CASE REPORT

Ultrasound-Guided Portal Vein Puncture for The Treatment of Hepatic Portal Venous Gas: A Case Report

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Background: Hepatic portal venous gas (HPVG) is a critical imaging finding, often indicative of an acute abdominal catastrophe of gastrointestinal origin. The condition progresses rapidly and is associated with an extremely high mortality rate. Conventional conservative management or surgical intervention carries significant risk, particularly for perioperative patients.

Case Summary: A 64-year-old female patient was admitted to our hospital on August 1, 2023, with a chief complaint of abdominal pain, distension, and cessation of defecation and flatus for one day. The diagnosis was small bowel obstruction, for which an endoscopic nasojejunal feeding tube placement was performed. On August 30, a follow-up abdominal CT scan revealed intrahepatic biliary duct dilation and HPVG. Due to clinical deterioration, the patient was transferred to the ICU. Following a multidisciplinary consultation, an ultrasound-guided portal vein puncture and catheterization was performed first. This intervention successfully alleviated the signs of HPVG, thereby reducing the risk for the subsequent laparotomy. The patient was ultimately successfully treated.

Conclusions: In this case, the hepatic portal vein was directly punctured under ultrasound guidance, and a PICC catheter was inserted into the portal vein. A mixture of blood and gas was successfully aspirated post-puncture. An immediate post-procedural scan revealed a significant reduction of gas within the intrahepatic portal veins, alleviating HPVG and mitigating the risk for the subsequent laparotomy. This demonstrates that this method can effectively provide direct relief from HPVG and offers a novel therapeutic approach for the management of similar cases.

Key words: Hepatic portal venous gas; Interventional ultrasound therapy; Ultrasound-guided; Acute intestinal obstruction

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Hepatic portal venous gas (HPVG) is an imaging finding characterized by the abnormal accumulation of gas within the portal vein and its intrahepatic branches due to various etiologies. It is characterized by sudden onset, rapid clinical progression, poor prognosis, and markedly high mortality rate, often referred to as a "sign of impending death", necessitating urgent clinical attention [1]. In clinical practice, due to the significant risks associated with surgical intervention, it often leads to death or the decision to abandon treatment [1]. However, attempting to resolve the portal venous gas prior to surgery may reduce the associated surgical risk of HPVG. This article reports a case in which an interventional ultrasound procedure was utilized preoperatively to address the portal venous gas, creating a critical opportunity for successful treatment.

Clinical Information

History of present illness and past medical history

History of Present Illness A 64-year-old female

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patient was admitted to the emergency department of our hospital on August 1, 2023, with a chief complaint of abdominal pain, distension, and cessation of flatus and defecation for one day. An emergency abdominal CT scan indicated small bowel obstruction. The patient received symptomatic and supportive therapy, but the therapeutic efficacy was poor. She was subsequently transferred to the gastrointestinal surgery department and underwent an "endoscopic nasojejunal feeding tube placement". Postoperatively, the nasojejunal tube was retained; the patient was kept nil per os (NPO) and received enteral nutrition therapy. Subsequently, the abdominal pain and distension alleviated slightly, but abdominal distension remained significant. Supportive treatments including somatostatin, gastric protection, and acid suppression were continued. On August 30, a follow-up abdominal CT scan revealed intrahepatic biliary duct dilation and HPVG. Due to worsening of her clinical condition, the patient was transferred to the ICU for continued treatment.

Past Medical History and Comorbidities The patient had a history of coronary heart disease for over 2 years and hyperlipidemia for over 6 years.

Auxiliary examinations

Laboratory findings: White blood cell count: 12.11 × 10^9/L, lactate: 4.1 mmol/L, ALT: 112 U/L, AST: 135 U/L.

Ultrasonographic findings (Fig. 1A): The liver parenchyma demonstrated diffusely distributed, small, patchy areas of hyperechoicity with ill-defined borders, accompanied by the "gas flow" sign. A non-contrast enhanced CT scan of the entire abdomen was performed. The CT (Fig. 1B-C) findings revealed multiple, branching, linear hypodensities tracking along the course of the portal venous system. Additionally, the abdominal bowel loops were markedly dilated and fluid-filled, with visible air-fluid levels.

Diagnosis and differential diagnosis

The CT manifestation of the patient consisted of tubular, branching filling defects, with the typical intrahepatic presentation of "dry branch sign", and the gas distributed peripherally within the liver. The ultrasonographic presentation featured bubble-like and punctate hyperechoic foci within the portal vein moving with blood flow, alongside diffusely distributed, small, patchy hyperechoic areas within the liver parenchyma with poorly-defined borders. A diagnosis of HPVG and gas within its branches was confirmed.

