Portomesenteric Venous Gas

Imaging Findings With an Emphasis on Sonography

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Objective. Portomesenteric venous gas is a rare condition with an unclear pathogenesis. Most studies in the medical literature mention computed tomography (CT) as the primary imaging tool for this entity. The objective of this study was to outline the advantages and disadvantages of sonography in the evaluation of patients with portomesenteric venous gas. ***Methods.*** We describe 7 patients (3 female and 4 male; age range, 47–83 years) with portomesenteric venous gas. Both CT and sonographic examinations were performed in each patient. Our patient population consisted of 2 patients with superior mesenteric artery occlusion, 3 with ischemia of the colon, small bowel, or both, 1 with gastric ulcer perforation, and 1 with ischemic bowel disease presumably secondary to complications of continuous ambulatory peritoneal dialysis. ***Results.*** Portal venous gas was observed in all 7 patients with sonography and in 6 patients with CT. Computed tomography was unable to show gas in the portal venous system in 1 patient. Sonography showed patchy hepatic gas accumulation (likely within small peripheral portal vein branches) with no correlative findings on CT. Computed tomography showed important associated findings, including pneumatosis intestinalis. ***Conclusions.*** In cases with portomesenteric gas, CT is the preferred modality for showing the underlying etiology. However, with its real-time imaging capability, sonography may also be a very valuable imaging modality in the evaluation of this entity. ***Key words:*** computed tomography; portal vein gas; portomesenteric gas; sonography.

Abbreviations
CAPD, continuous ambulatory peritoneal dialysis; CT, computed tomography; SMA, superior mesenteric artery; SMV, superior mesenteric vein

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Portomesenteric venous gas is a rare condition whose pathogenesis is unclear and incompletely understood. Despite its rarity, early detection and recognition are of the utmost importance for correct diagnosis and treatment. Since its first reported date in 1955 by Wolfe and Evans,[1] it has been regarded a sign of a grave clinical problem presumed to have an unfavorable prognosis. In early studies, the presence of this sign was said to be associated with a mortality rate of greater than 75%. However, with impressive developments in imaging technology, recognition of portal venous gas has substantially increased, and today it is not considered as grave a sign as once assumed. Recent studies indicated mortality rates as low as 29%.[2,3] The declining rate may also be attributed to an increased detection rate rather than advances in therapeutic measures and improvements in intensive care medicine.

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Most published studies in the medical literature mention computed tomography (CT) as the primary imaging tool for diagnosis in these patients.[2–6] This may partly be attributed to institutional and personal preferences, the ability to perform CT examinations quickly in emergency settings, and the relative objectivity of the examinations. Despite the mentioned advantages of CT technology, with the rapid advances in sonographic technology and increased experience with this technique, it may be a very useful and versatile alternative in adequate clinical contexts. In experienced hands, sonography may be highly accurate in the detection of not only portomesenteric gas but also associated and causative processes in some cases.

The aim of this study was to outline the advantages and disadvantages of sonography in the evaluation of portomesenteric venous gas as well as other associated findings.

Materials and Methods

We describe 7 patients with portomesenteric venous gas who were examined between February 2003 and February 2006. Three of the patients were female, and 4 were male, with an age range of 47 to 83 years. The patient population was selected in a prospective manner and consisted of cases with portomesenteric gas diagnosed sonographically and then followed by CT examination. Cases with no CT examinations were not included in our series. Sonographic examinations were done with either a LOGIQ 7 or LOGIQ 9 system (GE Healthcare, Milwaukee, WI) using a 2- to 6-MHz convex transducer. Helical CT examinations were performed with a HiSpeed CT/i system (GE Healthcare). For each case, the CT examination was performed 15 minutes to 1 hour after the sonographic examination. Five patients underwent contrast-enhanced CT, and 2 patients underwent unenhanced CT. The CT scans were reviewed by 2 observers in consensus with regard to portomesenteric venous gas and other associated imaging findings, including bowel changes such as wall thickening, bowel distension, and intestinal pneumatosis. All the findings were easily detectable, with agreement by both observers. Portomesenteric venous gas was described as the presence of gas in the main portal vein or intrahepatic branches, mesenteric veins, or both.

