Air in periportal space: Beyond the classic triad

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Abstract: Intrahepatic gas, in particular when located in the bile duct and in the portal vein, has distinctive morphological patterns especially evident on CT studies. This gas, however, may be found not only in these places, but also in the periportal space, a little known extension of the subperitoneal space: it may exhibit intrahepatic distribution patterns similar to those already described, although with completely different pathological and diagnostic implications. For these reasons we decided to characterize this sign and its CT findings, along with its main differential diagnosis.

Keywords: Bile ducts, Cystoides intestinalis, Intestinal perforation, Pneumatosis, Pneumoperitoneum, Portal system, Retroperitoneal space.

Resumen: El gas intrahepático, en particular el ubicado en relación con la vía biliar y la porta, tiene patrones morfológicos característicos especialmente evidentes en los estudios por tomografía computada. El aire, sin embargo, no solamente puede encontrarse en estos lugares, sino que también puede ubicarse en el espacio periportal; una extensión poco conocida del espacio subperitoneal, con patrones de distribución intrahepáticos similares a los ya descritos, pero con implicancias patológicas y diagnósticas completamente diferentes. Por estas razones se decide caracterizar este signo y sus hallazgos en TAC, así como sus principales diagnósticos diferenciales.

Palabras clave: Cystoides intestinalis, Ductos Biliares, Espacio Retroperitoneal, Perforación intestinal, Pneumatosis, Pneumoperitoneo, Sistema portal.

Introduction

Gas in the human body may exhibit many distributions, some normal, and some pathological. Concerning the latter, the intrahepatic gas, mainly the one located either in the bile duct or in the portal vein, presents a typical distribution pattern, particularly evident on CT studies. However, it may also have a very similar distribution and yet not being directly linked to what is commonly referred to as portal triad. Not only this gas but also other pathological processes may affect the periportal space, which implies an important range of differential diagnoses, usually ignored when assessing a CT study. In particular, lack of knowledge of this area appears to have greater importance when working in emergency care systems, especially in patients with acute abdominal pathology. These reasons have led us to fully describe this space, implications of presence of air at this level, its main differential diagnoses, and its morphological appearance on axial CT studies.

Periportal space

The Glisson capsule covers the liver surface as an extension of the peritoneum, except for the bare area. Glisson sheath corresponds to the portion of the capsule surrounding the intrahepatic portion of the hepatic portal system (Figure 1A). The portal triad, nerves, and lymphatics (Figure 1b) follow this path of connective tissue through the liver, becoming an extension of the subperitoneal space (subserosal) that comes from the gastrohepatic and hepatoduodenal ligaments (Figure 2a-b)(1-3). At hepatic level, the Glisson sheath also continues to cephalic portion with the subperitoneal space of ligamentum teres and falciform ligament (Figure 1a).
Thus, the anatomical continuity of subperitoneal space allows for disease dissemination, both among intraperitoneal structures and between extra- and intraperitoneal regions\(^1,4,5\). Among the pathological phenomena that may use the periportal route of spread, fluid (edema), blood, inflammatory processes (pancreatic exudates), tumor infiltrations (Figure 3), and air are included\(^1-3\). The latter is often associated, but not limited, to perforated viscus, mainly of the upper gastrointestinal segment (especially if recent); intrahepatic gas may be observed in periportal location as well as in the liver fissure (by extension) surrounding the round ligament (Figure 4), and continuing through this pathway even to its umbilical insertion\(^1,3,6\).

The gas, in this case, is located in the interstitial tissue that surrounds the portal vein, showing intra and extrahepatic distribution (Figure 5). However, both the bile duct and the portal vein by themselves may, under certain conditions, contain air and mimic the distribution of above-described findings, especially when there is little air.

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**Figure 1.** a) Glisson capsule and Glisson sheath. The diagram depicts the continuity of the Glisson sheath, which extends surrounding the portal vein and its extension through the ligamentum teres and the falciform ligament (see Figure 3). b) Periportal space. The diagram illustrates the portal vein (blue) and the structures of the periportal region which include the hepatic artery (red), bile duct (green), lymphatics (white) and nerves (yellow). Interstitial connective tissue is not represented, but it corresponds to the space between these structures.

