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CO_2 Portovenography: Potential Role in TIPS

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ABSTRACT

Carbon dioxide (CO_2) is an inexpensive, colourless, odourless, compressible gas requiring unique methods of handling and injection. Intravascular CO_2 causes no nephrotoxicity or allergic reactions and allows accurate imaging with little risk. In this review article, we discuss potential role of CO_2 as an intravascular contrast agent in Transjugular Intrahepatic Portosystemic Shunt (TIPS) procedure.

KEYWORDS

Nephrotoxicity; Transjugular; Shunt; Varices

INTRODUCTION

CO_2 was first time used intravenously in 1950 to diagnose pericardial effusion [1,2]. Use of CO_2 to evaluate the portal venous system and hepatic venous system was first reported in 1967 [3,4]. Hawkins IF pioneered use of CO_2 in the peripheral and visceral arterial circulation [5].

CO_2 displaces, rather than mixes with blood and thus acts as a negative contrast agent. The small change in density between a blood vessel containing blood, and a blood vessel containing gas, can be demonstrated using digital subtraction angiography (DSA). Image quality can be further improved by using post-processing functions like pixel shifting, remasking, edge enhancement and image summation.

A rapid injection rate rather than a large injection volume is needed to quickly displace blood and completely fill the vessel. If too small a volume is used, CO_2 tends to float on the blood, thereby incompletely filling the lumen of the vessel. This may result in underestimation of vessel diameter and non-visualization of nondependent structures.

CO_2 rapidly dissolves in blood and is excreted as it passes through the lungs [6]. Even large volumes of intravenously injected CO_2 results in no change in arterial pH, pCO_2 and pO_2 [7,8]. But CO_2 has been found to be neurotoxic and use of CO_2 angiography above diaphragm is not advocated [9].

TIPS

Transjugular intrahepatic portosystemic shunt (TIPS) is a percutaneously created connection within the liver parenchyma that establishes connection between the inflow portal vein (PV) and the outflow hepatic vein (HV). The goal of TIPS placement is to reduce portal

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pressure in patients with complications related to portal hypertension, by diverting portal blood flow into HV [10,11]. Shunt patency is maintained by placing an expandable metal stent across the intrahepatic tract.

TIPS procedure was first time described by Rosch J, et al. [12] in 1969. TIPS procedure was first time used in a human patient by Colapinto RF, et al. [13] in 1982, but this was unsuccessful. The first successful TIPS procedure was reported by Rossle M, et al. [14] in 1989.

Indications for TIPS

The accepted indications [15-17] for TIPS are as follows:

1. Uncontrolled variceal hemorrhage from esophageal, gastric, and intestinal varices that do not respond to endoscopic and medical management.
2. Refractory ascites.
3. Hepatic pleural effusion (Hydrothorax)

TIPS placement technique

PV patency should be confirmed first, prior to attempts to TIPS placement. PV thrombosis is not an absolute contraindication to TIPS placement but makes the procedure technically more demanding. All patients undergoing TIPS, should receive prophylactic broad-spectrum antibiotics. Appropriate resuscitation with fluids and blood products is indicated, prior to the procedure. Platelets are routinely administered when platelet counts are less than 50,000 mm^3 and fresh frozen plasma (FFP) is used when international normalized ratio (INR) is greater than 1.5. Most patients can safely undergo TIPS placement with intravenous conscious sedation involving short acting benzodiazepines and opiates.

First access to the internal jugular vein is gained using ultrasound guidance. Thereafter, a guidewire and introducer sheath is typically placed. This enables the interventional radiologist to gain access to the patients HV, by travelling from superior vena cava (SVC), through the heart into inferior vena cava (IVC). Once the catheter is in the hepatic vein, a wedge pressure is obtained to calculate the pressure gradient in the liver (Figure 1).

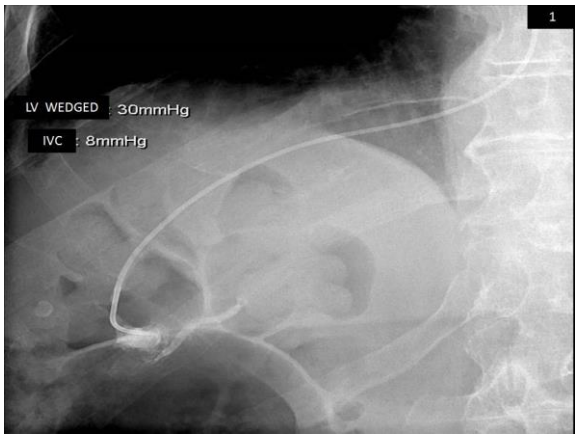

Figure 1: Initial image showing pressure gradient of 22 mm Hg (30-38 mm Hg).

