Luo et al., Int J Radiol Med Imag 2017, 3: 124
https://doi.org/10.15344/2456-446X/2017/124

International Journal of
Radiology & Medical Imaging

Review Article Open Access

TIPS, >10000 Cases: A Review Spanning 25 Years

Shi Hua Luo[1], Jian Guo Chu[*2],He Huang[2] and Ke Chun Yao[3]

[1]*Department of Interventional Radiology, Guizhou Provincial People's Hospital, Guiyang 550002, Guizhou Province, China*

[2]*Department of Radiology, Air Force General Hospital of PLA, Beijing 100142, China*

[3]*Department of Ultrasound, Air Force General Hospital of PLA, 30 Fucheng Road, Haidian district, Beijing, 100142, P. R. China*

Abstract

Transjugular intrahepatic portosystemic shunt (TIPS) is currently used for the treatment of complications of portal hypertension [1]. The establishment of TIPS has been widely accepted as an alternative to surgery in the management of complications of portal hypertension, such as variceal bleeding, refractory ascites, Budd–Chiari syndrome, hepatorenal syndrome, hepatic hydrothorax and even hepatopulmonary syndrome [2]. After TIPS was introduced as an alternative treatment for complications related to portal hypertension, it has become increasingly recognized as an effective therapeutic option in a growing number of clinical situations [3,4].

Publication History:

Received: November 21, 2017
Accepted: December 27, 2017
Published: December 29, 2017

Keywords:

Portal hypertension, Transjugular intrahepatic portosystemic shunt

Introduction

Transjugular intrahepatic portosystemic shunt (TIPS) is currently used for the treatment of complications of portal hypertension [1]. The establishment of TIPS has been widely accepted as an alternative to surgery in the management of complications of portal hypertension, such as variceal bleeding, refractory ascites, Budd-Chiari syndrome, hepatorenal syndrome, hepatic hydrothorax and even hepatopulmonary syndrome [2]. After TIPS was introduced as an alternative treatment for complications related to portal hypertension, it has become increasingly recognized as an effective therapeutic option in a growing number of clinical situations [3,4].

The TIPS procedure was first described by Joseph Rösch in 1969. It is an interventional technique to establish a TIPS in which a tract or conduit is constructed within the liver between the systemic venous and portal systems, with the aim of portal decompression [5]. Our hospital first carried out TIPS treatment in 1992, although this was later than in Europe and America, it was one of the earliest centers for TIPS placement in China. At the time of this review, we have performed > 10,000 TIPS procedures over 25 years.

During these 25 years, our center has progressed from initial use of TIPS technology, to mastery of the technology, improvement of various aspects of the technology, and expansion of the indications for TIPS. In this paper, we review improvement of the technology and optimization of the whole treatment process. Several innovations have also been made, including a 5-year follow-up plan, punctured left branch of the portal vein, and stent grafting for treatment of sinusoidal obstruction syndrome (SOS).

Improvement TIPS Technology

Reshape the puncture set

In the TIPS procedure, there are many processes, among which portal vein puncture is the most difficult and important. If the portal vein is successfully punctured, it means more than half the work has been done. Generally speaking, interventional radiology techniques can be described as "getting in by every hole", but TIPS is described as "No hole while needed enter into", which increases the technical difficulty of operation, and the hepatic vein and portal vein between the complex three-dimensional anatomical position, angle of the relationship between the cirrhosis of liver atrophy after each blood caused by pipe changes to TIPS difficult operation. The most severe complication of TIPS is intraperitoneal bleeding, which often occurs in this situation, so mastering puncture of the intrahepatic portal vein determines the success rate and prognosis of TIPS [6].

The RUPS-100 liver access set (Cook Inc., Bloomington, IL, USA) is commonly used in China for portal vein puncture. The RUPS-100 needle is easily bent or damaged after repeated use due to the hardness of liver fibrosis. In China, the majority of cirrhosis develops from hepatitis, and a small proportion is caused by schistosomiasis or alcohol [7]. The liver volume of cirrhosis patients in China is reduced and the texture is hard. In addition, the position of the intrahepatic portal vein and the bifurcation of its left and right branches are different. In view of this, we need to reshape the angle of the RUPS-100 puncture set.

The original angle of RUPS-100 puncture set is fixed since it is made. During the TIPS process, the needle of the RUPS-100 puncture set will be turned to different direction depended upon the different anatomy of portal verin of the right branch or the left branch of portal vein. But the needle is straight, then you changed the angle of metal cannula will guiding the direction of punture needle.

In general, before the portal vein punctured, according to vein portography is shown in the portal phase at the posterior anterior position and at lateral position under fluoroscopy guidance, respectively, reshape the angle of RUPS-100 metal cannula to extend the line tip whether effective distance (maximum puncture distance RUPS-100 is 4.8cm) and desire angle through the portal vein branch intersection until satisfied. RUPS-100 metal cannula hardness is small, then easy to adjust (Figure 1).

Change from TIPS to direct intrahepatic portocaval shunt (DIPS)

Before 2000, we used the classic TIPS procedure [8]. The right hepatic vein was reached using a TIPS set after hepatic venography, and the right branch of the portal vein was punctured from the right hepatic vein under the guidance of superior mesenteric artery digital subtraction angiography in both the posterior anterior and lateral

***Corresponding Author:** Dr. Jian-Guo Chu, Department of Radiology, Air Force General Hospital of PLA, 30 Fucheng Road, Haidian District, Beijing 100142, China, Tel: +86-15611161272; E-mail: cjgchina@126.com

Citation: Luo SH, Chu JG, Huang H, Yao KC (2017) TIPS, >10000 Cases: A Review Spanning 25 Years. Int J Radiol Med Imag 3: 124. doi: https://doi.org/10.15344/2456-446X/2017/124

positions of indirect porto angiography. When the branch of the portal vein was punctured and confirmed by porto angiography, a balloon dilated the hepatic tract. A stent was used for TIPS creation and portosystemic gradient (PSG) were measured before and after TIPS.

When a patient is confirmed with Budd Chiari syndrome [9], SOS [10], or hepatic vein stenosis or occlusion, catheterization of the right hepatic vein may not be possible. In these, as well as in the rare patients with inaccessible hepatic veins, direct puncture through the inferior vena cava (IVC) may be inevitable, using DIPS [11].

In the DIPS procedure, the puncture point is at the hepatic segment of the IVC, and the puncture needle can be directed to the left or right branch of the hepatic portal vein in any direction, and the condition of the hepatic vein is not considered. In the traditional TIPS procedure, the distortion of the puncture angle caused by the right hepatic vein is reversed, along with the adverse effects of the stent placement on the hepatic vein flow [12]. In addition, TIPS of the punctured point from the hepatic vein interferes with the normal structure of the second hepatic hilum, but DIPS is avoided (Figure 2). For>17 years, we have performed DIPS with high success and patency rate. The indications included hepatitis cirrhosis, alcoholic cirrhosis, Budd-Chiari syndrome, SOS, and other cryptogenic cirrhosis, with related complications of variceal bleeding and/or ascites.

Turned puncture right to left branch of portal vein

During the DIPS procedure, we punctured as far as possible the left branch of the portal vein. When the left branch of the portal vein was punctured and confirmed by porto angiography, a balloon dilated the hepatic tract. A stent was used for DIPS creation and PSG were measured before and after DIPS (Figure 3).

One of the advantages of the left portal vein being punctured and acting as a shunt target vessel is that the caudal end of the stent is parallel to the portal vein wall, which probably decreases the risk of portal vein stenosis. The stent is straight, avoiding the shear force of the blood flow caused by the stent [13]. Long ago has come from the hypothesis [14,15] that splenic vein and superior mesenteric venous reflux from the blood in the main portal vein in fluid dynamics, alongside the trunk on both sides of the wall of portal vein, and failed to fully mixed, the right branch of the portal vein receives superior mesenteric venous blood, and the left branch of the portal vein mainly receives splenic venous blood.

