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Imaging of the Portal Vein During Transjugular Intrahepatic Portosystemic Shunt Procedures: a Comparison of Carbon Dioxide and Iodinated Contrast

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We report our experience with wedged hepatic injections of carbon dioxide (CO_2) in the imaging of the portal vein during transjugular intrahepatic portosystemic shunt (TIPS) procedures.

In all patients CO_2 allowed quick and effective visualization of the portal vein. The image quality and extent of visualization of the portal vein was considered superior to iodinated contrast media in all cases. We suggest that CO_2 should be used more frequently during TIPS. Sheppard, D. G., Moss, J. & Miller, M. (1998). *Clinical Radiology* **53**, 448–450. Imaging of the Portal Vein During Transjugular Intrahepatic Portosystemic Shunt Procedures: a Comparison of Carbon Dioxide and Iodinated Contrast

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Carbon dioxide (CO_2) was used in the 1920s to investigate retroperitoneal structures and in the 1950s to diagnose pericardial effusions. Capnosplenoportography has been described as far back as1966 [1]. Pioneering work by Hawkins and colleagues at the University of Florida, who have used CO_2 in over 800 patients, has renewed interest in CO_2 as an alternative to iodinated contrast media (ICM) in angiography [2,3] and to image the portal vein during TIPS [4,5].

We report our initial experience, where wedged hepatic venous injections of CO_2 have been compared with ICM to demonstrate the portal vein and its branches, during TIPS procedures.

PATIENTS, METHODS AND RESULTS

Patient 1. A 32-year-old man with alcohol induced portal hypertension referred for a TIPS for uncontrolled variceal haemorrhage. Wedged hepatic injections of CO_2 (Fig. 1*a*) and ICM (Fig. 1*b*), were performed. There was better visualization of the portal vein and its branches with CO_2 compared to ICM.

Although there was some reflux of ICM into the hepatic vein, there was adequate wedging, as suggested by the degree of parenchymal staining.

Patient 2. A 51-year-old man referred for a TIPS for uncontrolled variceal haemorrhage. Using a wedged hepatic vein injection there was again better visualization of the portal venous system using CO_2 (Fig. 2*a*) than with standard ICM (Fig. 2*b*) and less tissue staining with CO_2. The catheter position was changed slightly between injections. Despite adequate wedging, indicated by the parenchymal staining, there was significant reflux of ICM into the hepatic vein, which might in part explain the superior visualization with CO_2.

Patient 3. A 46-year-old woman with portal hypertension. An oesophageal stent had been placed for a resistant sclerotherapy induced stricture.

Endoscopy had failed to demonstrate a site for recurrent episodes of bleeding.

Wedged hepatic injections of CO_2 (Fig. 3) and ICM were performed. The portal venous system was again best demonstrated using CO_2. There was inadequate filling of the portal venous system and significant staining after the well wedged ICM injection. As the portal venous system had been well demonstrated with CO_2, a repeat ICM injection was not performed. While no oesophageal varices were noted, intra-abdominal varices were demonstrated.

Our technique for TIPS involves a standard jugular approach, and identification and cannulation of the right or middle hepatic veins. A 5 French end-hole catheter is advanced until the tip is gently, but firmly wedged, in a peripheral hepatic vein branch. A length of tubing, to which an air filter and a three way tap are connected, is attached to a CO_2 cylinder. A 60 ml syringe, with a one-way high pressure valve (Boston Scientific U.K.), is attached to the three way tap. The CO_2 cylinder is opened and the syringe fills. The three way tap is then opened to the atmosphere and the CO_2 in the syringe is discharged. This procedure is repeated several times to remove any residual air from the syringe. The syringe is then filled and the high pressure valve closed. Pressure on the plunger is required to prevent the CO_2 pushing the plunger out of the syringe. The syringe is then connected to the catheter.

Keeping the high pressure valve closed, the CO_2 in the syringe is pre-compressed from a volume of 60 ml to ≈30 ml. The valve is then opened and the precompressed gas is then injected, resulting in a more controlled and compact delivery of CO_2. This technique was used in all three cases reported. The ICM injections involved injecting ≈10 ml of non-ionic contrast media (300 mg I/ml). The filming rate was 6 frames/s, using 75 kV and 30 mA for both techniques. Only a single injection of ICM was used due to the marked parenchymal staining. Usually a single injection of CO_2 was also used but occasionally a second injection was made.