Differential diagnosis: HPVG can be easily confused with pneumobilia (intrahepatic biliary gas). The distinction between the two entities primarily lies in their imaging manifestations: On CT, the gas in HPVG is typically located in the peripheral subcapsular region of the liver, aligns with the direction of portal venous flow, and exhibits a branching, "arborizing" distribution. In contrast, pneumobilia, due to the centripetal flow of bile, tends to be located centrally within the liver hilum and appears more clustered. On ultrasonography, a key differentiating feature is the absence of the "gas flow" sign in cases of pneumobilia.

Course of treatment

Procedures of ultrasound-guided portal vein puncture: The patient was placed in the left lateral decubitus position. A pre-procedural ultrasound examination was performed to determine the optimal puncture site. Following routine disinfection and draping, local anesthesia was administered using 2% lidocaine. Under ultrasound guidance, a puncture needle (Chiba needle, Angitech 18G) was advanced into a branch of the portal vein within liver segment S8. Aspiration returned a mixture of blood and gas. A guidewire was then introduced through the needle, followed by needle withdrawal. A PICC catheter (Bard DARD 4F) was advanced over the guidewire into the main portal vein, and then the guidewire was removed, and approximately 50 mL of the blood/gas mixture was aspirated. Subsequent ultrasound examination (Fig. 2) revealed a significant reduction of gas within the portal vein. Following slow infusion and exchange with 50 mL of normal saline, the gas within the portal vein was almost completely eliminated. The catheter was then flushed with heparinized saline,

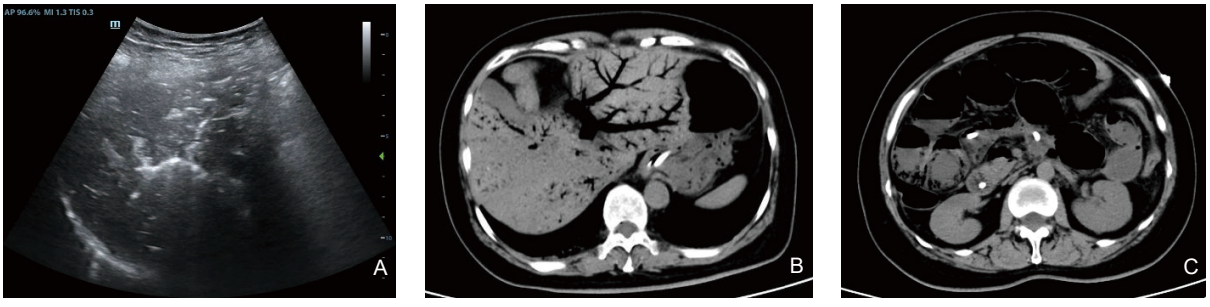

Figure 1 (A) Pre-puncture ultrasound; (B) Pre-puncture abdominal CT; (C) Pre-puncture abdominal CT.

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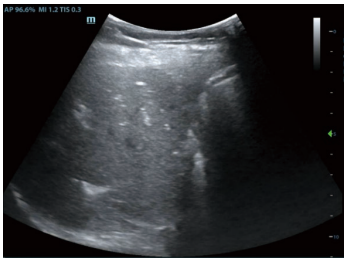

Figure 2 Immediate post-puncture abdominal ultrasound.

locked, and the site was sutured and dressed with a sterile bandage for fixation. The drainage tube was temporarily clamped.

The patient subsequently underwent an abdominal CT scan (Fig. 3A-B) and then proceeded to laparotomy. Intraoperative findings revealed: diffusely dilated bowel loops with significant gas and fluid accumulation. Approximately 150 cm proximal to the ileocecal valve, a segment of small intestine was found to be tightly adherent to the mesentery and omentum, with constriction by an adhesive band. The bowel distal to the point of obstruction was not dilated. No space-occupying lesions were identified in the small intestine or colon. The blood supply to the dilated small bowel appeared adequate. Consequently, a surgical procedure comprising reduction of the intestinal volvulus and adhesiolysis was performed. The operation was completed successfully with an estimated blood loss of 100 mL.

Treatment outcome, follow-up, and prognosis

A follow-up CT scan on the third postoperative day confirmed the complete absence of gas within the portal venous system. The patient was discharged following subsequent symptomatic and supportive therapy. At the time of manuscript completion, follow-up indicated that the patient was recovering well.