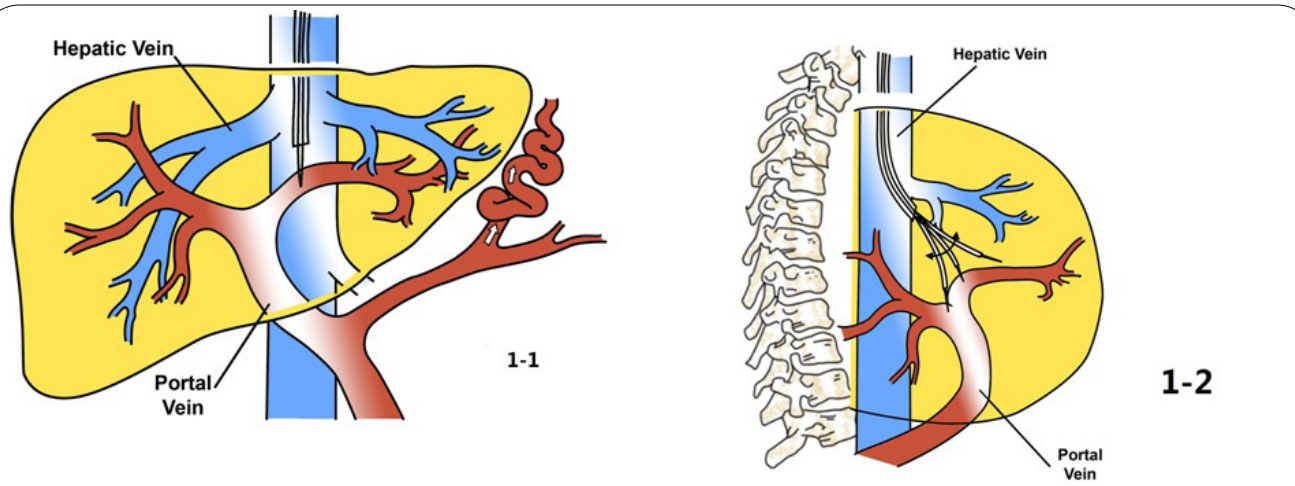

Figure 1. Reshape the angle of RUPS-100 metal cannula to puncture portal vein. Reshape the angle of RUPS-100 metal cannula to extend the line tip whether effective distance and desire angle through the portal vein branch intersection until satisfied. Figure1-1 shows the needle is inserted into the left branch of portal vein directing to front in the posterior anterior positions. Figure 1-2 showed the metal cannula of RUPS-100 puncture set reshaped to different angle according to the formation of portal vein, the needle could insert into the right, left branch of portal vein or failed in the lateral positions.

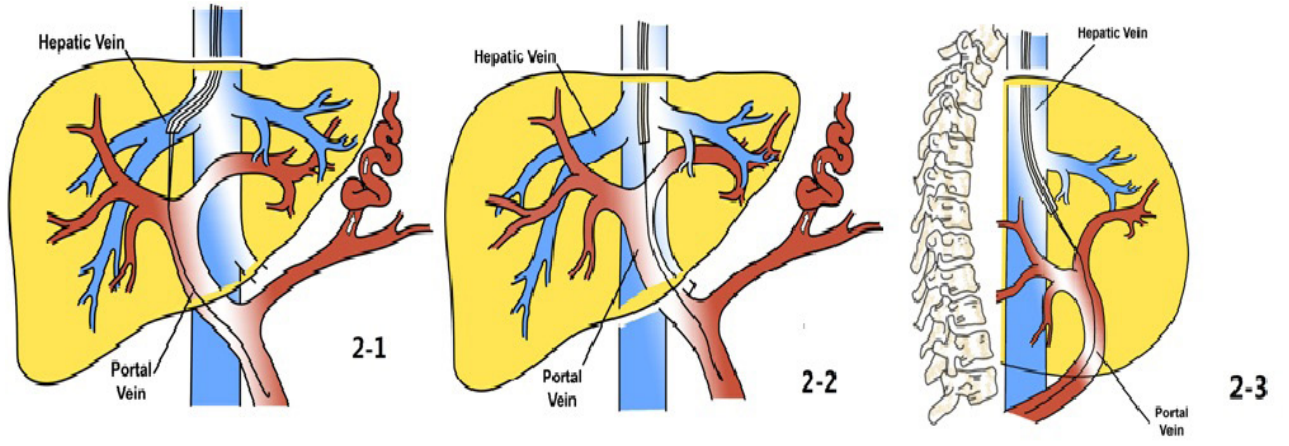

Figure 2: Change from classical TIPS to DIPS. We have performed from classical TIPS to DIPS more than 17 years with high success. Figure 2-1 shows classical TIPS. Figure 2-2, 2-3 shows punctured from segment of liver of IVC to left branch of intrahepatic portal vein, the guide wire passed through to superior mesenteric vein in the posterior anterior and lateral positions, respectively.

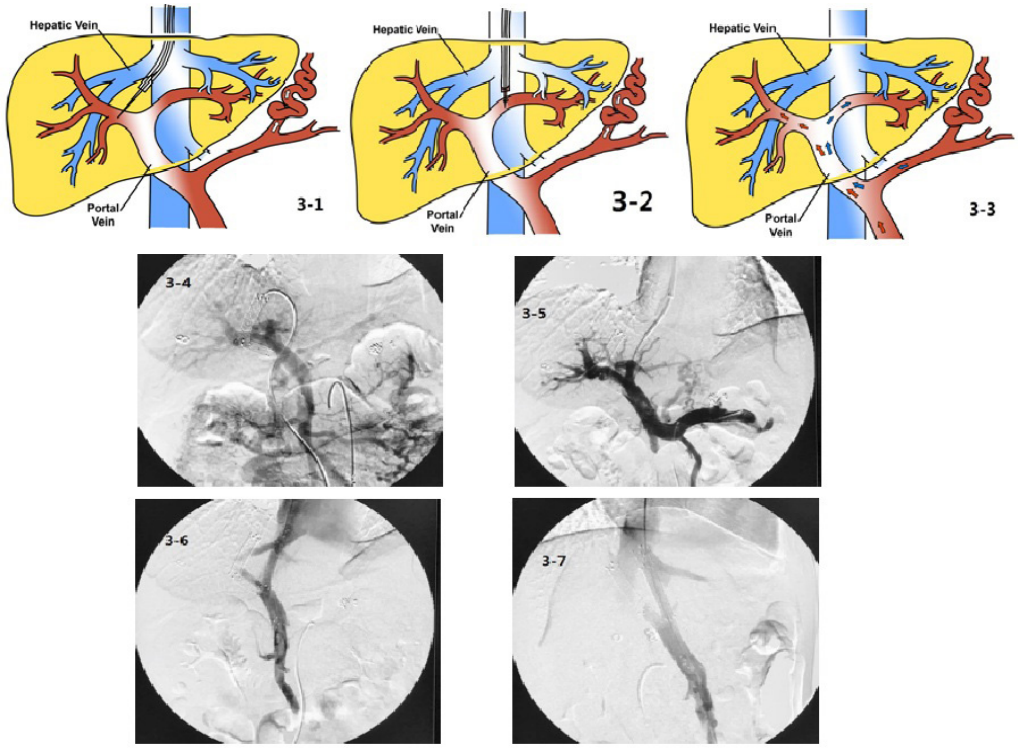

Figure 3: Turned puncture right to left branch of portal vein. Puncture of the left portal vein has many advantages compared to the right branch in TIPS. Figure 3-1 shows the needle punctrued the right branch of inhepatic portal vein in classical TIPS. Figure 3-2 shows the change of turned puncture right to left branch of portal vein. Figure 3-3 shows the hypothesis that splenic vein and superior mesenteric venous reflux from the blood in the main portal vein in fluid dynamics. Figure 3-4 shows it is easy to cause the stent angulation, flex, thereby affecting the patency rate in classical TIPS of punctured right vessel. Figure 3-5, 3-6 and 3-7 shows a parallel DIPS created by punctured the left branch of intrhepatic portal vein. The shun is short and straight compared with the former.

