T.I.P.S. : follow-up imaging and revision procedure

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Abstract

TIPS patency can be assessed by different imaging techniques : angiography, color Doppler sonography, CT angiography, scintigraphy.

Percutaneous angiography with measurement of the porto-caval pressure gradient is the gold standard in the diagnosis of shunt failure, but, because its invasive nature and the necessity of frequent control of the shunt function, a noninvasive procedure is preferable for routine checkup.

Color Doppler sonography in intervals of 3 to 6 months, with the use of different criteria, is considered as an accurate imaging technique with a high degree of sensitivity and specificity to evaluate TIPS patency.

Angiography is indicated when CDS is not successfull or in each clinical recurrence.

Revision procedure may restore shunt efficiency and is indicated when the TIPS patency is compromised. (Acta gastroenterol. belg., **2000**, 63, **174-178**).

Key words : TIPS, patency, imaging technique, color Doppler sonography, angiography, revision procedure.

Introduction

The TIPS procedure is an alternative therapeutic solution for portal hypertension. Its limits and indications are now better described and defined (1). The duration of the TIPS efficacity is generally short because of frequent complications. This inconvenient necessitates frequent controls and revisions. Several methods exist to control TIPS patency. All of those have the object to determinate if the stent is effective in term of portal pressure reduction and if a revision procedure is required.

These different modalities are presented and discussed in the present revue.

TIPS follow-up : a necessity

Patency rate of a TIPS is known to be short : in a recent revue of 102 TIPS procedures, using a Kaplan-Meier method of analysis, Latimer *et al.* found shunt survival rates of 76% at 1 year and 58% at 2 years (2). In 1995, La Berge *et al.* had already similar conclusions with survival rates of 60% at 1 year and 51 % at 2 years (3). For Sterling *et al.*, the primary patency rate decreases during the time : 67% at 6 months, 48% at 1 year, 26% at 2 years (4). The main reason of this phenomenon is the high frequency of complications leading to shunt insufficiency : according to the authors, the cumulative 1-year rate of shunt insufficiency is 31-80% (5).

Early insufficiency is generally due to a complete occlusion of the shunt secondary to a thrombosis. Late insufficiency is the consequence of the development of a stenosis, either inside the stent or in the hepatic vein draining the shunt.

Mechanisms leading to the development of a stenosis are now better known (5,6). Intra-stent stenosis are caused by an intimal thickening of the walls leading to a narrowing of the stent lumen. Two factors are incriminated to explain the intimal cellular reaction : a local platelet aggregation with organized thrombus and a local inflammation due to a biliary lackage. Hepatic vein stenosis are due to cells proliferation secondary to the shear stress caused by the local high flow velocity and the activation of smooth muscle cells by growth factors.

The limited middle term and, of course, long term patency rate requires frequent follow-up to keep shunt patent for a longer time and to reduce rebleeding rate.

A safe, reproductible, costless method giving reliable diagnosis of patency is needed. Different conceptual approaches of the patency control exist. Angiography with manometric measurements is the only technique providing morphologic and pressure informations. It is considered actually as the gold standard imaging technique to control TIPS permeability and patency (7). However, it is not totally atraumatic and safe : repeat angiography may lead to shunt restenosis. Because its relative aggressivity and its cost, many authors prefer to use less invasive method to control the stent patency. Different imaging techniques have been evaluated like CT scanner, MR-angiography, scintigraphy and color Doppler sonography (CDS).

TIPS patency control : imaging modalities

CT scan

Few number of studies have been published describing the use of helical computed tomographic angiography in the evaluation of TIPS (8,9,10).

Helical CT angiography of TIPS is performed after a rapid I.V. injection of a bolus of low osmolality contrast medium, followed by helical data acquisition of the

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region of the shunt using thin sections (3 mm collimation). The data are reprocessed in multiplanar reconstructions. Comparison between morphologic findings at CTangiography and at transjugular portography shows a good correlation, especially for the diagnosis a complete occlusion and severe stenosis. The technique may have limitations related to the patients (iodine allergy, pregnancy, poor venous access, polypneic patient) or to the software (artefactual thikening).

Today, the use of CT angiography as a screening procedure for TIPS patency is not yet widespread and a larger prospective study should be performed.

MR angiography

MR angiography is mainly used before the TIPS procedure to define the portal and hepatic venous anatomy : the technique facilitates accurate determination of vessel patency and orientation and may help to decrease the difficulty and lenght of the procedure (11,12,13).

Today, to our knowledge, no studies have been published describing the use of MR angiography in the evaluation of TIPS patency.

Scintigraphy

Liver perfusion scintigraphy (with technetium-99m diethylene triamine penta-acetic acid) has been evaluated in comparison with Doppler sonography in the assessment of changes in the hepatic blood flow after TIPS procedure (14,15). After TIPS placement, a significant increase in portal venous perfusion is observed at scintigraphy (38%). In case of TIPS occlusion, a significant reduction of the portal flow is observed in contribution to hepatic blood flow.