Our patient population consisted of 2 patients with superior mesenteric artery (SMA) occlusion, 3 with ischemia of the colon, small bowel, or both, 1 with gastric ulcer perforation, and 1 with ischemic bowel disease presumably secondary to complications of continuous ambulatory peritoneal dialysis (CAPD). In all these patients, the diagnosis was determined either surgically or by follow-up, compounded with the imaging findings and clinical picture. Of these 7 patients, 3 (1 with gastric ulcer perforation and 2 with bowel ischemia) underwent surgery. Two of these patients survived, and 1 with extensive ischemia of the right colon and small bowel died. Overall, 5 patients died, and 2 (the patient with gastric ulcer perforation and 1 with ischemia of the left and transverse colon) survived.

Results

Sonographic and CT findings of the patients, together with demographic and clinical details, are summarized in Table 1. Gas in the portal vein, main branches, or both was observed in all patients on sonography and in 6 patients on CT. In 1 patient with ischemia of the colon, CT was unable to show gas in the portal venous system. A second sonographic examination performed immediately after the CT examination also revealed findings that were similar to those of the initial sonographic examination in this particular patient.

In all patients, sonography showed patchy hepatic gas accumulation, probably due to gas in peripheral portal vein branches, whereas CT failed to show this finding in all the cases. In 1 patient with SMA occlusion, portal gas was associated with widespread gas in the splenic vein, which was observed both on sonography and CT (Figure 1).

Gas in the superior mesenteric vein (SMV) or branches could be observed on CT in 3 patients. In these patients, sonography failed to show gas in the SMV; however, in 1 patient, gas in mesenteric vein branches could be detected on a subsequent sonographic examination by retrospective evaluation.

Associated radiologic findings seen with CT included pneumatosis intestinalis in 5 patients, intestinal wall thickening in 2, bowel distension in 3, hepatic perfusion abnormalities in 2, intraperitoneal free air in 1, ascites in 4, gas in mesenteric vein branches in 2, and gastric wall thickening in 2. Associated findings seen with sonography included a hydropic gallbladder in 2 patients.

Table 1. Demographic Features, Etiology, and Imaging Findings of Patients With Portomesenteric Gas

Patient	Age, y/Sex	Cause	Portal Vein Gas		Hepatic Parenchymal Gas Accumulation		SMV Gas		Additional Imaging Findings (CT, S, or Both)
			S	CT	S	CT	S	CT	
1	73/F	Occlusion of SMA	+	+	+	–	–	+	Gas in splenic vein, hydropic gallbladder
2	77/F	Ischemia of right colon and small bowel	+	+	+	–	–	+	Hepatic perfusion changes, gas in SMV branches, thickening of bowel wall, intestinal pneumatosis
3	63/M	Gastric ulcer perforation	+	+	+	–	–	–	Ascites, gastric wall thickening, intraperitoneal free air
4	83/M	Ischemia of small bowel?	+	+	+	–	–	–	Intestinal pneumatosis, hepatic perfusion changes
5	55/M	Occlusion of SMA	+	+	+	–	–	+	Minimal ascites, intestinal pneumatosis, gas in mesenteric vein branches, bowel distension
6	47/F	Ischemia of left and transverse colon	+	–	+	–	–	–	Intestinal pneumatosis, ascites, bowel distension
7	51/M	Ischemic bowel disease secondary to complications of CAPD?	+	+	+	–	–	–	Ascites, intestinal pneumatosis, bowel distension, thickening of bowel wall and gastric wall

F indicates female; M, male; and S, sonography.

Discussion

The detection of gas in the portomesenteric venous system typically predicts a poor prognosis when associated with bowel ischemia. However, a wide variety of nonischemic conditions may also be associated with portomesenteric gas, including iatrogenic, traumatic, inflammatory, infectious, neoplastic, and obstructive causes.[6–14] Hemodialysis and, rarely, CAPD were also reported to cause nonocclusive mesenteric infarction, presumably secondary to a high frequency of hypotensive episodes, as presumably was the case in 1 patient of our series.[15] No definitive etiologic cause can be found in approximately 15% of cases.[16] The presumed factors favoring the development of portal venous gas are intestinal wall alterations, bowel distension, and intraabdominal sepsis.[6,17,18] The presence of portomesenteric gas is usually a benign finding, especially when associated with conditions such as pancreatitis, cardiac-induced hypotension, blunt abdominal trauma, and iatrogenic causes such as liver transplantation, endoscopy, and barium enemas. In such cases, the prognosis is favorable, and surgery is not required. The pathogenesis of portomesenteric venous gas is thought to be quite different in these two groups of patients, which may explain the difference in outcome.[19]

