Role of Computed tomography in predicting prognosis of Hepatic portal venous gas

Makram Moussa, Inès Marzouk, Kais Abdelmoula, Amira Manamani, Nadida Dali, Leila Charrada Ben Farhat, Lotfi hendaoui

Department of Surgery, University Hospital of Bizerta, Tunisia
Department of Diagnostic and Interventional Radiology, University Hospital Mongi Slim Marsa, Tunisia

ABSTRACT

BACKGROUND: The aim of this study was to report through 13 cases the particularities of abdominal computed tomography (CT) aspects of hepatic portal venous gas (HPVG) and its correlation with patient prognosis.

METHODS: We analyzed abundance of HPVG and its association with pneumatosis intestinalis (PI) in correlation with fatal outcome using chi-square tests.

RESULTS: Etiologies were mesenteric infarction (n = 5), sigmoid diverticulitis (n = 1), septic shock (n = 1), postoperative peritonitis (n = 1), acute pancreatitis (n = 1), iatrogenic cause (n = 3) and idiopathic after a laparotomy (n = 1). The outcome was fatal in for 6 patients. Abundance of HPVG was expressed in total number of hepatic segments involved. The involvement of 3 or more segments was a sensitive sign for lethal outcome with high sensitivity (100%) but it was not specific (50%). Negative predictive value of this sign was 100% (p ≤ 0.005). Positive predictive value of PI for death was 100% (p ≤ 0.001).

DISCUSSION: Abundance of HPVG is correlated with prognosis. The presence of PI announces poor outcome Negative predictive value of presence of HPVG in 3 or more segments is interesting. Predicting prognosis with CT can help surgeons to assess the most adequate treatment. Iatrogenic causes are increasingly described after interventional radiology procedures with favorable course.

CONCLUSION: The first etiology radiologists should look for in front of HPVG involving more than 3 hepatic segments and associated with PI is intestinal necrosis which announces a poor prognosis. This study shows that outside of shock situations, HPVG involving 2 or less hepatic segments without PI predicts a good outcome.

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1. Introduction

Hepatic portal venous gas (HPVG) is a rare radiological sign, defined by the presence of gas in the portal system. This sign is most often associated with extensive intestinal necrosis. In some cases HPVG can be associated with benign etiologies. Unnecessary exploratory laparotomy should be avoided in these conditions. Nowadays, HPVG is much more easily detected through the routine use of ultrasound and computed tomography (CT). In this cases series, we review the CT manifestations of HPVG and their causes in 13 adults. We focused on the correlation between characteristics of HPVG appearance on CT, etiology and patient prognosis.

2. Patients and methods

The medical records of 13 patients with HPVG or mesenteric venous gas were selected. Seven cases collected over a period of 7 years from January 2008 to January 2015 retrospectively reviewed through the Picture Archiving And Communicating System (PACS) of the radiology department of Mongi Slim university hospital. The search key words were “portal venous gas”; “mesenteric ischemia”; mesenteric infarct”; “pneumatosis intestinalis”. Six other cases were prospectively included from two centers (Marsa and Bizerta).

Two scan machines were used. A monoslice SOMATOM plus 4 (Siemens Medical System, Erlanger, Germany) was used from January 2008 to March 2012. A multislice Aquilion 64 (Toshiba medical Systems, Otawara, Japan) was used for the period going from April 2012 to March 2016. Helical CT scans were performed before and after intravenous contrast agent administration using a power injector (80–120 at a rate of 4 ml/s with 35 s scan delay for the arterial phase and 70–80 s for the portal phase). The following
Table 1
Summary of the clinical history, imaging features and outcomes for all 13 cases of the study.

