

## The Role of Transjugular Intrahepatic Portosystemic Shunt (TIPS) in the Management of Portal Hypertension: Update 2009

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The 2009 update of the American Association for the Study of Liver Diseases (AASLD) Practice Guideline “The Role of Transjugular Intrahepatic Portosystemic Shunt (TIPS) in the Management of Portal Hypertension” is now posted online at [www.aasld.org](http://www.aasld.org). This is the first update of the original guideline published in 2005.<sup>1</sup>

The key changes in the 2009 guidelines are new recommendations on the use of covered versus bare stents in the creation of the TIPS. Use of expanded polytetrafluoroethylene (ePTFE)-covered stents is now preferred. The lower risk of shunt dysfunction and perhaps improved outcomes using covered as opposed to bare stents are the basis for this recommendation.<sup>2,3</sup> Creation of a TIPS increases the risk of hepatic encephalopathy but the prophylactic use of nonabsorbable disaccharides or antibiotics does not appear to reduce this risk and is not recommended.<sup>4</sup>

The value of TIPS versus a surgical shunt in the prevention of variceal rebleeding in patients who have failed medical therapy has been clarified by the publication of a controlled trial comparing TIPS to distal splenorenal shunt (DSRS).<sup>5</sup> Both were effective in preventing rebleeding (rebleeding incidence in 5.5% of DSRS versus 10.5% of TIPS; not significant) with no difference in encephalopathy or survival. The patients in whom TIPS

was performed required significantly more interventions to maintain patency because of the use of bare stents. A cost analysis showed TIPS to be slightly more cost effective than DSRS at year 5,<sup>6</sup> and these two approaches are now considered to be of equal efficacy in the prevention of variceal rebleeding.

The other significant change to the guidelines is how TIPS should be used in the management of patients with Budd-Chiari syndrome. A large (221 patients) retrospective study was published in which patients who failed to improve with use of anticoagulation had a TIPS created (133 patients). One-year and 10-year transplant-free survival was 88% and 69%, respectively, which is better than predicted.<sup>7</sup> TIPS patency was best in those who received a covered stent. The recommendation now is for creation of a TIPS in those who fail to improve with anticoagulation.

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*Abbreviations: DSRS, distal splenorenal shunt; TIPS, transjugular intrahepatic portosystemic shunt.*

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# **AASLD Practice Guidelines: The Role of Transjugular Intrahepatic Portosystemic Shunt (TIPS) in the Management of Portal Hypertension**

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## **Preamble**

These recommendations provide a data-supported approach. They are based on the following: (1) formal review and analysis of recently published world literature on the topic (Medline search); (2) The American College of Physicians' *Manual for Assessing Health Practices and Designing Practice Guideline*<sup>1</sup>; (3) policy guidelines, including the American Association for the Study of Liver Diseases' Policy Statement on Development and use of Practice Guidelines and the American Gastroenterological Associations' Policy Statement on the Use of Medical Practice Guidelines<sup>2</sup>; and (4) the authors' years of experience in the care of patients with portal hypertension and use of TIPS in the management of these disorders. These recommendations are fully endorsed by the AASLD and the Society for Interventional Radiology.

Intended for use by physicians, these recommendations suggest preferred approaches to the diagnostic, therapeutic, and preventative aspects of care. They are intended to be flexible, in contrast to standards of care, which are inflexible policies designed to be followed in every case. Specific recommendations are based on relevant published information. In an attempt to characterize the quality of evidence supporting recommendations, the Practice Guidelines Committee of the American Association for the Study of Liver Diseases requires a grade to be assigned and reported with each recommendation (Table 1).

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*Abbreviations: BCS, Budd-Chiari syndrome; GAVE, gastric antral vascular ectasia; HVPG, hepatic venous pressure gradient; HRS, hepatorenal syndrome; IVC, inferior vena cava; LVP, large volume paracentesis; MELD, Model for End-Stage Liver Disease; PHG, portal hypertensive gastropathy; PTFE, polytetrafluoroethylene; SOS, sinusoidal obstruction syndrome; TIPS, transjugular intrahepatic portosystemic shunt.*

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## **Introduction**

TIPS has been in use for more than 20 years to treat the complications of portal hypertension and TIPS have been created in thousands of patients with liver disease worldwide.<sup>3-6</sup> Despite the extensive use of TIPS to treat the complications of portal hypertension there initially was a lack of consensus on which patients should receive a TIPS as compared to other forms of therapy. In 1995 a conference sponsored by the National Institutes of Health concluded that TIPS was effective in the acute control and prevention of recurrent bleeding from varices but it was unclear when TIPS should be used as compared to medical and surgical therapy for these complications of portal hypertension. In addition, the efficacy of TIPS to control refractory ascites or treat the Budd-Chiari syndrome was unclear but promising.<sup>7</sup> Since then, more than one thousand patients have been enrolled in multiple controlled trials comparing TIPS to endoscopic and pharmacologic therapy in the prevention of rebleeding from varices and to large volume paracentesis in the treatment of refractory cirrhotic ascites. Further, about a 1,000 papers have been published on TIPS in the English literature alone. This body of work allows for more definitive recommendations about in whom and when to use TIPS in the treatment of the complications of portal hypertension.

The guidelines are divided into two large categories. The first category is a review of the technical aspects of the procedure, its complications and the data on which patients are most at risk for an adverse outcome following a TIPS. The second category is a review of the indications for TIPS. The use of TIPS for primary prevention of variceal bleeding and in the control of acute bleeding are discussed first. Next the two indications for TIPS that have been subjected to controlled trials (prevention of recurrent bleeding from varices and refractory ascites) will be discussed and guidelines developed. Lastly, all of the other indications for TIPS that have been described in the literature but have not been subjected to controlled trials will be discussed and guidelines created.

To prepare these guidelines, a Medline search was performed from 1966 to 2009. A total of 1143 articles were found under the subject heading "transjugular intrahe-

**Table 1. Quality of Evidence on Which a Recommendation Is Based**

Grade	Definition
I	Randomized controlled trials
II-1	Controlled trials without randomization
II-2	Cohort or case-control analytic studies
II-3	Multiple time series, dramatic uncontrolled experiments
III	Opinions of respected authorities, descriptive epidemiology

patric portosystemic shunt". Controlled trials and large series were sought during this search. Recently published papers were also used as a source of references missed by the Medline search and the personal files of the two authors were also used as a source of references.

