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Transjugular Intrahepatic Portosystemic Shunt Plus Thrombectomy versus Transjugular Intrahepatic Portosystemic Shunt Alone for Portal Vein Thrombosis – a Safety Analysis

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Abstract

Purpose To analyze the safety of transjugular intrahepatic portosystemic shunt alone and transjugular intrahepatic portosystemic shunt plus thrombectomy for portal vein thrombosis. Materials and Methods A retrospective study including 38 transjugular intrahepatic portosystemic shunt creation for patients with portal vein thrombosis between January 2022 and December 2025 was performed at a single academic center. Baseline demographics and labs were collected. 21 of these patients had thrombectomy. The mean fluoroscopy time, total procedure time, bleeding complications, hepatic encephalopathy, overall survival and stent patency were evaluated. An independent T-test was performed to compare the means of nominal variables. The Chi Square Test used to compare categorical variables. Kaplan Meier curves with Log Rank test were performed to assess overall survival and stent patency over a maximum follow up of 12 months Results Demographics and baseline labs were not significantly different between the two groups. 78.6% of patients with Yerdel I portal vein thrombosis received transjugular intrahepatic portosystemic shunt alone, while 88.9% of patients with Yerdel IV received thrombectomy together (p=.005). There was no significant difference in mean fluoroscopy time (45.96 min vs 52.28 min, p=.316), total procedure time (149.25 min vs 171.33 min, p=.381), bleeding complication (0% vs 9.5%, p=.315), post-procedure hepatic encephalopathy (29.4% vs 38.1%, p=.666), overall survival (p=.063) and stent patency (87.5% vs 63%, p=.132). Conclusion Our analysis suggests that transjugular intrahepatic portosystemic shunt plus thrombectomy in patients with severe thrombosis burden is comparable to transjugular intrahepatic portosystemic shunt alone in safety aspects with low rates of adverse events.

Introduction

Portal vein (PV) thrombosis (PVT) develops in 1%-10% of patients with cirrhosis, which can affect up to 26% of patients as the severity of cirrhosis increases [1], [2]. Noncirrhotic portal vein thrombosis (NC-PVT) is a rare disease with a prevalence of 0.3% in the general population, which occurs due to prothrombotic disorders, abdominal inflammation, or previous abdominal surgery [3]–[6]. Primary and secondary hepatobiliary neoplasms can result in PVT that develops double in primary cancer compared with secondary cancer (8.5% vs 3.3%, respectively) [7]. Regardless of the etiology of PVT, portal hypertension (PH) or portal cavernoma resulting from PVT may lead to variceal bleeding, mesenteric venous ischemia, and portal cholangiopathy [8]–[11]. Particularly in patients requiring liver transplantation (LT), PVT reduces surgical success and survival following the transplantation [12]–[14].

The ultimate goals of treatment and management of PVT are to achieve recanalization and restore flow to prevent adverse events (AEs) related to worsening PH and allow subsequent LT [2], [11]. For the treatment of recent NC-PVT, early initiation and maintenance of anticoagulation for at least 6 months with hematologic evaluation is the current consensus supported by the American Association for the Study of Liver Diseases (AASLD) and the European Association for the Study of the Liver (EASL) guidelines [1], [2]. However, recanalization rate of PV by early anticoagulation is suboptimal ranging from 35% to 45% even though the recanalization of the superior mesenteric vein (SMV) and the splenic vein

(SV) (61% and 54%) were more successful and occurred after 6 months [15], [16]. Furthermore, that rates even lower in patients with chronic PVT who have progressed to portal cavernoma [17], and patients with recent PVT extending to the SMV pose a high tendency of developing portal cholangiopathy [9], [18], [19]. Moreover, the guideline for anticoagulation for recent cirrhotic PVT is not established [2].

The role of endovascular management is increasingly recognized to achieve recanalization in patients with PVT and overcome the limitations of anticoagulation and surgical management [2], [11], [20]. The long-term complete or partial resolution of PVT following anticoagulation plus pharmacochemical thrombectomy and thrombolysis showed higher rates (71% – 79%) compared with anticoagulation therapy alone [11], [21]. However, given the higher rate of major hemorrhage associated with thrombolysis (17.6%), transjugular intrahepatic portosystemic shunt (TIPS) placement alone or TIPS placement and thrombectomy (major hemorrhage risk of 3.3%) may be preferred as an initial management in the acute PVT at high-volume centers after multidisciplinary discussion [11], [22]. Nowadays, patients with cirrhosis and complete PVT otherwise being considered for LT or denied listing, and patients with chronic PH secondary to extrahepatic NC-PVT that is not responsive to anticoagulation should be considered for portal vein recanalization (PVR) and TIPS based on level of evidence (LoE) 5. PVR and TIPS creation could facilitate LT eligibility in patients with cirrhosis and chronic complete PVT with LoE 3. In patients with acute NC-PVT and PH, thrombectomy/thrombolysis with or without TIPS should be considered in case of failure or poor response to anticoagulation; LoE 4 [23]–[25]. Even though there is a high level of evidence and favorable outcomes of TIPS alone and TIPS-PVR for the treatment of PVT, no report compared safety profiles between them. The purpose of this study is to analyze the safety of TIPS alone and TIPS plus thrombectomy for the best choice of treatment options to manage PVT.

