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Transjugular Intrahepatic Porto Systemic Shunt: A comprehensive review of innovations and future perspectives

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Abstract
Portal hypertension is a serious problem of chronic liver disease, supporting to the life-threatening circumstances such as variceal bleeding and refractory ascites. A minimally spreading process called Transjugular Intrahepatic Portosystemic Shunt (TIPS) has been become popular for treating portal pressure reduction in patients who are not responding to conventional therapy. This review aims to evaluate the technological evolution, mechanism of action, clinical indications, and performance outcomes of TIPS, with emphasis on innovations such as covered stents, advanced procedural techniques, and future directions. The database PubMed, Embase, and Scopus were used to perform a through literature review. Involved were pertinent equipment reports, meta- analyses, and clinical trials executed between 1987 and 2025. Global guidelines, device evaluations, and randomized controlled trials (RCTs) were emphasized. The use of ePTFE-covered nitinol stents and hybrid delivery methods has improved procedure accuracy and patency rates. TIPS relieve the symptoms of hepatic hydrothorax, Budd-Chiari syndrome, and hepatic hydrothorax, Budd-Chiari syndrome, and hepatopulmonary syndrome and are more effective than large volume paracentesis in treating refractory ascites. Nonetheless, certain restrictions still exist, such as the possibility of hepatic encephalopathy (HE0, the lack of standardized post-TIPS surveillance, and the scarcity of paediatric data. Ai-based risk prediction, 3D modelling for pre-procedure planning, and biodegradable or adjustable-flow stents are examples of novel approaches currently in development. The primary treatment for problem from portal hypertension was still TIPS. To maximized results, especially in special populations and long-term care setting, more developments in device design, patient selection device, and multicenter trials are required.

Keywords: Hepatic encephalopathy, covered stents, refractory ascites, variceal haemorrhage, TIPS, portal hypertension, and biodegradable stent

Introduction

The pathophysiological disease identified as portal hypertension, which is most commonly caused by cirrhosis and hepatic fibrosis, is characterized by increased pressure within the portal venous structure. It sources of the major complications, involving ascites, hepatic hydrothorax, and spontaneous bacterial peritonitis, gastroesophageal varices, and hepatorenal disease, all of which remarkably increase morbidity and mortality in patients with advanced liver condition [1, 2]. Of these, acute variceal haemorrhage is still extremely dangerous, with a 6- week morality rate that range from 15% to 25%, even with advancement in endoscopic and pharmacologic therapy [3, 4].

A minimally invasive, image-guided treatment called the Transjugular Intrahepatic Portosystemic Shunt (TIPS) operation decompresses the portal circulation by establishing a parenchyma tract between the hepatic and portal veins [5]. First described experimentally by Rösch in 1969 and clinically implemented by Colapinto in 1987 [6, 7], TIPS has advanced dramatically with the development of expanded polytetrafluoroethylene (e PTFE) covered stents, leading to enhanced long-term patency and reduced shunt dysfunction [8]. The precision and safety of process have been further improved by technological development such as intravascular ultrasound (IVUS), fusion CT guidance, and 3D navigation systems [9].

This review's goal is to objectively assess TIPS's development, clinical usefulness, and potential future applications in the treatment of portal hypertension and related consequences. The review summarizes the most recent data on stent technology, indications, patient selection, procedural methods, results, and complication management, with a focus on hepatic encephalopathy.

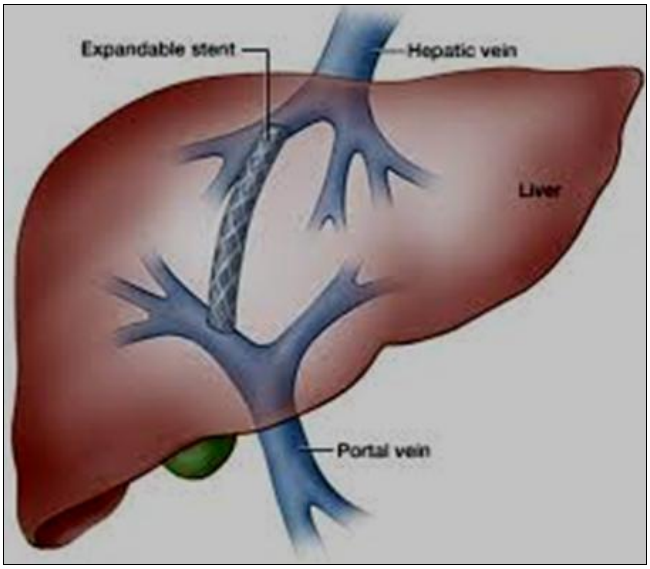

Fig 1: Transjugular Intrahepatic Portosystemic Shunt [10]