## The Procedure

A TIPS is created by an interventional radiologist or in Europe by a specially trained physician. The technique is reviewed in several publications and will not be discussed here.<sup>3,4,7</sup> The procedure may be performed under conscious sedation (most common) or general anesthesia. If the procedure is going to be prolonged or the patient is hemodynamically unstable then general anesthesia is preferred as this allows for careful monitoring by the anesthesiologist. The success rate with TIPS for the decompression of the portal vein is high, > 90% of cases in most series.<sup>8-14</sup> The Society of Interventional Radiology developed guidelines for creation of a TIPS in 2001 and the consensus was that a technically successful outcome (includes both creation of the shunt and decrease in portal pressure to < 12 mm Hg) should be achieved in 95% of patients and clinical success (resolution of the complication of portal hypertension) should be achieved in 90% of cases. Failure to achieve this threshold should lead to a review of the departmental policy and procedures.<sup>15,16</sup>

Early mortality following TIPS placement was originally reported to be quite high due to poor patient selection but subsequent analysis demonstrated that pre-procedure clinical features (such as high model for end-stage liver disease (MELD) or APACHE II scores, high total bilirubin levels, emergent versus elective setting, presence of pneumonia-see below) accounted for this high death rate. In most situations death is due to progressive liver disease perhaps as a result of portal diversion and not due to complications of the procedure itself, such as intraperitoneal bleeding (see below).<sup>14,17-19</sup> In a retrospective series of 1,750 patients, the incidence of fatal

complications (intraabdominal hemorrhage, laceration of the hepatic artery or portal vein and right heart failure) was 1.7% (range 0.6%-4.3%). Of interest the risk of fatal complications was 3% in institutions that had performed less than 150 TIPS total as compared to 1.4% in those who had performed a greater number.<sup>14</sup> These data suggest that there is a learning curve associated with the safe creation of a TIPS. Major procedural complications are expected in no more than 3% of cases, and if rates exceed these levels, then internal quality assessment should be considered.<sup>16</sup> Authors of manuscripts on TIPS have been asked by the Society of Interventional Radiologists to report the approximate number of TIPS performed in their centers before instituting the reported study to get a better understanding of the amount of training required to perform TIPS with an acceptable morbidity and mortality and it is hoped these data will be forthcoming.<sup>16</sup>

The purpose of a TIPS is to decompress the portal venous system and therefore prevent rebleeding from varices or stop or reduce the formation of ascites. As to varices it is well established that if the hepatic venous pressure gradient (HVPG) or portal pressure gradient (PPG) after TIPS creation can be reduced to less than 12 mm Hg then the risk of bleeding will fall significantly. More recent data suggest that achieving a PPG of < 12 mm Hg may not be required to prevent rebleeding. In one series the risk of rebleeding following TIPS revision was 18%, 7%, and 1% in patients whose PPG had been reduced by 0%, 25%-50%, and >50%, respectively.<sup>20</sup> In a second series a 50% reduction in the initial PPG was associated with a rebleeding rate at one year of 11% whereas those with a lesser reduction had a 31% probability of rebleeding during the first year.<sup>21</sup> In the latter study the only absolute value for prevention of rebleeding was a PPG of < 12 mm Hg but at the cost of an increased incidence of encephalopathy. Although the gold standard for prevention of rebleeding remains a HVPG of < 12 mm Hg, further studies are needed to determine if lesser reductions have acceptable efficacy with a lower incidence of encephalopathy.

The optimal PPG that needs to be obtained for the control of refractory cirrhotic ascites is even less clear. In one series, the degree of portal decompression did not correlate with successful treatment of refractory cirrhotic ascites and the authors suggested a PPG of < 8 mm Hg should be the hemodynamic goal.<sup>23</sup> The selection of a value of 8 mm Hg is based on limited data and because the development of cirrhotic ascites reflects changes in both hepatic and renal function, it may be difficult to establish an absolute value of decompression that needs to be achieved in most patients with refractory ascites. In patients with significant preexisting encephalopathy in

whom a TIPS may still be necessary for ascites control, a higher gradient may be appropriate (in order to limit worsening encephalopathy); this affords the opportunity to further enlarge the TIPS at a later date if diuresis is inadequate and encephalopathy is satisfactorily controlled. Further study in this area is warranted.

Finally, in the authors' experience the effective gradient needed to prevent rebleeding from gastric varices may be lower than 12 mm Hg and even with apparent decompression embolization of the gastric varices may be required to minimize the risk of early rebleeding. Also, rebleeding from gastric varices may occur with small increases in portal pressure suggesting surveillance of this group of patients following a TIPS is of particular importance.<sup>21</sup>

Further complicating the issue is the problem of how the pressures are obtained. The classic way is to measure the free and wedged hepatic vein pressure and then to subtract the two values yielding the HVPG.<sup>22</sup> The use of the free hepatic vein or inferior vena cava (IVC) pressure is necessary to correct for the intra-abdominal pressure and allows for measurement of the true pressure gradient across the liver. After TIPS creation the portal pressure is obtained and the PPG calculated. Most radiologists use the right atrial pressure as the reference point because the hepatic vein is now part of the shunt and thus a free hepatic vein pressure cannot be obtained after shunt creation as the diverted portal flow artifactually raises the pressure within the outflow hepatic vein that drains the TIPS. The right atrium is of course in the chest and the basal pressure in the chest is lower than the intraabdominal pressure and the true PPG is not measured using this reference point. In addition, once the TIPS has been created the right atrial pressure tends to rise, thus complicating the measurement. One solution to this problem is to use the IVC pressure as the reference value but this has not been adopted by the interventional radiologic community. No standardization of where in the IVC the pressure should be obtained has limited this approach and currently the right atrial pressure is used by most interventional radiologists despite the above limitations. Some of these uncertainties could be resolved with standardization of how the HVPG or PPG is measured during creation of a TIPS so that the measurements are uniform and can be used to judge hemodynamic success more accurately.

### Pre-Tips Evaluation and Contraindications

Most patients who are referred for a TIPS should be under the care of a gastroenterologist or hepatologist. It is this individual in consultation with the interventional radiologist who must reach the decision that a TIPS is the appropriate form of treatment for a complication of por-

**Table 2. Contraindications to Placement of a TIPS**

<b>Absolute</b>
Primary prevention of variceal bleeding
Congestive heart failure
Multiple hepatic cysts
Uncontrolled systemic infection or sepsis
Unrelieved biliary obstruction
Severe pulmonary hypertension
<b>Relative</b>
Hepatoma especially if central
Obstruction of all hepatic veins
Portal vein thrombosis
Severe coagulopathy (INR > 5)
Thrombocytopenia of < 20,000/cm <sup>3</sup>
Moderate pulmonary hypertension

tal hypertension. As discussed in the following section it is clear that there are predictors of a poor outcome following TIPS. However, the risk of the procedure must always be balanced with the severity of the complication from which the patient is suffering and the likelihood of the patient surviving long enough to receive a liver transplant following creation of a TIPS. Thus, the decision to perform or not perform a TIPS in a high risk patient should be reached by the gastroenterologist/hepatologist and the interventional radiologist together. Ideally, in a high risk patient, a transplant center should also be consulted preceding the final decision. In the emergent setting of acute, uncontrolled variceal hemorrhage, contacts with transplantation centers may be secondary to the need for shunt creation.

Listed in Table 2 are contraindications to the creation of a TIPS. These include both absolute contraindications to any form of portosystemic diversion, be it surgical or percutaneous. Absolute contraindications include congestive heart failure, severe tricuspid regurgitation and severe pulmonary hypertension (mean pulmonary pressures of > 45 mm Hg as these patients are not candidates for a liver transplant).<sup>24</sup> Whether patients with more mild pulmonary hypertension can receive a TIPS safely is unclear. Relative contraindications include anatomic ones that can complicate the creation of the shunt and reduce the technical success, including portal venous obstruction, large hepatic tumors, extensive polycystic liver disease, and hepatic vein obstruction. It is well established that shunts can be created in all of these cases with the right experience and under appropriate clinical circumstances but the difficulty of creating the TIPS needs to be balanced with the need of the patient. Situations in which these relative contraindications might be outweighed by clinical necessity include palliative TIPS in patients with a hepatoma and refractory variceal bleeding, recanalization of occluded portal veins in patients with recurrent variceal bleeding or refractory ascites, or a patient with Budd-

Chiari syndrome and progressive liver failure in whom there are no patent hepatic veins.