Materials and Methods

Study Design

An institutional review board approved, and Health Insurance Portability Accountability Act-compliant retrospective chart review was conducted to extract patient data from a single institution database and electronic medical record. Informed consent of the participants was waived for human subjects research. 254 total patients who underwent new TIPS creation procedures between January 2022 and December 2025 were screened for inclusion in this study. Patients who underwent TIPS with pre-existing portal vein thrombosis were included. Patients with chronic portal vein thrombosis, suggested by cavernous transformation of the main portal vein with obliteration of the main portal vein remnant, and model for end-stage liver disease (MELD) scores over 18 were excluded. In total, 38 patients who underwent TIPS creation with pre-existing portal vein thrombosis were included. 21 of these patients had TIPS plus thrombectomy, and 17 patients had TIPS alone. The presence of cirrhosis was confirmed based on biopsy results or by imaging features of cirrhosis on cross-sectional imaging. The Severity of PVT was classified by the Yerdel grading system according to the imaging findings of PVT on cross-sectional imaging [26].

Procedure Techniques

The TIPS and TIPS-thrombectomy procedure was performed by a team of experienced interventional radiologists with 1–32 years of experience in the TIPS and TIPS-thrombectomy procedure. All TIPS procedures were performed using a standard technique in a stepwise fashion to achieve the PV and TIPS patency during the index hospitalization.

In two patients (one in TIPS alone group and one in TIPS-thrombectomy group), CO2-guided TIPS procedure was performed with a single 10 French sheath in the right internal jugular vein. After selection of the right or middle hepatic vein, right atrial, free hepatic and wedge hepatic pressures were measured. A wedge hepatic CO2 venogram was performed. Using the CO2 venogram as a guide, an access needle was directed through a metal cannula into either the right or left portal vein. A portal venogram was obtained using a measuring flush catheter to assess the length of TIPS tract for stent length selection. After balloon assisted sheath advancement into the portal vein, an appropriate length Viatorr stentgraft (W. L. Gore & Associates, Flagstaff, Arizona) was deployed. Post-TIPS pressure measurement and portal venogram were then performed. Any residual varices were embolized, followed by post-embolization portal venography and pressure measurements.

For the other 36 patients, ICE guided TIPS procedure was performed using two 10 French sheaths. One sheath was used for the ICE probe (ViewFlex Xtra, St Jude Medical, St. Paul, Minnesota), and the other was used for the TIPS access. The liver was typically scanned with the ICE probe prior to hepatic vein selection. The middle or right hepatic vein was then selected with a catheter based on which vein seemed to have the easiest in-plane approach for portal puncture on ICE images. After hepatic vein selection, right atrial, free and wedge hepatic pressures were measured. Using ICE guidance, a needle was then advanced through a metal cannula into the right or left portal vein. Expected tract length was measured based on the ICE images. After balloon assisted advancement of the sheath into the portal vein, an appropriate length Viatorr stentgraft (W. L. Gore & Associates, Flagstaff, Arizona) was deployed. Post-TIPS pressure measurement and portal venogram were then performed. Any residual varices were embolized, followed by post-embolization portal venography and pressure measurements.

The aspiration catheter was then advanced over a wire into the portal vein, and thrombectomy was performed. The sheath was typically advanced into the portal vein to facilitate thrombectomy catheter advancement into the portal vein. Thrombectomy was performed either before or after deployment of the stent within the TIPS tract, the 10 French sheath was exchanged for a 12, 16, 17 or 18 French sheath to accommodate the aspiration catheter. This was based on proceduralist preference. Thrombectomy system used includes Penumbra Lightening Flash 16 French catheter in 16 patients, Penumbra Lightening 12 French catheter in 1 patient, Penumbra 8 French catheter in 1 patient (Penumbra Indigo System, Penumbra, Inc., Alameda, California), Cleaner Vac 18 French aspiration catheter (Argon Medical Devices, Inc., Plano, Texas) in 1 patient, and 16 French Symphony Thrombectomy System catheter (Imperative Care, Inc., Campbell, California) in 2 patients.

Treatment and Outcome Variables

Portal venous patency was defined as a restoration of blood flow with no or less than 50 stenosis on post-TIPS-thrombectomy portogram. Technical success was defined as the patency of the TIPS and absence of thrombosis in all portomesenteric vessels after the final procedure during the index hospitalization. The primary patency of TIPS was defined as patency achieved by procedures during the index hospitalization and requiring no additional endovascular procedures over the course of the 1-year follow up. This study evaluated only primary patency of TIPS because additional angioplasty, stent placement, or thrombectomy was not performed during or after index admission. The primary and secondary outcomes were estimated for up to 1 year. The primary outcomes consisted of mortality and primary TIPS patency. The secondary outcomes included procedure-related AEs and hepatic encephalopathy, which were graded according to the Society of Interventional Radiology (SIR) classification system [27].

Statistical Analysis

Statistical analysis of the 38 portal vein thrombosis patients who underwent TIPS procedure with or without thrombectomy was performed. Data was collected using EPIC electronic medical records and Sectra PACS. Descriptive statistics of nominal variables are given as percentages and total number of patients. Descriptive statistics of numeric variables are given as mean and standard deviation. An independent T-test was performed to compare the means of nominal variables. The Chi Square Test used to compare categorical variables. Kaplan Meier curves with Log Rank test were plotted with patient death up to 365 days post-TIPS as the analyzed event. Kaplan Meier with a log rank test was also performed to assess TIPS patency over a maximum follow up of 12 months. Patients were censored at the time of liver transplantation, at loss of follow up, or at the end of the 12-month maximum follow up. Statistical analysis was performed using SPSS 29.0.2.0 (20).

