Gas in the liver, what a radiologist need to know

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Learning objectives

1. To illustrate the spectrum of manifestations of gas in the liver

2. To describe diagnostic clues in differentiating parenchymal gas, portal venous gas, pneumobilia and gas in the lymphatic system
Background

The spectrum of causes of hepatic gas detected at computed tomography (MDCT) is widening. Many iatrogenic and non-iatrogenic causes exist (Fig. 12). Hepatic gas may be an indication of serious acute disease like an infarct, infection, abscess, bowel inflammation, or trauma. But it may also be an expected finding related to therapeutic interventions like surgery, embolization, tumour ablation, or sphincterotomy.

It is important to look whether the gas is located in the liver parenchyma, bile ducts, vascular structures, or in the lymphatic system in order to determine the origin.

When the gas is located in the liver parenchyma, we should think of an infectious process like a liver abscess due to septic emboli, ascending cholangitis, or hematogenous dissemination of bacteria. Surinfection of infarcted liver parenchyma is a rare cause of liver infection and often leads to an emphysematous hepatitis. Surgery, hepatic artery embolisation, and tumour ablation are iatrogenic causes of gas in the liver parenchyma. The incidence of these therapeutic interventions is rising, and therefore radiologists will become more often faced with gas in the liver due to one of these entities.

Gas in the portal vein is commonly related to bowel ischemia, inflammation or distension of the gastrointestinal system (for example during colonoscopy).

Gas in the biliary tree is most often caused by previous sphincterotomy or choledochojejunostomy. Sometimes non-iatrogenic pathologies are the underling cause of pneumobilia such as an emphysematous cholangitis - ascending cholangitis, gallstone ileus, or bilioenteric fistula.

Once gas is present in the liver parenchyma, it can spread through the hepatic veins, bile ducts or the lymphatic system.
### Causes of Hepatic Gas Detected at CT and US

<table>
<thead>
<tr>
<th>Noniatrogenic causes</th>
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<tbody>
<tr>
<td>Mesenteric infarction, necrotizing entero colitis, colitis</td>
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<tr>
<td>Liver abscess</td>
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<tr>
<td>Hepatic artery thrombosis in a liver transplant</td>
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<td>Inflammatory bowel disease</td>
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<tr>
<td>Abdominal trauma</td>
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<td>Emphysematous cholecystitis, ascending cholangitis</td>
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<table>
<thead>
<tr>
<th>Iatrogenic causes</th>
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<tbody>
<tr>
<td>Biliary gas*</td>
</tr>
<tr>
<td>Hepatic artery embolization†</td>
</tr>
<tr>
<td>Percutaneous tumor ablation‡</td>
</tr>
<tr>
<td>Colonoscopy, barium enema examination</td>
</tr>
<tr>
<td>Liver biopsy</td>
</tr>
<tr>
<td>Migration of hepatic venous gas§</td>
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<tr>
<td>Oxidized cellulose</td>
</tr>
</tbody>
</table>

*For example, from sphincterotomy or choledochojejunostomy.
†Chemoembolization, brachytherapy, or posttraumatic embolization.
‡Radiofrequency ablation, cryotherapy, laser photocoagulation, or ethanol chemoablation.
§From a femoral venous, spinal, or epidural catheter or lumbar puncture.

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**Fig. 12**

Imaging findings OR Procedure details

In order to better understand the imaging findings it is important to know the anatomy of the liver (Fig 1). The liver has 8 segments, each with their own arterial and portal venous blood supply and their draining bile ducts and veins. The lymphatic system in the liver consists of a deep and a superficial system. The deep system is situated near the hepatic veins and the porta hepatis (Fig 2) and the superficial system is located around the liver periphery and in the falciform ligament (Fig 3).