Preprocedure laboratory studies include serum electrolytes, blood count, coagulation parameters, and tests of liver and kidney function. Cross section liver imaging by Duplex ultrasound, CT scan or MRI is appropriate in all but the most life-threatening situations in order to assess portal vein patency or the presence of liver masses. When a history of congestive heart failure, tricuspid regurgitation, cardiomyopathy, or pulmonary hypertension is present, then cardiac evaluation is appropriate prior to TIPS. This evaluation may include cardiac echo, cardiology consultation, and, possibly atrial fluid challenge. However, in the absence of a cardiac history the routine performance of a cardiac echo preceding a TIPS is unnecessary in the opinion of the authors. However, others feel that as up to 16% of patients referred for liver transplantation may have pulmonary hypertension that an echo should be performed on all patients preceding a TIPS.<sup>24</sup> Elevated right atrial pressures (typically measured at the start of the TIPS procedure) may warrant abandonment or delay of the procedure pending diuresis or further medical evaluation. Lastly, patients with a significant coagulopathy may be able to undergo a TIPS following the use of clotting factors or platelets. The finding of a small liver during the evaluation is not a contraindication to creation of a TIPS but does indicate that the procedure may be difficult and prolonged.

## Mortality

The 1-year mortality rates for TIPS are dependent somewhat on the indication for the procedure. When TIPS has been placed for bleeding varices 1 year survival varies from 48%-90%. Survival rates are somewhat lower when the indication is ascites, being 48%-76%.<sup>25-30</sup> In one series but not another survival rates were significantly worse when the indication was refractory ascites as compared to variceal bleeding.<sup>26,29</sup> These differences likely reflect variations in the severity of liver disease between the different studies.

As the use of TIPS has increased there has been interest in models that predict outcome. MELD and a number of other models have been developed to predict survival following TIPS.<sup>25-29</sup> The modified MELD model utilizes serum bilirubin, International Normalized Ratio (INR) for prothrombin time, and serum creatinine. Previously the cause of cirrhosis was also used but has been abandoned. The three variables are used to create the following equation:  $[3.8 \log_e (\text{bilirubin [gm/dL]}) + 11.2 \log_e (\text{INR}) + 9.6 \log_e (\text{creatinine [mg/dL]})]$ . A second model used a bilirubin  $> 3.0$  mg/dL (1 point), ALT  $> 100$  IU/L (1 point), pre-TIPS encephalopathy (1 point) and urgency of TIPS (2 points) and divided patients into three groups (low risk- 0 points, medium risk -1-3 points and

high risk- 4-5 points).<sup>26</sup> These two models and Child-Pugh scores were used prospectively in a subsequent study to predict survival.<sup>30</sup> All three accurately predicted 3-month survival to a similar degree whereas 1-year survival was predicted best by the MELD model. Short-term mortality has also been predicted by using bilirubin alone or a combination of serum bilirubin, APACHE-II score and TIPS urgency.<sup>31,32</sup> Irrespective of which model is chosen the short term and one year survival can be predicted with some accuracy. These survival estimates can be used to advise patients about expected outcomes and can also be used to decide which patients require referral to a liver transplant center.

## Recommendations

**1. TIPS should only be performed by experienced interventional radiologists (or specially trained physicians). Success and complication rates should be monitored and if they fail to meet expected rates then review of the program should be considered. Evidence-III**

**2. The decision to perform a TIPS, especially in a high risk patient, should be reached by a team consisting of a gastroenterologist/hepatologist, interventional radiologist and where appropriate a transplant physician. Evidence-III**

**3. Preceding creation of a TIPS, tests of liver and kidney function should be performed as well as cross-sectional imaging of the liver to assess portal system patency and exclude liver masses. Evidence-III**

**4. Reduction in HVPg to less than 12 mm Hg should be achieved when the indication is bleeding esophageal varices. Embolization of gastric varices may be required despite adequate decompression of the portal-venous system. Evidence-II-2**

**5. The degree of reduction in HVPg to control ascites is unclear but at present a gradient of at least  $\leq 12$  mm Hg has been suggested to be a reasonable goal. Evidence-II-2**

**6. Patients with high predicted 30-day mortalities (MELD  $> 15-18$  or serum bilirubin  $> 4.0$  mg/dL) should be informed of their prognosis and TIPS performed only in the absence of other options. Evidence-II-2**

**7. In high-risk patients, the need for liver transplantation should be discussed before the performance of an elective TIPS. Evidence-III**

## Complications

The most common complications and their reported frequency are listed in Table 3.

**TIPS dysfunction** is defined as a loss of decompression of the portal venous system due to occlusion or ste-

**Table 3. Complications of TIPS**

Complications	Frequency (%)
TIPS dysfunction	
Thrombosis	10-15
Occlusion/stenosis	18-78
Transcapsular puncture	33
Intraperitoneal bleed	1-2
Hepatic infarction	~1
Fistulae	Rare
Hemobilia	<5
Sepsis	2-10
Infection of TIPS	Rare
Hemolysis	10-15
Encephalopathy	
New/worse	10-44
Chronic	5-20
Stent migration or placement into IVC or too far into portal vein	10-20

Data from Boyer and Vargus<sup>126</sup> and Rössle et al.<sup>127</sup>

nosis of the TIPS. Although there is no consistency between investigators as to the exact criteria that should be used to define TIPS dysfunction in reference to degree of stenosis, a value of 50% is frequently used. In addition, a rise in the HVPG to > 12 mm Hg or a recurrence of the complication of portal hypertension for which the TIPS was performed indicates TIPS dysfunction.<sup>33,49</sup> Occlusion of the TIPS can either be due to thrombosis or hyperplasia of the intima. **Thrombosis** of the TIPS usually occurs early and can happen within 24 hours of TIPS creation. The frequency of this complication is on the order of 10%-15% when bare stents are used.<sup>34,35</sup> The cause of the thrombosis may be leakage of bile into the shunt, hypercoagulable syndromes, or inadequate coverage of the TIPS tract with sufficient stent(s).<sup>36,37</sup> Thrombosis of the TIPS is identified by Doppler ultrasound and patency re-established by repeat catheterization. In one controlled trial use of phenprocoumon (an anticoagulant) was associated with a lower rate of complete occlusion within the first three months following TIPS placement.<sup>38</sup> However, in the absence of more studies the routine use of anticoagulation is not recommended.