Discussion

Etiology of HPVG

HPVG is not an independent disease but rather an imaging finding often associated with gastrointestinal pathologies. The related mechanisms, based on the source of HPVG, can be classified into three categories: (1) Absorption of intestinal gas into the portal venous circulation, such as in intestinal ischemia and necrosis, gastrointestinal dilation, ulcerative colitis, gastric ulcer, endoscopic procedures, and abdominal trauma; (2) Gas produced by gas-forming microorganisms entering the portal venous system, such as after liver transplantation, in septic mesenteritis, and in pylephlebitis; (3) Direct introduction of external gas into the intrahepatic portal venous system, such as during liver biopsy or radiofrequency ablation of hepatic tumors. Furthermore, cases of idiopathic HPVG have been reported, such as those associated with seizures [2]. Among the various etiologies, approximately 85% of HPVG cases result from mucosal injury allowing intraluminal gas to enter the mesenteric veins and subsequently the portal venous system, primarily caused by intestinal ischemia and necrosis due to strangulating bowel obstruction. In this case, laparotomy confirmed that the cause of HPVG was an adhesive band causing constriction and small bowel obstruction at the distal small intestine, where the bowel was tightly adherent to the mesentery and omentum. Despite prior intestinal decompression and supportive therapy, gas continued to enter the portal venous system [3].

Imaging manifestations of HPVG

HPVG itself does not cause specific symptoms; patients primarily present with clinical manifestations of the underlying acute abdominal condition, such as abdominal pain, distension, and gastrointestinal dysfunction [4]. Diagnostic modalities include plain abdominal radiography, US, CT, and MRI. The sensitivity of US and CT is superior to that of plain radiography [5,6]. US has relatively high sensitivity for detecting HPVG and can serve as an initial screening examination. However, the utility of US is somewhat limited as it requires a higher degree of patient cooperation, including changes in position and breathing, which may be unfeasible in critically ill patients. The characteristic ultrasonographic findings of HPVG include: (1) Bubble-like and punc-

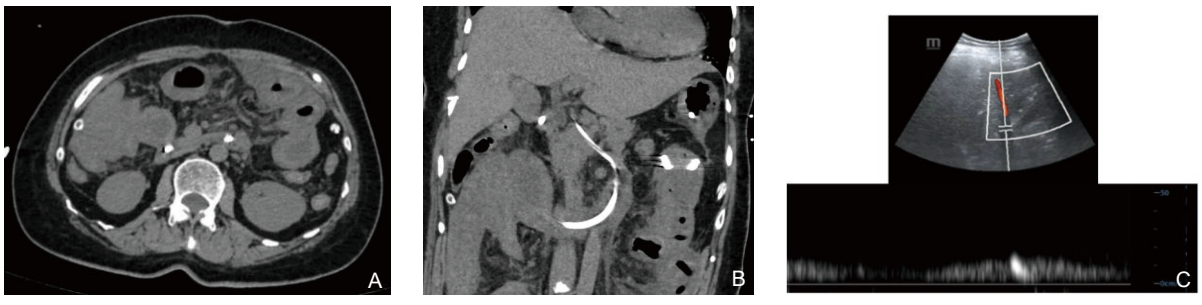

Figure 3 (A) Post-puncture abdominal CT; (B) Post-puncture abdominal CT; (C)Pre-puncture CDFI image.

tate hyperechoic foci within the portal vein moving with blood flow; (2) When the gas volume is substantial, diffusely distributed, small, patchy hyperechoic areas with ill-defined borders can be seen within the liver parenchyma, typically located in the non-dependent portions of the liver; (3) On color Doppler (CDFI) ultrasound, HPVG may manifest as turbulent flow within the portal vein (Fig. 3C). During spectral Doppler examination, placing the sample volume within the portal vein may reveal sharp, vertical spikes superimposed on the portal venous spectrum. This is caused by the high acoustic impedance mismatch between the gas bubbles and the blood as the bubbles traverse the ultrasound beam [7].

The management of HPVG lacks standardized protocols or guidelines. Clinically, the primary approaches are surgical intervention and conservative management. The choice between these strategies depends predominantly on the patient's underlying disease and the severity of their clinical condition. For mild cases or patients with stable vital signs who are unsuitable for surgery, an initial attempt with conservative management is recommended, primarily involving gastrointestinal decompression and nutritional support therapy [8]. Conversely, for patients with a high initial suspicion of concomitant intestinal necrosis, gastrointestinal perforation, or severe infection, aggressive emergency surgical intervention is indicated. However, as HPVG is typically associated with severe abdominal pathologies, this characteristic directly contributes to its exceedingly high operative risk and elevated mortality rate (75%) [4]. Analysis of the causes of death reveals that gas enters the portal venous system via the intestines due to conditions such as intestinal obstruction, mesenteric vascular disease, abdominal trauma, or post-liver transplantation, accumulating within the liver and portal vein. Excessive gas accumulation first induces necrosis and even anatomical disintegration of the intestinal tract and portal venous system. Furthermore, if gas travels retrograde through the portal system into the heart, it can be dispersed into minute bubbles, potentially causing pulmonary gas embolism.