| Case | Age (y) | Gender | Clinical Symptoms | CT protocol | Site | associated CT Signs | Surgery | etiology | outcome |
|------|---------|--------|-------------------|-------------|------|---------------------|---------|----------|---------|
| 1    | 75      | male   | Diffuse abdominal pain in a patient with atrial fibrillation | – unenhanced | Left lobe (II, III, IV) | – mesenteric venous gas, – PL, – Anomaly of parietal enhancement, – Occlusion of the superior mesenteric artery | Yes | Acute Mesenteric infarction. | death |
| 2    | 78      | female | septic shock | – Portal phase, – unenhanced | Segment II | – Pneumoperitoneum, – Hepatic perfusion disorders, – Bilateral pneumonitis | No | Pneumonitis. | alive |
| 3    | 73      | male   | Postoperative course of a colonic tumor surgery, fever | – Arterial phase, – Portal phase, – unenhanced | Left lobe (II, III, IV) | – Multiple intraperitoneal collections, – Contrast opacification of the bile ducts pneumobilia | Yes | Peritonitis | death |
| 4    | 69      | female | CT after external biliary drainage. | – Arterial phase, – Portal phase, – unenhanced | Left lobe (II, III, IV) | – PL, – mesenteric venous gas, – Anomaly of enhancement of intestine wall – Perfusion liver disorders, – Obstruction of distal branches of the SMA | No | Iatrogenic | alive |
| 5    | 72      | male   | Diffuse abdominal pain | – unenhanced | Segments VII and VIII | – PL, – mesenteric venous gas, – Anomaly of enhancement of the wall of the digestive handles – Thinning of the wall inlets, – Heterogeneous enhancement of the pancreas | Yes | Acute Mesenteric infarction. | death |
| 6    | 71      | female | circulatory collapse | – Portal phase, – unenhanced | Left lobe (II, III, IV) | – PL, – mesenteric venous gas, – Anomaly of enhancement of the wall of the digestive handles – Thinning of the wall inlets, – Obstruction of distal branches of the SMA | No | Acute Mesenteric infarction. | death |
| 7    | 67      | female | Diffuse abdominal pain | – unenhanced | All the liver | – PL, – mesenteric venous gas, – Anomaly of enhancement of the wall of the digestive handles – Thinning of the wall inlets, – Obstruction of distal branches of the SMA | Yes | Acute Mesenteric infarction. | death |
| 8    | 54      | male   | Diffuse abdominal pain | – Portal phase | All the liver | – PL, – mesenteric venous gas, – Anomaly of enhancement of the wall of the digestive handles – Thinning of the wall inlets, – Obstruction of distal branches of the SMA | No | Necrotizing pancreatitis | death |
| 9    | 66      | female | Fever and pain of the left lower quadrant. | – unenhanced | Left lobe (II, III, IV) | – PL, – mesenteric venous gas, – Anomaly of enhancement of the wall of the digestive handles – Thinning of the wall inlets, – Obstruction of distal branches of the SMA | Yes | Sigmoid diverticulitis. | alive |
| 10   | 72      | female | percutaneous drainage of a liver abscess and biopsy of a liver | – unenhanced | Left lobe (II, III, IV) and segment VII, segment VIII | Liver collection (suspected tumoral necrosis), – Cholecystic liver | No | Iatrogenic | alive |
| 11   | 43      | male   | – Waning of percutaneous radiofrequency ablation | – unenhanced | Left lobe (II, III, IV) and segment VII, segment VIII | 3 nodules treated with radiofrequency | No | Iatrogenic | alive |
| 12   | 82      | female | Diffuse abdominal pain, shock | – unenhanced | All the liver | – PL, – mesenteric venous gas, – Anomaly of enhancement of the wall of the digestive handles – Thinning of the wall inlets | No | Acute Mesenteric infarction. | death |
| 13   | 74      | male   | epigastric pain | – Arterial phase, – Portal phase | All the liver | – PL, – mesenteric venous gas, – Anomaly of enhancement of the wall of the digestive handles – Thinning of the wall inlets | Yes | Acute Mesenteric infarction. | alive |
scanning parameters were used: thickness 1 mm, reconstruction interval 1 mm.

CT scans and medical records were reviewed. We recorded for each patient the clinical signs available on medical file; we reviewed on CT DICOM images the extension of the HPVG in the liver. The number of involved segments ≥to 3 and the presence of pneumatosis intestinalis (PI) were also analyzed in correlation with fatal outcome of patients.

The chi-square tests were used to make comparisons and an a priori statistical level of significance of p value ≤0.01 was used to adjust for multiple comparisons.

3. Results

The clinical histories, imaging features and outcomes are summarized in the table (Table 1).

Patients, 5 males and 6 females, were aged 68.9 on average (range 43–82 years). They were hospitalized in cardiology, general surgery and intensive care departments.

In our series, abdominal CT scan was performed on the basis of diffuse abdominal pain in 5 cases. In the other patients, it was indicated by septic shock with abdominal distension and by abdominal tense with fever after surgery, and following an attempt of external biliary drainage, hepatic mass biopsy and percutaneous radiofrequency ablation of hepatocellular carcinoma in one case each.