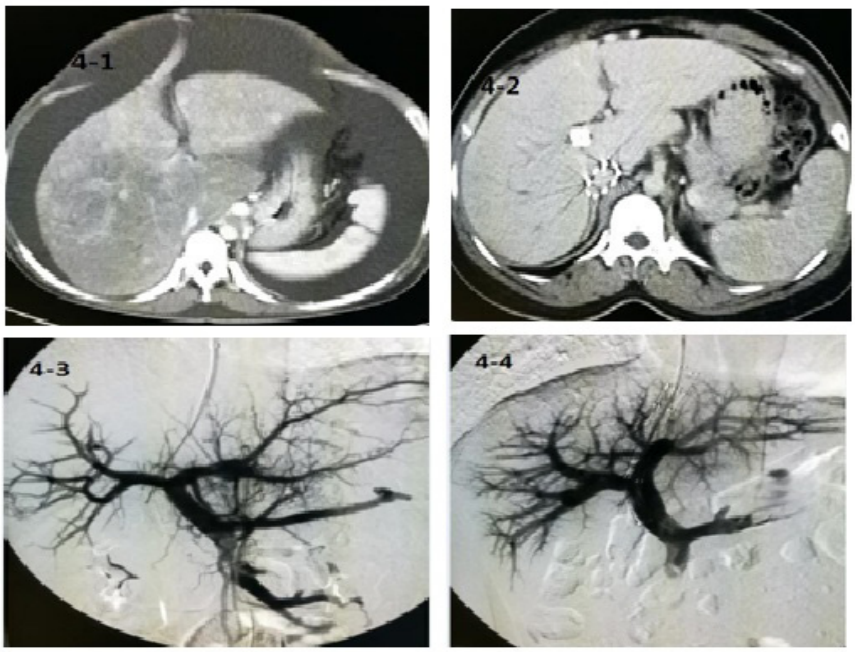

Figure 4: Imaging of a patient during follow-up protocol. A patient with SOS related hepatic cirrhosis that was reversed after TIPS treatment. Figure 4-1 shows preoperative CT shows reduced liver lobes and hepatic volume reduction. Figure 4-2 shows 2 years after TIPS treatment, liver CT scanning showed that the lobe of the liver increased, and the left lobe was markedly increased. Figure 4-3 shows a patient undergoing primary TIPS treatment portal vein angiography sparse branch of intrahepatic portal vein. Figure 4-4 shows 2 years after TIPS treatment, angiography showed shunt stent occlusion, development of the portal vein and its branches, and PSG decreased to normal level.

The second advantage of the left portal vein acting as the target shunt in DIPS, is that diverting the non-nutritive blood from the splenic vein into the TIPS reduces the incidence of hepatic encephalopathy (HE) [16,17]. Since about 2000, we changed from TIPS to DIPS, and tried to use the left branch of the portal vein as the shunt target vein. The incidence of HE was significantly reduced. Another advantage of the left portal vein acting as the target shunt in DIPS, is the shun is short and straight compared with the classical TIPS, which decrease the stent angulation, flex, thereby affecting the patency rate caused by blood flow is remodeled by the inflow position after stent placement, which produces a vortex and turbulence, and the shear force and uneven flow cause endometrial damage, thrombosis, intimal hyperplasia and stenosis (Figure 3-4, 5, 6, 7).

Improvement of stent deployment

It was previously thought that the shear force of the blood flow at the end of the stent, and fibrotic healing response to the injury of shunt creation lead to parenchymal stenosis, resulting in stenosis and occlusion due to pseudo intimal hyperplasia of the shunt end [18]. A previous study has suggested that the end of the stent positioned in the hepatic vein within 2 cm of the junction between the hepatic vein and IVC improves the primary patency of DIPS [19]. Other factors such as tract angle influence the primary patency of DIPS [12], portal vein to parenchymal tract and hepatic vein to parenchymal tract angle.

In our center we have investigated the problem of initial stent position at the time of TIPS creation and have predicted stent patency. We have confirmed that the initial end of the stent position within the outflow of

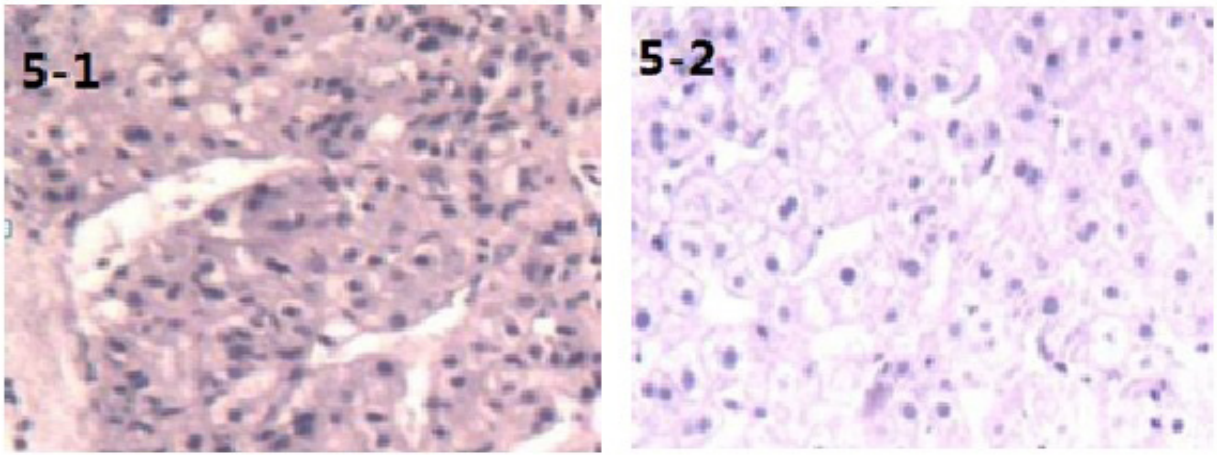

Figure 5: Pathological manifestation of an SOS patient during the follow-up protocol. In a patients with SOS due to oral Tusanqi (Gynura segetum) treated with IVC stenting and DIPS, liver cirrhosis was reversed. Figure 5-1 shows formation of liver cirrhosis; liver sinus surrounding inflammatory cell infiltration, and hepatic sinus expansion before treatment. Figure 5-2 shows after treatment, the liver cirrhosis nodules disappeared, and hepatocyte swelling and hepatic sinusoid dilatation were seen after 5 years follow-up.