Treatment strategy and novelty of intervention

The traditional treatment strategy adheres to the principle of "etiology-directed management, with surgery for severe cases": patients with stable vital signs and no signs of ischemia or perforation may initially receive gastrointestinal decompression, antibiotics, and supportive therapy; whereas laparotomy for exploration and intervention should be performed promptly once intestinal necrosis or perforation is suggested [9]. However, direct surgery carries two practical risks in patients with extensive HPVG: firstly, anesthesia and intraoperative circulatory complications (potential for massive gas entry into the portal/right heart system, exacerbating hemodynamic instability); secondly, increased complexity of the surgical field and perioperative management (due to systemic instability from severe infection, acidosis, hyperlactatemia, etc.). Recent multicenter studies and case series also indicate that, although overall prognosis has improved compared to earlier eras, both surgical and conservative strategies carry inherent risks of failure, with the key factor being the timing of intervention [10].

The core innovation of this case lies in the preoperative application of ultrasound-guided portal vein puncture for "decompression": aspirating the blood-gas mixture from the portal vein to directly reduce the intrahepatic HPVG load before proceeding with laparotomy. Compared to direct surgery, this "decompression-first" strategy may reduce perioperative risk through three potential mechanisms: (1) Short-term stabilization of hemodynamics: Reducing the gas load theoretically decreases the probability of catastrophic events caused by gas entering the right heart/pulmonary circulation; (2) Optimization of the anesthesia safety window: Performing bedside decompression prior to surgery avoids inducing anesthesia in a patient "carrying a significant gas load"; (3) Enhancement of surgical controllability: Alleviating turbulence within the portal vein and the burden of intrahepatic hyperechoic artifacts facilitates intraoperative decision-making and team coordination.

The significant reduction of gas within the portal vein observed on immediate post-procedural ultrasound in this case provides imaging support for the above hypotheses.

Bedside operability and value in the ICU

Compared to performing vascular interventions in the catheterization lab, ultrasound-guided techniques can be completed at the point-of-care, which holds particular clinical significance for ICU patients who cannot be safely transported. Point-of-Care Ultrasound (POCUS)/ Critical Care Ultrasound (CCUS) is already widely used in critical care settings for the evaluation of shock types, respiratory failure, and septic shock, as well as for guiding bedside invasive or minimally invasive procedures. Its importance has been consistently emphasized in recent guidelines. For instance, the 2025 CCUS guidelines released by the Society of Critical Care Medicine (SCCM) state that POCUS has become a key decision-making tool for hemodynamic assessment and fluid management; its use is expected to improve patient outcomes in critical conditions such as sepsis and cardiogenic shock [11]. Furthermore, the latest 2025 guide-

lines from the American Society of Echocardiography (ASE) propose that ultrasound-guided vascular access can significantly increase the success rate of catheterization and reduce puncture-related complications, establishing it as a recommended standard for ICU care and critical care procedural operations [12].

In the management of HPVG, bedside ultrasound offers unique advantages: it can not only dynamically monitor changes in intrahepatic portal venous "gas flow" and "patchy echoes," but also provide real-time assessment of clinical progression during acidosis correction and resuscitation. More importantly, it enables the performance of ultrasound-guided puncture or catheterization procedures directly at bedside on patients unsuitable for movement. Previous reports have emphasized that POCUS can be used for bedside procedures in ICU, particularly for patients with severe systemic inflammatory responses who cannot tolerate surgical intervention, where initial local decompression and drainage is a viable option [13]. This case represents the first report of a successful experience with ultrasound-guided portal vein puncture and decompression for HPVG performed at bedside in the ICU, demonstrating its characteristics of operational simplicity, repeatability, and low risk associated with patient movement. This approach is particularly suitable for critically ill patients with unstable circulation or those who cannot be transported. This innovative technique provides a potential solution for similar cases and expands the direction for future clinical practice of interventional ultrasound in critical care environments.

Acknowledgment

Not applicable.

Authors' Contributions

SJH contributed to the conception and design of the study, data acquisition, image interpretation, and drafting of the manuscript. ZY and WSY participated in the clinical management of the patient and data collection.HLW contributed to image analysis and literature review. DSB supervised the study and critically revised the manuscript for important intellectual content. All authors read and approved the final manuscript.

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Data Availability

The datasets used and analyzed during the current study available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

The patient and her family provided signed written informed consent for the procedure and publication of the case.

Conflict of interest

The authors have no conflict of interest to declare.

Consent for publication

Not applicable.

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