Technological Evolution

The Transjugular Intrahepatic Portosystemic Shunt (TIPS) process was first conceptualized and desplays in animal models by Rösch *et al*. in 1969 [11]. Eventually, the method was translated into human application by Gordon *et al*. in 1987 [12]. In the early stages of the procedure, the artificially

created shunt between the portal and hepatic venous system was kept open using bare metal stents. But, long-term patency was remarkably compromised due to high rates of in-stent thrombosis and stenosis [13].

Expanded polytetrafluoroethylene (ePTFE) covered stents were created and released in order to overcome these restrictions. These stents considerably decreased the need for recurrent reinterventions and showed a notable improvement in preserving shunt patency [14, 16]. Additional advancements were made by combining self-expanding nitinol-based frameworks techniques, as the My TIPS TM system [17, 18]. All of these technological developments have enhanced overall clinical outcomes, the longevity of equipment, and the success of process.

Method and Materials

There are two primary parts to the My TIPS™ Transjugular Intrahepatic Portosystemic Shunt (TIPS) Endoprosthesis System:

a. an endoprosthesis that is implanted
b. a method for delivering stents over the wire (OTW)

An electro polished, self-expanding stents made of nickel-titanium alloy (nitinol) serves as the endoprosthesis. It is externally supported by an expanded polytetrafluoroethylene (ePTFE) graft with reduced permeability. The two separated functional components of the system are a graft-lined intrahepatic segment and an unlined portal segment. The junction between these segments is demarcated by a circumferential radiopaque platinum-iridium marker band. In addition, a radiopaque tantalum marker is positioned at the trailing edge of the device to aid in fluoroscopic visualization.

The endoprosthesis is ready to use on a 10 French (Fr) delivery system. The OTW stent delivery system is designed to be compatible with a 0.035-inch guide wire and is available in lengths ranging from 80 to 100 cm.

Table 1: Size Matrix of MyTIPS™

Internal Diameter; mm	Graft Lined	Length/Unlined length mm/mm)	
Identified	40/20	60/20	80/20
8	√	√	√
10	√	√	√
12	√	√	√

Table 2: Technical specifications

Sr. No.	Parameter	Specification
1	Stent Material	Nitinol
2	Marker Material	Platinum, Iridium & Tantalum
3	Stent Diameter; mm	8,10,12
4	Stent Length; mm	60,80,100
5	Guide wire compatibility; inch	0.035
6	Sheath compatibility; Fr	10
7	Delivery System Usable Length; cm	80-100

1. Mechanism of Action

The fundamental method by which TIPS generates its therapeutics impact is the creation of low- resistance intrahepatic conduit that connect the portal vein directly to the systemic circulation via the hepatic vein, this artificial channel aids in reducing the portal venous system by rerouting portal blood flow from the fibrotic hepatic parenchyma [19, 21]. This can successfully lower the risk of consequences such as refractory as cites, variceal haemorrhage, and other portal hypertension symptoms.

The establishment of a low-resistance intrahepatic conduit that links the portal vein directly to the systemic circulation through the hepatic vein is the basic mechanisms by which TIPS have its therapeutic effect. By diverting portal blood flow away from the fibrotic hepatic parenchyma, this artificial channel helps decompress the portal venous system [19, 21]. This makes it possible to successfully reduce the risks of consequence such variceal haemorrhage, refractory ascites, and other symptoms of portal hypertension that are lined to elevated portal pressure.

2. Application in clinical Practices

TIPS have well established clinical values in the treatment of a number of advanced problems related to portal hypertension. Treatment of refractory ascites, hepatic hydrothorax, hepatorenal syndrome, Budd-Chiari syndrome, hepatopulmonary syndrome, and acute or frequent variceal haemorrhage are among the indications [22, 26]. While there is a higher risk of hepatic encephalopathy (HE) as a remarkable side effect, unsystematic controlled trials have shown that TIPS offer better fluid control in patient's refractory ascites than large-volume paracentesis [27, 29].

