Benign Pneumatosis Coli in a Dog with a Congenital Intrahepatic Portosystemic Shunt: Case Report and Literature Review

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ABSTRACT

Pneumatosis coli (PC) is a rare condition characterized by intramural gas within the colonic wall. It is rarely reported in human medicine, and it is often reported as an incidental finding. It is even less frequently documented in veterinary medicine, where it is currently considered a clinically significant finding. This report describes a 5-year-old spayed female Weimaraner diagnosed and medically managed for an intrahepatic congenital portosystemic shunt (ICPSS). During diagnostic workup and follow-up imaging for the shunt, abdominal ultrasound (US) and computed tomography (CT) examinations revealed PC as an incidental finding. The dog received standard medical management for ICPSS, including antibiotics, gastroprotectants, and lactulose. A follow-up ultrasound performed three months later showed complete resolution of the PC, with no associated clinical signs. The incidental nature of PC in this case raises questions regarding its clinical relevance in veterinary patients. While the role of antibiotics in the resolution of PC herein remains unclear, this case highlights the need for further investigation into the significance of PC as a diagnostic finding in veterinary medicine, especially in asymptomatic patients.

Key words: Canine; Pneumatosis; Porto Systemic Shunt; Computed Tomography.

INTRODUCTION

Gastrointestinal pneumatosis describes the presence of gas within the subserosal or submucosal layers of the gastrointestinal tract (1-3). When gas accumulation is confined to the intestinal walls, it is termed pneumatosis intestinalis (PI), hence, intramural gas in the colonic walls is specifically termed pneumatosis coli (PC). In human medicine, PI is classified into primary and secondary forms which differ in radiologic appearance and clinical significance.

Primary PI (also known as benign PI or pneumatosis cystoides coli (PCC) when the colon is involved) accounts for approximately 15% of cases. It is idiopathic, often asymptomatic, and is considered benign (1, 4-6). Secondary PI (in the colon termed pneumatosis linearis coli [PLC]) is associated with a range of underlying critical conditions, including mesenteric ischemia, bowel necrosis, trauma, inflammatory bowel disease (IBD), malignancy, autoimmune disorders, infections, chronic obstructive pulmonary disease, and medications such as immunosuppressants, corticosteroids, and chemotherapeutic agents (1, 4-6). On a Computed Tomography (CT) scan, as reported in human medicine literature, Primary PI (including PCC) typically presents as well-circumscribed cysts or bubbles, most commonly located in the right colon. Secondary PI (including PLC) exhibits a linear or circumferential distribution of intramural gas (1, 4, 5).

The pathogenesis of gastrointestinal pneumatosis remains poorly understood, with various proposed pathophysiological mechanisms potentially acting as singular or combined contributing factors (1, 4, 6-10). The mechanical theory suggests that disruption of mucosal integrity, coupled with increased

intraluminal pressure, allows direct gas migration into the intestinal wall. While the infectious theory proposes that gas-producing bacteria translocate into the intestinal walls. The pulmonary theory attributes the condition to elevated intrathoracic pressure, leading to alveolar rupture and subsequent gas diffusion to the intestinal wall via vascular and lymphatic pathways. All these theories may involve contributing factors such as intestinal mucosal inflammation, physical damage, and immune barrier dysfunction. Additionally, nutritional imbalances, dysbiosis, and gastrointestinal dysmotility are considered potential ancillary causes.

Limited information is available on gastrointestinal pneumatosis in veterinary medicine. Reported cases have been classified based on anatomic location and include the esophagus (7), stomach (Canine – 7, 11, 12; Feline – 13-18; Both – 19), small intestine (Canine – 20- 22; Feline – 8, 23), and colon (Canine – 2, 9, 24-30 ; Feline – 23). A recent retrospective study (3) reviewed cases of gastrointestinal pneumatosis affecting various sites along the gastrointestinal tract, with the stomach and colon reported as the most commonly affected locations. Most cases of gastrointestinal pneumatosis in veterinary patients present with severe clinical signs, requiring intensive care or surgery, developing life-threatening complications and an overall mortality of up to 53% (3). Notably, no significant difference in mortality was observed based on the anatomic location of pneumatosis (3). Unlike in human medicine, incidental findings of gastrointestinal pneumatosis in veterinary medicine are rare, with only six cases reported in dogs overall—three with esophageal pneumatosis (EP) (7) and three with gastric pneumatosis (GP) (3, 19). These cases included dogs with mild or no clinical signs, some with clinical signs unrelated to gastrointestinal diseases, and some resolving without intervention or under mild conservative management.

