Targeting of the portal vein during TIPS by hepatic artery guidewire/catheter: A review and comparative case series of this technique

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Authors: E. Tang, R. Arya, D. Kim; Boston, MA/US
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Learning objectives

Transhepatic intrajugular portosystemic shunt (TIPS) creation is now established therapy for certain complications of portal hypertension. However, TIPS-related complications can occur, including during its most unpredictable and difficult step, the blind transhepatic puncture of the portal vein, which various methods to improve portal vein targeting have attempted to address. The objectives of this presentation are:

1) To review several methods of portal vein targeting and their advantages/limitations in TIPS creation, particularly the widely-used wedged hepatic venography and the lesser-known hepatic artery guidewire as periportal target.

2) To illustrate the relevance of portal triad anatomy to targeting of the portal vein by hepatic artery guidewire during TIPS creation.

3) To present outcomes in a 6-year series of TIPS cases at our institution with vs. without hepatic artery guidewire.
Background

Overview of TIPS:

By relieving portal hypertension, TIPS creation is now an established procedure for prevention of variceal bleeding and treatment of refractory variceal bleeding and refractory ascites, among other complications of portal hypertension [1].

Conventionally, the general steps of the procedure include:

1) Cannulation of the hepatic venous system via percutaneous right internal jugular vein access
2) Measurement of pre-shunt hepatic pressures
3) Visualization of the hepatic/portal venous system, to target shunt placement
4) Transhepatic puncture into the portal venous system from the hepatic venous system
5) Portosystemic shunt creation with insertion of stents along the punctured tract
6) Measurement of post-shunt portal pressure, with dilatation of shunt as needed

Complications related to portal vein puncture in TIPS:

However, TIPS procedure-related complications can occur [2]. One particularly fraught and unpredictable step in TIPS is the transhepatic portal vein puncture, which involves an essentially blind puncture of the central aspect of the portal venous system (typically the right portal vein near its confluence into the main portal vein), via a needle throw from the central aspect of the hepatic venous system (typically in the anteroinferior direction from the more posterosuperiorly-located right hepatic vein). Due to the blind nature of the puncture, multiple passes may be required until the portal venous system is successfully punctured, and with each pass comes risk of unintentional puncture/injury of nontarget structures, such as hepatic structures (hepatic artery, biliary system, liver capsule) or nearby extrahepatic organs (eg, right kidney puncture <2% [3]). Although unintentional punctures are usually well-tolerated, consequences can include biliary fistula formation (<5% [3]), symptomatic hepatic arterial injury (<2% [3-4]), or organ-specific damage, and may require follow-up intervention.

Portal vein targeting in TIPS:

Improvement of portal vein targeting is crucial to decreasing the number of passes and the inherent risks. Preprocedure imaging allows for consideration of anatomic variants
and vessel patency but is not real-time. Bony anatomic landmarks are helpful [5] but can vary relative to the portal vein position through different phases of respiration. Thus, other methods of portal vein targeting have been developed.

**Wedged hepatic venography** (WHV) is commonly used, with placement of either a directly-wedged catheter/sheath or balloon occlusion catheter into a selected hepatic vein, followed by injection of either iodinated or carbon dioxide contrast into the wedged hepatic vein for retrograde outflow into the portal venous system, which can then be used as a roadmap for targeting. An additional benefit of this method is that the order of portal vein branch opacification can help deduce which hepatic vein branch has been selected and wedged. However, this roadmap is not real-time and cannot account for changes in view or respiratory motion. The injection of contrast in WHV has also been associated with liver laceration (up to 7.5% with iodinated contrast [6], 1.8% with the less viscous carbon dioxide [7]), and even capsular injury requiring intervention [8]. Since the risk of bleeding in capsular injury may be worse in the presence of ascites, preprocedure paracentesis has been advocated. An additional disadvantage of carbon dioxide WHV (cWHV) is requirement of a high imaging frame rate, increasing operator radiation exposure.

Another less commonly utilized option is **intraprocedure ultrasound**, which allows for real-time visualization of hepatic vessels and structures without the use of contrast [9]; however, its use is highly operator-dependent and sonographic visualization of the needle and other objects can be difficult.