It has been demonstrated that in about 60-80% of treated individual with hepatic hydrothorax, TIPS result in partial or total clinical relief [30, 32]. Additionally, TIPS has been used as a definitive therapy or as a bridge to transplantation in a limited number of patients with Budd-Chiari syndrome or hepatopulmonary syndrome, contingent on anatomical feasibility and individual hepatic reserve.

3. Comparative Performance

The comparative capacity of TIPS versus standard treatment-involve pharmacological supervision, endoscopic variceal ligation, and paracentesis has been extended estimate using multiple casually regulate trials and meta-analyses. These studies have repeatedly shown that TIPS is more effective than other methods at achieving haemostasis in variceal haemorrhage and more long-lasting control of refractory ascites [33, 35]. Overall survival benefit, however, is still variable and mostly depends on choosing the right patients, especially in terms of encephalopathy risk and hepatic functional reserve.

The relative efficacy of TIPS in relation to traditional therapies, including pharmacological management,

endoscopic variceal ligation, and paracentesis, has been thoroughly evaluated in a number of randomized controlled trials and meta-analyses. These studies have consistently demonstrated that TIPS is superior to other approaches in achieving more long-lasting control of refractory ascites and haemostasis in variceal haemorrhage [33, 35]. Overall survival benefit, however, is still variable and mostly depends on choosing the right patients, especially in terms of encephalopathy risk and hepatic functional reserve.

Table 3: Comparisons between Conventional & Advanced TIPS Procedure

Sr. No.	Feature	Conventional TIPS	Advanced TIPS
1	Access Route	Right hepatic to right portal	Multiple (e.g., left side, transcaval)
2	Imaging Guidance	Fluoroscopy	Ultrasound, IVUS, 3D navigation
3	Tools	Standard stents & needles	Newer stents, snares, custom tools
4	Suitable For	Standard anatomy	Complex or thrombosed anatomy
5	Technical Difficulty	Moderate to high (in complex)	Lower (with experience and tools)
6	Success rate in Challenging Cases	Lower	Higher

4. Regulatory Landscape

The stent systems used in the TIPS procedure, MyTIPS™ endoprosthesis-have undergone rigorous evaluation and are currently approved for clinical use by major regulatory bodies, including the U.S. The European Conformity (CE) marketing system and the Food and Drug Administration (FDA). Regulatory approval usually requires clinically significant results in pivotal trials, favourable biocompatibility profiles, and persistence shunt patency [40].

Limitations and Research Gaps

Despite its initiated clinical role, several crucial restrictions of Transjugular Intrahepatic Portosystemic Shunt (TIPS) therapy stay unresolved. Exceptionally, phase II/III clinical trials estimating biodegradable or drug-eluting TIPS instruments are presently deficient, which restrictions to the translation of promising pre-diagnostic biomaterial innovations into mainstream therapeutic options [40].

Besides, risk grouping tools for post-TIPS hepatic encephalopathy (HE), such as the HE risks score and MELD-based indices; have not been fully incorporated into routine medical practice [41]. Their incorporation could enable more precise identification of patients susceptible to HE, thereby optimizing post-TIPS management strategies.

Limited data availability in paediatric populations is another significant gap. There is not enough data to determine long-term patency, vascular adaptability, or procedural safety in this particular cohort, and the majority of studies in children are small-scale, retrospective, or case-based [42]

Addressing this gap depend multicenter paediatric TIPS registries and well-powered experiments.

In conclusion, the absences of a globally standardized post-TIPS surveillance protocol—including defined schedules for imaging (e.g., Doppler ultrasonography), biochemical monitoring, and reinterventions thresholds-leads to inconsistent follow-up and may negatively impact clinical consequences [43]. International groups are motivated to create guidelines to harmonize care pathways across healthcare structure.

Future Directions

The future direction of TIPS technology is anticipated to be significantly impact by interdisciplinary developments in biomaterials, computational modelling, and personalized medicine. One of the most promising advancements is the creation of drug-eluting or biodegradable TIPS stents with anti-fibrotic coating and tailored degradation kinetics to reduce initial hyperplasia while preserving sufficient shunt patency across the critical clinical window [40, 44].

