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Editorial Comment

CO_2 Angiography for Peripheral Arterial Imaging: The Good, Bad, and Ugly

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Key Points

- This article demonstrates that carbon dioxide (CO_2) based angiography can be performed in patients at risk of acute kidney injury (AKI) with a resulting rate of AKI of ~5%.
- The study also demonstrates a high rate of complications from CO_2 angiography—ranging from pain to death.
- Future research will need to focus on clarifying the role of CO_2 angiography given the safety profile noted in the literature.

The use of carbon dioxide (CO_2) for intravascular imaging has been employed since the 1950s. The principle, however, of using a gas to displace blood in conjunction with X-ray imaging has been around since the 19th century. CO_2 is a ubiquitous compound in the human body and as such is non-toxic to the kidneys and is not allergenic. It rapidly dissolves into the target blood vessel where after displacing the blood pool, a negative X-ray image can be produced outlining the lumen.

THE GOOD

Numerous centers over the past 30 years have demonstrated the efficacy of CO_2 imaging. It should be noted that these centers are high volume CO_2 angiography sites who have significant experience with this technique. For the most part, the bulk of the data for peripheral arterial disease (PAD) imaging had been limited to the aorta and its branches (renal artery) as well as the larger ilio-femoral vessels. Vascular definition of the smaller infrapopliteal arteries had been sub-optimal, particularly in the context of chronic total occlusions (CTOs) or small collateral vessels. However, more recent advancements in digital subtraction angiography (DSA) technology have allowed for better vessel definition with the quality of images approaching or in many cases matching those of traditional iodinated contrast angiograms. It should be noted that higher frame rates are often used with CO_2 based DSA imaging and therefore radiation dose can be higher than standard DSA.

THE BAD

A quick survey of the literature will quickly reveal that numerous challenges with the use of CO_2 imaging remain. Despite the aforementioned advances in DSA technology, the image quality compared to iodine-based DSA is notably variable across centers and publications. The data presented by Fujihara et al. in this issue of *Catheterization and Cardiovascular Interventions* are consistent with this theme as complete and thorough evaluation of vessel lumen by CO_2 alone was noted in only 63% of the superficial femoral artery (SFA) cases [1]. Also consistent with the literature is the common adjunctive use of iodinated contrast agents with CO_2 imaging to obtain complete vessel information—in the present paper the average reported dose of low osmolar contrast media was 15.0 ± 18.1 ml (range 0–70 ml). So it can best be stated that CO_2 based imaging greatly reduces but may not obviate the need for iodinated contrast.

Image quality aside, the adoption of CO_2 angiography has additional safety hurdles. Being a gas, it can be contaminated by room air and therefore meticulous technique is required for each injection. Some additional variables which must be considered when injecting CO_2 include: rate of delivery, time interval

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between dosages (to allow for dissolving), method of delivery (catheter type), and size of syringe (which can influence potential for explosive delivery). Despite good technique, pain can still occur from vessel stretch and transient CO_2 trapping.

THE UGLY

The greatest fear when using CO_2 for intravascular imaging is the potential for catastrophic air embolism resulting in bowel ischemia, tissue infarction, or stroke. Prolonged trapping of CO_2 at the origin of vessels, for example, may impair inflow and cause ischemia. Patients with right to left intra-cardiac shunting may also be at risk of gas embolism to the cerebral or systemic circulation if CO_2 is used on the venous side. In their paper, Fujihara et al. report a 17% complication rate with the use of CO_2—most of which was due to transient leg or abdominal pain. Two patients however, developed severe mesenteric ischemia leading ultimately to death. One of the patients who expired presented with stage 4 chronic kidney disease had undergone angiography and intervention for a SFA CTO—a large price to pay for relief from lifestyle limiting claudication. Though clear in hindsight, this case example is all the more concerning when we examine the existing literature concerning the relationship between iodinated contrast volume during endovascular therapy and acute kidney injury (AKI). In comparison to the coronary circulation, there remains a void in the understanding of the role of contrast volume, PAD specific patient and lesion risk factors, preventive measures, and renal outcomes. Reduction or avoidance of iodinated contrast volume in PAD patients at risk of AKI makes logical sense, and in selected centers CO_2 may address this goal. At this time, universal adoption of CO_2 angiography remains unlikely given the numerous limitations highlighted above.

REFERENCE

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