The sonographic characteristics of portomesenteric venous gas were described by Lafortune et al[20] based on observations in patients with portomesenteric gas and after in vivo studies on anesthetized dogs. Intravascular gas may be identified in the lumen of the vessel as small mobile echogenic foci or a series of gas bubbles resembling a "string of pearls" moving in the direction of blood flow, whereas on CT it is seen as linear tubular lucency branching from the portal hilum to the periphery of the liver. Because of centrifugal flow in the portal vein, gas tends to accumulate in the periphery of the liver, whereas gas in the biliary system tends not to proceed closer than 2 cm to the liver capsule.[6,17] This finding is a useful clue for differentiating venous gas from gas in the biliary tree. Detection of gas in the main portal vein and its intraparenchymal branches is relatively easier in mesenteric vessels because of their more superficial location and the acoustic window of the liver parenchyma, although obesity or overlying bowel gas may obviate the mentioned advantages.

In 1 case of our series, CT could detect gas in portal vein branches but not in the main portal vein, whereas sonography readily revealed gas bubbles in the main portal trunk. In the literature, as well, there are cases in which portal venous gas

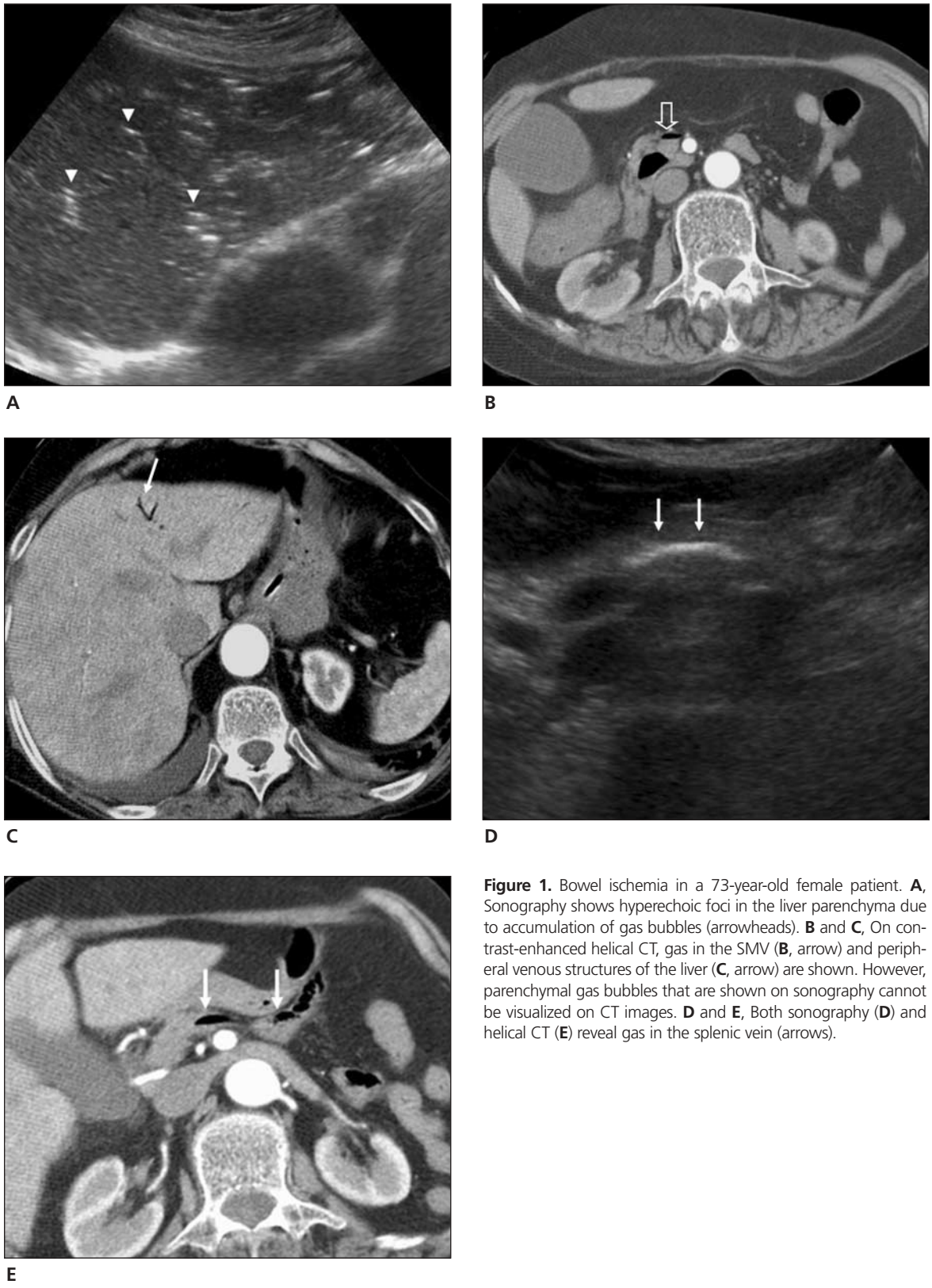


Figure 1. Bowel ischemia in a 73-year-old female patient. **A**, Sonography shows hyperechoic foci in the liver parenchyma due to accumulation of gas bubbles (arrowheads). **B** and **C**, On contrast-enhanced helical CT, gas in the SMV (**B**, arrow) and peripheral venous structures of the liver (**C**, arrow) are shown. However, parenchymal gas bubbles that are shown on sonography cannot be visualized on CT images. **D** and **E**, Both sonography (**D**) and helical CT (**E**) reveal gas in the splenic vein (arrows).

has been detected by sonography alone with no correlative findings on CT, and the diagnosis was made on the basis of either gray scale or Doppler sonographic features.[19,20] Maher et al[19] showed that even with the full range of pathognomonic findings of portomesenteric venous gas on sonography, it can still be undetectable on CT, even when performed immediately after sonography. Sonography may have higher sensitivity in the detection of gas in the portal vein and its peripheral branches, which was linked to its real-time imaging capability, thereby allowing detection of even minor amounts of tiny mobile air bubbles, and the strong reflective nature of air with the ultrasound beam. Doppler sonography, in particular, was suggested to be more sensitive than gray scale or CT imaging. The Doppler tracings reveal sharp, tall spikes superimposed on the background of a normal spectral trace of portal vein flow (Figure 2). This characteristic spectral waveform was thought to represent an artifact caused by acoustic reflections from the mobile intravascular gas bubbles.[19,20] Patchy hepatic gas accumulation detected with sonography probably represents tiny gas bubbles in small peripheral portal vein branches, which are too small to resolve with sonography, whereas the gas in the lumen is easily visible (Figure 3). This may be an important supporting clue to the superior accuracy of sonography with regard to this finding.