Results

Patient Demographics

Patient baseline characteristics are shown in Table 1. 31.6% (n = 12) patients were female, and 67.6% (n = 25) patients were male. In the TIPS alone group, 29.4% (n = 5) patients were female. 70.6% (n = 12) patients in the TIPS alone group were male. 28.6% (n = 6) of the patients in the TIPS-Thrombectomy group were female, and 66.7% (n = 14) of the patients in the TIPS-Thrombectomy group were male.

Table 1
Baseline Patient Characteristics

Characteristics	Overall (n = 37)	TIPS Alone (n = 16)	TIPS-Thrombectomy (n = 21)	*P*-Value
Age (y)*	58.7 (11.9)	56.18 (13.37)	60.62 (10.61)	.268
Male/female	25 (67.6%)/12 (32.4)	11 (68.8%)/5 (31.2%)	15 (71.4%)/6 (28.6%)	.860
BMI*	29.7 (6.1)	28.53 (6.8)	30.59 (5.55)	.319
Cirrhosis	24 (64.9%)	12 (75%)	12 (57.1%)	.260
Malignancy	10 (27%)	4 (25%)	6 (28.6%)	.809
PVT Severity				
Yerdel grade 1	14 (37.8%)	11 (68.75%)	3 (14.3%)	.005
Yerdel grade 2	6 (16.2%)	2 (12.5%)	4 (19%)	
Yerdel grade 3	8 (21.7%)	2 (12.5%)	6 (28.6%)	
Yerdel grade 4	9 (24.3)	1 (6.25%)	8 (38.1%)	
Operator Experience in years*	4.92 (6.5)	4.75 (7.47)	5.05 (5.92)	.893

BMI = body mass index; PVT = portal vein thrombosis; TIPS = transjugular intrahepatic portosystemic shunt

*Mean (standard deviation)

The mean age of the overall included population was 58.4+/-11.9 years old. The mean age of the TIPS thrombectomy patients is 60.15+/-10.66 years old. The mean age of the TIPS alone group is 56.18+/-13.37 years old. The body mass index (BMI) of the overall included population was 29.66+/-6.07. The mean BMI of the TIPS Thrombectomy group was 30.74+/-5.65, and the mean BMI of the TIPS alone group was 28.53+/-6.8.

24 of 37 (64.9%) total patients in this study had cirrhosis. 12 of 21 patients (57.1%) had cirrhotic in the TIPS plus thrombectomy, and 12 of 16 (75%) patients in the TIPS alone group had cirrhosis. The most common underlying cause of liver disease in the TIPS thrombectomy group was metabolic dysfunction-associated steatohepatitis (MASH) (n = 5). Alcoholic cirrhosis was the most common underlying liver disease in the TIPS alone group (n = 4).

23.8% (n = 5) of the patients in the TIPS Thrombectomy group had malignancy. 4 of these patients had hepatocellular carcinoma, and 1 patient had B cell lymphoma. 23.5% (n = 4) of the patients who received TIPS alone had malignancy. All 4 of these patients had hepatocellular carcinoma.

The severity of thrombus was worse in the TIPS Thrombectomy group than in the TIPS alone group. 78.6% (n = 11) of the 14 patients with Yerdel I portal vein thrombosis received TIPS alone, while 88.9% (n = 8) of the 9 patients with Yerdel IV portal vein thrombosis received TIPS plus thrombectomy. X^2 was 12.23 with 3 degrees of freedom (p-value=.005).

Operator experience at the time of the procedure was also documented. In total, procedures were performed by 7 different Interventional Radiologists with experience ranging from 1 year to 32 years. The mean overall experience was 4.92 +/- 6.5 years. Six different interventional radiologists performed procedures in the TIPS plus thrombectomy group with experience at the time of the procedure ranging from 1 year to 30 years. The mean operator experience in the TIPS plus thrombectomy group was 5.05 +/- 5.92 years. Procedures in the TIPS alone group were performed by 5 different interventional radiologists with experience ranging from 1 year to 32 years. The mean operator experience in the TIPS alone group was 4.75 +/- 7.47 years. This difference in operator experience was not significant (p-value=.893)

Baseline labs of patients are described in Table 2. Enzymes related liver disease and liver functions including aspartate aminotransferase, alanine aminotransferase, total bilirubin, albumin, creatinine, international normalized ratio, and platelet show no significant difference between TIPS alone group and TIPS-thrombectomy group. The mean MELD score for the overall included population was 10.75+/-2.63. The mean MELD score for the TIPS Thrombectomy group was 10.25+/-2.49, and the mean MELD score for the TIPS alone group was 11.38+/-2.75.

Table 2
Baseline Patient Labs

Mean (SD)	**Overall (n = 37)**	**TIPS alone (n = 16)**	**TIPS -Thrombectomy (n = 21)**	***P*-Value**
AST	39.3 (30.16)	41.25 (30.1)	37.9 (30.8)	.740
ALT	42.2 (83.8)	25.19 (20.8)	55.15 (109.1)	.288
Total Bilirubin	4.73 (10.56)	5.7 (13.6)	4 (7.8)	.632
Albumin	3.22 (0.61)	3.15 (0.65)	3.28 (0.6)	.542
Creatinine	0.84 (0.22)	0.88 (0.23)	0.82 (0.21)	.344
INR	1.31 (0.26)	1.32 (0.16)	1.31 (0.32)	.877
Platelet	152.46 (111.5)	122.7 (84.8)	175.1 (125.5)	.159
MELD	10.75 (2.63)	11.38 (2.75)	10.61 (2.96)	.433

ALT= alanine aminotransferase; AST = aspartate aminotransferase; INR = international normalized ratio; MELD = model for end-stage liver disease; SD = standard deviation

Procedure

The mean fluoroscopy time in the TIPS thrombectomy group was 52.28+/-19.90 minutes. The mean fluoroscopy time of the TIPS alone group was 45.94+/-23.96 minutes. The difference in means is not significant (7.3387; standard error 7.2112; P-value=.316).