Though this technique can provide usefull informations in case of TIPS occlusion, the real clinical benefit in term of TIPS insufficiency assessment is not yet clearly demonstrated.

Color Doppler sonography (CDS)

CDS has been evaluated by numerous authors in the litterature (16-28). For the great majority of them, it is a reliable noninvasive imaging technique to evaluate TIPS patency.

Several sonographic and Doppler signs have been described allowing anatomic evaluation and quantification of patent, occluded and stenosed shunt.

1. Patent TIPS

After TIPS placement, because of the high porto-systemic pressure gradient, more than 90% of the portal flow is derived through the shunt to the general circulation (15). This high flow characterizes a well functioning shunt : the velocities inside the stent are high (table n°1) and the color signal is typically desatured (aliasing). Reverse color signal inside the intrahepatic portal branches (hepatofugal flow to the stent) are usually observed with a negative spectral signal. Spectral Doppler analysis of the normal intra-TIPS signal shows a classical monophasic pattern with marked spectral broadening. A cardiac modulation is present in 65% of the cases. Portal trunk and hepatic artery velocities (buffer response) are also increased. The hepatic vein draining the TIPS is colored in its usual color (absence of reverse flow) ; a reverse flow may be present along the first centimer of the proximal venous segment but is localised without pathologic significance.

2. TIPS occlusion

The occluded stent contains echoic material. No color signal or spectral signal is present inside the stent. Intrahepatic portal flow is hepatopetal and the portal trunk velocity is decreased. Sensitivity and specificity of CDS for the detection of an occlusion are 96 and 99% respectively. False positive exists, almost due to incorrect Doppler settings (ie inadequate Doppler frequency in case of deep stent), or due to bad conditions like deep TIPS or TIPS parallele to the Doppler beam.

3. TIPS stenosis

Detection of a TIPS stenosis is based on the analysis of the sonographic aspect of the stent and the analysis of the Doppler spectral signal present into and around the shunt.

Table 1. — **Patent T.I.P.S. : spectral analysis**

stent	peakVmax	95-150	cm/sec
	TAMV	55-67	cm/sec
portal vein	peakVmax	41-43	cm/sec
	TAMV	16-22	cm/sec
	vol flow	1731	ml/min
hepatic artery	peakVmax	119-131	cm/sec
	RI	0,75	

peakVmax = peak velocity maximum
TAMV = time average mean velocity
vol flow = volume flow
RI = resistive index.

Stent wall thikening may be directly visible at sonography, especially in the distal or mid segment of the prothesis. Generally, a typical aliasing signal is present confirming the stenosis. However, direct sonographic observation of the stenosis is inconstant. Doppler spectral signal analysis providing measurements allows quantification of the flow. Theoretically, the best Doppler sign of a stenosis is the increased velocity inside the jet of the stenosis. This direct signal may be observed inside the TIPS, most of the time at the proximal segment of the prothesis, sometimes in the mid part of the stent. Unfortunatelly, the detection of such a specific signal is bad with a low sensitivity (Se 42%, Sp 95%).

Because the technical difficulty to measure the velocity in the jet of the stenosis, most of the authors are measuring the velocity in the mid segment of the stent,

upstream the stenosis. Classically, in case of proximal stenosis (either inside the stent or in the hepatic vein draining the shunt), the velocity decreases in the mid part of the stent. The velocity threshold under which the dysfunction appears is variable, according to the authors, between 50 and 60 cm/sec of maximum velocity, 40 cm/sec of mean velocity. Some interpretates a temporal change in the velocity as an indirect sign of dysfunction : a difference in the velocity, either a decrease or even an increase, is considered as a good indirect sign of stenosis (table 2). Portal trunk flow decreases in case of stenosis. However, velocity measurement of the portal flow, despite a recent report, does not seem to be an accurate sign of dysfunction probably, partly, because the portal flow decreases spontaneously in case of well functioning shunt. The direction of the intrahepatic portal flow changes when the stent is stenosed : an hepatopetal flow in the portal branches is a good indirect sign because it has a high pronostic value and it is easy to recognize with color (table 3).

Table 2. — **Stenosis criteria**

mid stent velocities : punctual analysis				
		Sensitivity	Specificity	
peakVmax (cm/sec)	<90-189>	84	70	Kanterman
	<60	100	98	Foshager
	<50	100	93	Chong
	<50	78	99	Felstein
TAMV (cm/sec)	<40	90	96	Puttemans
peakVmax = peak velocity maximum ; TAMV = time average mean velocity.				
mid stent velocities : temporal analysis				
▲ or	50 cm/sec	93	77	Dodd
or ▼	60 cm/sec	75	84	Kanterman
>20%		84	89	Lafortune

Table 3. — **Stenosis criteria**

change in portal flow direction : punctual analysis			
	Sensitivity	Specificity	
intrahepatic hepatopetal flow			
R PV	90	100	
L PV	95	92	Puttemans
change in portal flow direction : temporal analysis			
change from hepatofugal to hepatopetal portal flow	100	92	Feldstein

Others indirect signs have been described like the presence of a reversed flow in the hepatic vein draining the shunt or a lack of cardiac modulation of the stent signal.