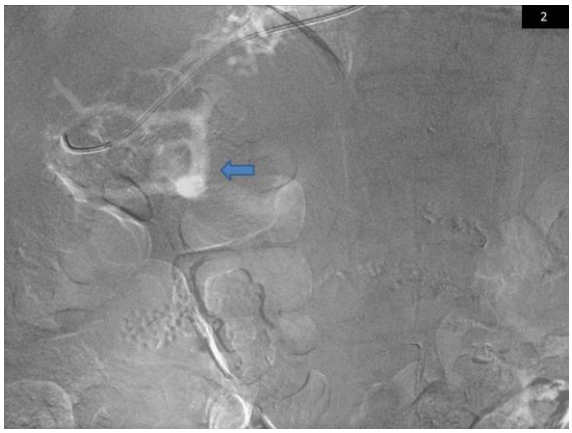

Figure 2: Note relation of portal vein with right hepatic vein on CO_2 Portovenography.

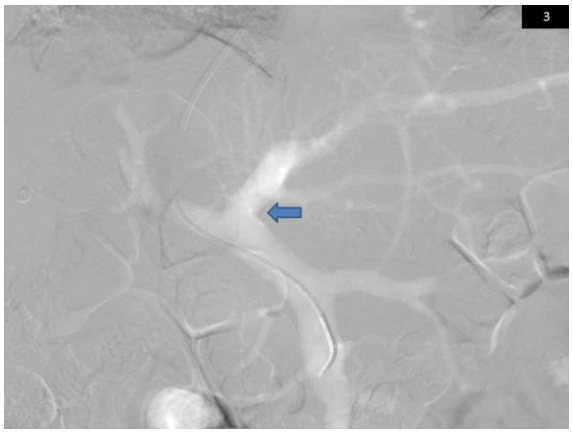

Figure 3: CO_2 Portovenography showing main portal vein and portal bifurcation.

Following this, CO_2 is injected to locate the portal vein. Typically, a 50 ml manual injection of CO_2 is used. This

procedure usually demonstrates the location of the main PV, as well as that of the left and right branches (Figure 2 & Figure 3). Frequently more than one CO_2 injection is required to obtain a good portogram. If wedge injection fails to fill the PV, an occlusion balloon catheter may be used in hepatic vein.

Thereafter, Colapinto needle is advanced through the liver parenchyma, directed in an anteroinferior direction, to connect HV to the PV, near the centre of the liver. An intrahepatic access site with entry into the right PV, at least 1 cm from the main PV bifurcation is desired. Several punctures may be necessary for success. The needle is gently aspirated, as it is withdrawn across the parenchymal tract. Once portal venous blood is freely aspirated, contrast material is injected through the needle to verify the point of entry into the vessel.

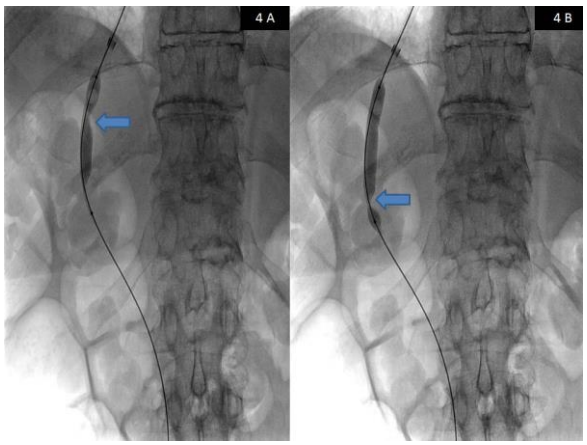

Figure 4: Note initial balloon waist indicating site of portal vein entry and hepatic vein exit.