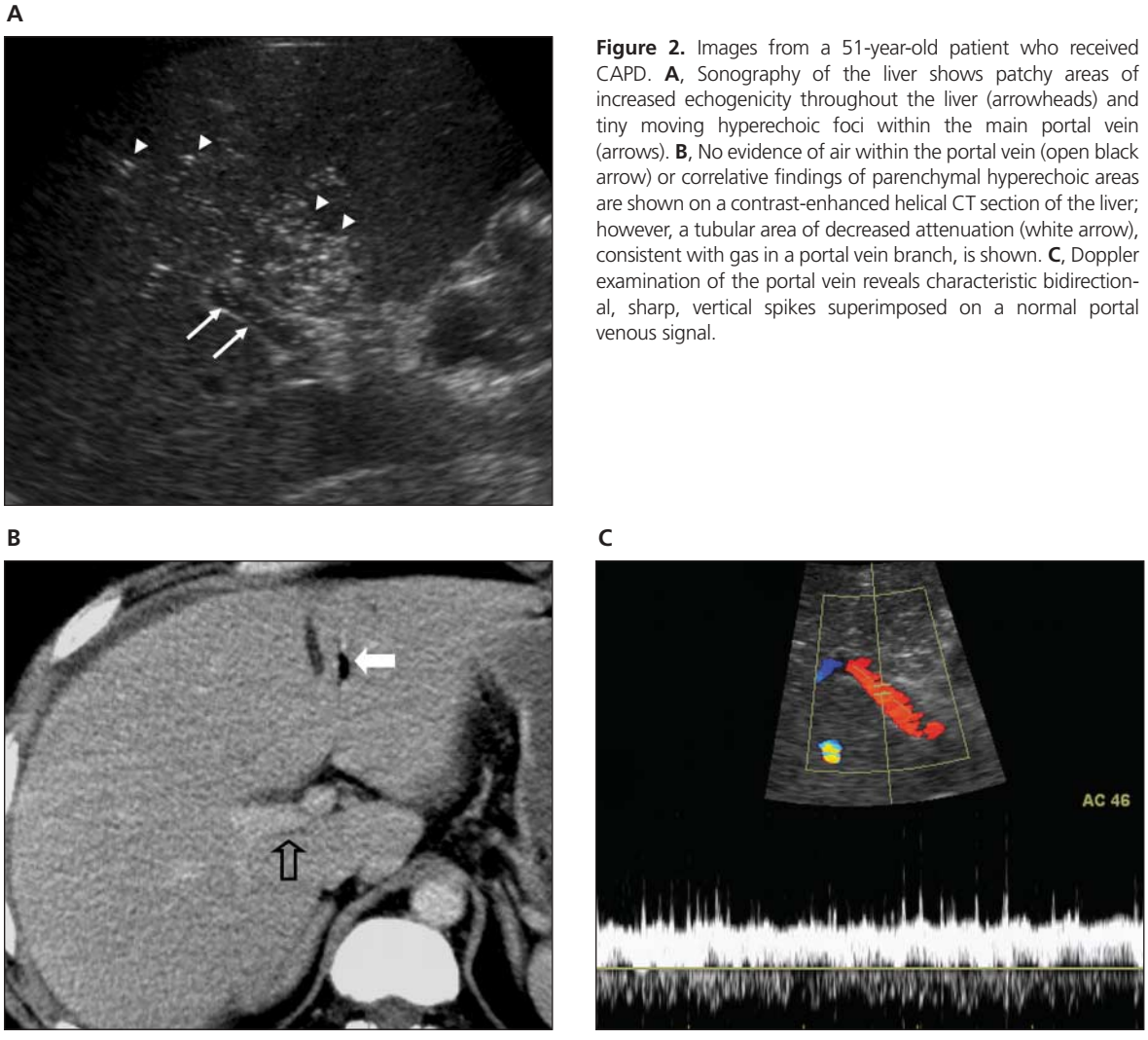


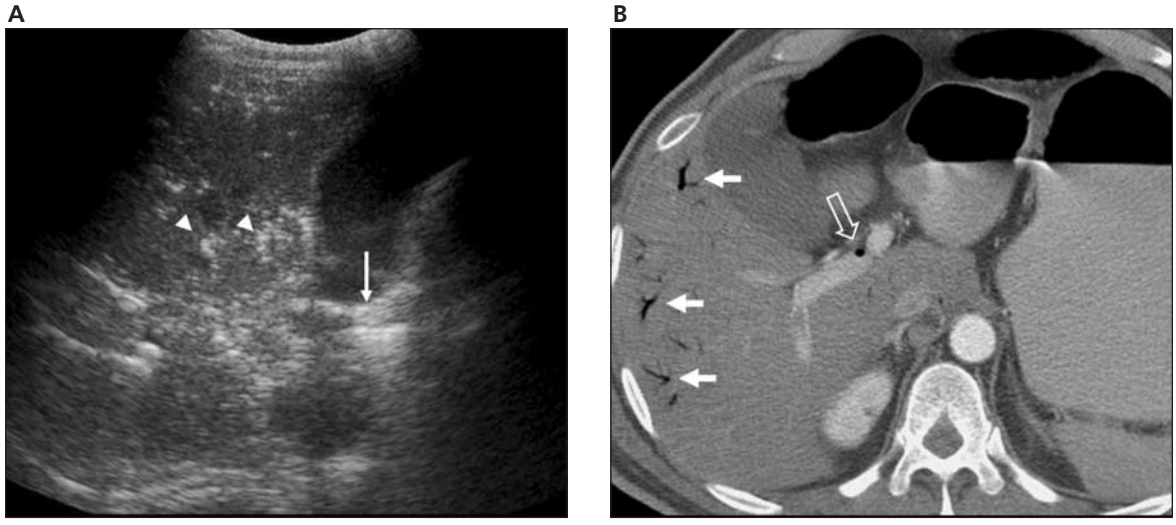
Figure 2. Images from a 51-year-old patient who received CAPD. **A**, Sonography of the liver shows patchy areas of increased echogenicity throughout the liver (arrowheads) and tiny moving hyperechoic foci within the main portal vein (arrows). **B**, No evidence of air within the portal vein (open black arrow) or correlative findings of parenchymal hyperechoic areas are shown on a contrast-enhanced helical CT section of the liver; however, a tubular area of decreased attenuation (white arrow), consistent with gas in a portal vein branch, is shown. **C**, Doppler examination of the portal vein reveals characteristic bidirectional, sharp, vertical spikes superimposed on a normal portal venous signal.

