

Real Time MR Guided Meso-Caval Puncture: Towards the Development of a Percutaneous MR Guided Mesocaval Shunt

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Introduction: Cirrhosis is a significant worldwide healthcare burden. Due to irreversible scarring of the liver in cirrhosis, the development of portal hypertension causes decreased hepatic blood flow and leads to many of the life threatening complications of cirrhosis such as gastric and esophageal varices, ascites, and eventual liver failure.

Decompression of the portal venous system has traditionally been accomplished with: (1) a surgical end-to-side meso-caval shunt which decompresses the portal vein or (2) a percutaneous transjugular intrahepatic portosystemic shunt (TIPS). Because the meso-caval shunt is a partial shunt (portal vein flow is maintained), there is a low rate of encephalopathy, rebleeding and improved quality of life. Since TIPS is a complete shunt (no flow to the portal vein), there is a high incidence of encephalopathy and shunt occlusion. In addition, since TIPS is performed blindly, without direct visualization of the portal venous system, there are a number of potential complications including traversal of the liver capsule, creation of fistulous tracts between the shunt and the hepatic artery or bile ducts. Prior experiments have tried to reproduce the TIPS procedure under MR guidance[2] with success. However, a percutaneous creation of a meso caval shunt would provide the maximum benefit of a selective shunt with a lower rate of complications. Due to difficulty in identifying the superior mesenteric vein and splenic vein under conventional fluoroscopy, prior attempts of a percutaneous meso-caval shunts have been cumbersome and not practical. [3]

Using an intravascular needle system that can be actively visualized under MRI we have developed the first stage of a hybrid procedure – a minimally invasive meso-caval shunt. Using real time MR, this procedure allows for direct, simultaneous visualization of the extruded needle, inferior vena cava, portal vein, and the surrounding abdominal organs, thereby avoiding the most serious complications of TIPS and of general surgery.

Methods: Three IVC – superior mesenteric venipunctures were performed in a porcine model (90-100 lb pigs). A novel active MR intravascular needle system was utilized for proper needle tracking and extra caval puncture. This needle as seen in Figure 1 is made of concentrically configured nitinol hypotubings arranged to form a loopless antenna[1]. All imaging was performed solely under MR guidance in a 1.5 T MR scanner (CV/i, GE Medical Systems Waukesha, WI). Images were acquired using a combination of external phased array coils and the intravascular needle. The needle was introduced through a standard clinical 12 F sheath which had been placed in the common femoral vein. Using a real-time FIESTA sequence (3.4 ms TR, 1.2 ms TE, 45° flip angle, 125 kHz bandwidth, 10 mm slice thickness, 30 cm FOV, 128 x 128 image matrix, and 1 NEX) in combination with an interactive scan plane acquisition (i-Drive, GE), the needle was advanced into the IVC. It was then guided to the level where the superior mesenteric vein is closest to the IVC. Using a fast SPGR sequence (6.0 ms TR, 1.5 ms TE, 60° flip angle, 125 kHz bandwidth, 7 mm slice thickness, 35 cm FOV, 256x256, and 1 NEX) providing a temporal resolution of 1 slice/second, the needle was oriented to face the superior mesenteric vein. Under realtime FIESTA sequence, the needle system was guided through the IVC and into the superior mesenteric vein. The location of the distal tip of the needle in the superior mesenteric vein was then confirmed by ECG-gated FSE sequence with double inversion black blood (1904 ms TR, 4.5 ms TE, 62.5 kHz BW, 3 mm slice thickness, 36 cm FOV, 256 x 128 image matrix, and 1 NEX). After confirmation, a portogram, using Gd-DTPA with concentration of 25%, was performed using a FSPGR (6 ms TR, 1.3 ms TE, 90° flip angle, 31.2 kHz BW, no slice selection, 45 x 22.5 cm FOV, 256 x 128 image matrix, 1 NEX, 1.5 frames/sec)[4].