The mean total procedure time is 171.33+/-71.897 minutes for the TIPS thrombectomy group. The mean for the total procedure time of the TIPS alone group was 149.25+/-78.802 minutes. The difference in means was not statistically significant (22.083; standard error 24.866; p-value=.381).

35.3% (n = 6) of the patients who received TIPS alone underwent embolization of either varices or spontaneous portosystemic shunts at the time of TIPS. 23.8% (n = 5) of the patients in the TIPS Thrombectomy group had embolization of either varices or spontaneous portosystemic shunts at the time of the TIPS. TIPS alone and TIPS-thrombectomy were technically successful in achieving PV patency in all patients immediately after the procedure. TIPS was created in all patients with technical success.

Bleeding Complications

There were two bleeding complications in the TIPS plus thrombectomy group, and there were no bleeding complications in the TIPS alone group. The two bleeding complications were self-limiting, and they did not require additional procedures or escalation of care. This difference in bleeding complications was not statistically significant (X^2 = 1.611; df 1; p-value=.315).

Hepatic Encephalopathy

13 of 38 (35.1%) of the total patients had hepatic encephalopathy post-procedure (OR 1.354; 95% CI 0.342 to 5.360). 5 of 17 (29.4%) patients in the TIPS alone group developed post-procedure hepatic encephalopathy (OR = 1.11; 95% CI 0.694 to 1.778). 8 of 21 patients (38.1%) in the TIPS plus thrombectomy group developed post-TIPS hepatic encephalopathy (OR 0.820; 95% CI 0.331 to 2.035). The difference between the groups was not statistically significant (X^2=.187; df = 1; p-value .666).

Overall Survival

The median follow up was 266 days. Overall survival was plotted with Kaplan Meier Curve with a log rank, as shown in Fig. 1. There was no significant difference in survival between the two groups (X^2 = 3.460; df 1; p-value=.063). Median survival was not reached.

TIPS Patency

1 year patency was 87.5% in the TIPS alone group and 63% in the TIPS plus thrombectomy group (Fig. 2). TIPS patency between the two groups was also not significantly different (X^2 = 2.272; df = 1; p-value=.132). The median was not reached.

Discussion

PVT can be a complication of several pathologic conditions resulting from any components of Virchow's triad (stasis of blood flow, endothelial injury, and hypercoagulable state) [22]. The most common risk factor is liver cirrhosis, but NC-PVT can include lots of risk factors including solid cancer, myeloproliferative neoplasm, inflammatory bowel disease, anti-phospholipid syndrome, paroxysmal nocturnal hemoglobinuria, autoimmune disease, abdominal inflammation/infection, abdominal surgery, hormonal therapy, pregnancy or puerperium, sport-related trauma, factor V Leiden mutation, prothrombin G20210A mutation, JAK2V617F mutation, protein C deficiency, protein S deficiency, and antithrombin deficiency [28]. The Yerdel grading system considering the location, obstruction, and extension of PVT has been the most representative and well recognized classification of PVT for LT [26], [29]. Accordingly, most patients (64.9%) in this study have cirrhosis as a risk factor for PVT and the severity of PVT was estimated by the Yerdel grading system.

Thrombectomy to restore flow in the PV can be performed through balloon, rheolytic, or aspiration thrombectomy. All techniques showed successful application for PVT thrombectomy, but there is no prospective data comparing the results of the different techniques [30]. Despite controversy regarding the combination of thrombectomy and direct thrombolysis, thrombectomy can minimize thrombolysis-related complications by decreasing the duration of subsequent thrombolysis and enhancing thrombus dissolution [31]–[33]. Thrombectomy could increase the risk of the vessel's wall injury leading to recurrent thrombosis in the medium and long term, but the long-term effects of thrombectomy remain still unclear [34], [35]. Aspiration thrombectomy was used in this study considering its rapid reduction of thrombus volume and the simplest setup [35]. Eventually, there was no significant difference in fluoroscopic time and total procedure time between the TIPS alone group and the TIPS-thrombectomy group in this study. The significantly higher Yerdel grade in TIPS-thrombectomy group compared with that of TIPS alone group was noted because the decision of thrombectomy was made in patients with the higher volume of PVT.

In this study, TIPS alone and TIPS-thrombectomy were technically successful in achieving PV patency in all patients. 100% technical success rate of TIPS, which describes the successful creation of a shunt between the hepatic vein and intrahepatic branch of the portal vein, is satisfying the quality improvement guidelines for SIR recommending 95% of threshold rate regardless of PVT [36].

The results of this study indicate that TIPS-thrombectomy is comparable to TIPS alone in safety aspects with low rates of AEs. Only two procedure-related AEs (only minor bleeding) occurred (10%) which was successfully managed during the course of the index hospitalization. This safety profile compares favorably with thrombolysis treatment, whereby the incidence of major bleeding events can be as high as 17.6% [11], [22]. The major complication rate including mortality was 0% during 224 days of median follow-up in both groups. Those complication rates are below the suggested complication-specific threshold of SIR quality improvement guidelines describing that death, major complications and minor complications should occur in each below 2%, 5% and 8% [36].

