Sonographic Findings of Systemic and Hepatic Venous Gas Associated With Hemodialysis

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Sonography has high sensitivity for detecting intravascular gas. Historically, most attention in the literature has focused on portal venous gas, an increasingly common finding with myriad causes, both benign and catastrophic. However, there are only a few reported cases of systemic and hepatic venous gas, rare findings associated with iatrogenic causes and more serious medical conditions.

We report the sonographic findings of systemic and hepatic venous gas secondary to hemodialysis.

Case Report

A 55-year-old man with a complex medical history including active intravenous drug use, critical aortic stenosis, congestive heart failure, and chronic kidney disease was admitted to the San Francisco Veterans Affairs Medical Center with sepsis secondary to lower extremity cellulitis. His hospital course was complicated by acute renal failure requiring hemodialysis. On hospital day 30, he was transferred to the intensive care unit for respiratory failure, hypotension, and critical anion gap metabolic acidosis. Before intubation, the patient reported new severe diffuse abdominal pain.

A physical examination at this time revealed an intubated, sedated, and ventilated patient. He was afebrile and normotensive on a norepinephrine drip. An abdominal examination revealed tenderness to palpation in both upper quadrants but was otherwise unremarkable. Laboratory test results revealed a pH of 7.09, a lactate value of 13.2 mmol/L, mild leukocytosis, and a slight elevation in total bilirubin and alkaline phosphatase levels.
Abdominal sonography (Acuson Sequoia; Siemens Medical Solutions, Mountain View, CA), performed at the bedside during hemodialysis via a right common femoral vein catheter, revealed a moderate amount of ascites and a normal-sized liver without intrahepatic or extrahepatic biliary ductal dilatation. The pancreas was not well visualized. The gallbladder was contracted with a wall thickness of 1.1 cm. A small gallstone was seen at the gallbladder neck. Normal flow was identified within the portal vein and hepatic artery. Innumerable tiny high-amplitude hyperechoic foci compatible with gas bubbles were visualized within the left hepatic vein and associated hepatic venous radicles in the surrounding liver (Figures 1 and 2). The inferior vena cava also contained multiple gas bubbles but was otherwise normal (Figure 3). No gas was identified within the portal venous system (Figure 4). Abdominal computed tomography (CT) did not show pneumatosis, free air, or intravenous gas but showed a small collection of gas in the right atrium. The clinical team was immediately notified of these findings. Several hours later, with continuing profound acidosis, hypotension, and multiorgan dysfunction, the patient went into pulseless electrical activity arrest. Advanced cardiac life support was used without success, and the patient died.

Discussion

Intravascular gas bubbles are detected sonographically as multiple tiny high-amplitude transient intraluminal echogenic foci. Gas bubbles are also easily identifiable because they have an apparent velocity greater than that of adjacent blood.3 A potential pitfall in the diagnosis of intravascular gas is the presence of multiple low-level echoes in slow-flowing blood due to clumped erythrocytes or other particles.4 However, gas bubbles produce highly reflective echoes and characteristic spikes on Doppler spectral analysis, which should make this differentiation readily possible. Both CT and sonography have high sensitivity for detecting intravascular gas. Sonography offers the added advantages of real-time interpretation, organ-targeted imaging, portability, and accessibility.

Hepatic venous gas may be associated with systemic venous gas or portal venous gas or rarely identified in isolation. Systemic venous gas may result from decompression sickness, blunt abdominal trauma, and iatrogenic causes.3 Systemic venous gas has also been reported in a patient with pneumatosis intestinalis and portal hypertension.5 Several cases of concurrent systemic and portal venous gas have been reported. The presumed mechanisms include a portosystemic shunt, surgery, passage of gas bubbles...
through hepatic sinusoids, and overwhelming sepsis from gas-forming organisms. Only 2 cases of isolated hepatic venous gas have been reported: 1 patient had emphysematous pyelonephritis, and the other was undergoing hemodialysis through a tunneled femoral vein catheter.

The intravascular gas identified in our patient, who was undergoing hemodialysis through a right femoral vein catheter, is interesting for several reasons. First, whereas intraluminal gas bubbles may be seen with intravenous injections, presumably formed in the injection tubing or from turbulence as the injected fluid enters the bloodstream, such a large amount of gas detected in real time is unexpected. Second, although benign in etiology, the burden of systemic venous gas may have contributed to the patient's abrupt death, given the right atrial gas identified on subsequent CT. Finally, gas originating in the systemic venous system was identified in the left hepatic vein and surrounding liver. Gas bubbles most likely passed retrograde from the inferior vena cava into the hepatic veins because of elevated right atrial pressure, given the patient's history of congestive heart failure. Furthermore, on real-time imaging, gas bubble flow was apparently both hepatopetal and hepatofugal, further supporting the possibility of retrograde flow or even flow related to the cardiac cycle.

Portal venous gas is an increasingly common finding with a spectrum of nonischemic causes, ranging from lumbar puncture to steroid therapy. On the other hand, systemic and hepatic venous gas seen in the absence of portal venous gas is rare and should prompt a search for an iatrogenic cause or widespread infection from a gas-forming organism. Whenever intravascular gas is encountered, follow-up imaging and management should be based on a thorough and tailored clinical evaluation.

References
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