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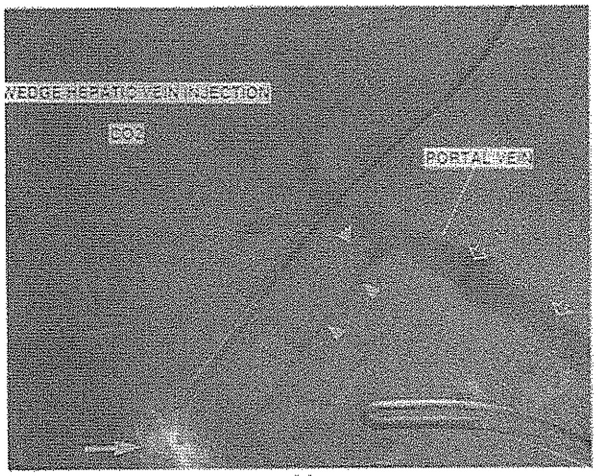
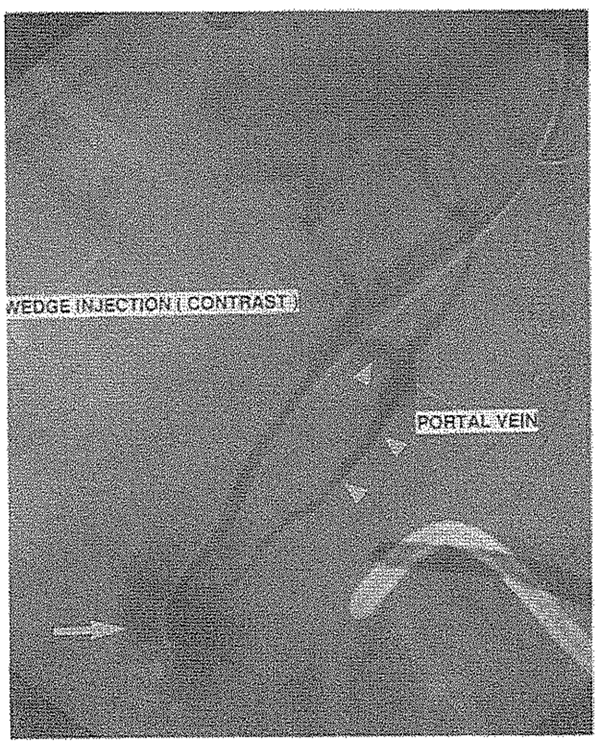
Although software is available for CO_2 imaging that looks at minimum rather than maximum pixel values, thus compensating for the lower natural contrast of CO_2 relative to standard ICM and image stacking facility that compensates for CO_2 fragmentation (Philips CO_2 view trace), the three cases described were performed with standard software. A CO_2 pump was not used [3,6].

DISCUSSION

The physical and chemical properties of CO_2, the principles of gas delivery, its behaviour in the vascular system,

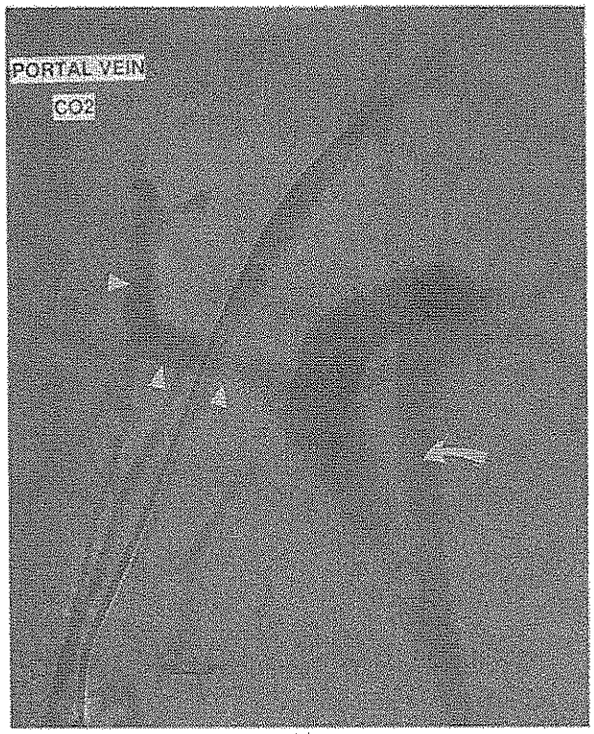


(*a*)



(*b*)

Fig. 1 – Patient 1. Wedged hepatic venous (*a*) CO_2 and (*b*) ICM injections. While there was better filling of the peripheral branches with ICM (arrowheads), the main portal vein (open arrows) was only visualized with CO_2. There was more parenchymal staining with the ICM than the CO_2 injection (closed arrow).