Positive diagnosis of HPVG was established in the 100% of cases by abdominal CT independently of the protocol. The extension of HPVG was correlated with the number of hepatic segments involved. The left lobe was involved in 10 cases. Three or more segments were involved by HPVG in 10 cases with fatal outcome in 6 cases. The right lobe was exclusively involved in 2 cases caused by iatrogenic and idiopathic etiologies. PI was exclusively observed with mesenteric infarction (n = 3) and was associated with a lethal outcome.

The etiology of HPVG was determined on the basis of CT findings in 12 cases. Acute mesenteric ischemia five patients (38%) with (AMI) (Fig. 1). Two cases were related to a septic context (15%). The iatrogenic context was observed in 3 cases (23%) (Fig. 2). In one case (case 8) with serum amylase and lipase levels at 5 times normal, CT scan showed necrotic pancreatitis with multiple fluid collections (Fig. 3). In one case (case 9), the HPVG was located in the left lobe and was associated with a colonic diverticulitis. In one case (case 5), the HPVG was observed in small quantities in the left lobe (Fig. 4) and CT scan didn’t show any extra sign suggestive of a gastrointestinal tract condition.

Four patients underwent surgery with 2 death complications in the postoperative course of a mesenteric infarction and peritonitis. In three other cases, death was observed within 2 h in 2 cases of extended mesenteric infarction and on day 2 after a necrotic pancreatitis (Fig. 4). The Clinical and radiological monitoring by X-ray and abdominal CT was considered to confirm the diagnosis in the other patients.

The involvement of 3 or more segments was a sensitive sign for lethal outcome with high sensitivity (100%) but it was not specific (50%). Negative predictive value of this sign was 100% (p ≤0.005).

The specificity of PI for death was about 66.67% and the specificity 100%. Positive predicting value of this sign was 100% (p ≤0.001).

4. Discussion

HPVG indicates the presence of gas in the portal vein and its branches. It was historically associated with a poor prognosis with a mortality rate estimated between 84 and 90% [1,2]. More recently

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**Fig. 1.** 72 years-old male with atrial fibrillation, Diffuse abdominal pain, a: pneumoperitoneum (black arrow), HPVG (black bold arrow) b: Superior mesenteric artery occluded (bold white arrow) c and a: pneumatosis intestinalis (white arrows).
reported mortality rates in the literature put it in the range of 27–47% [3,4]. Better prognosis of the HPVG is linked to the development of radiological cross sectional techniques especially the CT allowing detecting of small quantities. In our series, the mortality rate reached 46%; four patients died after an extensive mesenteric infarction, one patient after an acute severe pancreatitis and one during a reoperation for postoperative peritonitis for anastomotic leakage.

CT is efficient; it’s now considered the imaging tool of choice for the diagnosis of HPVG. HPVG occurs usually in elderly patients with co-morbidities and radiologists face often a contraindication to administrate iodinated contrast because of an underlying renal insufficiency. The pre-contrast phase is sufficient to detect HPVG and it can be the only acquisition to perform. The enhanced CT with a single-phase (portal) or with biphasic acquisition (arterial and portal) is very helpful for the etiological diagnosis. Complementary lung window is recommended for the identification of gas because of its higher sensitivity of detection of small quantities of gas [1,3]. The main differential diagnosis remains pneumobilia which is defined by the presence of air in the bile ducts. It is mainly located in the central part of the liver and situated to more than 2 cm from the hepatic capsule [5,6] unlike HPVG which can reach the periphery. In some cases, pneumobilia and HPVG may coexist depending on the etiology.

The appearance of the gas in the portal system may result from intestinal mucosal injury, increased intraluminal pressure in the digestive tract or sepsis [5,6]. Intravascular gas is most com-
monly found in the portal trunk [7]. The left lobe of the liver is predisposed to develop HPVG, possibly because of peculiarities in hepatic venous anatomy [6]. In our series left lobe was involved in 9 cases. According to many authors reported that there is no relationship between the extension of the HPVG and the prognosis of the underlying disease [4,8,9]. However, Heye and al [8] showed that the distribution of gas at certain anatomical locations in the porto-mesenteric venous system, namely the arcade and segmental vessels, achieved a better diagnostic performance in detecting ischemic etiology. When gas distribution is limited to segmental portal branches; it’s linked to a better prognosis with a high frequency of non ischemic etiologies. In our study the involvement of 3 or more segments was correlated to poor prognosis in 75% of cases. High negative predictive value of this sign suggests that HPVG identified in 2 or less hepatic segments without any clinical severity evidence could avoid surgery for the patient. Seak and coll [2] raised the correlation of the association of shock and PI with high rate of mortality. In our series the association of PI with HPVG was correlated to fatal course in 100% of cases.