The major difficulty with TIPS is the unpredictable patency of the shunts due to **pseudointimal hyperplasia** within the parenchymal tract or within the outflow hepatic vein. The occluded stents are coated by a collagenous matrix that is covered by endothelial cells.<sup>36,37,39,40</sup> The incidence of stenosis varies from 18 to 78% depending upon the surveillance techniques used, frequency of assessment, and definitions of 'failure', e.g. elevated portasystemic gradient, ultrasound velocity criteria, or percent diameter stenosis.<sup>9,11,12,42-46</sup> Most physicians rely on Doppler ultrasound to identify TIPS stenosis. Unfortunately, the earlier studies claiming >90% accuracy for

sonographic prediction of shunt dysfunction have failed to stand under the light of larger prospective or retrospective studies. In one series several ultrasonographic features were used to identify TIPS stenosis including flow reversal, jet lesion, and decreased flow in the TIPS or portal vein. The sensitivity of each of these tests varied from 10%-26% with a specificity of 88%-100%. Thus, the negative predictive value was poor and the positive predictive value acceptable.<sup>47</sup> In a second series of 31 occluded or stenotic stents ultrasound predicted shunt malfunction in only 11 and incorrectly predicted patency in 20 and thus the sensitivity was only 35%.<sup>48</sup> Many of the sonographic studies are methodologically flawed because sonographic criteria of shunt dysfunction were used to trigger TIPS venography, however when sonography suggested no shunt dysfunction proof of shunt patency by venography was not performed. Part of the difficulty of using sonography is that it is an imaging study which measures velocity, from which diameter within a conduit can be estimated. However, with TIPS it is portal decompression, not percent shunt stenosis that is important in assessing TIPS function. One prospective study compared 151 Doppler sonograms with TIPS venograms and assessment of portal pressure. Using a success or failure definition of a portosystemic gradient of < or ≥15 mm Hg, respectively, sonography provided a sensitivity and specificity of only 86% and 48% respectively.<sup>49</sup> Thus, an abnormal Doppler ultrasound is predictive of occlusion or stenosis whereas a normal ultrasound does not exclude TIPS dysfunction. The best indicator of TIPS dysfunction is a recurrence of the problem for which the TIPS was originally inserted, either variceal bleeding, hepatic hydrothorax, or ascites. If recurrent varices are identified by upper endoscopy then the TIPS is most likely insufficient.<sup>47</sup> Documentation of patency can only be achieved with certainty by re-catheterization of the shunt.

The development of covered stents has reduced the frequency of TIPS dysfunction.<sup>50</sup> Two large series have recently been published that have examined the use of polytetrafluoroethylene (PTFE)-cover stent-grafts for TIPS. One of the reports is of a series of 71 patients all of whom received the covered stents whereas the second report is a randomized controlled trial comparing the covered stents to the standard bare stents.<sup>33,51</sup> In the nonrandomized series a total of eight shunt revisions were performed for an incidence of 11.3% and primary patency rates at 6 and 12 months were calculated to be 87% and 81%, respectively.<sup>51</sup> Although these results are better than what would be expected with bare stents, all patients did not undergo venography and therefore the true incidence of shunt stenosis is unknown. In the randomized study eighty patients with cirrhosis and either uncon-

trolled or recurrent bleeding from varices or refractory ascites were enrolled in the study. Patients were followed with Doppler ultrasound and venography was performed at 6, 12, and 24 months post-TIPS. Five (13%) of the 39 patients receiving the PTFE covered-stent-grafts had shunt dysfunction whereas 18 (44%) of those receiving the bare-stent had shunt dysfunction ( $P < 0.001$ ). In addition, early thrombosis of the TIPS was observed in three patients who received the bare-stents. The actuarial rates of primary patency in the covered and bare-stent groups were 86% and 47%, respectively at year one and 80% and 19% at year two. Recurrence of the complication of portal hypertension for which the TIPS was placed was also significantly more common in the bare-stent group as compared to the PTFE covered-stent group. The incidence of hepatic encephalopathy was less in the covered-stent group (difference not significant) and survival was the same.<sup>33</sup> A second controlled trial of covered versus bare stents found a primary patency rate of 76% and 36% at 2 years respectively. The probability of remaining free of encephalopathy was significantly greater with covered (67%) as compared to bare (51%) stents. Survival at two years was not significantly different between the two groups.<sup>52</sup> In a retrospective series survival was significantly better in the PTFE covered-stent group as compared to those who received a bare stent. However, the two groups were from different times and it is difficult to know if patient selection as opposed to the use of different stents accounted for the observed survival differences.<sup>53</sup> The PTFE covered TIPS endoprotheses are available in Europe, South America, and the USA. The use of the PTFE coated-stent-grafts should decrease significantly the incidence of shunt dysfunction and recurrence of the complications of portal hypertension. It is unclear, however, whether this development will improve the cost-effectiveness of TIPS as compared to other forms of therapy.

Puncture of the liver capsule is common but serious intraperitoneal bleeding is infrequent, 1-2% of cases. Similarly creation of a biliary-venous or hepatic artery-portal vein fistula is rare. The development of jaundice or sepsis following TIPS suggests the former whereas pulsatile flow in the portal vein suggests the latter.<sup>54,55</sup> Hemolysis may occur following TIPS placement and appears to be due to damage to the red cells by the stent.<sup>56-58</sup> Recognition that the rise in bilirubin levels is due to hemolysis is an important diagnosis as an alternative diagnosis is liver failure following the TIPS which carries a poor prognosis.<sup>59</sup> Hepatic infarction is a rare complication of TIPS and is generally related to injury and/or thrombosis of the hepatic artery that supplies the affected segment.<sup>60</sup>

**Hepatic encephalopathy** and TIPS dysfunction are the two complications that have limited the effectiveness

of TIPS most significantly. The incidence of new or worsening encephalopathy following TIPS is 20-31%.<sup>25,61,62</sup> In controlled trials comparing TIPS to alternative forms of therapy the incidence of encephalopathy is always greater in those who received a TIPS (see below). Pre-TIPS factors associated with an increased risk of post-TIPS encephalopathy in one study included etiology of liver disease other than alcohol, female gender and hypoalbuminemia.<sup>62</sup> In a second series increasing age, past history of encephalopathy and evidence of encephalopathy at the time of TIPS were predictive of post-TIPS encephalopathy.<sup>61</sup> It is important to note that if the encephalopathy was precipitated by variceal bleeding then prevention of rebleeding should make it less likely that the patient will have recurrent encephalopathy. Only if the hepatic encephalopathy is uncontrollable is a TIPS contraindicated.<sup>15</sup> In most patients the encephalopathy responds to standard therapy and only rarely (~5%) must the TIPS be occluded to control the encephalopathy.<sup>63,64</sup> A TIPS also can be reduced in caliber, should excessive encephalopathy prove difficult to control and yet allow for continued portal decompression.<sup>65</sup> Based on one small randomized trial there appears to be no benefit in the prophylactic use of nonabsorbable disaccharides or antibiotics in the prevention of post-TIPS encephalopathy.<sup>66</sup>