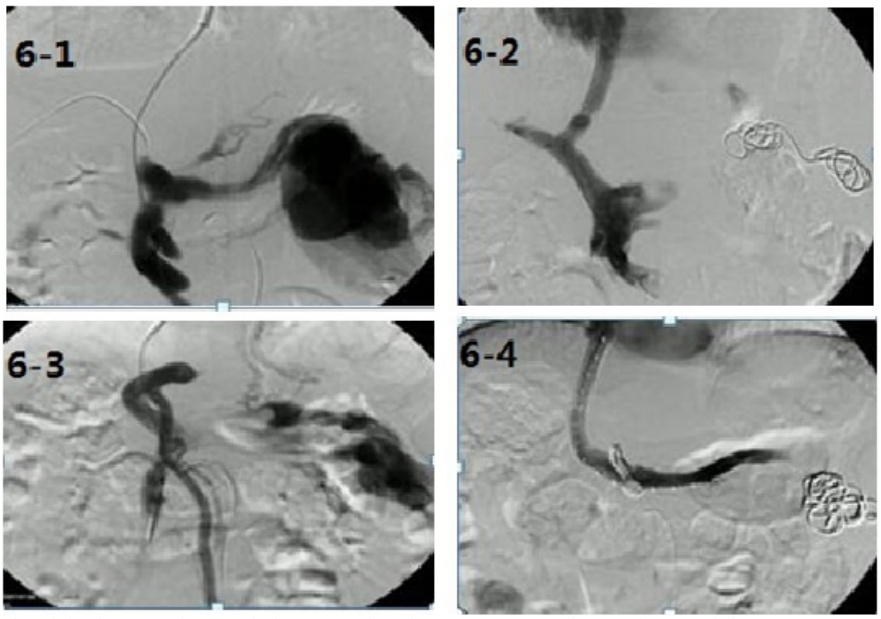

Figure 6. Splenorenal and umbilical venous shunt embolization with coils. Figure 6-1, 6-2 shows splenorenal shunt. Figure 6-3,6-4 shows umbilical vein shunt. Patients with coil embolization had reduced risk of bleeding and guaranteed prograde portal flow to the liver.

the DIPS shunt is an important determinant of shunt patency. Stenosis or occlusion in cases with shunt dysfunction correlates well with initial stent position, and we suggest that an adequate stent should be extended to the junction of the hepatic vein and IVC. The portal blood flow is remodeled by the inflow position after stent placement, which produces a vortex and turbulence, and the shear force and uneven flow cause endometrial damage, thrombosis, intimal hyperplasia and stenosis [12,20,21]. Thus, we suggest that if improvement is needed at the front end of the stent, one should not enter the main portal vein, to reduce the possibility of stenosis or occlusion.

The initial stent position within the outflow and inflow of the DIPS creation is an important determinant of shunt primary patency. We suggest that the initial stent position of the outflow should be extended to the junction of the hepatic vein and IVC, and the inflow to the left branch of the portal vein [22].

Concept Improvement

Five-year follow-up protocol

All of the patients who underwent TIPS were evaluated and followed up by the same medical team using a prospective protocol diagnostic work-up and surveillance strategy. Before the operation, the patients' medical histories were taken, and after TIPS, the patients' were followed up according to the same protocol.

Baseline duplex sonography was performed on the day after TIPS creation. Subsequent shunt velocities were compared to this baseline result during follow-up. After TIPS, patients were placed into a routine follow-up protocol identical for each group. They were seen as outpatients 1 mo after the procedure and then every 3 mo or whenever needed. Each consultation included a clinical examination, blood

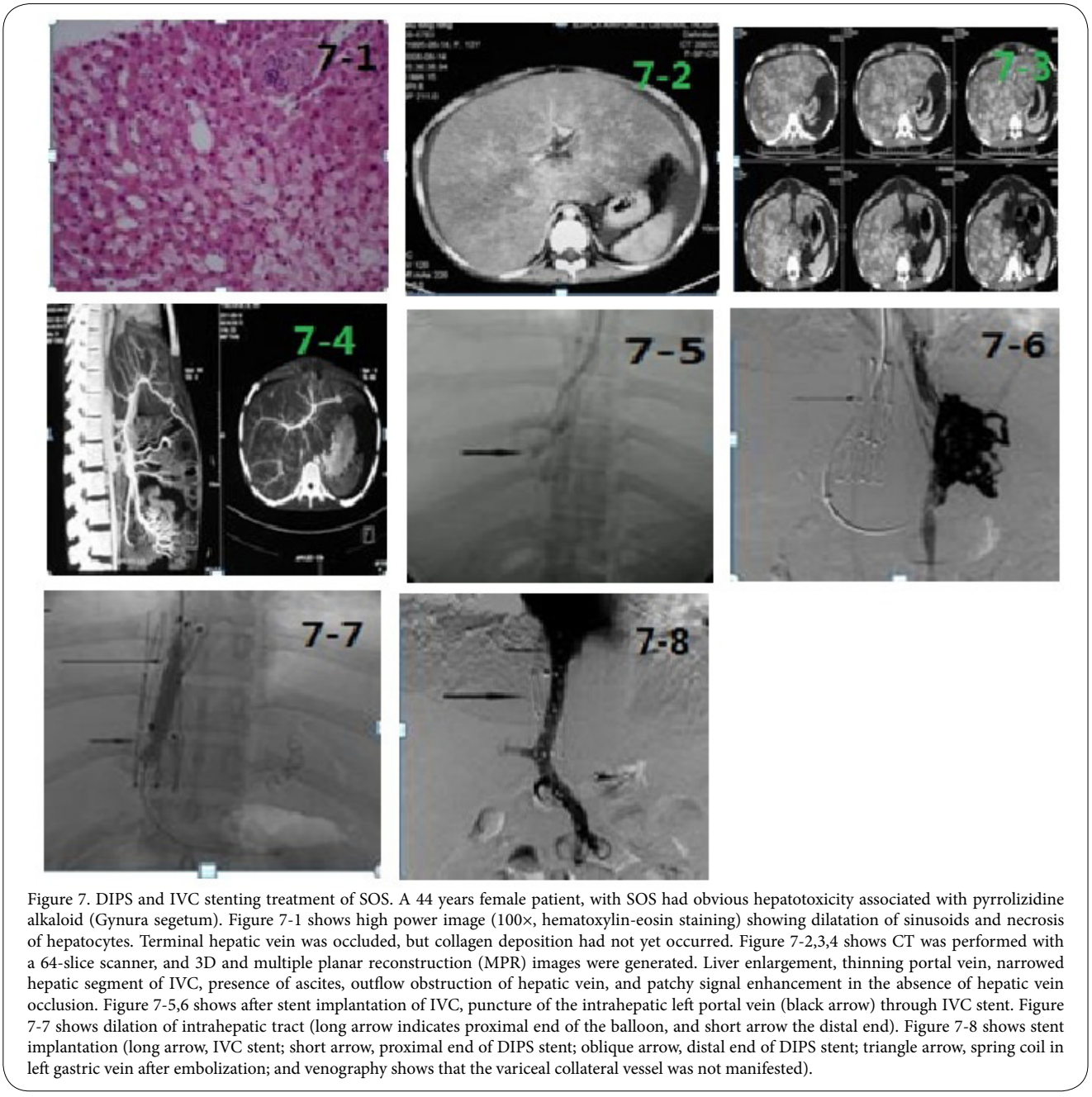

Figure 7. DIPS and IVC stenting treatment of SOS. A 44 years female patient, with SOS had obvious hepatotoxicity associated with pyrrolizidine alkaloid (Gynura segetum). Figure 7-1 shows high power image (100×, hematoxylin-eosin staining) showing dilatation of sinusoids and necrosis of hepatocytes. Terminal hepatic vein was occluded, but collagen deposition had not yet occurred. Figure 7-2,3,4 shows CT was performed with a 64-slice scanner, and 3D and multiple planar reconstruction (MPR) images were generated. Liver enlargement, thinning portal vein, narrowed hepatic segment of IVC, presence of ascites, outflow obstruction of hepatic vein, and patchy signal enhancement in the absence of hepatic vein occlusion. Figure 7-5,6 shows after stent implantation of IVC, puncture of the intrahepatic left portal vein (black arrow) through IVC stent. Figure 7-7 shows dilation of intrahepatic tract (long arrow indicates proximal end of the balloon, and short arrow the distal end). Figure 7-8 shows stent implantation (long arrow, IVC stent; short arrow, proximal end of DIPS stent; oblique arrow, distal end of DIPS stent; triangle arrow, spring coil in left gastric vein after embolization; and venography shows that the variceal collateral vessel was not manifested).

chemistry, and assessment of HE. Ultrasonography was performed at 1 and 4 week after TIPS and then at 3 and 6 months, and at 6-months intervals thereafter, or in cases of recurrent bleeding or ascites. If the patient did not have any symptoms, then they were followed up once a year.