Five etiologies were represented in our case series. In the literature, the most dangerous and the most common one are the acute mesenteric ischemia (AMI) (70%) accompanied by a mortality of around 80% [10]. In case of a high level of suspicion of AMI, a biphasic (arterial and portal) mesenteric multi-detector CT angiography should be performed because of its high sensitivity and specificity [10–12]. On CT, direct signs of AMI are the abrupt termination of the vessel or the filling defects in the vessel lumen. Bani Hani and coll [13] found in their study that CT findings suggestive of ischemic PI and HPVG, did not diagnose AMI accurately enough to reliably identify patients needing operation. Associated signs such as bowel dilation, wall thickening, attenuation, fat standing and ascites should be investigated on CT [14].

Other surgical etiologies include infectious causes, in particular, sigmoid diverticulitis, acute cholecystitis and acute appendicitis.

HPVG is a rare complication of diverticulitis [15] which is the second most frequently reported cause [16]. Associated highly suggestive signs are colonic diverticulosis, fat standing or abscess in contact with colon wall thickening. Intra-venous antibiotic treatment is recommended even if HPVG is present on CT [9]. In case of non improvement, surgery must be performed.

iatrogenic HPVG has been reported and mostly occurs in the course of retrograde endoscopic cholangio-pancreatography [17], during colonoscopy [18] or after barium enema [19,20]. In our series, HPVG was detected on control CT after external biliary drainage in one case, after percutaneous drainage and biopsy of a septic and necrotic hepatic mass in another case and after a percutaneous radiofrequency ablation of a hepatic cellular carcinoma in a third case. After antibiotic treatment under clinical monitoring with short hospitalization, the post-operative courses were uneventful for all three patients.

There are other even rarer causes of HPVG such as gastrointestinal cancers [15,21,22], inflammatory diseases such as crohn’s disease and acute pancreatitis [15,18,23,24]. Abdominal trauma has been described as a possible cause of HPVG [25,26]. However, benign cases of HPVG have been reported [27]. This entity does not require any surgical treatment and has a good clinical outcome. In some cases, the etiology remains unknown and may require laparoscopic investigation [28]. In our series, a small quantity of HPVG was distributed in the distal vessels of both segments VII and VIII of the right lobe in one case (case 5) without any extra CT sign. Surgery was performed only because of a high level of suspicion of AMI in a 72 year-old man with acute diffuse abdominal pain. Laparoscopic surgery allowed us to rule out all cited etiologies of HPVG.

5. Conclusion

HPVG is rarely observed in imaging. The first diagnosis that radiologists should look for before discussing other etiologies is the intestinal necrosis due to its severe prognosis and the need for emergency surgery. Multi phased enhanced CT is helpful for the etiological diagnosis of HPVG with high sensitivity and specificity. Outside of shock situations, HPVG involving 2 or less hepatic segments without PI could avoid emergency surgery. Once the AMI is excluded, etiological investigation must be oriented by the clinical signs. If any doubt remains on ischemic origin, laparoscopy or laparotomy should then be undertaken.

Conflict of interest

All authors declare that they have no conflict of interest.

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Ethical approval

All the figures are anonymized for the case series. Our work is in accordance with medical ethics.

Author contributions

We certify that we have participated sufficiently in the intellectual content, conception and design of this work or the analysis and interpretation of the data, as well as the writing of the manuscript, to take public responsibility for it and have agreed to have our name listed as a contributor.

1. Makram moussa Study concept and design, Drafting of the manuscript.
2. Ines marzouk Drafting of the manuscript, correcting.
3. K. Abdelmoula Analysis and interpretation of the data.
4. A. Manamani Study supervision.
5. Nadida dali Acquisition of the data (CT).
6. L. Charrada-Ben Farhat Critical revision of the manuscript for important intellectual content.
7. L. hendauï Critical revision of the manuscript for important intellectual content.

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