**TIPS in the transplant candidate.** Patients awaiting liver transplantation frequently bleed from varices or have refractory cirrhotic ascites and therefore are candidates for a TIPS. Because these patients will subsequently undergo a hepatectomy there are complications of a TIPS that are unique to this population. A TIPS is created within the substance of the liver and most interventional radiologists attempt to place the stent as close as possible to the hepatic vein/inferior vena cava ostium to reduce the risk of developing stenosis within the hepatic vein. With the exception of cases of benign or malignant portal vein thrombosis, the stent should extend the shortest possible distance into the main portal vein both to allow creation of a durable shunt and yet not complicate the portal to portal vein anastomosis performed during transplantation. When the stent extends into the inferior vena cava (or atrium) or deep into the main portal vein, then transplantation difficulties can arise. In one series of 12 patients who had a TIPS preceding liver transplantation, four patients had portal vein stents near the coronary vein or extending into the superior mesenteric vein and in one venous reconstruction was required.<sup>67</sup> In a second series of 24 patients who had a TIPS created preceding transplantation, eight patients had more complicated surgeries that were attributable to the presence of a TIPS. Four of the stents were in the inferior vena cava, one in the superior mesenteric vein and in three the portal vein was

thrombosed. Despite being able to complete the transplant in all eight patients, patient and graft survival were somewhat worse in those with complications related to the presence of the TIPS.<sup>68</sup> However, in other series, despite the technical issues that arose during the transplant because of the presence of the shunt, operative time and patient and graft survival were the same in patients who were transplanted in the presence and absence of a TIPS.<sup>69,70</sup> Most recently 61 patients with a pre-transplant TIPS were compared to 591 patients transplanted without a TIPS. Graft and patient survival were somewhat better in those who had a TIPS pretransplant. Migration of the TIPS was found in 28% of cases which prolonged the time on bypass.<sup>71</sup> All patients who have a TIPS created should be considered possible liver transplant candidates and thus care should be taken to not extend the stents beyond the minimum necessary portions of the portal and hepatic vein/inferior vena cava junction required to insure a functioning shunt. If the patient is being considered for living related transplantation then lining the entire hepatic vein to the inferior vena cava may complicate transplantation as a cuff of hepatic vein is required to complete the transplant in these patients.

#### Recommendations

**8. Those performing TIPS need to be aware of both the procedural complications and those due to portal diversion and be experienced in their management.-Evidence-II-3**

**9. Each center performing TIPS should have an established program of TIPS surveillance, and although there are no established guidelines Doppler ultrasound should be performed at specified intervals following the procedure and on the yearly anniversary of the TIPS thereafter.-Evidence-II-1**

**10. Ultrasonographic findings suggesting TIPS dysfunction or recurrence of the complication of portal hypertension that lead to the initial TIPS should lead to repeat shunt venography and intervention, as indicated. The recurrence of symptoms in the face of a 'normal' ultrasound does not eliminate the need for TIPS venography. -Evidence-II-2**

**11. TIPS stenosis is common when bare stents have been used, especially in the first year, and Doppler ultrasound lacks the sensitivity and specificity needed to identify many of these patients. Therefore repeat catheterization of the TIPS or upper endoscopy should be considered at the one-year anniversary of TIPS creation, especially in those who bled from varices. Evidence-II-3**

**12. ePTFE-covered stents are preferred to bare stents to lower the risk of shunt dysfunction. Evidence-I**

**Table 4. Indications for TIPS**

<b>Efficacy determined by controlled trials</b>		
Secondary prevention variceal bleeding		
Refractory cirrhotic ascites		
<b>Efficacy assessed in uncontrolled series</b>		
Refractory acutely bleeding varices		
Portal hypertensive gastropathy		
Bleeding gastric varices		
Gastric antral vascular ectasia		
Refractory hepatic hydrothorax		
Hepatorenal syndrome	Type 1	Type 2
Budd-Chiari syndrome		
Veno-occlusive disease		
Hepatopulmonary syndrome		

**13. As with any form of portosystemic diversion, the risk of developing hepatic encephalopathy is increased following TIPS creation. The prophylactic use of nonabsorbable disaccharides or antibiotics does not appear to lower this risk. -Evidence-I**

#### Indications

Table 4 lists the variety of conditions for which TIPS has been used. It is recognized that a number of listed indications, such as hepatorenal syndrome or Budd-Chiari syndrome may never be assessed in larger prospective randomized controlled trials because of their low incidence. Accordingly, for these conditions recommendations will be based on review of uncontrolled series and expert opinion.

#### Primary Prevention of Variceal Bleeding

The development of varices is a common sequela of portal hypertension. The frequency of esophageal varices varies from 30%-70% in patients with cirrhosis and 9%-36% will have so called high risk varices. Esophageal varices will develop in patients with cirrhosis at a yearly rate of 5%-8% but in only 1%-2% will the varices be large enough to pose a risk of bleeding. In patients with small varices, about 4%-30% of the patients each year will develop large varices and therefore be at risk of bleeding.<sup>72-75</sup> Use of treatments to prevent bleeding from these varices that have never bled is termed primary prophylaxis and currently beta blockers are considered the best approach to prevent bleeding in this group of patients.<sup>73</sup> Previously when surgical shunts were used as primary prophylaxis, bleeding from varices was prevented but at the unacceptable cost of increased mortality in the shunted as compared to the control patients.<sup>76</sup> No trials comparing TIPS to other forms of therapy in the prevention of the first bleed from varices have been performed. Because TIPS, like a surgical shunt, brings with it the risks of hepatic encephalopathy, liver failure and procedural complica-



**Table 5. Surgical Shunts and TIPS Versus Endoscopic Therapy in the Prevention of Rebleeding**

Number of Patients	Rebleeding Rate		Encephalopathy		Mortality	
	Endo	PCS	Endo	PCS	Endo	PCS
376	49.8%	12.4%*	8.6%	17.2%**	28.8%	28.8%
811	46.6%	18.9%*	18.7%	34.0%**	26.5%	27.3%

Endo, endoscopic therapy; PCS, portacaval shunt. \*By meta-analysis, rebleeding significantly less with PCS or TIPS compared to Endo. \*\*By meta-analysis, incidence of encephalopathy greater with PCS or TIPS compared to Endo. Data taken from D'Amico et al.<sup>73</sup> and Papatheodoridis et al.<sup>81</sup>

tions, TIPS cannot be recommended for primary prophylaxis and its use in this situation should be limited to unique situations.

### Acutely Bleeding Esophageal Varices Refractory to Medical Treatment

Most patients who present with actively bleeding varices can be controlled with pharmacologic and endoscopic therapy. However, an occasional patient will re-bleed or continue to bleed despite aggressive management and these patients become candidates for portal decompression. Previous experience with surgical shunts was poor because of the high mortality (31-77%) associated with urgent or emergent shunting.<sup>72,73</sup> Although TIPS has now been used in this situation successfully, it is important to note that the urgency of TIPS is an independent predictor of early mortality.<sup>26,28</sup> One report analyzed 15 studies in which TIPS was used to control bleeding in patients who had failed medical therapy. TIPS controlled bleeding in  $93.6 \pm 6.7\%$  of patients and early rebleeding was seen in only  $12.4 \pm 6.1\%$  of the patients. However, hospital mortality at 6 weeks was high,  $35.8 \pm 16\%$ .<sup>78</sup> It is clear that the pre-procedural condition of the patients (MELD score, APACHE II score, urgent indication) predict the 30 day survival after TIPS in this group of patients. Although TIPS has not been compared to alternative treatments in the acutely bleeding patient, non-selective portacaval shunts have been compared to endoscopic therapy. Shunts were more effective than endoscopic therapy in the control of bleeding but mortality rates of 31-77% were observed.<sup>73</sup> Similar results would be expected if TIPS were compared to endoscopic therapy in the acute control of bleeding but these studies are unlikely to occur given the desperate state of many of these patients. Patients at greatest risk for rebleeding in the hospital are those with advanced disease and active bleeding at the index endoscopy. If those at greatest risk for rebleeding could be identified then urgent TIPS might improve survival. HVPG has been measured in cirrhotics within 24 hours of presentation with an acute variceal bleed.<sup>77</sup> Those with a gradient below 20 mm Hg received standard medical therapy and 12% were medical failures. Those with pressures equal or greater than 20 mm Hg were considered high risk for medical failure and were

randomized to TIPS (n = 26) or standard therapy (n = 26). Treatment failure occurred in 12% of the TIPS group and 50% of the non-TIPS group (difference significant). In hospital mortality was significantly less in the TIPS (11%) as compared to the non-TIPS (38%) groups. This study suggests that if we could stratify rebleeding risk accurately the early use of TIPS in this situation could improve outcomes. Pending the development of alternative therapies, TIPS will remain the only choice to control acute variceal bleeding that is refractory to medical therapy.