Results: Successful MR guided IVC – superior mesenteric vein punctures were performed in all three of the procedures. Using the FIESTA and SPGR sequences, the catheter was successfully tracked and oriented within the IVC, and once in proper location and orientation, the IVC to superior mesenteric vein puncture was made (Figure 2). Active tracking of the needle traversing the IVC towards the SMV was possible. The location of the catheter tip was then confirmed using the FSE-XL sequence (Figure 3: sagittal in A, axial in B and C). With the needle system still in the SMV a final confirmatory gadolinium portogram was performed. Figure 4 demonstrates the 3 phases of the portogram: portal venous phase in A, hepatic parenchymal phase in B, and supra-hepatic vena caval phase in C. No contrast is seen within the IVC or within the abdominal parenchyma at any time.

Conclusion: Using only MR guidance and a novel MR intravascular needle system we were repeatedly able to successfully puncture the superior mesenteric vein from the inferior vena cava in a highly controlled manner with direct visualization of all components including the needle, the inferior vena cava, the superior mesenteric vein and the surrounding abdominal organs. This is the first stage in the development of a minimally invasive meso-caval shunt, designed to relieve portal hypertension in the cirrhotic patient, which can be performed without the risks associated with general surgery and without many of the risks inherent to fluoroscopy-guided TIPS.

This work was supported by NIH grants RO1HL61672 and RO1HL57483.

1. Ocali, O. and E. Atalar, *Intravascular magnetic resonance imaging using a loopless catheter antenna*. Magn Reson Med, 1997. **37**(1): p. 112-8.
2. Kee, S.T., et al., 1999 *Gary J. Becker Young Investigator Award. MR-guided transjugular portosystemic shunt placement in a swine model*. J Vasc Interv Radiol, 1999. **10**(5): p. 529-35.
3. Kaminou, T., et al., *Percutaneous retroperitoneal splenorenal shunt: an experimental study in swine*. Radiology, 1998. **206**(3): p. 799-802.
4. Serfaty, J.M., et al., *Real-time projection MR angiography: feasibility study*. Radiology, 2000. **217**(1): p. 290-5.

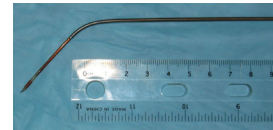


Figure 1: Novel active MR intravascular needle system. Concentric configuration of nitinol tubings forms a loopless antenna.

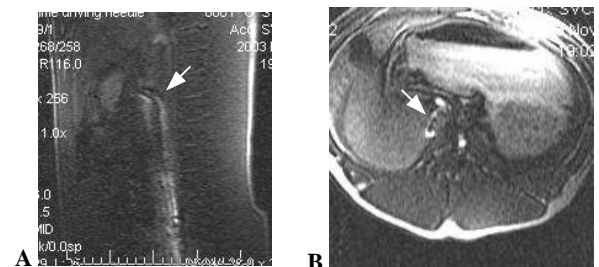


Figure 2: The active needle system is tracked in the IVC, placed at the proper level and oriented towards the SMV. A. Sagittal plane (FIESTA). B. Axial plane (SPGR). (arrow points to active needle)

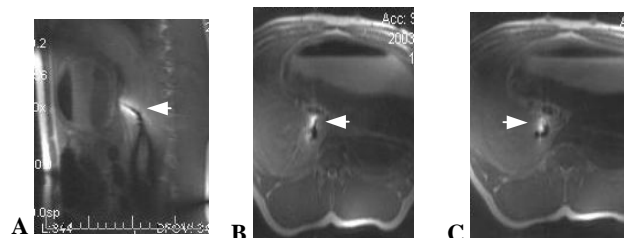


Figure 3: Post-puncture localization of the needle tip (FSE), A. Sagittal plane, B & C. Axial plane - arc of needle system is seen extending from the IVC to the SMV. (arrow points to needle extending outside of IVC)

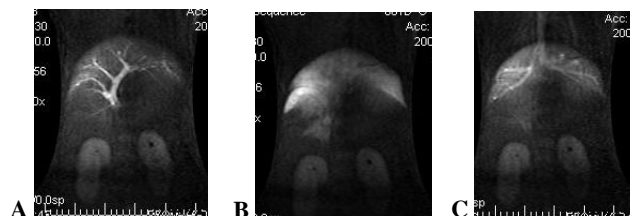


Figure 4: Gadolinium portogram using FSPGR, all three phases are seen. A. Portal venous, B. Hepatic parenchymal, C. Hepatic venous and supra-hepatic vena caval phase.