At the same time, efforts are underway to stratify risks for complications like early shunt thrombosis or hepatic encephalopathy using AI-powered predictive analytics. To inform patient-specific decision-making, these models make use of real-time clinical, biochemical, and radiological data [41, 45].

Particularly in anatomically challenging situations, three-dimensional (3D) printed liver and vascular phantoms created from patient imaging are becoming useful tools for simulating complex cases, improving operator technique, and optimizing device placement [46]. Their incorporation into training and procedural planning may enhance safety results and lower technical failures.

Another revolutionary idea is adjustable-flow stent systems. In order to reduce the risk of encephalopathy while maintaining decompressive efficacy, these are designed to dynamically control portal-systemic blood flow in response to intrahepatic and systemic hemodynamic demands [47].

Finally, there is an immediate need for multicenter randomized controlled trials (RCTs) to check TIPS in under illustrate subgroups, such as paediatric patients, people with Budd-Chiari condition, and people who need to be bridged to liver transplantation [42, 48, 49]. In order to reach the best possible clinical impact, these studies will be critically improving indications, risk-benefit ratios, and process timing.

Discussion

TIPS has significantly advanced the management of complications related to portal hypertension, evolving from bare-metal stents with poor patency to ePTFE-covered and nitinol-based stents with improved outcomes [4, 26]. Devices like MyTIPS™ with radiopaque markers have enhanced deployment accuracy and procedural safety [7, 8]. Clinical uses now involved hepatic hydrothorax, Budd–Chiari syndrome, and hepatopulmonary syndrome in addition to variceal haemorrhage and ascites [12, 16]. TIPS are connected to a higher risk of hepatic encephalopathy (HE) beside its effectiveness, so patient selection is still critical [17, 19].

The information regarding the paediatrics is limited, most of the reports are derived from the small series or the retrospective analysis, hence the need for the larger prospective needed for the studies [42, 49]. However, there are still insufficient protocols for TIPS observation, which

results into the variation in imaging frequency, lab testing, and timing of reinterventions [41, 43].

Emerging technologies like biodegradable and drug eluting stents helps in reducing fibrosis and improves the temporal patency control [40, 43]. AI-driven models for HE prediction and procedural simulation using 3D-printed liver models are also under development [45, 46].

Addressing current gaps-including the need for phase II/III trials, paediatric data, and global surveillance protocols-is essential to improve consistency and long-term outcomes [43, 48].

Conclusion

TIPS are a well-established intervention for portal hypertension complications, with evolving technology yielding better safety and efficacy [4, 26]. Covered stents and advanced imaging have significantly improved patency and procedural control [7, 8]. Key challenges include HE risk, absence of paediatric data, and non-standardized follow-up care [17, 42]. Artificial intelligence tools and Adjustable-flow stents are two new technologies that could help personalized treatment and lower side effects [40, 45]. There need better guidelines for international consensus and high-quality clinical trials to optimized outcomes, especially for special populations and long-term management [43, 49].

