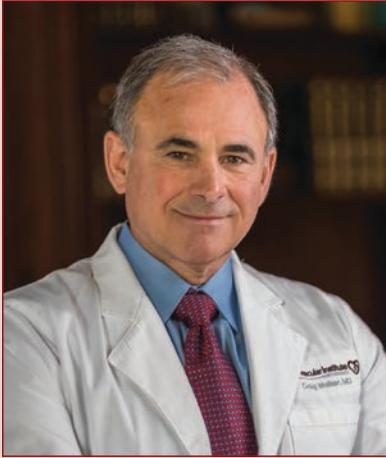


# Tips and Tricks to Improve CO<sub>2</sub> Angiography



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Hello and welcome to the June 2022 edition of *Vascular Disease Management*. There are multiple interesting articles in this issue worthy of commentary, but I have chosen to comment on the present national shortage of iodinated contrast that has limited interventional procedures at many institutions across the United States.

Although iodinated contrast is required in coronary and carotid interventions, most peripheral arterial and venous interventions can be performed utilizing CO<sub>2</sub> as a radiographic contrast agent or external duplex guidance to guide therapy.

I will specifically discuss CO<sub>2</sub> angiography with tips and tricks to improve imaging as I think this most nearly replicates how most procedures are performed today with iodinated contrast. By utilizing CO<sub>2</sub>, many procedures can be performed with no iodinated contrast, and almost all procedures can be performed with much less iodinated contrast. Seeger demonstrated excellent correlation with iodinated contrast angiography in peripheral angiography with 92% correlation as compared with standard contrast when CO<sub>2</sub> was utilized as a sole agent and 100% correlation when supplemented with small doses of iodinated contrast.

CO<sub>2</sub> has many advantages over iodinated contrast media. It is readily available and inexpensive. There is no risk of contrast allergic response or nephrotoxicity. It may provide superior imaging in cases of high-grade stenoses. Disadvantages include an inability to image with movement, and an inability

to utilize it in coronary, carotid, ascending aorta, or neurovascular procedures. Images may occasionally require stacking, a form of postprocessing, to obtain ideal image quality. CO<sub>2</sub> imaging requires digital subtraction with CO<sub>2</sub> settings, which is different than standard digital subtraction. Many imaging systems do not allow roadmap function with CO<sub>2</sub>. Overlying gas in the abdomen may limit imaging. There is greater radiation exposure.

When utilizing CO<sub>2</sub> as a radiographic contrast agent, it is important to understand that as opposed to iodinated contrast media, which blocks the transmission of X-ray energy, CO<sub>2</sub> facilitates the transmission of X-rays, resulting in an image that is the negative of that created with iodinated contrast. As opposed to contrast, which mixes with blood, CO<sub>2</sub> needs to displace the blood to achieve ideal images. Digital subtraction imaging utilizing CO<sub>2</sub> settings with no patient movement is required. Unlike room air, which is composed primarily of nitrogen and oxygen, CO<sub>2</sub> has a dramatically faster dissolution coefficient (>40 times more soluble than CO<sub>2</sub>, which is far more soluble than nitrogen), resulting in less risk of flow obstruction noted with air emboli. CO<sub>2</sub> is buoyant, therefore positioning of the patient may be instrumental in obtaining ideal images, particularly in vessels arising from the posterior aspect of the aorta. CO<sub>2</sub> is far less viscous than iodinated contrast, making it easier to inject at low pressures. Because of its low viscosity, in cases of critical high-grade stenoses that appear as total occlusions by iodinated contrast angiography, CO<sub>2</sub> may disclose that there is a lumen that may dramatically alter therapy in cases such as a high-grade distal graft stenosis, which can be treated with simple angioplasty, rather than having to utilize measures to remove thrombus first, including lysis with its inherent risks. CO<sub>2</sub> is rapidly cleared from the body within several respiratory cycles.

CO<sub>2</sub> has no risk of nephrotoxicity. Contrast-induced nephropathy (CIN) is the third most common cause of hospital-acquired acute renal failure (behind shock and nephrotoxic drugs). CIN dramatically increases mortality, morbidity, length of stay, and cost. The only absolute preventive measure is to avoid use of iodinated contrast. As more complex peripheral

interventions are being performed in older, sicker patients with hypertension and diabetes, the risk of CIN has increased. With CO<sub>2</sub> intervention, additional imaging in prolonged procedures poses little risk.