### Esophageal Variceal Rebleeding

Once varices have bled the risk of rebleeding is at least 50% and many of these patients will die.<sup>79,80</sup> Hence, a number of therapies have been used to prevent rebleeding in these patients and most have been subjected to controlled trials.<sup>73</sup> When surgical shunts were compared to endoscopic therapy, rebleeding rates were reduced whereas the incidence of hepatic encephalopathy was increased in the surgical groups and mortality was unaffected (Table 5).<sup>72,73</sup> When TIPS was first developed, it was hoped that the effect on rebleeding would mirror that of surgical shunts, but with lower rates of encephalopathy because of the ability to tailor shunt size to the minimum necessary diameter required to decompress the portal system. This has not proven to be the case for a variety of reasons including the unpredictable patencies of uncovered stents and the lack of controlled trials using different diameter stents to prevent rebleeding. In 1999 a meta-analysis of the 11 published controlled trials comparing TIPS to endoscopic therapy was reported.<sup>81</sup> The results with TIPS mirrors the results with surgical shunts, i.e. there is less rebleeding compared to endoscopic therapy but at the price of more encephalopathy without an improvement in survival (Table 5). As has been seen in the trials comparing surgical shunts to endoscopic therapy, the rate of cross-over between treatment groups was greater for endoscopic therapy (17%) than with TIPS (2%). The cost of treating the patients with TIPS was greater than endoscopic therapy because of the need for frequent re-intervention to maintain TIPS patency.<sup>82</sup> A more recent meta-analysis came to the same conclusions,

less rebleeding, fewer deaths due to rebleeding, more encephalopathy and no improvement in overall survival.<sup>83</sup> TIPS has also been compared to pharmacologic therapy in a small number of patients. In one series of about 90 patients the risk of rebleeding during two years of followup was 39% in those who received pharmacologic therapy and 13% in those receiving TIPS. The frequency of encephalopathy was about twice in those treated with TIPS. Child-Pugh class improved in 72% of the drug group but in only 45% of the TIPS group. The two-year probability of survival was the same in both groups, 72%. Endoscopic reintervention was required in 12 of the drug treated patients and in five portal decompressions, either by TIPS or surgery, was required for variceal rebleeding. The cost of therapy for those receiving TIPS was twice that of the pharmacologic group in part because 70% of the TIPS patients required reintervention.<sup>84</sup> It is important to note the variation in the cohorts amongst the different trials in that in some studies patients were medical failures with several bleeds whereas in others they had a single bleed before being randomized.

It is clear from the above studies that both TIPS and surgical shunts are the most effective method for the prevention of rebleeding. There has been a published trial in which TIPS was compared to a H-graft surgically placed shunt.<sup>85</sup> The patients were not randomized but were done as pairs, i.e. one getting a surgical shunt and the second a TIPS. A total of 132 patients were in the study. The frequency of rebleeding was 16% in the TIPS group and 3% in the surgical group. The patients undergoing TIPS required frequent interventions to maintain TIPS patency. Thirty day and total mortality were 15% vs 20% and 43% vs 30% in the TIPS and surgery groups respectively. Another randomized controlled trial comparing TIPS (bare metal Wallstents) to distal splenorenal shunt (DSRS) has been published.<sup>86</sup> One hundred and forty patients with variceal rebleeding and Child-Pugh class A/B cirrhosis were randomized. Rebleeding was seen in 5.5% of the DSRS patients and 10.5% of the TIPS patients (difference not significant), encephalopathy occurred in 50% of patients in both groups and survival at 2 and 5 years was 81% and 62% (DSRS) and 88% and 61% (TIPS). However, only 11% of the DSRS patients required reintervention to maintain patency whereas 82% of the TIPS patients required reintervention. Thus, both TIPS and DSRS are effective in preventing rebleeding in patients who have failed pharmacologic or endoscopic therapy but TIPS patients require more frequent reintervention to prevent rebleeding. A cost-effectiveness analysis of this trial has been reported.<sup>87</sup> Costs of both in- and out-patient care were obtained on all patients during the trial. In addition, quality of life was measured using SF-

36. The average yearly cost over a 5 year period were \$16,363 for TIPS patients and \$13,492 for the DSRS patients. These yearly costs are similar to what has been reported for pharmacologic and endoscopic management of patients with bleeding varices. TIPS was slightly more cost effective than DSRS at year five (\$61,000 per life saved) but difference was felt not to be significant. Using covered rather than bare walls stents was estimated to increase the cost-effectiveness of TIPS only slightly. The authors conclude that TIPS is as effective as DSRS in the prevention of variceal rebleeding and may be slightly more cost-effective.<sup>86,87</sup>

### **Bleeding from Gastric Varices**

The efficacy of TIPS in the control of rebleeding from gastric varices has been reported in a number of small series. In most of the series the outcome of patients with bleeding gastric varices was compared to those who had bled from esophageal varices. In none of the trials were the patients randomized to alternative therapies and in most the TIPS was performed because of refractory bleeding. In some series the initial HVPG in those with gastric varices was lower than in those with esophageal varices whereas in other series no differences were observed.<sup>88-90</sup> In these small series TIPS was equally effective in controlling bleeding from gastric as well as esophageal varices.<sup>88-91</sup> TIPS has been compared to glue in the treatment of gastric variceal bleeding.<sup>92</sup> 72 patients were randomized and there was significantly less rebleeding from gastric varices in the TIPS group (11.4%) versus the glue group (38.8%). As expected more patients developed encephalopathy following TIPS and there was no difference in survival. In the authors' opinion, TIPS is an important tool in the control of gastric variceal bleeding, though the final portosystemic gradient required to achieve variceal decompression may be lower than what is required for esophageal variceal bleeding and embolization of the varices also may be required.