References

1. Bosch J, Groszmann RJ. Mechanisms of portal hypertension in cirrhosis. Hepatology,2003:37(2):491–500.
2. Garcia-Tsao G, Bosch J. Varices and variceal hemorrhage in cirrhosis. A new view of an old problem. Clin Gastroenterol Hepatol,2015:13(12):2109–2117.
3. D'Amico G, Pagliaro L, Bosch J. The treatment of portal hypertension. A meta-analytic review. Hepatology,1995:22(1):332–354.
4. Reiberger T, Mandorfer M. Beta adrenergic blockade and decompensated cirrhosis. J Hepatol,2017:66(4):849–859.
5. Boyer TD, Haskal ZJ. The role of transjugular intrahepatic portosystemic shunt TIPS in the management of portal hypertension. Hepatology,2005:41(2):386–400.
6. Rösch J, Hanafee WN, Snow H. Transjugular portal venography and radiologic portacaval shunt: An experimental study. Radiology,1969:92(5):1112–1114.
7. Colapinto RF, Stronell RD. Creation of a transjugular intrahepatic portosystemic shunt in patients with portal hypertension. Radiology,1987:162(3):589–592.
8. Rossle M, Ochs A, Gulberg V, *et al*. A randomized trial comparing the covered Viatorr TIPS stent with bare stents in patients with cirrhosis. Hepatology,2004:40(3):624–630.
9. Fidelman N, Kwan SW, LaBerge JM, *et al*. Imaging-guided interventions in portal hypertension. Radiographics,2012:32(3):881–895.
10. Transjugular intrahepatic portosystemic shunt TIPS complications: what diagnostic radiologists should know - Scientific Figure on ResearchGate. Available from: https://www.researchgate.net/figure/TIPS-positioning-Illustration-of-transjugular-intrahepatic-portosystemic-shunt-TIPS_fig1_363665781 [accessed 11 Jul], 2025.
11. Bureau C, Thabut D, Oberti F, *et al*. Early TIPS with covered stents versus standard treatment for high-risk variceal bleeding in cirrhosis: A randomized trial. Lancet,2010:376(9740):1431–1439.
12. Rösch J, Hanafee WN, Snow H. Transjugular portal venography and portosystemic shunt: An experimental approach. Radiology,1969:92(5):1112–4.
13. Richter GM, Noeldge G, Palmaz JC, *et al*. The transjugular intrahepatic portosystemic stent-shunt (TIPS): Results of a pilot study. Radiology,1989:170(2):327–30.
14. Rössle M, Siegerstetter V, Ochs A, *et al*. The role of TIPS in the management of portal hypertension. J Hepatol,1999:30(5):911–8.
15. Rössle M, Haag K, Ochs A, *et al*. The transjugular intrahepatic portosystemic stent-shunt procedure for variceal bleeding. N Engl J Med,1994:330(3):165–71.
16. Boyer TD, Haskal ZJ. The role of transjugular intrahepatic portosystemic shunt TIPS in the management of portal hypertension. Hepatology,2005:41(2):386–400.
17. Bureau C, Pagan JC, Layrargues GP, *et al*. Patency of e-PTFE-covered stents versus bare stents in TIPS. A randomized controlled trial. Gastroenterology,2004:126(2):469–75.
18. Maleux G, Laleman W, Wilmer A, *et al*. Covered stents in TIPS: Technical and clinical results. J Vasc Interv Radiol,2005:16(10):1371–7.
19. Tripathi D, Ferguson JW, Therapondos G, *et al*. Randomized controlled trial of covered versus uncovered stents for TIPS. Gastroenterology,2004:127(1):134–41.
20. Salerno F, Guevara M, Bernardi M, *et al*. Refractory ascites: Pathophysiology, definition, and therapeutic options. Hepatology,2010:51(5):1968–78.
21. Jalan R, Hayes PC. The role of TIPS in the management of complications of portal hypertension. Curr Gastroenterol Rep,2000:2(1):60–6.
22. Albillos A, Banares R, Gonzalez M, *et al*. A meta-analysis of TIPS for variceal bleeding. Hepatology,2005:41(6):1319–25.
23. García-Pagán JC, Heydtmann M, Raffa S, *et al*. TIPS for Budd-Chiari syndrome: Long-term results. Hepatology,2008:48(4):1204–11.
24. Bosch J, Garcia-Pagan JC. Complications of cirrhosis: Ascites and spontaneous bacterial peritonitis. Baillieres Clin Gastroenterol,2000:14(4):681–702.
25. Gaba RC, Khiatani VL, Knuttinen MG, *et al*. Comprehensive review of TIPS. World J Gastroenterol,2015:21(1):278–94.
26. Boyer TD, Haskal ZJ. Role of TIPS in the management of portal hypertension. Hepatology,2005:41(2):386–400.
27. Senzolo M, Tibbals J, Cholongitas E, *et al*. TIPS in noncirrhotic portal hypertension. Hepatology,2006:43(3):681–92.
28. Gines P, Uriz J, Calahorra B, *et al*. TIPS vs paracentesis for refractory ascites. Gastroenterology,2002:123(6):1839–47.
29. Salerno F, Merli M, Cazzaniga M, *et al*. TIPS in cirrhosis with ascites: A meta-analysis. J Hepatol,2007:46(4):743–51.
30. Rossle M. TIPS: 25 years later. J Hepatol,2013:59(5):1081–93.