In patients with gas in superior mesenteric vessels and mesenteric side branches, sonography was less precise when compared with CT. In 1 case, however, gas in lower-order branches of the mesenteric vein could be visualized on retrospective evaluation as linear echogenicity between the mesenteric fat planes, associated with typical Doppler sonographic findings (Figure 4).

The absence of intestinal pneumatosis in all cases of portomesenteric gas secondary to intestinal ischemia, as seen in 1 of our patients, is logical, as Wiesner et al[2] suggested, because accumulation of intramural gas in an ischemic bowel segment may not indicate the concomitant leakage of air into the mesenteric veins. Even if rare, after an ischemic insult to the intestinal wall, intraluminal gas may gain access into the portomesenteric veins directly without producing a radiologically detectable pneumatosis. In 2 of our patients, the presence of intestinal pneumatosis was suspected sonographically because of the presence of suggestive intramural echogenic gas bubbles (Figure 5). Computed tomography is superior for detecting this finding; however, sonography may also be useful in detection of pneumatosis, as suggested by some authors.[21,22]

In conclusion, in cases with portomesenteric gas, a CT study of the abdomen and pelvis is warranted because intestinal ischemia is a common cause of portomesenteric gas, and the clinical outcome of these patients depends on the delay between diagnosis and surgical exploration. However, with its real-time imaging capability, sonography is also a very valuable imaging modality for evaluation of these cases in the appropriate clinical context.

Figure 3. Superior mesenteric artery occlusion in a 55-year-old male patient. **A**, Sonography shows gas in the portal vein (arrow) and parenchymal hyperechoic foci due to accumulation of gas bubbles (arrowheads). **B**, Contrast-enhanced helical CT shows tubular areas of decreased attenuation extending to the periphery of the liver (small arrows), consistent with gas in the portal vein branches, and a small amount of air in the main portal vein (open arrow). However, no parenchymal findings corresponding to hyperechoic foci of parenchymal gas bubbles are shown on CT.



