent velocities as a variable, as stent design might significantly alter the turbulence patterns. However, there is no basis for altering either the PVV or intrahepatic branch directionality. Moreover, the patency rates for this clinical scenario were similar to those reported in the literature [21].

Conclusion

Despite adequate symptom control, many patients have a post-TIPS PPG ≥ 12 mmHg if hemodynamic revision is systematically performed. The assessment of PVV and its temporal dynamics can reliably predict a PPG ≥ 12 mmHg despite adequate symptomatic control and provide a rationale for referral to a hemodynamic revision. However, US lacks the prerequisites of a firm diagnostic instrument and, to this point, cannot replace systematic TIPS revision for diagnosing clinically silent dysfunction.

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Contributors' Statement

Prof. Zeno Spârchez and Dr. Bogdan Procopeț share senior authorship.

Conflict of Interest

The authors declare that they have no conflict of interest.

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