At the once yearly follow-up, patient received direct portography through the jugular vein into the TIPS, to investigate the changes in portal system hemodynamics and portal vein pressure. The shunt could be dilated by balloon, stent replacement, shunt reduction, or repeated TIPS creation when needed. We persisted in this follow-up procedure for 5 years for every patient who underwent TIPS placement in our center although some cases were lost to follow-up. The 5-year follow-up protocol detected changes in the patients after TIPS placement, and detected when related symptoms occurred.

Liver cirrhosis reversal after TIPS operation

During 5-years follow-up, some patients showed no symptoms related to portal hypertension, PSG levels decreased to normal two or three times, no gastroesophageal collateral vessels were observed during portography, prograde portal flow and the small branches of the intrahepatic portal vein developed well, the shunt showed stenosis or occlusion in many patients, and computed tomography or magnetic resonance imaging showed liver changes, including liver density or signaling becoming uniform, reduction in sclerotic nodules, the relative edge finishing, the proportion of non leaf disorders, the maximum transverse diameter of the liver increasing compared with preoperatively, and the maximum anteroposterior diameter was larger than that before the operation (Figure 4).

We hypothesize that if only the liver cirrhosis is reversed, then some of the patients undergo percutaneous liver biopsy or transjugular hepatic vein liver biopsy before and after TIPS during follow-up. Pathological examination shows that liver pathology associated with cirrhosis reversal is manifested as an increase in normal liver cells, reduced fibrous tissue, increased normal lobular structure, and decreased or absent sclerotic nodules (Figure 5).

Liver cirrhosis is induced by chronic inflammation and fibrous tissue proliferation. Portal hypertension is a common complication of advanced cirrhosis. Previously, it was believed that cirrhosis was not reversible, but in recent years, some studies have confirmed that even if chronic liver disease develops into cirrhosis, if the pathogenic factors are effectively controlled, it is also possible to reverse it [23]. Many animal experiments and clinical research results have confirmed that the primary pathogenic factors in liver fibrosis are reversible [24] that fifty-seven patients with chronic hepatitis B treated with entecavir for 3 years showed improved liver tissue, reduced Knodell score by > 2 points in up to 96%, and decreased Ishak fibrosis score by ≥ 1 points in up to 88%, including 10 cases of severe fibrosis or cirrhosis in patients with [24]. A recent systematic review showed reversal of cirrhosis after antiviral treatment to obtain a sustained viral response in patients with chronic hepatitis B and chronic hepatitis C. In 463 patients with of hepatitis B cirrhosis and 58 with hepatitis C cirrhosis, 70% of the former and 64% of the had reduced or dissipated cirrhosis after treatment [26]. Limited data show that, in patients with long-term control of the pathogenesis of cirrhosis, liver inflammation subsides, and it is possible to reduce or reverse cirrhosis.

TIPS in principle, its essence is the limited portacaval side using a minimally invasive approach in the liver of the side shunt, in some sense equivalent to the selective distal splenorenal shunt, should belong to choose regional pressure shunt category also, can be seen as one of the pathogenic factors of removal of portal hypertension. The phenomenon of cirrhosis reversal observed during the follow-up of patients after TIPS, and it will be confirmed by animal experiments in the future, and the clinical analysis of multiple factors should be carried out to confirm.

Ectopic venous embolization in TIPS treatment

Portal hypertension is characterized by abnormal portal hemodynamics, increased resistance of the portal venous system. Because of the pathological changes in liver structure and microcirculation, the vascular resistance of the liver increases and portal vein perfusion decreases [27]. Although the hepatic arterial blood flow increases significantly after TIPS, the increase in hepatic artery perfusion does not fully compensate for the decrease in portal perfusion, leading to a decrease in hepatic blood flow, and HE [28].

In splenorenal, gastrorenal and umbilical vein shunts, the shunt diverts part of the portal vein blood flow and reduces portal vein pressure. The reduction in portal blood flow can damage liver function and increase susceptibility to HE; the incidence of which increases with time [29]. In addition, in these three kinds of shunt, blood flow is usually higher, which makes blood vessels prone to life-threaten bleeding [30]. During the TIPS procedure, patients who undergo splenorenal, gastrorenal and umbilical venous shunt embolization have increased portal blood supply, but also can prevent the rupture of these vessels after embolization.

We retrospectively identified 53 consecutive patients with splenorenal, gastrorenal and umbilical vein shunt with coil embolization during the TIPS procedure. Portal vein angiography showed that the shunt was occluded and the blood flow direction of the portal vein shifted to the prograde portal flow, thus ensuring perfusion of the TIPS (Figure 6).

Extension of indications for TIPS

TIPS has been used to treat most of the complications of portal hypertension. It has mainly been used for variceal bleeding and refractory ascites, although other indications have been accepted, such as Budd-Chiari syndrome, hepatorenal syndrome, hepatic hydrothorax and even hepatopulmonary syndrome. In the past 25 years, our center has progressed from initial use of TIPS technology, to mastery of the technology, improvement of various technical aspects, and expansion of the indications to include variceal bleeding and refractory ascites. Later we developed to the management of Budd–Chiari syndrome, hepatorenal syndrome, hepatic hydrothorax and hepatopulmonary syndrome with TIPS. In the process of TIPS development, we realized that other conditions could also be treated by TIPS, including liver cancer patients with portal hypertension, patients with portal cavernous transformation, and stent grafting for SOS.

Understanding and DIPS treatment of SOS

SOS is a rare vascular disease of the liver, which can lead to lethal liver failure and portal-hypertension-related complications [31]. The clinical syndrome is characterized [32] by hepatomegaly, ascites, weight gain, increased aminotransferase levels, and jaundice due to sinusoidal congestion, which can be caused by alkaloid ingestion [33], hematopoietic stem cell transplantation (HSCT) [34], bone marrow transplantation, radiation-induced liver disease, and chemotherapy,

and it is also seen after solid organ transplantation [35]. The most common cause of SOS in China is herbal medicines containing pyrrolizidine alkaloids, mostly Tusanqi (Gynura segetum) [36].

DIPS involves creation of a side-to-side shunt between the portal vein and IVC via the caudate lobe of the liver [12]. A major advantage of DIPS is that it does not involve the hepatic vein, thus, it is especially useful in hepatic vein obstruction. However, those who have SOS with hepatomegaly, or narrowed or obstructed IVC, may undergo IVC stenting to recanalize the IVC blood flow.

We retrospectively identified 21 consecutive patients with proven SOS associated with hepatotoxicity of pyrrolizidine alkaloid related decompensated cirrhosis from January 1999 to January 2010. Indications for stent graft shunt were variceal hemorrhage, refractory ascites and hepatopulmonary syndrome. The technical success rate in all 21 patients was 100%, and there were major complications of the procedure. No patient died within 30 days after DIPS and IVC stenting, with an early survival rate of 100%. After the treatment, the symptoms disappeared, and the main index of liver function decreased to normal level. We conclude that IVC stenting combined with DIPS improves liver function and symptoms (Table 1, Table 2) (Figure 7). It also has a survival benefit for SOS associated with ascites and variceal bleeding of pyrrolizidine alkaloid related decompensated cirrhosis.