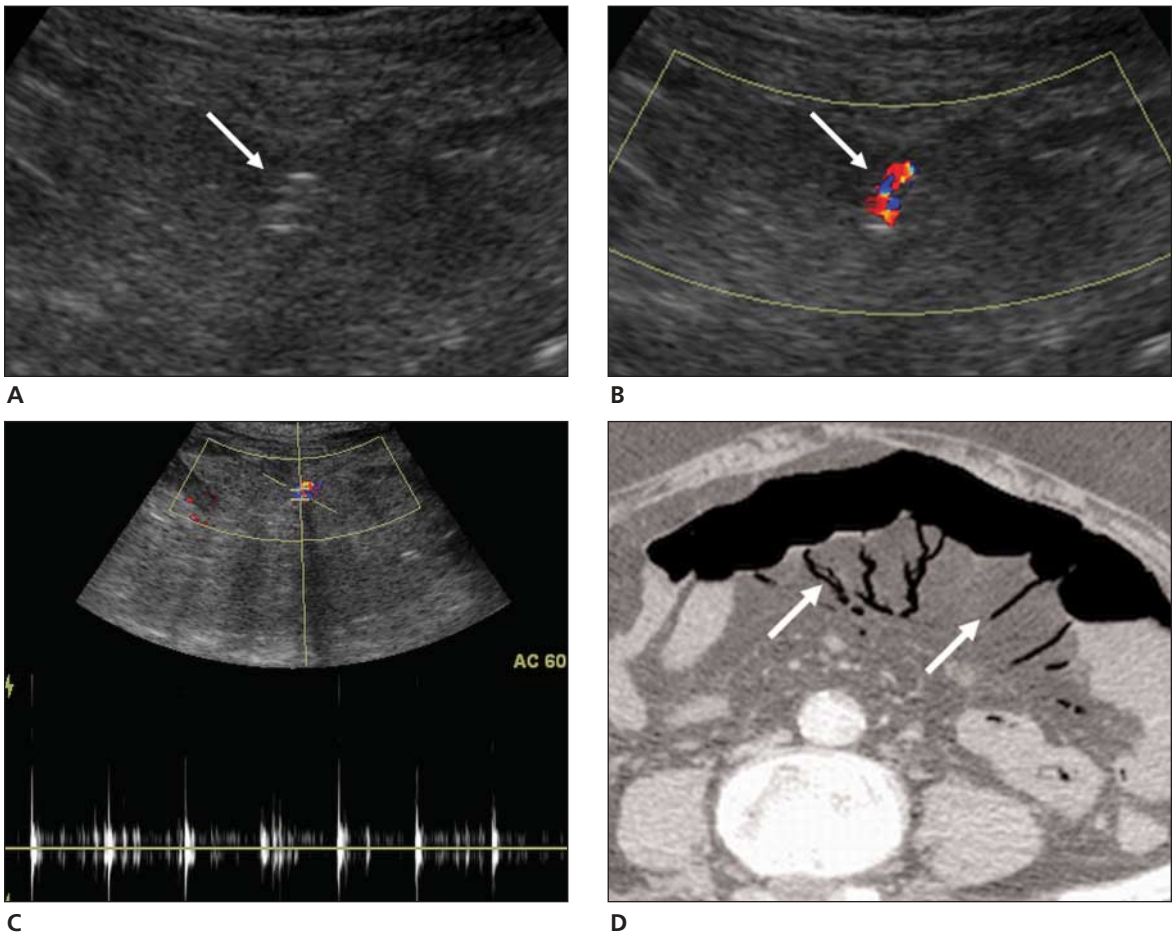
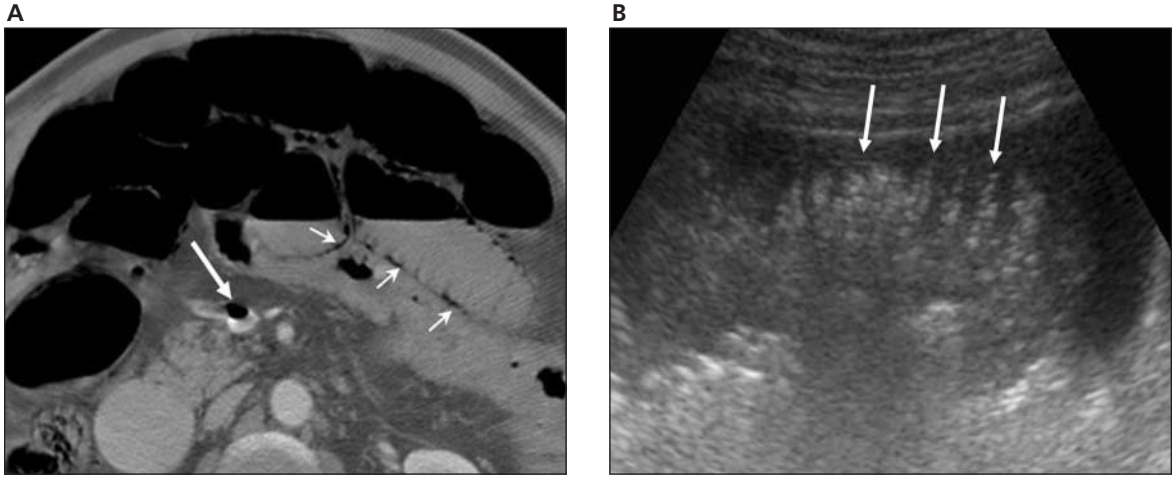


Figure 4. Portomesenteric gas due to bowel ischemia in a 77-year-old female patient. **A** and **B**, Gray scale sonography (**A**) shows linear echogenicity between the mesenteric fat planes (arrow), corresponding to air in mesenteric vein branches, which is verified with color Doppler sonography as well (**B**, arrow). **C**, Spectral Doppler examination reveals typical high-amplitude spikes superimposed on the normal slow-flow waveform of the vein, which corresponds to acoustic reflection from the intravascular gas. **D**, Abdominal CT examination clearly shows multiple tubular areas of low attenuation in the mesentery (arrows), consistent with air in the mesenteric vein branches.

Figure 5. Superior mesenteric artery occlusion in a 55-year-old male patient. **A**, Computed tomography reveals pneumatosis intestinalis (short arrows) and gas in the SMV (long arrow). **B**, Sonography performed approximately at the same level reveals hyperechoic foci in the bowel wall (arrows), consistent with intramural gas.