### **Prevention of Bleeding from Portal Hypertensive Gastropathy (PHG) and Gastric Antral Vascular Ectasia (GAVE)**

The diagnosis of PHG and GAVE are made endoscopically. The mucosa in PHG may show a mosaic-like pattern ('snake skin') or in more severe cases cherry red spots and black-brown spots are seen. The changes are usually seen in the fundus or body of the stomach. GAVE is localized to the antrum and is characterized by red patches or spots that may be diffuse or linear in appearance. PHG is limited to patients with portal hypertension whereas GAVE can be seen in a variety of different disorders in-

**Table 6. TIPS Versus Large Volume Paracentesis in Treatment-Refractory Cirrhotic Ascites**

Reference Number	Number of Patients		Ascites Improved		Survival@		New or Severe Encephalopathy	
	TIPS	LVP	TIPS	LVP	TIPS	LVP	TIPS	LVP
98	13	12	38%	0%	29%	60%	15%	6%
99	29	31	84%*	43%	58%	32%	23%	13%
100	35	35	51%*	17%	26%	30%	60%*	34%
23	52	57	58%*	16%	35%	33%	38%	21%
101	33	33	79%*#	42%	59%*	29%	61%	39%

\*Significant difference between two groups. #End-point was failure which was defined as need for at least 4 LVPs for recurrent ascites. @Transplant-free survival after 2 years for first three studies.

LVP, large volume paracentesis; TIPS, transjugular intrahepatic portosystemic shunt.

cluding cirrhosis.<sup>93</sup> The effect of TIPS on PHG and GAVE has been examined in several small series. In one report, 75% of patients with severe PHG showed both endoscopic improvement and a decrease in the need for transfusions.<sup>94</sup> In another series, 9 of 10 patients showed endoscopic improvement in PHG following TIPS.<sup>95</sup> In contrast, bleeding from GAVE in patients with cirrhosis was unaffected by TIPS.<sup>94</sup>

### Recommendations

**14. The use of TIPS to prevent bleeding from varices that have never bled is contraindicated because of the risk of increasing morbidity and mortality. Evidence-III**

**15. TIPS is effective in controlling acute bleeding from varices that is refractory to medical therapy and TIPS should be used in preference to surgery. Evidence-II-3**

**16. Pending the development of tests that accurately predict the risk of rebleeding, TIPS should not be used for the prevention of rebleeding in patients who have bled only once from esophageal varices. Its use should be limited to those who fail pharmacologic and endoscopic therapy. Evidence-I**

**17. TIPS is effective in the prevention of rebleeding from gastric and ectopic varices (including intestinal, stomal and anorectal varices) and is the preferred approach for the prevention of rebleeding in this group of patients. Evidence-II-3**

**18. In patients with good liver function, either a TIPS or a surgical shunt are appropriate choices for the prevention of rebleeding in patients who have failed medical therapy. Evidence-I**

**19. In patients with poor liver function TIPS is preferred to surgical therapy in the prevention of rebleeding in patients who have failed medical therapy. Evidence-III**

**20. The use of TIPS in the management of portal hypertensive gastropathy should be limited to those**

**who have recurrent bleeding despite the use of beta-blockers. Evidence-II-3**

**21. TIPS is ineffective in controlling bleeding from GAVE in patients with cirrhosis and should not be used in this situation. Evidence-II-3**

### Cirrhotic Ascites

Ascites develops in patients with cirrhosis because of the development of portal hypertension in concert with splanchnic vasodilation, renal sodium retention and active renal vasoconstriction.<sup>96</sup> As the liver disease progresses the ascites becomes more resistant to diuretic therapy and refractory ascites develops. Ascites is said to be refractory to medical treatment when it is unresponsive to sodium restriction and the use of high doses of diuretics (400 mg/day spironolactone and 160 gm/d furosemide) or the patients are intolerant of diuretic therapy.<sup>97</sup> Once refractory ascites develops the patient has a poor prognosis with ~50% of the patients dead within 12 months.<sup>96</sup> A number of approaches have been taken in the management of patients with refractory ascites including peritoneo-venous shunts, repeated large volume paracentesis (LVP) and TIPS. Peritoneo-venous shunts have been abandoned because of a lack of efficacy and high rate of complications except in unusual circumstances.<sup>96</sup> TIPS has been compared to LVP in the treatment of patients with refractory cirrhotic ascites. The data from 5 published controlled trials is shown in Table 6. There were a total of 330 patients enrolled in the 5 trials.<sup>23,98-101</sup> In the TIPS groups the percentage (mean  $\pm$  SD) of patients who showed improvement in their ascites (lack of need for paracentesis) was  $62.0 \pm 19.2\%$  while in the LVP groups improvement was seen in  $23.6 \pm 18.5\%$  of patients. The transplant free two year survival in three of the studies<sup>98-100</sup> was similar being  $37 \pm 17.7\%$  for the TIPS patients and  $40.1 \pm 16.8\%$  for the LVP patients and in the fourth study<sup>23</sup> survival was also similar in the two groups. Only in the most recently published report was

survival significantly better in the TIPS group.<sup>101</sup> A meta-analysis of four of the published series has recently been reported.<sup>102</sup> TIPS was more effective than paracentesis and its use was associated with a significantly better transplant free survival (TIPS year-1, 63.1%; year-2, 49.0%; versus LVP year-1, 52.5%; year-2, 35.2%). Encephalopathy occurred somewhat more frequently in the TIPS groups as compared to the LVP groups ( $39.4 \pm 20.9\%$  and  $22.6 \pm 13.9\%$  of patients, respectively). Somewhat surprisingly there was no difference in the quality of life between the two groups in one of the studies.<sup>23</sup> Cost effectiveness was not examined in any of the studies.

## Refractory Hepatic Hydrothorax

Hepatic hydrothorax develops in patients with cirrhotic ascites when there is direct communication between the abdominal and thoracic cavities. It may develop in patients with or without clinically apparent ascites. In most patients the defect is in the diaphragm that overlies the dome of the liver.<sup>103</sup> In a series of small studies the effect of TIPS on patients with recurrent hepatic hydrothorax has been relatively uniform with either resolution of the hepatic hydrothorax or a decrease in the need for thoracentesis.<sup>104–106</sup> The impact of TIPS on the survival of these patients can not be determined as there was no control group, however, overall survival was poor. As the therapeutic alternatives in these patients are limited, TIPS is an important tool for the management of this complication of ascites.

## Hepatorenal Syndrome (HRS)

HRS is a dreaded complication of cirrhosis as its development is associated with a poor prognosis. HRS exists in two forms. Type 1 is defined as the rapid (over a two week period) development of renal failure whereas with type 2 HRS the renal failure develops more slowly.<sup>96,97</sup> The prognosis for patients with type 1 is significantly worse than for those with type 2 HRS.<sup>96</sup> TIPS has been used in a number of patients with HRS. In these small series the use of TIPS has been associated with improvements in glomerular filtration rates and renal plasma flow as well as falls in serum creatinine and plasma aldosterone levels.<sup>107–109</sup> However, as none of the trials were controlled, no comparative survival benefit has been shown. In one series, only 20% of the patients with type 1 HRS were alive one year after TIPS creation whereas with type 2 HRS ~45% were alive after one year.<sup>107</sup> These results are somewhat better than expected based on the experience of others but care must be exercised in comparing uncontrolled studies as severity of disease may not be the same across studies.<sup>96</sup> In one of the controlled trials in which

TIPS was compared to LVP in the control of refractory cirrhotic ascites discussed above, a reduced incidence of HRS in those receiving a TIPS was observed.<sup>23</sup> Similar to the findings when TIPS has been used for other complications of portal hypertension, pre-TIPS bilirubin levels were predictive of survival in these patients as well.<sup>107</sup> Finally, creation of a TIPS in HRS patients can be difficult because of concerns about fluid overload and the need to limit the volume of contrast used. TIPS needs to be compared to other therapies, such as terlipressin and other vasoactive compounds, before its role in the treatment of the HRS is determined and currently its use should be considered investigatory.<sup>102,110</sup>