**Figure 2.** a) Anatomical relationship between the portal triad, gastric antrum and duodenal bulb. The gastric antrum and the duodenal bulb are attached to the lesser omentum. b) The liver and the various gastrointestinal tract segments are interconnected by ligaments and mesenteries. Between the liver and the stomach, gastrohepatic ligaments and the hepatoduodenal ligament are found. Subperitoneal space is the basis for the potential interconnection between retroperitoneum and peritoneal cavity. This complex interconnecting space is mainly composed of fatty tissue that contains nerve structures, vessels, and lymphatic tissue surrounded by serous layers which constitute the ligaments and mesenteries associated with the major abdominal organs and viscera. Therefore, it represents an important pathway for disease spread within the peritoneal cavity. The thick arrow in 2a) depicts the possible routes of air spread among the lesser omentum folds, dissecting the periportal space.
**Figure 3.** Patient with peritoneal carcinomatosis of unknown primary site with invasion of periportal space and ligamentum teres. More progressively cephalic slices. b) There is a carcinomatous mass compromising the interior of the lesser sac (arrowheads), ventral to the pancreas (wide arrows), and in c) it invades the hepatic hilum, involving the periportal space (black arrows); it communicates through this with the ligamentum teres (white arrows), which is better seen in b). Liver metastases (*).
Portal venous gas

Portomesenteric venous gas and its associated finding, i.e., intestinal pneumatosis, represent signs traditionally associated with a poor prognosis since they generally indicate an acute intestinal injury, usually either ischemic or infectious. Nevertheless, anything altering the intestinal wall integrity and causing disruption of the mucosal surface may cause these findings, which include pathological dilatation of bowel loops, intestinal ulcers, trauma, inflammatory bowel disease, and surgical procedures, among others. Likewise, there are a number of benign diagnoses that may be associated with this signology, so it is highly relevant to consider the clinical context of each individual patient (7, 8). On CT scans, images of air-filled tubular structures may be observed; they ramify from the center toward the periphery of the liver, even to reach the capsule of this organ (Figure 6 ab) (8, 9, 10). Then, depending on its volume, the air tends to have an antigravitational distribution, predominantly in the left liver lobe. Associated findings such as pneumatosis intestinalis may also be observed (Figure 6 c-d) (7).
Gas in the biliary tract (aerobilia)

It refers to the accumulation of air in the biliary tree secondary to multiple causes, being the most frequent ones surgical biliary-enteric anastomosis, spontaneous biliary-enteric fistulas, and incompetence of the sphincter of Oddi (commonly iatrogenic, secondary to post ERCP sphincterotomy, and rarely due to non-iatrogenic causes, e.g., secondary to recent passage of stones, among others). Less common causes include infections (cholangitis), and bronchopleural fistula\(^9\).

On CT studies, gas has a typical distribution on the Scout view (Figure 7 a) that correlates perfectly with its morphology in the axial slices, where it is displayed as branches with air density that tend to have a more central location, converging in the common hepatic duct (due to centripetal flow of bile) (Figure 7 b-c), preferably occupying the left hepatic lobe, as described concerning air in the portal vein. Due to bile flow distribution, air in the periphery rarely extends to within 2 cm of the liver capsule (Figure 7d)\(^9,11,12\).
Figure 7. A 45-year-old female patient with biliary-digestive bypass for recurrent pancreatitis secondary to anatomical variation of the choledochopancreatic duct junction. a) Scout View. Classical radiological image (simulating a “Y”) in the right upper quadrant of the abdomen, corresponding to the common right and left bile ducts. Intrahepatic bile duct with air (black arrows) and common hepatic duct with air (white arrow) just before its distal anastomosis. b) Contrast CT scan axial cut showing biliary tract gas within 2 cm of the liver capsule (black arrows). The bile duct of the posterior aspect (white arrow) is dilated but with no air in its lumen (antigravitational distribution). Portal vein (arrowhead). c) Axial CT slice showing loop (top arrow) anastomosed to the common hepatic duct (thin arrow). Also, biliary duct air (black arrows), and drainage at the surgical site (broad arrow) may be observed. d) Axial section from another patient in which location of the air in biliary tract is more clearly seen (black arrows), separated from the portal vein (arrowhead). Incidentally, chronic liver damage and sequelar focal dilatation of the posterior region of the bile duct (without air) is seen (*).

Conclusions
Periportal space is rather unknown as a region of abdominal pathology. It is best understood if considered as an intrahepatic extension of the subperitoneal space (mesenteric and retroperitoneal spaces). Although periportal space may be affected by any process of subperitoneal spread, the presence of air at this level is highly suggestive of hollow viscus perforation, mainly of its upper gastrointestinal segment; it must be differentiated from its main differential diagnoses, i.e., portal and biliary air, since its etiology and clinical outcome are completely different.

Bibliography