All the sonographic and Doppler signs integrated into a general and complete analysis are in good correlation with porto-systemic gradient elevation. Thus, the overall sensitivity of Doppler sonography for the detection of TIPS stenosis is high (70% - 100%).

A controversy exits in the litterature concerning the value of CDS in the assessment of TIPS patency.

Owens *et al.* reported a low sensitivity of only 35% for the duplex ultrasonography detection of shunt stenoses (30). This findings is in complete contradiction with the conclusions of the majority of the studies published to date in the litterature. In a letter to the editor, Nolte *et al.* points out that this finding might lead to the conclusion that CDS would be inappropriate and that angiography would be necessary for surveillance of shunt function after TIPS. Owens's methodology uses a single quantitative criterion (reduced velocity in the shunt) which is considered as insufficient to detect a stenosis. As Nolte and others, we think that a single color Doppler criterion is insufficient to establish a diagnosis of TIPS stenosis and that accuracy depends on analysis of multiple sonographic and Doppler parameters (26,31).

Doppler evaluation of a TIPS must take into account the general clinical status of the patient including the cardio-vascular state, the hepatic collaterals of the portal system, the liver function, the hepatic encephalopathy and the endoscopic findings. For the same reason, some technical considerations are important to notice : a modern equipment is required with 2.5 or 3.5 Mhz phased-array transducer. Doppler settings must be adapted including high pulse repetition frequency (PRF) for the TIPS analysis and low PRF for the portal vein, the collaterals and the hepatic veins analysis. The sampling must encompass the TIPS or the veins, the angle of the Doppler beam must be inferior or equal to 60° and the beam must be focused.

Recently, several authors have shown the benefit of using power Doppler and echo-enhanced color Doppler sonography to increase the sensitivity and specificity (close to 100%), in the diagnosis of shunt dysfunction (32,33)

Despite its high level of performance, CDS remains a technique typically dependent to the operator : a training and a good knowledge of the Doppler settings are mandatory.

Follow-up : when ?

A first CDS has to be performed the day of (or after) the TIPS placement : the hemodynamic status of the well-functioning shunt is considered as the basic reference for futur controls.

Since the occurrence and time of shunt insufficiency cannot be predicted, shunt patency must be assessed frequently : in most studies, a CDS is performed at 30, 60, 90 days after TIPS placement, then at 6, 9 and 12 months and each 6 months after 1 year. A CDS is also performed in case of clinical recurrence.

Angiography is mandatory in each episode of clinical recurrence and when CDS is positive or inaccurate.

TIPS revision procedure

The aim of a TIPS revision is to restore, through a safe and effective procedure, TIPS patency (2,34).

Pseudointimal hyperplasia, the most common complication, is treated in 20-30% by balloon angioplasty and in 60-70% by additional stent. In case of difficult shunt access (angulation), a new parallel shunt may be placed or a transvenous transhepatic approach may be used. The acute occlusion (thrombosis) is treated by thrombolysis or, eventually, by mechanical thrombectomy. The late chronic occlusion may be recanalized or treated by balloon assisted mechanical thrombectomy. Finally, in case of refractory encephalopathy, the TIPS must be reduced or sometimes occluded.

Conclusion

It is obvious that, because the high frequency of complications like stenosis or occlusion, TIPS procedure requires a careful follow-up with frequent controls of the shunt patency.

The real efficiency of the control, in term of portal pressure reduction, necessitates angiography with pressure measurements, but the relative invasive nature of angiography limits its frequent use for the routine checkup.

Shunt patency can be evaluated by several other methods based on the detection of morphologic or hemodynamic signs of stenosis and occlusion.

Despite an accuracy depending on the operator experience and the quality of the material used for the investigation, CDS is considered as a valuable, noninvasive, costless and accurate imaging technique to control TIPS patency : the detection of a shunt insufficiency is based on a multiple Doppler and sonographic criteria analysis, taking into account the general hemodynamic and clinical status of the patient.

CDS in intervals of 3 to 6 months is generally performed.

Angiography and eventual revision procedure is required in case of positive CDS or inaccurate CDS and in each case of clinical recurrence.

The aim of the revision procedure is, through a simple manipulation, to restore shunt efficiency. It is indicated when the TIPS patency is compromised (stenosis, angulation or occlusion) or when the patient develops a secondary refractory encephalopathy (resulting from a too large shunt).

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