Many interventionists have little or no experience utilizing CO<sub>2</sub> as an angiographic agent. Obtaining ideal images requires technique that is different than the technique utilized with iodinated contrast. Injections should be made with end-hole catheters positioned as closely as possible to the area being imaged to ensure displacement of blood. Operators must ensure that there is no air in the injection and that the amount of CO<sub>2</sub> injected is not excessive. (One must realize that CO<sub>2</sub> is compressible, therefore more may be administered if compressed with the same volume in a syringe, unlike iodinated contrast, which is noncompressible.) Slow low-pressure injections are optimal. Because it is far less viscous than iodinated contrast, the operator must consciously inject with less force, otherwise there may be patient discomfort. The system should be flushed with saline between each injection to limit bubbles at the beginning of the next injection. Despite these measures, occasionally patients may experience some discomfort with injections. Because CO<sub>2</sub> is buoyant, positioning or rotation of the patient on the X-ray table may be required.

While historically the source of CO<sub>2</sub> was simply industrial tanks without medical specifications or sterilization, new systems that aim to ensure the purity of CO<sub>2</sub>, that there are no contaminants, that the CO<sub>2</sub> is sterile, and to limit introduction of air or inadvertent high-volume pressurized injection, have been developed. One example, but not the only one, of these newer systems include the CO<sub>2</sub>mmmander (Angio Advancement), which is the device that I have used most frequently. This device has a CO<sub>2</sub> cannister and delivery tubing with a v-shaped stopcock, which delivers CO<sub>2</sub> under pressure to the first syringe. The stopcock is then turned, and the CO<sub>2</sub> in the first syringe is used to fill the second syringe with low pressure. The stopcock is then turned again, allowing the CO<sub>2</sub> in the second syringe to be injected into the patient. This stopcock array ensures that compressed high-volume CO<sub>2</sub> is not directly injected into the patient.

In my video commentary, you will see a patient who has densely calcified lesions in the superficial femoral and popliteal arteries that appear on the video slide as totally occluded by prior contrast injection. Here, CO<sub>2</sub> shows that there is a microchannel that we can easily follow. I was able to follow this microchannel with a guidewire, crossing the lesion, staying intraluminal rather than having a long subintimal passage. This was followed first by laser and then balloon angioplasty, ideally prepping this vessel, following which Supera stents (Abbott) were placed, and we can see a very nice result in a very densely calcified vessel.

The next case in the video is of inferior vena cava filter removal using CO<sub>2</sub>, and I often use CO<sub>2</sub> in the venous system as well, performing iliac venography in cases of suspected iliac vein compression or May-Thurner syndrome. In the video you'll see a single injection from a femoral aspect, showing both iliac arteries as well as the left superficial femoral with total occlusion and profuse disease in the profunda femoris. We can certainly utilize this to treat a patient. You'll also see there is overlying bial gas; by rotating the patient if we need to, we can see the iliac well behind that gas, as I mentioned earlier, of rotation sometimes for imaging.

CO<sub>2</sub> angiography has advantages and disadvantages. As I have become more experienced with CO<sub>2</sub> imaging, I now use it in far more procedures to limit nephrotoxicity and risk of allergic response, to image with smaller bore or longer catheters, and to limit contrast in limb salvage cases where I may use CO<sub>2</sub> primarily, supplemented by limited, specifically targeted iodinated contrast, as required, to achieve ideal and adequate imaging. By utilizing this combined technique at the start of complex procedures, I have been able to often avoid the need for high-contrast load to complete long, complicated procedures. Patients who historically may have been unable to have interventions because of severe renal impairment can safely undergo intervention. CO<sub>2</sub> has drastically changed my practice; there is no renal function too impaired, no limit on imaging, and no preadmission for hydration or prolonged stay for observation following iodinated contrast administration to monitor renal function.

In the present era where iodinated contrast availability is limited, I feel it is imperative that peripheral vascular interventionists become facile with CO<sub>2</sub> imaging. Perhaps this will provide an opportunity to explore utilizing CO<sub>2</sub> in appropriate cases as well in the future. ■