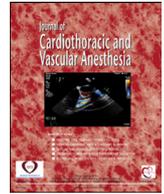


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Letters to the Editor

Possible Gas Pulmonary Embolus During Carbon Dioxide Angiography of the Lower Extremity

To the Editor:

Carbon dioxide (CO₂) angiography is increasingly used in vascular surgery as a nontoxic, inexpensive contrast medium for patients at high risk for contrast-induced nephropathy. It is important for the anesthesiologist to be aware of potential risks, including vapor lock phenomenon, local injection site pain, and neurotoxicity.¹

We report a recent case in which an elderly patient with complex cardiac and pulmonary history as well as stage 4 chronic kidney disease presented with lower extremity pain and ulceration concerning for critical limb ischemia. Out of consideration for her chronic kidney disease, she was scheduled to undergo urgent CO₂ angiography for diagnosis and treatment planning. During the procedure, the surgeon performed several handheld CO₂ angiograms with digital subtraction angiography. She received no sedation. After the third injection of CO₂, the patient became unresponsive but maintained adequate respirations. She quickly worsened, with bradycardia and hypotension. After intubation and escalating doses of vasopressors and inotropes, her condition stabilized. An emergent transesophageal echocardiogram revealed right ventricular dysfunction worst at the apex and severely reduced left ventricular ejection fraction with regional wall motion abnormalities. Notably, though the patient and her family endorsed a history of heart failure, owing to the urgent nature of the procedure, her preoperative evaluation lacked any prior echocardiograms, and her baseline heart function was unclear. The interventional cardiology service was consulted emergently for coronary angiography, which revealed no significant occlusions with widely patent stents.

Adverse reactions related to CO₂ angiography include abdominal pain, leg pain, air contamination, aortic vapor lock, cardiac or pulmonary artery vapor lock, thrombotic atheroembolism, spinal cord ischemia, pancreatitis, bowel ischemia, and neurotoxicity.¹⁻⁷ The buoyancy of CO₂ leads to gas trapping in nondependent structures that can obstruct blood flow and cause ischemia, which is called vapor lock. If pockets of CO₂ persist within the circulation, they can be replaced by less soluble oxygen or nitrogen, leading to prolonged tissue ischemia.² This adverse effect commonly

occurs in mesenteric arteries, causing pancreatitis and bowel ischemia. In one study, this led to livedo reticularis, rhabdomyolysis, intestinal infarction, and death.⁴ Paradoxical gas embolism can be seen, particularly in patients with a patent foramen ovale, in response to pulmonary artery pressure increases with CO₂ injection.⁷

Our patient had multiple comorbidities which may have predisposed her to serious adverse effects from CO₂ angiography, including severe cardiac dysfunction and moderate chronic obstructive pulmonary disease. It has been postulated that cardiac dysfunction can contribute to delayed or decreased clearance of CO₂.³ Some describe chronic obstructive pulmonary disease as a relative contraindication to CO₂ angiography because there is a theoretical risk that subsequent CO₂ retention can increase pulmonary artery pressures and cause right heart dysfunction.^{2,3} The risk of air contamination is higher using a hand injection technique, as in our case.

The differential diagnosis list for our patient's sudden hemodynamic and neurologic collapse is broad. She received no sedation, so it is unlikely to be an effect of oversedation, hypoxia, hypercarbia, or medication allergy. Her urgent left heart catheterization did not reveal any coronary artery lesions that might have caused an acute myocardial infarction. A subsequent head computed tomography scan did not reveal any evidence of acute stroke. Most likely, her decompensation was related to CO₂ angiography, given her medical risk factors and the surgeon's choice of hand injection technique and, perhaps, failure to account for her potential for delayed CO₂ clearance when timing multiple injections. This case report demonstrates the importance of intraoperative monitoring and constant vigilance even in a nonsedated patient. It is also important for the anesthesiologist to be knowledgeable on the specific risks that CO₂ angiography presents.

Conflict of Interest

This document received no funding, and we have no declarations of interest or acknowledgments.

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