### Recommendations

**22. TIPS will decrease the need for repeated large volume paracentesis in patients with refractory cirrhotic ascites. However, given the uncertainty as to the effect of TIPS creation on survival and the increased risk of encephalopathy, TIPS should be used in those patients who are intolerant of repeated large volume paracentesis. Evidence-I**

**23. TIPS is effective in the control of hepatic hydrothorax but it only should be used in patients whose effusion can not be controlled by diuretics and sodium restriction. Evidence-II-3**

**24. TIPS is of investigatory use for the treatment of HRS, especially type 1, pending the publication of controlled trials. Evidence-II-3**

### Budd-Chiari Syndrome (BCS)

BCS results from blockage of exit of the blood from the liver either due to hepatic vein thrombosis or obstruction of the inferior vena cava.<sup>111,112</sup> Liver injury results from hepatic congestion and previously side-to-side portocaval shunts were used for the management of this disorder. More recently the prognosis for these patients has been examined based on a number of variables and it is clear some of the patients require no intervention whereas for others the only solution appears to be a liver transplant. A model has been created using the following equation that allows for the prediction of survival of patients with BCS:  $1.27 \times \text{encephalopathy} + 1.04 \times \text{ascites} + 0.72 \times \text{prothrombin time} + 0.004 \times \text{bilirubin}$ .<sup>113</sup> Based on this model patients can be separated into three groups with good, intermediate and poor 5 year survivals. Only in patients with an intermediate prognosis was a side-to-side portocaval shunt shown to have a positive impact on survival.<sup>113</sup> Although side-to-side portocaval shunts have been used effectively in this group of patients, operations within the portal space are to be avoided, if possible, as many of these patients may eventually require a liver

transplant. There have been a number of case reports and two small series on the outcome of patients with BCS who have received a TIPS.<sup>114,115</sup> In one series patients with good prognostic indices were treated symptomatically and with anticoagulation and did well.<sup>113</sup> In both series it was the patients with progressive disease who underwent a TIPS. Patients with acute hepatic failure due to BCS did poorly with half of the patients dying in the immediate post-procedure period. Patients with more chronic disease did much better and had relief of symptoms, improvement in liver function and a good intermediate (mean follow-up was 2-4 years) survival. Most of the patients had an underlying prothrombotic disorder and required long-term anticoagulation.<sup>115</sup> The frequency of TIPS insufficiency and thrombosis in the BCS patients did not differ from the frequency of these events in patients with cirrhosis. A recent report on the use of TIPS in a large number of patients with BCS defines more clearly the role of TIPS in the management of BCS. In a retrospective report from Europe 221 patients with BCS were identified.<sup>116</sup> All received anticoagulation following diagnosis and were observed. One hundred and forty-seven failed to improve and 133 had creation of a TIPS attempted with 124 completing the procedure successfully. Eighteen percent had a complication of the procedure and two died from these complications. This higher than expected rate of complications reflects the difficulties in creating a TIPS in patients with hepatic vein thrombosis. One and ten year transplant free survival was 88% and 69% respectively which are better than predicted using a risk scoring system developed for BCS patients. TIPS dysfunction was observed significantly more often in those who received a bare as compared to a covered stent. Performing a TIPS in the patient with BCS can be difficult if the hepatic veins are completely occluded. In this latter situation a transmesenteric TIPS may be performed but this approach is limited to a few centers with extensive experience in creating a TIPS.<sup>117,118</sup>

### **Veno-Occlusive Disease or Sinusoidal Obstruction Syndrome (SOS)**

SOS is seen most commonly following hematopoietic stem cell transplantation but also can occur following exposure to toxins in plants such as bushtea.<sup>119</sup> Symptoms vary from mild sodium retention to progressive liver failure leading to death. In patients with the severe form of the disease ascites is common due to the development of portal hypertension. TIPS has been used in a small number of these patients.<sup>120-123</sup> In these series TIPS did improve ascites, lowered levels of AST and ALT but did not effect serum bilirubin levels. Most of the patients died despite the creation of the TIPS.

## **Hepatopulmonary Syndrome**

Hepatopulmonary syndrome is a complication of cirrhosis in which shunts develop in the lung leading to the development of hypoxia.<sup>124</sup> Six patients have been reported who had hepatopulmonary syndrome and received a TIPS. Five of the six patients showed improvement in oxygenation and some but not all showed a decrease in the intrapulmonary shunts.<sup>125</sup> The mechanism by which TIPS may improve intrapulmonary shunting in patients with portal hypertension is unclear.

### **Recommendations**

**25. The decision to create a TIPS in a patient with Budd-Chiari syndrome should be based on the severity of their disease and only those with moderate disease and who have failed to respond to anticoagulation appear to be reasonable candidates for a TIPS. Evidence-II-3**

**26. Patients with Budd-Chiari syndrome and mild disease can be managed medically whereas those with more severe disease or acute hepatic failure are best managed by liver transplantation. Evidence-II-3**

**27. The use of TIPS to treat SOS cannot be recommended. Evidence-II-3**

**28. The use of TIPS to treat hepatopulmonary syndrome is not recommended. Evidence-II-3**

## **Conclusions**

TIPS is an important part of our current armamentarium used to treat the complications of portal hypertension. Most fellowship trained interventional radiologists are capable of creating a TIPS in a patient with patent hepatic and portal veins. Creation of a TIPS ranks among the more complex procedures performed by interventional radiologists and it is important that each physician monitor their success and complication rates. As with any complex intervention the decision to create a TIPS should be reached by a gastroenterologist or hepatologist who is experienced in the management of these patients in concert with an interventional radiologist. Pre-TIPS evaluation includes routine tests of liver and kidney function as well as a Doppler ultrasound or contrast enhanced abdominal CT scan or MRI of the liver. Once a TIPS is created it can not be forgotten. The patient requires frequent monitoring by Doppler ultrasound and clinic visits to look for the development of TIPS dysfunction. The use of PTFE covered stents reduces the risk of TIPS dysfunction but it will not eliminate the need for continued surveillance.

TIPS will effectively prevent rebleeding from varices and decrease the need for repeat thoracentesis in patients

with hepatic hydrothorax or for large volume paracentesis in patients with refractory ascites. However, TIPS will increase the incidence of hepatic encephalopathy and will not improve survival in any of these patients. Hence, TIPS should not be considered as primary therapy for any complication of portal hypertension with the exception of bleeding gastric or ectopic varices. In all other situations TIPS should only be created when the patient has failed other forms of medical therapy, i.e., pharmacologic or endoscopic therapy, diuretics or repeated large volume paracentesis or thoracentesis. In patients with good liver function and recurrent bleeding from varices despite medical treatment a surgical shunt or TIPS appear to be equivalent therapies. Which patients with BCS are best managed by TIPS remains undefined although creation of a TIPS in select patients appears to be of benefit. Creation of a TIPS for the treatment of HRS or hepatopulmonary syndrome is of unproven benefit and should be considered investigatory.

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