Pneumatosis coli (PC) is uncommon in veterinary medicine and is rarely identified as an incidental finding. Clinical signs of PC are not specific and are often related to the underlying condition, including diarrhea, hematochezia, anorexia, tenesmus, abdominal pain, vomiting and other non-specific symptoms (2, 3, 9, 23-30). Treatment typically involves supportive therapies such as antibiotics, dietary management, and gastroprotective agents, as well as treatment of the underlying pathology, if it exists.

Cases of spontaneous resolution without treatment have also been described (27). Outcomes in reported cases vary, with many dogs showing clinical resolution; however, some reports show high mortality rates, reflecting the underlying causes, such as portal hypertension, colonic torsion, and other severe systemic or gastrointestinal conditions (2, 3, 24).

Radiographic information on gastrointestinal pneumatosis in veterinary medicine is exceedingly rare, with CT findings being particularly scarce. Existing CT imaging data primarily focuses on a small number of cases (2, 3, 7, 15, 17, 24, 26), with even fewer specifically addressing CT findings in dogs with PC (2, 24, 26).

This report describes a case of PC as an incidental finding in a dog undergoing diagnostic imaging for an intrahepatic congenital portosystemic shunt (ICPSS). This case contributes to the limited veterinary literature on incidental PC and highlights the need to reevaluate its clinical significance, particularly in asymptomatic patients.

CASE REPORT

A five-year-old spayed female Weimaraner was referred to the Hebrew University Veterinary Teaching Hospital (HUVTH) for a second-opinion consultation after being diagnosed with an intrahepatic congenital portosystemic shunt two months earlier. The dog initially presented to the referring clinic with neurological signs, including weakness and disorientation, and had been treated over the preceding two months with lactulose (0.25 mL/kg, PO, q12h; Avilac, Perrigo, Yeruham, Israel), omeprazole (1.3 mg/kg, PO, q24h; Omepradex, Dexcel, Or Akiva, Israel), and a liver supportive supplement (3 tablets, PO, q24h; Wepatic, Wepharm, Batalha, Portugal). Neurological signs improved shortly following initiation of treatment, however, the owners reported persistent soft stools following the initiation of lactulose therapy. Physical examination was unremarkable apart from a body condition score of 3/9.

Laboratory Analysis

A complete blood count (CBC) revealed mild neutrophilic leukocytosis, mild eosinophilia, and mild thrombocytopenia. Serum biochemistry abnormalities included mildly elevated alanine aminotransferase (ALT) and aspartate aminotransferase (AST) activities, mild panhypoproteinemia, low blood urea, fasting plasma hyperammonemia (276 μg/dL; reference interval [RI], 0–59 μg/dL), and increased preprandial serum bile acid concentrations (123 μmol/L; RI, <5 μmol/L).