When gas is located in the liver parenchyma, most often this is due to an infectious process, like a liver abscess (Fig 4). Liver abscesses can be solitary or multifocal. In the acute stage there can be micro-abscesses (<2cm) with or without rim enhancement on contrast enhanced MDCT. These micro-abscesses can coalesce into a macro-abscess (>2cm). Pyogenic macro-abscesses are hypo-attenuating lesions with a thickened wall, and 19% of them contain gas. Often there is a double target sign due to the enhancement of the abscess capsule and the surrounding oedema in the liver parenchyma.

Emphysematous hepatitis (Fig 5 and 6) is a special form of infection, commonly related to liver infarction and infection. In these patients the arterial and portal venous blood supply is impaired causing sharply margined wedge shaped area’s, corresponding to the liver segments without contrast enhancement. In these infarcted liver segments the parenchyma is replaced by gas which can further spread through the hepatic veins, biliary tract, or the lymphatic system. Gas in the lymphatic system is rare but its distribution is parallel to the portal veins and bile ducts. Often the gas spreads to the falciform ligament (Fig 6, 7 and 8).

Also after surgery, hepatic artery embolisation, and tumour ablation (Fig 9), gas can be visible in the liver parenchyma.

Portal venous gas is the accumulation of gas in the portal vein and its branches. Because of the blood flow direction, the gas is often seen in a peripheral distribution (Fig 10). Gas in this system is often due to bowel infarction or inflammation but sometimes due to distension of the gastrointestinal system. This type of gas distribution needs to be distinguished from pneumobilia (Fig 11) where the gas is centrally located in the liver near the liver hilum and in the extra-hepatic bile ducts. Gas in the bile ducts is most often related to iatrogenic causes like sphincterotomy or hepaticojejunostomy but also non-iatrogenic causes exist like an emphysematous cholangitis, ascending cholangitis or gallstone ileus.
Fig. 1: Overview of the liver anatomy. There are 8 liver segments, each having their own portal and arterial blood supply. Each segment also has its own venous and biliary drainage.

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Fig. 2: The deep lymphatic system of the liver is located near the hepatic veins and in the porta hepatis.

**Fig. 3:** The superficial lymphatic system of the liver is located at the periphery of the liver and in the falciform ligament.

**Fig. 4:** Contrast enhanced MDCT in the arterial (a) and portoparenchymal phase (b) of a pyogenic liver abscess. There is a big lesion in the right liver lobe with rim-like enhancement surrounded by a hypodense zone (double target sign). A gas bubble is visible in this lesion. Note gas in the biliary tract (arrows).

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Fig. 5: Contrast enhanced MDCT in the portoparenchymal phase. A wedge shaped hypo-dense liver infarct is seen in segment 8. Gas and surinfection is replacing the liver parenchyma (emphysematous hepatitis).

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Fig. 6: Contrast enhanced MDCT scan in the portoparenchymal phase with coronal reconstruction. Same examination as in figure 5. Liver segment 8 is infarcted and contains gas due to the emphysematous hepatitis. Note two linear bands of gas in the lymphatic system at the porta hepatis.

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**Fig. 7:** Contrast enhanced MDCT in the portoparenchymal phase of the same patient as in figures 5 and 6. Gas in the deep lymphatic system (porta hepatis).

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Fig. 8: Contrast enhanced MDCT in the portoparenchymal phase of the same patient as in figures 5 and 6. Gas in the deep lymphatic system (porta hepatis) and the superficial lymphatic system (falciform ligament).

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**Fig. 9:** Radio-frequency ablation of a liver metastasis of a neuroendocrine tumour (a). After the procedure (b) there is gas in the ablated zone.

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**Fig. 10:** MDCT scan in a patient with bowel infarction. Note the pneumatosis intestinalis with gas migration into the mesenteric en portal veins. Portal venous gas is typically located in the periphery of the liver.

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**Fig. 11:** MDCT of a patient after ERCP procedure. Gas in the bile duct system which is typically centrally located near the liver hilum. Note additional free gas in the intraperitoneal en retroperitoneal space due to ERCP complication.

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Conclusion

Knowledge of the patient's clinical history, and a careful search for associated clues on images are all factors that may allow the radiologist to better determine the clinical relevance of gas in the liver.
References

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