Our results provide evidence that IVC stenting combined with DIPS placement can be performed safely, and achieve good clinical results and survival rate in patients with SOS related to botanical hepatotoxicity. This is not consistent with the results of some previous studies [36]. Previous studies about the TIPS procedure in SOS associated with herbal hepatotoxicity have been rare. But this does not mean that TIPS has no good clinical effect for SOS. These studies have focused more on patients treated with HSCT, bone marrow transplantation, radiation-induced liver disease, chemotherapy, or after solid organ transplantation.

TIPS treatment for hepatocellular carcinoma (HCC)

Liver cirrhosis and hepatic cancer can occur after further evolution of liver damage [38]. There is a close relationship between cirrhosis and HCC; liver cancer is often complicated by cirrhosis, while liver cirrhosis often leads to the occurrence of liver cancer [39]. TIPS can effectively reduce portal pressure and relieve the clinical symptoms associated with various medical conditions [40]. The risk of postoperative liver failure is a major reason why TIPS has remained contraindicated for patients with portal hypertension and liver cancer [41,42] in the past.

SOS patients	*n*	Mean ± SD
Age (yr)		
Total cases	21	17.5 (13-21)
Female	4	
Male	17	
Etiology (viral/not viral)	0	
Child–Pugh class A	0	
B	6	
C	15	
Recurrent bleeding	4	
Refractory ascites	16	
Hepatopulmonary syndrome	1	
Both	0	

Table 1: Baseline characteristics of SOS cases.
21 consecutive patients with proven SOS associated with hepatotoxicity of pyrrolizidine alkaloid related decompensated underwent inferior vena cava stenting and DIPS therapy.

	Before treatment	After treatment	P value
n	21	21	
Total bilirubin(μmol/L)	69.88±11.95	20.89±10.12	0.007
Albumin(g/L)	29.75±6.31	78.21±4.59	0.006
ALT(U/L)	>1000±126.54	16.73±3.33	0.001
AST(U/L)	>1000±126.54	18.66±2.45	0.001
GGT(U/L)	168.56±9.18	28.69±12.27	0.003
PSG(mmHg)	50.61±7.12	26.33±4.06	0.009
IVC pressure(mmHg)	26.16±2.74	8.67±6.71	0.004

Table 2: Clinical results of study.
After the treatment, the symptoms disappeared, the main index of liver function decreased to normal level. ALT, alanine aminotransferase, AST, aspartate aminotransferase, GGT, gamma glutamyl transpeptidase.

We conducted a retrospective analysis of 36 cases of portal hypertension with HCC that were treated in our hospital from January 2003 to January 2013 with TIPS plus palliative therapy, including TACE (transarterial chemoembolization, TACE) and percutaneous ethanol injection therapy or radiofrequency ablation, to assess the clinical safety and survival rate. There were no severe complications occurred. The 180-d, 1-year and 3-year cumulative survival rates were 95.10%, 87.12% and 68.03%, respectively. We concluded that TIPS combined with interventional treatments seems to be an effective and safe treatment for portal hypertension in patients with HCC (Figure 8).

Variceal bleeding of liver cirrhosis is the biggest threat in patients with primary liver cancer complicated with portal hypertension. In emergency cases during long-term cancer treatment, stopping

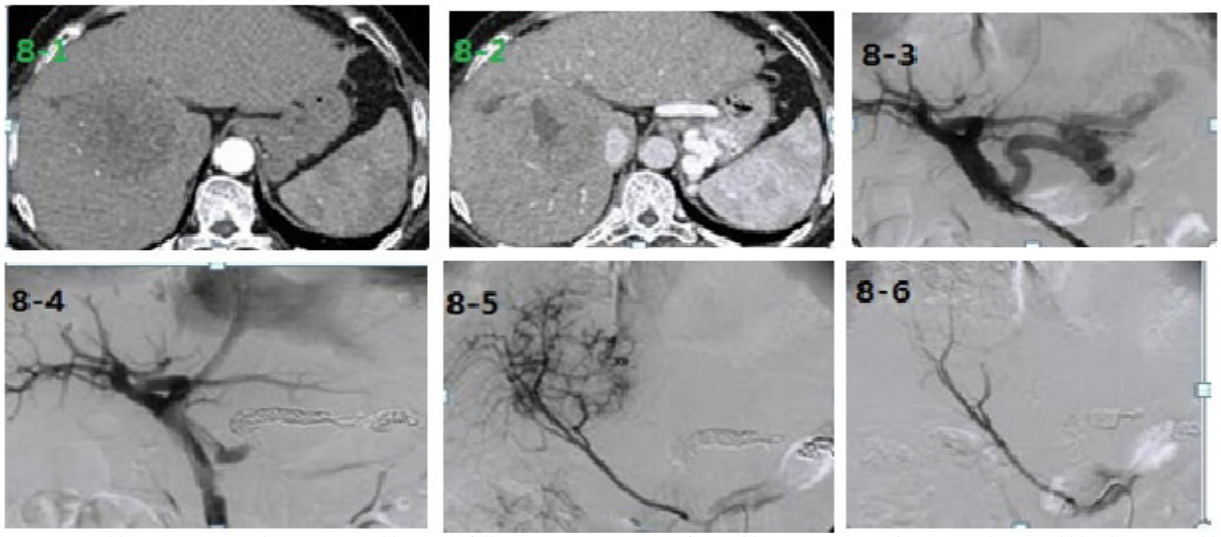

Figure 8. Portal hypertension with HCC treated by DIPS following TACE. A case of portal hypertension with HCC and variceal bleeding treated by DIPS following TACE. Figure 8-1, 8-2 shows HCC in the right liver lobe. Figure 8-3, 8-4 shows DIPS placement and embolization of the left gastric vein, with the shunt avoiding the solid tumor. Figure 8-5, 8-6 shows the patient undergoing TACE (transarterial chemoembolization, TACE).

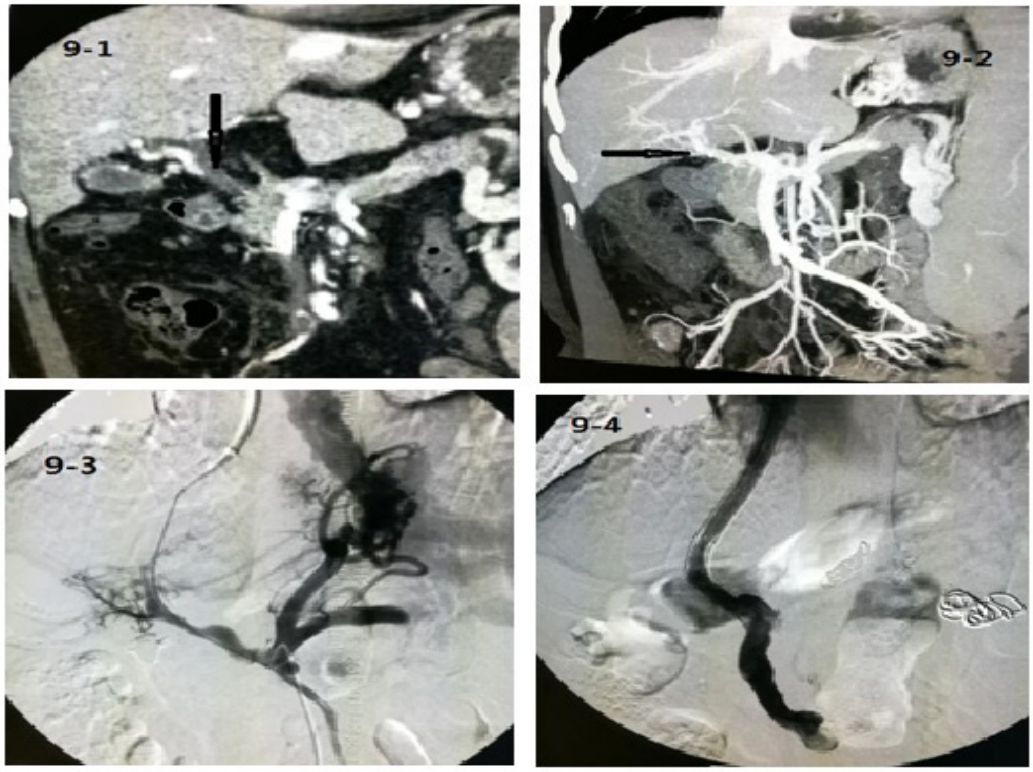

Figure 9: DIPS through intrahepatic collateral vessel. Figure 9-1 shows Thrombosis in the main portal vein and occluded (black arrow). Figure 9-2 shows collateral vessel formated in liver of CT imaging (black arrow). Figure 9-3 shows punctured the collateral vessel and guide wire passed to main portal vein. Figure 9-4 shows DIPS created through the collateral vessel and stent passed to main portal vein.

bleeding to extend the patient's life should be prioritized when there is a conflict between treatments. Therefore, in this study, TIPS treatment was conducted first, followed by treatment of liver cancer, in order not to lose the opportunity for implementing TIPS treatment.