(*a*)

(*b*)

Fig. 2 – Patient 2. Wedged hepatic venous (*a*) CO_2 and (*b*) ICM injections, using different catheter positions. In addition to more complete demonstration of the right portal system (arrowheads), the remainder of the portal system and the enlarged umbilical vein (curved arrow) were only shown with CO_2. Despite the apparently good wedging, as suggested by the parenchymal staining, there was significant reflux of ICM into the hepatic vein.

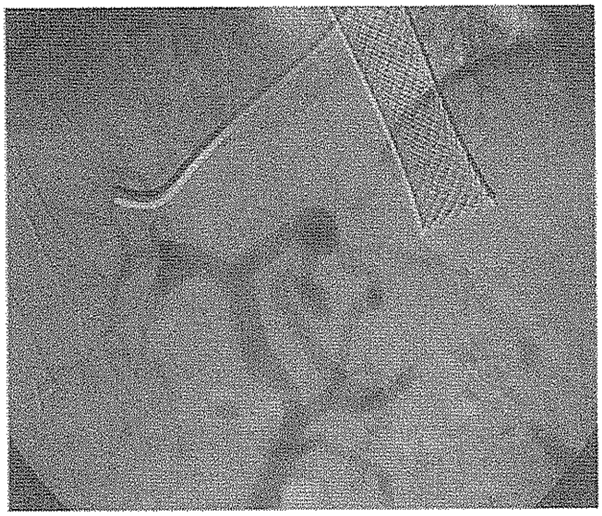


Fig. 3 – Patient 3. Wedged hepatic venous CO_2 injection. The entire portal system was outlined by CO_2. The ICM injection was nondiagnostic, with under-filling of the portal venous system and significant parenchymal staining (not shown).

the imaging principles, the safety considerations and the clinical applications have been previously described [2,3].

During a TIPS procedure, it is essential to enter a portal vein branch within the liver. A recent study has shown that the portal venous bifurcation is extra-hepatic in up to 48.4% of patients. It is suggested that puncturing the portal vein 3 cm proximal to the bifurcation should guarantee an intra-hepatic puncture [7]. Because of distortion of the normal anatomy by cirrhosis, some form of guidance is helpful to avoid inadvertent puncture of the hepatic artery, biliary or extra-hepatic structures, especially in the presence of ascites. Various techniques for targetting the portal vein during TIPS [4,5,8–13] have been described.

Compared to wedged injections of ICM, we had better delineation of the portal venous system using CO_2. This was not due to differences in catheter placement as the technique for wedging the catheters was identical for both the CO_2 and ICM injections. In all three cases there was good parenchymal staining with ICM confirming that the catheters were, at least initially, well wedged. The better opacification with CO_2 is due to its lower viscosity (1/400 of ICM) which allows rapid injections of large volumes of CO_2 through a small diameter catheter. The low viscosity also allows facilitates rapid transit through the vascular bed without the need for occlusion balloons or forceful catheter wedging. The rapid clearing of extravasated CO_2, also results in significantly less parenchymal staining, a problem with ICM. The reliable identification of the portal vein, using CO2, resulted in a decreased number of passes to access the portal vein, decreased procedure time and reduced ICM useage, which had averaged 350 ml for the prior 20 TIPS done at our institution.

Complications occur in ≈1.5% of patients undergoing angiography with CO_2 [3]. Although there have been no deaths with arterial and venous injections, there has been one death, resulting from a liver laceration, after a wedged hepatic vein injection of CO_2 [14]. In this case, a liver laceration occurred after an injection of 60 ml of CO_2, with the subsequent development of a subcapsular haematoma demonstrated by CT. Paracentesis demonstrated bloody ascites, although angiography failed to demonstrate a bleeding site. The patient subsequently died from multi-organ system failure 13 days later.

The authors subsequently report no complications using a reduced volume and rate of injection (noncompressed volume of 30–50 ml at 15 ml/s). They additionally recommend wedging the catheter in a central rather than peripheral portion of the hepatic vein and purging the catheter with 1–2 ml of CO_2 prior to the angiographic injection.

CONCLUSIONS

We have found CO_2 to be extremely useful in the identification of the portal vein during TIPS. An understanding of the behaviour of an intravascular gas and its effects on imaging is required. However, provided due care is paid to proper technique, CO_2 offers a practical alternative to ICM, with no loss of diagnostic accuracy.

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