References

1. Wolfe JN, Evans WA. Gas in the portal vein of the liver in infants: a roentgenographic demonstration with postmortem anatomical correlation. Am J Roentgenol Radium Ther Nucl Med 1955; 74:486–489.
2. Wiesner W, Mortele KJ, Glickman JN, Ji H, Ros PR. Pneumatosis intestinalis and portomesenteric venous gas in intestinal ischemia: correlation of CT findings with severity of ischemia and clinical outcome. AJR Am J Roentgenol 2001; 177:1319–1323.
3. Faberman RS, Mayo-Smith WW. Outcome of 17 patients with portal venous gas detected by CT. AJR Am J Roentgenol 1997; 169:1535–1538.
4. Hou SK, Chern CH, How CK, Chen JD, Wang LM, Lee CH. Hepatic portal venous gas: clinical significance of computed tomography findings. Am J Emerg Med 2004; 22:214–218.
5. Paran H, Epstein T, Gutman M, Feinberg MS, Zissin R. Mesenteric and portal vein gas: computerized tomography findings and clinical significance. Dig Surg 2003; 20: 127–132.
6. Sebastia C, Quiroga S, Espin E, Boye R, Alvarez-Castells A, Armengol M. Portomesenteric vein gas: pathologic mechanisms, CT findings, and prognosis. Radiographics 2000; 20:1213–1224.
7. Gurland B, Dolgin SE, Shlasko E, Kim U. Pneumatosis intestinalis and portal vein gas after blunt abdominal trauma. J Pediatr Surg 1998; 3:1309–1311.
8. Feczko PJ, Mezwa DG, Farah MC, White BD. Clinical significance of pneumatosis of the bowel wall. Radiographics 1992; 12:1069–1078.
9. Zhang D, Weltman D, Baykal A. Portal vein gas and colonic pneumatosis after enema, with spontaneous resolution. AJR Am J Roentgenol 1999; 173:1140–1141.
10. Zielke A, Hasse C, Nies C, Rothmund M. Hepatic-portal venous gas in acute colonic diverticulitis. Surg Endosc 1999; 32:278–280.
11. Brown MA, Hauschildt JP, Casola G, Gosink BB, Hoyt DB. Intravascular gas as an incidental finding at US after blunt abdominal trauma. Radiology 1999; 210:405–408.
12. Wakisaka M, Mori H, Kiyosue H, Kamegawa T, Uragami S. Septic thrombosis of the portal vein due to peripancreatic ligamental abscess. Eur Radiol 1999; 9:90–92.
13. Mallens WM, Schepers-Bok R, Nicolai JJ, Jakobs FA, Heyerman HGM. Portal and systemic venous gas in a patient with cystic fibrosis: CT findings. AJR Am J Roentgenol 1995; 165:338–339.
14. Chezmar JL, Nelson RC, Bernardino ME. Portal venous gas after hepatic transplantation: sonographic detection and clinical significance. AJR Am J Roentgenol 1989; 153:1203–1205.
15. Liu HL, Huang JJ, Lan RR, Wang MC, Sung JM, Hsieh RY. Ischaemic bowel disease in patients on continuous ambulatory peritoneal dialysis. Nephrol Dial Transplant 1999; 14:2032–2034.
16. Scheidler J, Stäbler A, Kleber G, Neidhardt D. Computed tomography in pneumatosis intestinalis: differential diagnosis and therapeutic consequences. Abdom Imaging 1995; 20:523–528.
17. Liebman PR, Patten MT, Manny J, Benfield JR, Hechtman HB. Hepatic-portal venous gas in adults: etiology, pathophysiology and clinical significance. Ann Surg 1978; 187: 281–287.
18. Hong JJ, Gadaleta D, Rossi P, Esquivel J, Davis JM. Portal vein gas: a changing clinical entity. Arch Surg 1997; 132: 1071–1075.
19. Maher MM, Torna BM, Malone DE, Gibney RG. Portal venous gas: detection by gray-scale and Doppler sonography in the absence of correlative findings on computed tomography. Abdom Imaging 2001; 26:390–394.
20. Lafortune M, Trinh BC, Burns PN, et al. Air in the portal vein: sonographic and Doppler manifestations. Radiology 1991; 180:667–679.
21. Vernacchia FS, Jeffrey RB, Laing FC, Wing VW. Sonographic recognition of pneumatosis intestinalis. AJR Am J Roentgenol 1985; 145:51–52.
22. Sigel B, Machi J, Ramos JR, Serota AI, Robertson AL. Ultrasonic features of pneumatosis intestinalis. J Clin Ultrasound 1985; 13:675–678.