Pressure measurements are obtained in the PV as well as in the right atrium. If the pressure gradient is significantly elevated (>12 mm Hg), the TIPS is placed. If the gradient is not elevated, the presence of a competitive shunt, such as splenorenal shunt must be evaluated. The channel for the shunt is next dilated by inflating an angioplasty balloon within the liver, along the tract created by the needle. Images of the initial balloon waist are saved because they demonstrate the locations of the PV entry site and HV exit site (Figure 4). Finally, stent is placed with covered portion in the hepatic parenchymal tract, with uncovered portions in PV and HV. (Figure 5 & Figure 6). After the procedure, fluoroscopic images are saved to document proper stent placement.

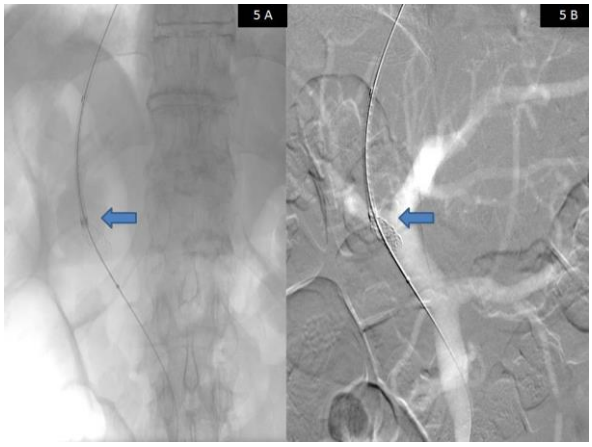

Figure 5: Note metallic stent entry site in right portal vein approximately 1 cm distal to portal vein bifurcation.

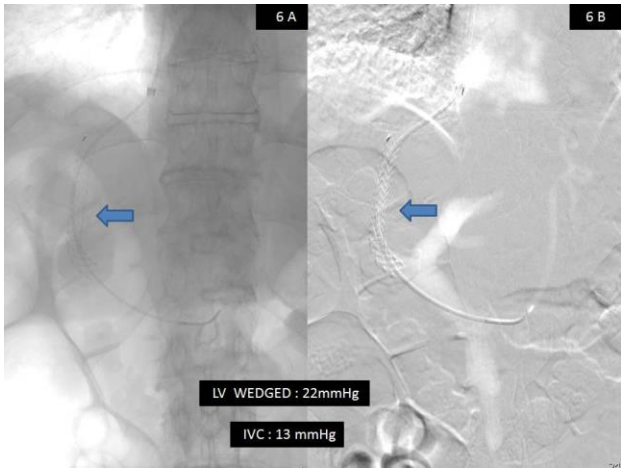

Figure 6: Post stenting pressure gradient is 9 mm Hg (22-13 mm Hg).

Role of CO_2 in TIPS

CO_2 has several roles in the placement of TIPS. Free hepatic venography wedged hepatic venography and portography, both before and after shunt placement may be performed. CO_2 wedged hepatic venography is particularly helpful in locating the portal bifurcation, thereby aiding the direction of the transhepatic puncture. Transhepatic CO_2 portography also clearly defines the presence of varices. These varices can be embolized successfully under CO_2 guidance.

Our technique evolved to take advantage of the buoyancy of CO_2. PV being anterior to hepatic veins is visualized better. The buoyancy of CO_2 can occasionally be disadvantageous. CO_2 can become trapped in large cavities such as abdominal aortic aneurysm (AAA) leading to a condition known as "vapour lock". If such a patient complains of prolonged symptoms of abdominal pain or becomes hemodynamically compromised after CO_2 angiography, they should be repositioned into decubitus position to allow dissolution of CO_2 within the blood stream.

Kearns SR, et al. [18] reported profuse watery diarrhea in 1 out of 80 patients, as a complication during CO_2 angiography for evaluation of AAA. Beese et al. [19] reported tolerable abdominal discomfort in 4 out of 47 patients, as a complication during CO_2 angiography, for evaluation of renal arteries. Further, CO_2 angiography had to be abandoned in 3 patients owing to severe abdominal pain and nausea.

Using the smallest volume of gas necessary for imaging, spacing injections apart temporally and changing the position of the area of concern to allow gas release, may help to avoid ischemia caused by CO_2 trapping. Limit volume to 100 cc/injection and purge catheter before definite injection of CO_2. Use medical grade CO_2 and prevent contamination with air.

We conclude that CO_2 is a safe and effective intravascular contrast agent with potential role in TIPS. A clear understanding of intravascular behaviour, methods of safe delivery and imaging principles of CO_2 should enable accurate vascular imaging during TIPS.

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