Additionally, two meta-analyses showed hepatic encephalopathy (HE) rates of 25% [37] and 16.4% [38] after TIPS for the treatment of PVT. TIPS alone group and TIPS-thrombectomy in this study showed that 31.3% and 38.1% of HE, of which rates are higher than those two analyses. However, considering the reported HE rates of 20%-40% in patients who underwent TIPS placement for cirrhotic portal hypertension, the rate of HE in this study is comparable [39]. Occurrence of HE after TIPS plus thrombectomy has not been comprehensively analyzed yet.

Finally, the 1-year primary patency of TIPS stent graft was 87.5% in the TIPS group and 63% in the TIPS-thrombectomy group without significant difference in this study. Per definition of patency, the range of patency rates were different from each previous report, but the 1-year primary patency rated over 77% [40], [41]. Although there is no report regarding TIPS stent patency in patients who underwent TIPS-thrombectomy for PVT treatment, the relatively low patency in TIPS-thrombectomy group of this study might be related to the initially larger burden of thrombus and more tendency of thrombosis in this group compared to TIPS alone group.

The present study has several limitations. First, this is a single-center, retrospective study with a non-randomized, noncontrolled study, which can result in related biases. Second, the sample size of this study is small because of the low prevalence of PVT in the general population. Therefore, a large randomized controlled prospective study should be performed to increase the power and generalizability of the study. Third, this study estimated 1-year mortality and 1-year primary patency of TIPS stent without evaluation of portal vein patency defined using standardized nomenclature as detailed by the AASLD practice guidelines for the description of PVT [2] because the study was designed for safety analysis during 1-year follow-up. Accordingly, long-term follow-up with evaluation of portal vein patency is necessary to compare the feasibility between TIPS alone and TIPS-thrombectomy. Nevertheless, this study is meaningful for the safety analysis comparing TIPS alone and TIPS-thrombectomy, which can be fundamental for the future evaluation of efficacy of TIPS-thrombectomy for the treatment of PVT.

In conclusion, our analysis suggests that there is no significant difference in bleeding risk or 12-month risk of death between patients who received TIPS plus thrombectomy compared to patients who received TIPS alone. There also seemed to be similar patency rates between both groups; however, the TIPS thrombectomy group had a more severe thrombosis burden.

Abbreviations

AASLD American Association for the Study of Liver Diseases

AEs Adverse events

ALT Alanine aminotransferase

AST Aspartate aminotransferase

BMI Body mass index

EASL European Association for the Study of the Liver

INR International normalized ratio

LoE Level of evidence

LT Liver transplantation

MASH Metabolic dysfunction-associated steatohepatitis

MELD Model for end-stage liver disease

NC-PVT Noncirrhotic portal vein thrombosis

PH Portal hypertension

PV Portal vein

PVR portal vein recanalization

PVT Portal vein thrombosis

SD Standard deviation

SIR Society of Interventional Radiology

SMV Superior mesenteric vein

SV Splenic vein

TIPS Transjugular intrahepatic portosystemic shunt

References

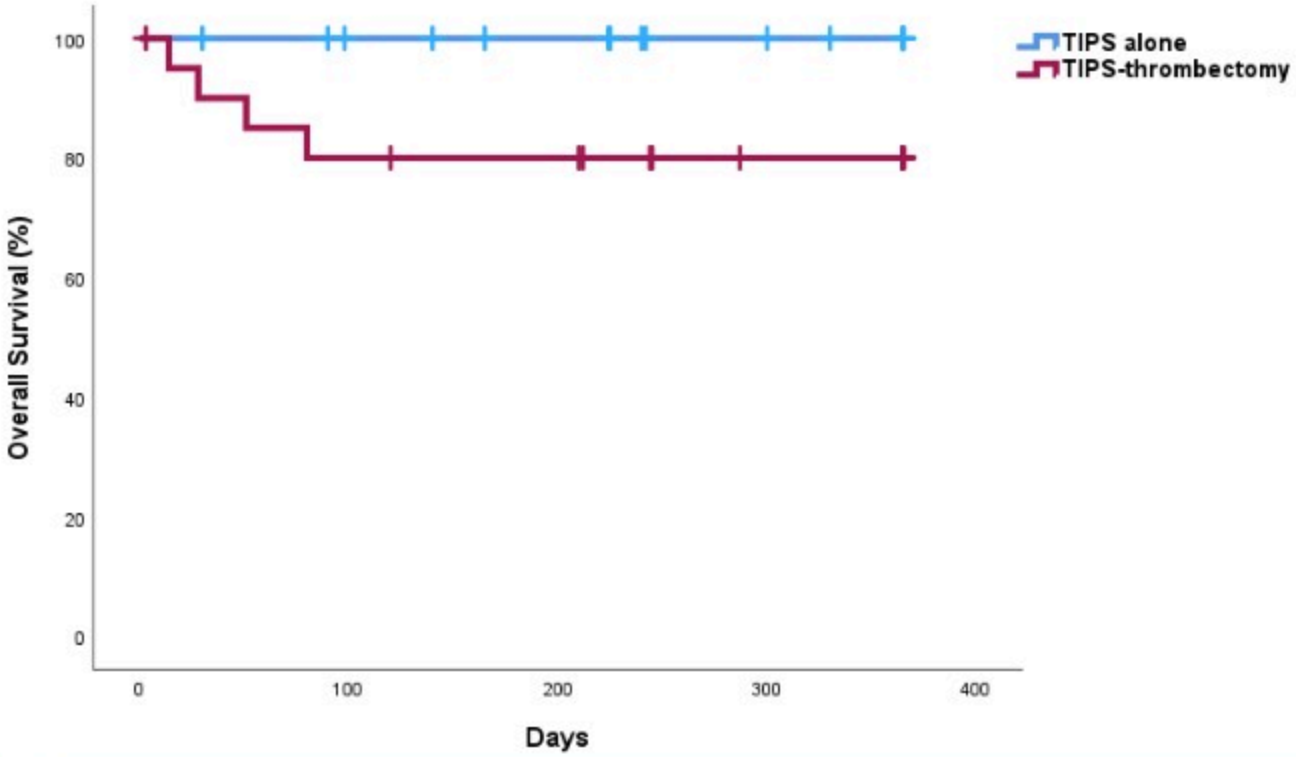
1. European Association for the Study of the Liver (Jan. 2016) EASL Clinical Practice Guidelines: Vascular diseases of the liver. J Hepatol 64(1):179–202. 10.1016/j.jhep.2015.07.040
2. Northup PG et al (2021) Vascular liver disorders, portal vein thrombosis, and procedural bleeding in patients with liver disease: 2020 practice guidance by the american association for the study of liver diseases., *Hepatology*, vol. 73, no. 1, pp. 366–413, Jan. 10.1002/hep.31646
3. Rajani R et al (2010) The epidemiology and clinical features of portal vein thrombosis: a multicentre study., *Aliment. Pharmacol. Ther.*, vol. 32, no. 9, pp. 1154–1162, Nov. 10.1111/j.1365-2036.2010.04454.x
4. DeLeve LD, Valla D-C, Garcia-Tsao G, and American Association for the Study Liver Diseases (2009), Vascular disorders of the liver., *Hepatology*, vol. 49, no. 5, pp. 1729–1764, May 10.1002/hep.22772