Other more invasive techniques of portal vein targeting include **cannulation of an enlarged umbilical vein** [10], **transhepatic placement of a portal vein guidewire** [11] or periportal coil, or the **transhepatic "gunsight" approach with placement of endovascular snares/wires for direct portocaval shunt** [12]. However, transhepatic and transvariceal approaches can be technically difficult and are risky in patients with coagulopathy, particularly those with ascites, both common issues in the patient population undergoing TIPS [3].

A lesser-known but relatively straightforward portal vein targeting technique, using a **hepatic artery microguidewire** as a target, has been advocated by Matsui et al [13] and Yamagami et al [14], taking advantage of the hepatic artery’s companion course with the portal vein. The hepatic arterial system typically courses anterior to the portal venous system in the portal triad (Fig. 1), therefore a particularly convenient target for a portal vein-directed needle throw that typically begins in the more posteriorly-located right hepatic vein. Placement of a periportal hepatic artery guidewire allows for real-time targeting, and the arterial access additionally allows for mesenteric and celiac portography, which can demonstrate both the portal venous anatomy and any associated varices in real-time. It can be performed safely and efficaciously by even less experienced operators and without the need for additional apparatus unlike in carbon
dioxide wedged hepatic venography. Yamagami et al [14] had a 100% success rate of TIPS creation without any symptomatic puncture-related complication, even when this technique was utilized by operators who did not frequently perform TIPS procedures, for 11 cases over a 5-year span. Although guidewire-related thrombus formation may be a theoretical concern [15], the liver is an organ rich in collateral supply, so hepatic artery microguidewire-related thrombus formation is of lesser concern, particularly in the cirrhotic population, which has high rates of coagulopathy and thrombocytopenia. Microguidewires have a relatively low profile and have been used quite successfully in cardiac and neurological interventions.

Here, we consider the outcomes in a 6-year series of TIPS creation cases, with hepatic artery guidewire versus with carbon dioxide wedged hepatic venography, supervised by a single operator at our institution.
**Fig. 1:** Hepatic arterial (HA) system courses anteriorly to portal venous (PV) system in the portal triad, a particularly convenient target in the right hepatic vein-right PV TIPS, which typically involves an anterior needle throw from hepatic vein to PV.

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A total of 10 TIPS placements supervised by a single interventionalist attending operator were performed from 2007-2012. Three cases utilized cWHV to target the portal vein, 6 cases utilized hepatic artery guidewire (HAG) technique, and one utilized both methods.

In cases with HAG (Fig. 2 & 3), a 5 Fr vascular sheath was placed with a micropuncture kit in the right common femoral artery and celiac +/- mesenteric angiography with delayed portography phase was performed to visualize the portal venous system. The common hepatic artery was then selected by a 4 or 5 Fr catheter, and a 0.018-inch microguidewire was advanced into the hepatic arterial branch accompanying the portal vein target.

In cases with only cWHV, no femoral artery puncture was made. A 5 Fr catheter was advanced from the right transjugular approach and directly wedged against a central portion of the right hepatic vein, with subsequent injection of carbon dioxide contrast to demonstrate portal venous anatomy for use as a roadmap (Fig. 4).

Once the targeting system was in place for either the HAG or cWHV method, a Colapinto needle and vascular sheath was advanced from the right hepatic vein towards the central right portal vein, with either the HAG or cWHV roadmap as the targeting guide. Successful portal vein cannulation was determined by aspiration of venous blood and contrast injection via the needle that successfully opacified the portal venous system.

<table>
<thead>
<tr>
<th>Case no.</th>
<th>Age/ Gender</th>
<th>TIPS indication</th>
<th>HAG used?</th>
<th>cWHV used?</th>
<th>TIPS created?</th>
<th>Complications</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>64/F</td>
<td>Refractory variceal bleeding</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>None</td>
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<tr>
<td>2</td>
<td>51/M</td>
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<td>No</td>
<td>Yes</td>
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<tr>
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<td>49/M</td>
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<td>No</td>
<td>No</td>
<td>None</td>
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<tr>
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<td>46/F</td>
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<td>Yes</td>
<td>Yes</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Case Details</td>
<td>Treatments</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>5</td>
<td>65/F</td>
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<td>Yes</td>
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<td>None</td>
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<td>50/M</td>
<td>Refractory massive variceal bleeding</td>
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<td>Yes</td>
<td>Yes</td>
<td>Nontarget right hepatic artery puncture requiring embolization</td>
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<td>7</td>
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<td>None</td>
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<td>8</td>
<td>65/M</td>
<td>Refractory ascites and prevention of variceal bleeding</td>
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<td>No</td>
<td>Yes</td>
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<tr>
<td>9</td>
<td>46/M</td>
<td>Prevention of variceal bleeding</td>
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<tr>
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<td>61/M</td>
<td>Refractory ascites</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>None</td>
</tr>
</tbody>
</table>