TIPS for portal vein thrombosis (PVT)

PVT refers to thrombosis that develops in the trunk of the portal vein, including its right and left intrahepatic branches, or that originates everywhere in the portal venous system and may even extend to the splenic or superior mesenteric veins or towards the liver, involving the intrahepatic portal vein branches[43]. The main clinical manifestations of PVT are caused by gastroesophageal varices, splenomegaly, hypersplenism and ascites, and mesenteric venous involvement caused by abdominal pain, nausea, vomiting, loss of appetite, abdominal distension and diarrhea and other gastrointestinal symptoms [44].

The recent reviews on clinical practice guidelines [45,46] for TIPS did not recommend TIPS for PVT. However, TIPS has been progressively performed to treat PVT in many centers since the first report in 1993 [47], although PVT is still considered a relative contraindication for TIPS, despite the fact that the advantages of TIPS for PVT in patients with cirrhosis are evident, as it addresses portal hypertension and reconstructs portal vein flow.

We conducted a retrospective analysis of >100 cases of portal hypertension with PVT that were admitted to our hospital for study of eligibility. We treated TIPS with portal hypertension in some patients with PVT. Under guidance of the fluoroscopy and supported by a catheter, the guidewire passed through the thrombus site, pumping and sucking the blood bolt, and was inserted into the stent. For 13 patients with PVT in whom it was difficult to access via the vascular route, we created DIPS through intrahepatic collateral vessels. Patients who underwent TIPS via the jugular vein, percutaneous transhepatic approach to the portal vein, and failed to open the portal vein by splenic puncture were given up the TIPS treatment.

Among these 13 cases, primary technical success was 100%, and no patient died of severe procedure-related complications (Figure 9.). The portal hypertension related symptoms disappeared after successful TIPS deployment. We concluded that targeting intrahepatic collateral vessels for TIPS creation seems to be a safe and effective procedure in selected patients with PVT.

In patients with portal cavernoma, many collateral vessels are present around the hepatic hilum or branches of the right and left intrahepatic portal veins [48]. The collateral vessels do not return to the hepatic vein through the sinusoids, but return to the IVC, instead of forming varicose veins around the esophagus and gastric fundus [49], therefore, occlusion of the main portal vein or portal vein branch can lead to hypertension. If the TIPS procedure performanced in this large intrahepatic collateral vessels, drainage portal will play the blood flow, reduce portal vein pressure.

Conclusion

During these 25 years, our center has progressed from technical advancements in skills and expansion of the indications for TIPS. We reviewed improvement of the technology and optimization of the whole treatment process. Several innovations have also been made, including a 5-year follow-up plan, punctured left branch of the portal vein, and stent grafting for treatment of sinusoidal obstruction syndrome (SOS). But controlled study and multicenter study should be performed in the future to confirm some hypothesis.

Acknowledgement

The authors thank all the patients who were involved in this study of our hospital for their contributions to the data collection.

Author Contributions

Chu JG designed the research, Luo SH wrote the paper, He Huang contributed the data and figures, Yao KC revised the paper.

Competing Interests

The authors declare that no competing interests exist.

References

1. García-Pagán JC, Caca K, Bureau C, Laleman W, Appenrodt B, et al. (2010) Early use of TIPS in patients with cirrhosis and variceal bleeding. N Engl J Med 362: 2370-2379.
2. Ascha M, Abuqayyas S, Hanouneh I, Alkukhun L, Sands M, et al. (2016) Predictors of mortality after transjugular portosystemic shunt. World J Hepatol 8: 520-529.
3. Nardelli S, Gioia S, Pasquale C, Pentassuglio I, Farcomeni A, et al. (2016) Cognitive Impairment Predicts The Occurrence Of Hepatic Encephalopathy After Transjugular Intrahepatic Portosystemic Shunt. Am J Gastroenterol 111: 523-528.
4. Rössle M (2013) TIPS: 25 years later. J Hepatol 59: 1081-1093.
5. Nardelli S, Gioia S, Pasquale C, Pentassuglio I, Farcomeni A, et al. (2016) Cognitive Impairment Predicts The Occurrence Of Hepatic Encephalopathy After Transjugular Intrahepatic Portosystemic Shunt. Am J Gastroenterol 111: 523-528.
6. Pillai AK, Andring B, Faulconer N, Reis SP, Xi Y, et al. (2016) Utility of Intravascular US-Guided Portal Vein Access during Transjugular Intrahepatic Portosystemic Shunt Creation: Retrospective Comparison with Conventional Technique in 109 Patients.J Vasc Interv Radiol 27: 1154-1159.
7. Stanaway JD, Flaxman AD, Naghavi M, Fitzmaurice C, Vos T, et al. (2016) The global burden of viral hepatitis from 1990 to 2013: findings from the Global Burden of Disease Study 2013. Lancet 388: 1081-1088.
8. Schmidt-Martin D, Armstrong MJ, Rowe IA (2017) Transplant-Free Survival Rates After Covered Transjugular Intrahepatic Portosystemic Shunt. Gastroenterology 153: 869-870.
9. Mancuso A (2015) An update on the management of Budd-Chiari syndrome: the issues of timing and choice of treatment. Eur J Gastroenterol Hepatol 27: 200-203.
10. Kakar F, Akbarian Z, Leslie T, Mustafa ML, Watson J, et al. (2010) An outbreak of hepatic veno-occlusive disease in Western afghanistan associated with exposure to wheat flour contaminated with pyrrolizidine alkaloids. J Toxicol 2010: 313280-313287.
11. Tsauo J, Yu Y, Luo X, Wang Z, Liu L, et al. (2014) Direct intrahepatic portocaval shunt creation via the inter-strut space of the inferior vena cava stent. ClinRadiol 69: 896-899.
12. Bai M, He CY, Qi XS, Yin ZX, Wang JH, et al. (2014) Shunting branch of portal vein and stent position predict survival after transjugular intrahepatic portosystemic shunt. World J Gastroenterol 20: 774-785.
13. Cura M, Cura A, Suri R, El-Merhi F, Lopera J, et al. (2008) Causes of TIPS dysfunction.AJR Am J Roentgenol 191: 1751-1757.
14. Kim HC, Kim TK, Sung KB, Yoon HK, Kim PN, et al. (2002) CT during hepatic arteriography and portography:an illustrative review. Radiographics 5: 1041-1051.
15. Maruyama H, Okugawa H, Ishibashi H, Takahashi M, Kobayashi S, et al. (2010) Carbon dioxide-based portography: an alternative to conventional imaging with the use of iodinated contrast medium. J Gastroenterol Hepatol 25: 1111-1116.