5. Kumar A, Sharma P, Arora A (2015) Review article: portal vein obstruction–epidemiology, pathogenesis, natural history, prognosis and treatment., *Aliment. Pharmacol. Ther.*, vol. 41, no. 3, pp. 276–292, Feb. 10.1111/apt.13019
6. Klinger C et al (Dec. 2017) Transjugular local thrombolysis with/without TIPS in patients with acute non-cirrhotic, non-malignant portal vein thrombosis. Dig Liver Dis 49(12):1345–1352. 10.1016/j.dld.2017.05.020
7. Ögren M (2006) Portal vein thrombosis: Prevalence, patient characteristics and lifetime risk: A population study based on 23 796 consecutive autopsies. World J Gastroenterol 12:2115. 10.3748/wjg.v12.i13.2115
8. De Gaetano AM, Lafortune M, Patriquin H, De Franco A, Aubin B, Paradis K (1995) Cavernous transformation of the portal vein: patterns of intrahepatic and splanchnic collateral circulation detected with Doppler sonography., *AJR Am J Roentgenol*, vol. 165, no. 5, pp. 1151–1155, Nov. 10.2214/ajr.165.5.7572494
9. Condat B et al (2001) Current outcome of portal vein thrombosis in adults: risk and benefit of anticoagulant therapy., *Gastroenterology*, vol. 120, no. 2, pp. 490–497, Feb
10. Abud A, Maddur H, Salem R (2021) Management of symptomatic portal cavernoma cholangiopathy with transplenic portal vein recanalization and transjugular intrahepatic portosystemic shunt., *Hepatology*, vol. 73, no. 1, pp. 456–459, Jan. 10.1002/hep.31411
11. Rodrigues SG et al (2019) Systematic review with meta-analysis: portal vein recanalisation and transjugular intrahepatic portosystemic shunt for portal vein thrombosis., *Aliment. Pharmacol. Ther.*, vol. 49, no. 1, pp. 20–30, Jan. 10.1111/apt.15044
12. Francoz C et al (May 2005) Splanchnic vein thrombosis in candidates for liver transplantation: usefulness of screening and anticoagulation. Gut 54(5):691–697. 10.1136/gut.2004.042796
13. Qi X et al (2015) Association between portal vein thrombosis and survival of liver transplant recipients: a systematic review and meta-analysis of observational studies. J Gastrointestin Liver Dis 24(1):51–59 4 p following 59, Mar. 10.15403/jgld.2014.1121.qix
14. Dumortier J et al (Nov. 2002) Eversion thrombectomy for portal vein thrombosis during liver transplantation. Am J Transpl 2(10):934–938. 10.1034/j.1600-6143.2002.21009.x
15. Hall TC, Garcea G, Metcalfe M, Bilku D, Dennison AR (2011) Management of acute non-cirrhotic and non-malignant portal vein thrombosis: a systematic review., *World J. Surg.*, vol. 35, no. 11, pp. 2510–2520, Nov. 10.1007/s00268-011-1198-0
16. Plessier A et al (2010) Acute portal vein thrombosis unrelated to cirrhosis: a prospective multicenter follow-up study., *Hepatology*, vol. 51, no. 1, pp. 210–218, Jan. 10.1002/hep.23259
17. Garcia-Pagán JC, Hernández-Guerra M, Bosch J (2008) Extrahepatic portal vein thrombosis., *Semin. Liver Dis.*, vol. 28, no. 3, pp. 282–292, Aug. 10.1055/s-0028-1085096
18. Walser EM et al (2011) Extrahepatic portal biliopathy: proposed etiology on the basis of anatomic and clinical features., *Radiology*, vol. 258, no. 1, pp. 146–153, Jan. 10.1148/radiol.10090923