**TIPS creation in 10 patients with complications from cirrhosis-related portal hypertension (notable cases in bold lettering).**

The number of passes for portal vein puncture was not documented for any of the cases. There were no portal vein puncture-related complications in any of the 7 cases utilizing HAG technique. With respect to the HAG placement, there were also no complications related to femoral artery puncture or evidence of hepatic artery thrombus formation. However, in one of the cases utilizing the HAG technique, unusual hepatic venous anatomy precluded successful anterior deployment of the Colapinto needle.

In the 3 cases with cWHV alone, TIPS was created successfully in all the cases, with one complication. This complication resulted in symptomatic nontarget puncture of a right hepatic arterial branch, with postprocedural bleeding (Fig. 5) that required hepatic arterial embolization the next day (Fig. 6).
In the case that utilized both cWHV and HAG, the HAG was shown to compensate for respiratory motion better than the roadmap, as depicted by images acquired in inspiration and expiration (Fig. 7). TIPS was created successfully in this case, using the HAG as the primary target.
**Fig. 1:** Hepatic arterial (HA) system courses anteriorly to portal venous (PV) system in the portal triad, a particularly convenient target in the right hepatic vein-right PV TIPS, which typically involves an anterior needle throw from hepatic vein to PV.

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Fig. 2: Hepatic artery guidewire technique steps: a) celiac artery (red arrow) angiogram shows opacification of splenic (black arrow) and hepatic artery (black arrowhead); b) delayed phase of celiac artery angiogram shows opacification of portal venous system (black arrow); c) guidewire placement into right hepatic artery (black arrow), note the relative position of right portal vein to the guidewire (red arrow); d) right hepatic vein cannulation (black arrow), note the relative position of the guidewire which is in the right hepatic artery (red arrow); e) Advancement of Colapinto needle through the hepatic parenchyma (black arrow) towards right hepatic vein using hepatic artery guidewire targeting (red arrowhead); f) successful guidewire (black arrow) advancement into the portal venous system (red arrowhead) via right hepatic vein access.

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Fig. 3: Stent deployment and subsequent contrast injection demonstrates patent flow through the TIPS (black arrow). Note the gastric varices (red arrow), which were subsequently coiled successfully (black arrowhead).

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**Fig. 4:** Carbon-dioxide wedged hepatic venography obtained after injection of carbon-dioxide via a catheter wedged in the right hepatic vein (red arrow) demonstrates opacification of the right (red arrowhead) and the left (blue arrowhead) portal veins.

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**Fig. 5:** Coronal image from non-contrast CT performed for hematocrit drop after TIPS placement (arrowhead) shows acute hemorrhage in the right paracolic gutter (arrows).

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Fig. 6: Selective microcatheter angiogram of the left hepatic artery demonstrates a blush of contrast (red arrow) consistent with active hemorrhage. Note the position of TIPS (white arrowhead). Angiogram performed after coil deployment (white arrow) does not demonstrate any blush.

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Fig. 7: On both inspiration (a) and expiration (b), hepatic artery guidewire (black arrow) was shown to move relatively with the portal vein guidewire (red arrow), therefore a better approximation of the portal vein course than the venography roadmap, which remained fixed despite respiratory motion.

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Conclusion

During TIPS procedure, portal vein targeting is the most important and difficult step, often the source of complications. Our series, although small in size, demonstrates that portal vein targeting by placement of a microguidewire in the right hepatic artery is safe and largely efficacious and should be considered as a viable alternative to carbon dioxide wedged hepatic venography. Hepatic artery guidewire can be used by operators without carbon dioxide venography capabilities and even by operators for whom TIPS is a less common procedure.