16. Chen L, Xiao T, Chen W, Long Q, Li R, et al. (2009) Outcomes of transjugular intrahepatic portosystemic shunt through the left branch vs. the right branch of the portal vein in advanced cirrhosis: a randomized trial. Liver Int 29:1101-1109.

17. Xue H, Yuan J, Chao-Li Y, Palikhe M, Wang J, et al. (2011) Follow-up study of transjugular intrahepatic portosystemic shunt in the treatment of portal hypertension. Dig Dis Sci 56: 3350-3356.

18. Seo TS, Oh JH, Park YK, Song HY, Park SJ, et al. (2005) Efficacy of a dexamethasone-eluting nitinol stent on the inhibition of pseudo-intimal hyperplasia in a transjugular intrahepatic portosystemic shunt: an experimental study in a swine model. Korean J Radiol 6: 241-247.

19. Cura M, Cura A, Suri R, El-Merhi F, Lopera J, et al. (2008) Causes of TIPS dysfunction. AJR Am J Roentgenol 191: 1751-1757.

20. Gallego C, Velasco M, Marcuello P, Tejedor D, De Campo L, et al. (2002) Congenital and acquired anomalies of the portal venous system. Radiographics 22: 141-159.

21. Saad WE, Davies MG, Lee DE, Patel NC, Sahler LG, et al. (2005) Transjugular intrahepatic portosystemicshunt in a living donor left lateral segment liver transplant recipient: Technical considerations. J VascInterv Radiol 16: 873-877.

22. Luo SH, Chu JG, Huang H, Yao KC (2017) Effect of initial stent position on patency of transjugular intrahepatic portosystemic shunt. World J Gastroenterol 23: 4779-4787.

23. Kowdley KV (2001) Is hepatic fibrosis reversible with therapy in hepatitis C?. Gastroenterology 120: 579-581.

24. Kaplan MM, DeLellis RA, Wolfe HJ (1997) Sustained biochemical and histologic remission of primary biliary cirrhosis in response to medical treatment. Ann Intern Med 126: 682-688.

25. Chang TT, Liaw YF, Wu SS, Schiff E, Han KH, et al. (2010) Long-term entecavir therapy results inthe reversal of fibrosis/cirrhosis and continued histological improvement in patients with chronic hepatitis B. Hepatology 52: 886-893.

26. Manne V, Akhtar E, Saab S (2014) Cirrhosis regression in patients with viral hepatitis B and C: a systematic review. J Clin Gastroenterol 48: 76-84.

27. Van Beers BE, Leconte I, Materne R, Smith AM, Jamart J, et al. (2001) Hepatic perfusion parameters in chronic liver disease: dynamic CT measurements correlated withdisease severity. AJRAmJRoentgenol 176: 667-673.

28. Kaufmann S, Schulze M, Spira D, Horger M (2016) Comparison of volume perfusion computed tomography and contrast-enhanced ultrasound for assessment of therapeutic effect of transarterial chemoembolization in patients with hepatocellular carcinoma: a preliminary report. Acta Radiol 57: 8-12.

29. Hayashi S, Yi SQ, Naito M, Terayama H, Buhe S, et al. (2006) A case of spontaneous splenorenal shunt associated with splenic artery aneurysm. Surg Radiol Anat 28: 311-315.

30. Caldwell S (2012) Gastric varices: is there a role for endoscopic cyanoacrylates, or are we entering the BRTO era? Am J Gastroenterol 107: 1784-1790.

31. Plessier A, Rautou PE, Valla DC (2012) Management of hepatic vascular diseases. J Hepatol 56: 25-38.

32. Helmy A (2006) Review article: updates in the pathogenesis and therapy of hepatic sinusoidal obstruction syndrome. Aliment Pharmacol Ther 23: 11-25.

33. Lin G, Wang JY, Li N, Li M, Gao H, et al. (2011) Hepatic sinusoidal obstruction syndrome associated with consumption of Gynurasegetum. J Hepatol 54: 666-673.

34. Mohty M, Malard F, Abecassis M, Aerts E, Alaskar AS, et al. (2016) Revised diagnosis and severity criteria for sinusoidal obstruction syndrome/veno-occlusivedisease in adult patients: a new classification from the European Society for Blood and Marrow Transplantation. Bone Marrow Transplant 51: 906-912.

35. Valla DC, Cazals-Hatem D (2016) Sinusoidal obstruction syndrome. Clin Res Hepatol Gastroenterol 40: 378-385.

36. Yu XZ, Ji T, Bai XL, Liang L, Wang LY, et al. (2013) Expression of MMP-9 in hepatic sinusoidal obstruction syndrome induced by Gynura segetum. J Zhejiang Univ Sci B 14: 68-75.

37. Azoulay D, Castaing D, Lemoine A, Hargreaves GM, Bismuth H, et al. (2000) Transjugular intrahepatic portosystemic shunt (TIPS) for severe veno-occlusive disease of the liver following bone marrow transplantation. Bone Marrow Transplant 25: 987-992.

38. Dezső K, Rókusz A, Bugyik E, Szücs A, Szuák A, et al. (2017) Human liver regeneration in advanced cirrhosis is organized by the portal tree. J Hepatol 66: 778-786.

39. Ahmed Mohammed HA, Yang JD, Giama NH, Choi J, Ali HM, et al. (2017) Factors Influencing Surveillance for Hepatocellular Carcinoma in Patients with Liver Cirrhosis. Liver Cancer 6: 126-136.

40. Riggio O, Ridola L, Angeloni S, Cerini F, Pasquale C, et al. (2010) Clinical efficacy of transjugular intrahepatic portosystemic shunt created with covered stents with different diameters: results of a randomized controlled trial. J Hepatol 53: 267-272.

41. European Association For The Study Of The Liver, European Organisation For Research And Treatment Of Cancer (2012) EASL-EORTC clinical practice guidelines: management of hepatocellular carcinoma. J Hepatol 56: 908-943.

42. Bruix J, Sherman M, American Association for the Study of Liver Diseases (2011) Management of hepatocellular carcinoma: an update. Hepatology 53: 1020-1022.

43. Klinger C, Riecken B, Schmidt A, De Gottardi A, Meier B, et al. (2017) Transjugular local thrombolysis with/without TIPS in patients with acute non-cirrhotic, non-malignant portal vein thrombosis. Dig Liver Dis 17: 30897-30903.

44. Chinchilla-López P, Hamdan-Pérez N, Guerrero-Ixtlahuac J, Barranco-Fragoso B, Méndez-Sánchez N, et al. (2017) The Role of TIPS in patients with Refractory Ascites and Portal Vein Thrombosis. Ann Hepatol 16: 619-620.

45. Boyer TD, Haskal ZJ (2005) American Association for the Study of Liver Diseases Practice Guidelines: the role of transjugular intrahepatic portosystemic shunt creation in the management of portal hypertension. J VascInterv Radiol 16: 615-629.

46. Kawamata H, Kumazaki T, Kanazawa H, Takahashi S, Tajima H, et al. (2000) Transjugular intrahepatic portosystemic shunt in a patient with cavernomatous portal vein occlusion. Cardiovasc Intervent Radiol 23: 145-149.

47. Radosevich PM, Ring EJ, LaBerge JM, Peltzer MY, Haskal ZJ, et al. (1993) Transjugular intrahepatic portosystemicbshunts in patients with portal vein occlusion. Radiology 186: 523-527.

48. Chawla YK, Bodh V (2015) Portal vein thrombosis. J Clin Exp Hepatol 5: 22-40.

49. De Gaetano AM, Lafortune M, Patriquin H, De Franco A, Aubin B, et al. (1995) Cavernous transformation of the portal vein: patterns of intrahepatic and splanchnic collateral circulation detected with Doppler sonography. AJR AmJ Roentgenol 165: 1151-11555.