19. Adachi Y, Kamisako T, Yamamoto T (Sep. 1991) The effects of temporary occlusion of the superior mesenteric vein or splenic vein on biliary bilirubin and bile acid excretion in rats. J Lab Clin Med 118(3):261–268
20. Quarrie R, Stawicki SP (2018) Portal vein thrombosis: What surgeons need to know. Int J Crit Illn Inj Sci 8(2):73–77. 10.4103/IJCIIS.IJCIIS_71_17
21. Rössle M et al (2020) A prospective, multicentre study in acute non-cirrhotic, non-malignant portal vein thrombosis: comparison of medical and interventional treatment., *Aliment. Pharmacol. Ther.*, vol. 52, no. 2, pp. 329–339, Jul. 10.1111/apt.15811
22. Salei A, El Khudari H, McCafferty BJ, Varma RK (2022) Portal interventions in the setting of venous thrombosis or occlusion., *Radiographics*, vol. 42, no. 6, pp. 1690–1704, Oct. 10.1148/rg.220020
23. Boike JR et al (2022) North American Practice-Based Recommendations for Transjugular Intrahepatic Portosystemic Shunts in Portal Hypertension., *Clin. Gastroenterol. Hepatol.*, vol. 20, no. 8, pp. 1636–1662.e36, Aug. 10.1016/j.cgh.2021.07.018
24. Davis JPE, Lim JK, Francis FF, Ahn J (Feb. 2025) AGA clinical practice update on management of portal vein thrombosis in patients with cirrhosis: expert review. Gastroenterology 168(2):396–404. 10.1053/j.gastro.2024.10.038
25. European Association for the Study of the Liver (Jul. 2025) EASL clinical practice guidelines on TIPS. J Hepatol 83(1):177–210. 10.1016/j.jhep.2025.01.029
26. Yerdel MA et al (May 2000) Portal vein thrombosis in adults undergoing liver transplantation: risk factors, screening, management, and outcome. Transplantation 69(9):1873–1881. 10.1097/00007890-200005150-00023
27. Baerlocher MO, Nikolic B, Sze DY (Jan. 2023) Adverse Event Classification: Clarification and Validation of the Society of Interventional Radiology Specialty-Specific System. J Vasc Interv Radiol 34(1):1–3. 10.1016/j.jvir.2022.10.011
28. Boccatonda A et al (Mar. 2024) Portal Vein Thrombosis: State-of-the-Art Review. J Clin Med 13(5). 10.3390/jcm13051517
29. Teng F, Sun K-Y, Fu Z-R (2020) Tailored classification of portal vein thrombosis for liver transplantation: Focus on strategies for portal vein inflow reconstruction., *World J. Gastroenterol.*, vol. 26, no. 21, pp. 2691–2701, Jun. 10.3748/wjg.v26.i21.2691
30. Jun KW et al (Jun. 2014) Mechanical thrombectomy-assisted thrombolysis for acute symptomatic portal and superior mesenteric venous thrombosis. Ann Surg Treat Res 86(6):334–341. 10.4174/astr.2014.86.6.334
31. Wolter K et al (Aug. 2018) Interventional treatment of acute portal vein thrombosis. Rofo 190(8):740–746. 10.1055/a-0631-9265
32. Kim HS, Patra A, Khan J, Arepally A, Streiff MB (2005) Transhepatic catheter-directed thrombectomy and thrombolysis of acute superior mesenteric venous thrombosis., *J. Vasc. Interv. Radiol.*, vol. 16, no. 12, pp. 1685–1691, Dec. 10.1097/01.RVI.0000182156.71059.B7

33. Hollingshead M, Burke CT, Mauro MA, Weeks SM, Dixon RG, Jaques PF (May 2005) Transcatheter thrombolytic therapy for acute mesenteric and portal vein thrombosis. J Vasc Interv Radiol 16(5):651–661. 10.1097/01.RVI.0000156265.79960.86
34. Uflacker R (2003) Applications of percutaneous mechanical thrombectomy in transjugular intrahepatic portosystemic shunt and portal vein thrombosis., *Tech. Vasc. Interv. Radiol.*, vol. 6, no. 1, pp. 59–69, Mar. 10.1053/tvir.2003.36433
35. Ueda T et al (2025) Endovascular treatment for acute portal vein thrombosis., *Interv Radiol (Higashimatsuyama)*, vol. 10, p. e20230027, Mar. 10.22575/interventionalradiology.2023-0027
36. Dariushnia SR et al (Jan. 2016) Quality improvement guidelines for transjugular intrahepatic portosystemic shunts. J Vasc Interv Radiol 27(1):1–7. 10.1016/j.jvir.2015.09.018
37. Valentin N, Korrapati P, Constantino J, Young A, Weisberg I (2018) The role of transjugular intrahepatic portosystemic shunt in the management of portal vein thrombosis: a systematic review and meta-analysis., *Eur. J. Gastroenterol. Hepatol.*, vol. 30, no. 10, pp. 1187–1193, Oct. 10.1097/MEG.0000000000001219
38. Zhang J-B et al (Jul. 2021) Systematic review and meta-analysis of trans-jugular intrahepatic portosystemic shunt for cirrhotic patients with portal vein thrombosis. World J Clin Cases 9:5179–5190. 10.12998/wjcc.v9.i19.5179
39. Shalvoy MR et al (2023) Transjugular Intrahepatic Portosystemic Shunt and Thrombectomy (TIPS-Thrombectomy) for Symptomatic Acute Noncirrhotic Portal Vein Thrombosis., *J. Vasc. Interv. Radiol.*, vol. 34, no. 8, pp. 1373–1381.e3, Aug. 10.1016/j.jvir.2023.05.009
40. Perello MP et al (2019) Sep., Long-term follow-up of transjugular intrahepatic portosystemic shunt (TIPS) with stent-graft., *Diagn. Interv. Radiol.*, vol. 25, no. 5, pp. 346–352. 10.5152/dir.2019.18416
41. Geeroms B et al (May 2017) Expanded polytetrafluoroethylene-covered stent-grafts for transjugular intrahepatic portosystemic shunts in cirrhotic patients: Long-term patency and clinical outcome results. Eur Radiol 27(5):1795–1803. 10.1007/s00330-016-4570-5

