MR Guided Transcaval Creation of 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.

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 percutaneous meso-caval shunts have been cumbersome and not practical. [3]

Using an intravascular needle system that can be actively visualized under MRI and an anastomotic device we have developed a novel hybrid procedure – a minimally invasive meso-caval shunt. The purpose was to create a new vascular anastomosis between the portal mesenteric venous system and the inferior vena cava utilizing both MRI and x-ray fluoroscopy.

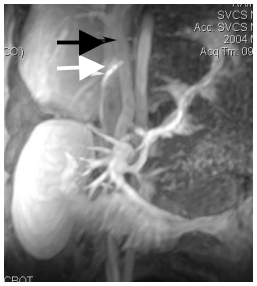

Figure 1. MRA/MRV demonstrates that the intravascular needle (white arrow) exits the IVC and enters the portal venous system (black arrow)

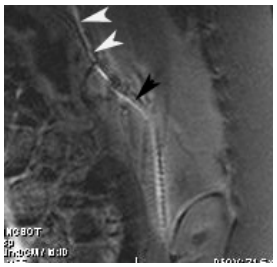

Fig 2 Advancement of a .018 nitinol wire (white arrows) through the active needle (black arrow) to catheterize the mesenteric venous system.

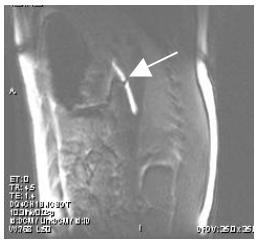

Fig 3 Angioplasty of the retroperitoneum with a Gd-DTPA filled balloon (arrow)

Methods: Fifteen IVC – superior mesenteric vein punctures were performed in ten swine (90-100 lb pigs). An active MR intravascular needle system was utilized for proper needle tracking and extra caval puncture. This needle is made of concentrically configured nitinol hypotubings arranged to form a loopless antenna[1]. The anastomosis device was constructed with a nitinol exoskeleton with flared anchors struts to create a connection between the two vessels. The device is deployed through an 11 Fr vascular sheath. The diameter of the anastomotic device was 1cm, with a length of 6-10 mm. **Stage 1.** The first stage of the procedure involved MR guided transcaval puncture of the portal or mesenteric vein. All MR imaging was performed 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 though 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, 45º 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. Prior to a puncture, an MRA/MRV **(Figure 1)** was performed with 30cc using Gd-DTPA (4.8 ms TR, 1.4 ms TE, 25º flip angle, 31.2 kHz BW, FOV, 256 x 256 image matrix). Under realtime FIESTA sequence with multiplanar views, the needle system was guided through the IVC and into the superior mesenteric vein or portal vein (n=15 punctures). After confirmation, a portogram, using Gd-DTPA with concentration of 25%, was performed using a FSPGR (6 ms TR, 1.3 ms TE, 90º flip angle, 31.2 kHz BW, no slice selection, 45 cm FOV, 256 x 256 image matrix, and 1 NEX)[4], a wire (.018") was advanced into the portal venous system under MRI (n=7) **(Figure 2)**. **Stage 2.** In order to place the anastomotic device, angioplasty of the retroperitnenoum was performed in both MRI (n=2) **(fig 3)** or under fluoroscopy (n=2). Animals were then transferred to X-Ray fluoroscopy for placement of the anastomosis device **(Fig 4 A)**. Under direct fluoroscopy, the anastomosis device was advanced to bridge the gap between the IVC and the mesenteric venous system (n=2). After deployment of the anastomosis device, catheter based angiography was performed to assess the anastomosis. Post procedure necropsy was performed.

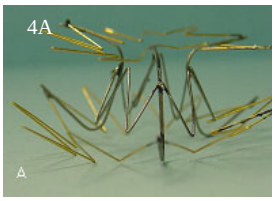

Fig 4A: Side view of self expanding anastomosis device is shown. Lateral stent struts (1,2) will hold the portal vein and the IVC together while the central circular stent, will allow blood flow from the portal vein to the IVC

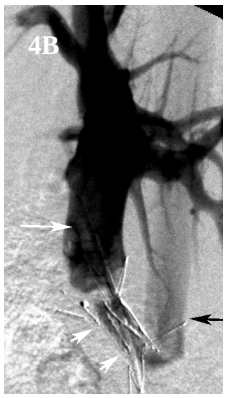

Fig 4B: Injection of contrast through a catheter in the portal vein (long white arrow) after deployment of anastomosis device demonstrates the successful creation of a meso-caval shunt (short white arrowheads). Flow into the IVC is seen (black arrowhead)

Results: Successful MR guided IVC – superior mesenteric vein punctures were performed in all 15 procedures. Using the FIESTA sequence, active tracking of the needle traversing the IVC towards the SMV was possible. With the needle system still in the SMV a confirmatory gadolinium portogram was performed. A .018" guidewire was used to successfully cannulate the mesenteric-portal venous system **(Figure 2).** After catheterization, angioplasty of the retroperitoneum was performed under fluoroscopy (n=2) and under MRI (n=2). **(Fig 3)** The anastomosis device was successfully placed under fluoroscopy to bridge the two vascular beds. **(Fig 4A,B)** No significant bleeding was noted on the final catheter angiogram. Post procedure necropsy demonstrated that the anastomosis was intact without any significant bleeding or damage to vasculature. **(Fig 5)**

Conclusion: Transcaval punctures to the mesenteric venous system were successfully performed. An anastomotic device that bridged the two vascular beds was successfully deployed and was used to created a meso-caval shunt. Using a combination of MRI and x-ray fluoroscopy for guidance we were able to successfully create a percutaneous shunt between the portal mesenteric venous system and the IVC. **(Figures 4B, 5)**

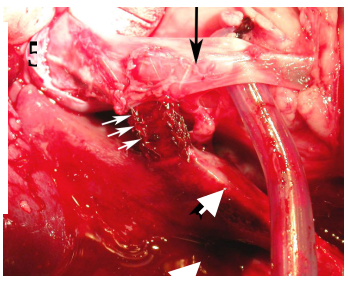

Fig 5 Post procedure necropsy demonstrates intact anastomosis (multiple short arrows) between the portal vein black arrow and IVC (short arrow)

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