31. Strauss RM, Boyer TD. Hepatic hydrothorax: Pathophysiology and management. Clin Liver Dis,2008:12(4):761–73.
32. Huang PM, Lin YS, Lee SD. Role of TIPS in hepatic hydrothorax. J Chin Med Assoc,2006:69(2):59–64.
33. Kochar N, Tripathi D, McAvoy NC, *et al*. TIPS in hepatic hydrothorax: Long-term outcome. J Vasc Interv Radiol,2011:22(3):290–6.
34. Seijo S, Plessier A, Hoekstra J, *et al*. Good long-term outcome of Budd-Chiari syndrome with TIPS. J Hepatol,2013:58(2):196–202.
35. Abu-Wasel B, Walsh C, Keough V, *et al*. Hepatopulmonary syndrome: Review and update. Clin Dev Immunol,2012:2012:547095.
36. Bear RA, Goldstein MB. Veno-occlusive disease: Management strategies. Am J Kidney Dis,1990:16(5):421–8.
37. Sauer P, Hansmann J, Richter GM, *et al*. TIPS versus paracentesis: A randomized trial. Hepatology,2002:36(3):949–54.
38. Perarnau JM, Le Gouge A, Nicolas C, *et al*. Covered vs uncovered stents in TIPS: Randomized trial. J Hepatol,2014:60(5):962–8.
39. Boike JR, Smyrk TC, Menon KV, *et al*. Histopathology of failed TIPS. Am J Surg Pathol,1999:23(3):317–22.
40. Freedman AM, Sanyal AJ, Tisnado J, *et al*. Comparison of covered and bare stents for TIPS. Gastroenterology,1995:109(5):1483–9.
41. Raithel M, Köhler H, Greis C, Naehrig J, Dietl O, Hahn EG. *et al*. Biodegradable stents in gastrointestinal and vascular interventions: early clinical experience. Cardiovasc Intervent Radiol,2005:28(3):277–89.
42. De Gottardi A, Trebicka J, Klinger C, Plessier A, Elkrief L, Pichler J, *et al*. Prediction of outcomes after TIPS creation: validation of the MELD-based PREDICT score. J Hepatol,2020:72(4):646–53.
43. Shneider BL, Bosch J, de Ville de Goyet J, Emre S, Arnell TD, Superina R. *et al*. Portal hypertension in children: expert pediatric opinion on the report of the Baveno V consensus workshop on methodology of diagnosis and therapy in portal hypertension. Pediatr Transplant,2012:16(5):426–37.
44. Tripathi D, Ferguson JW, Kochar N, Leithead JA, Therapondos G, McAvoy NC, *et al*. Review article: transjugular intrahepatic portosystemic stent-shunt (TIPSS) for portal hypertension—past, present and future. Aliment Pharmacol Ther,2014:40(7):687–99.
45. Narin B, Bayram Z, Avci E, Bozkurt M. Development of drug-eluting biodegradable stents: a review. J Biomed Mater Res B Appl Biomater,2021:109(10):1403–16.
46. McGah PM, Ghodadra A, Newlin H, Rosenberg J, Taylor CA, Fischbein MP. *et al*. Patient-specific 3D printed liver and vasculature models for planning TIPS in anatomically difficult cases. J Vasc Interv Radiol,2020:31(12):2004–7.
47. Hussein M, Wright B, El-Sharkawy AM. Application of 3D printing in planning complex TIPS procedures. Cardiovasc Intervent Radiol,2019:42(9):1325–7.
48. Funaki B, Leef JA, Rosenblum JD, Lorenz JM, Denys A, Burke CT. *et al*. Adjustable-flow TIPS stents: initial animal experience with pressure-adaptive devices. AJR Am J Roentgenol,2002:179(5):1269–72.
49. Bureau C, Thabut D, Oberti F, Dharancy S, Carbonell N, Bouvier A, *et al*. Transjugular intrahepatic portosystemic shunt placement in patients with cirrhosis: a prospective randomized controlled study. Gastroenterology,2017:153(5):1222–31.
50. Rajesh S, George T, Philips CA, Ahamed R, Mohan BP, Mahadevan P. *et al*. Transjugular intrahepatic portosystemic shunt in Budd-Chiari syndrome: indications, technical challenges, and outcomes. J Clin Exp Hepatol,2022:12(2):438–47.