Figures

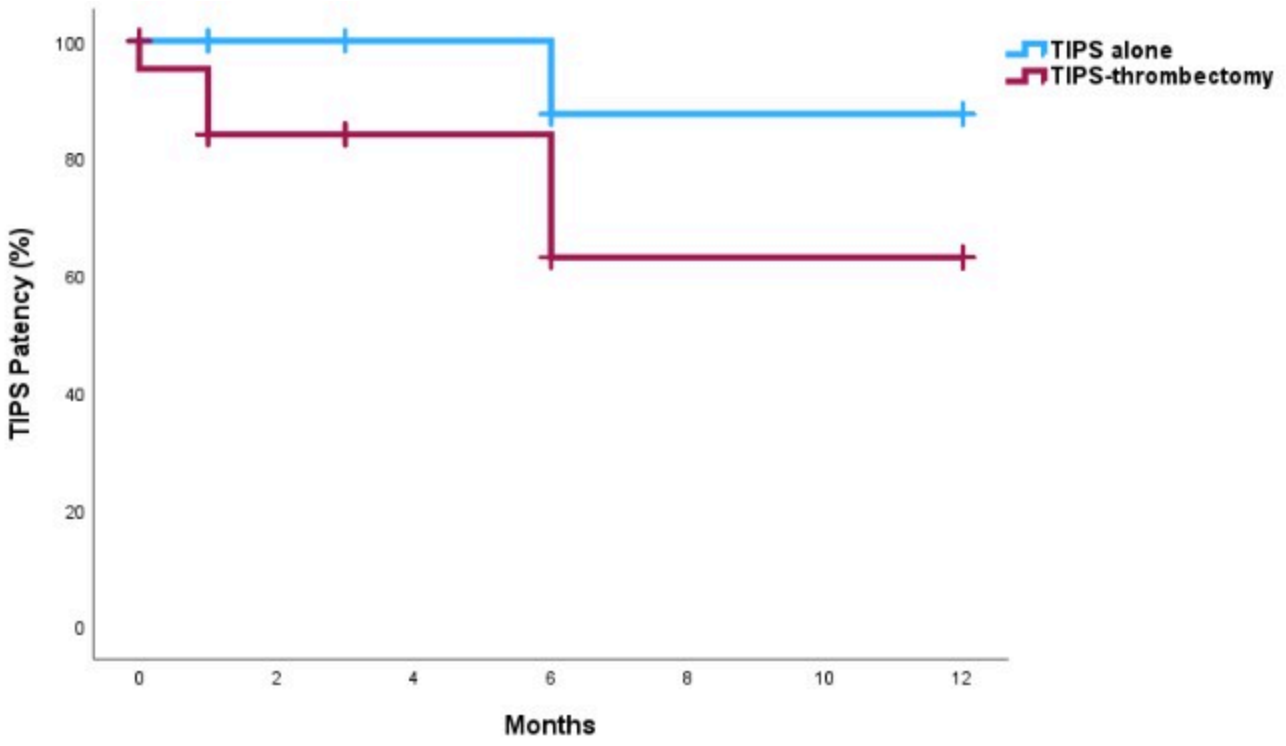


Survival Table

	Days	Remaining Patients	Events	Censored	Survival Function	Std. Error	Lower 95% CI	Upper 95% CI
TIPS-thrombectomy	14	20	1	0	0.95	0.05	0.86	1.00
	24	19	1	0	0.90	0.07	0.78	1.00
	51	18	1	0	0.85	0.08	0.71	1.00
	80	17	1	16	0.80	0.09	0.64	1.00

Figure 1

Kaplan-Meier overall survival rate and survival table, CI = confidence interval; Std. = Standard; TIPS = transjugular intrahepatic portosystemic shunt



Patency Table

	Months	Remaining Patients	Events	Censored	Survival Function	Std. Error	Lower 95% CI	Upper 95% CI
TIPS alone	6	8	1	7	0.88	0.12	0.67	1.00
TIPS-thrombectomy	0	21	1	3	0.95	0.05	0.87	1.00
	1	17	2	7	0.84	0.08	0.69	1.00
	6	8	2	6	0.63	0.14	0.40	0.98

Figure 2

Kaplan-Meier TIPS stent patency and patency table, CI = confidence interval; Std. = Standard; TIPS = transjugular intrahepatic portosystemic shunt