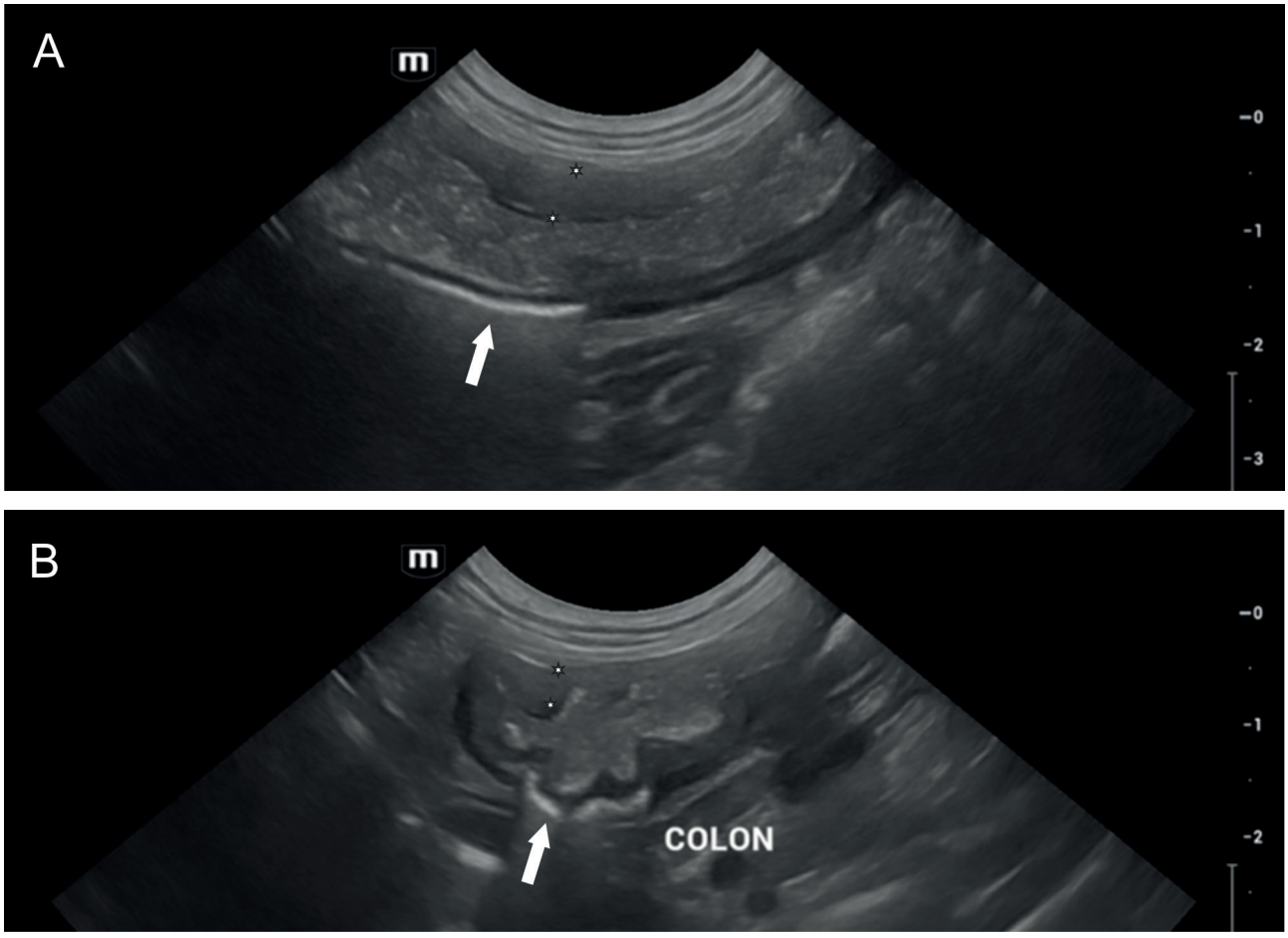


Figure 1: Ultrasonographic images of the colon in a sagittal plane (A), and a transverse plane (B). Mild, irregular thickening of the colonic wall is demonstrated (between cursors). There is an intramural linear gas pattern in the distant colonic wall, showing a reverberation artifact (arrow).

Diagnostic Imaging

Ultrasonography:

Ultrasonography was performed using a micro-convex array transducer in B-mode, at a frequency range of 3–11 MHz (Mindray Vetus 9 and Mindray M-9, Mindray Bio-Medical Electronics, Shenzhen, China). Harmonic imaging was applied in all scans.

Abdominal ultrasonography revealed several abnormalities. The liver was undersized, with no visible intrahepatic portal vasculature. The spleen was mildly heterogeneous and irregular. Both kidneys were mildly enlarged, with multiple cortical anechoic cysts and mildly irregular contours. The gastric wall was diffusely thickened, measuring up to 22 mm, with an indistinct wall layering. The colon appeared slightly distended and contained soft to liquid stool along with some intraluminal gas. In the descending colon, the wall was mildly thickened (up to 5 mm) and irregular, with several intramural gas foci identified as linear submucosal hyperechoic interfaces, producing a reverberation artifact (Figure 1). No additional abdominal abnormalities were identified. There was no evidence of enlarged or abnormal lymph nodes, and no altered echogenicity of intraperitoneal fat or membranes surrounding the colon or elsewhere in the abdominal cavity. Furthermore, intraluminal gas within the portal vasculature, or pneumoperitoneum were not observed.

Computed Tomography (CT):

CT was performed using a 40-slice helical scanner (CT imaging: Philips brilliance 40; 40 slice MDCT; Philips, Cleveland, OH, USA), using a helical scan mode, 1.5 mm thickness contiguous slices, at 120 kvp and 320 mA, and reconstruction algorithms of soft tissue, lung and bone. CT images were acquired before and immediately following manual

IV injection of a non-ionic contrast medium at 2ml/kg as a fast bolus (Omnipaque, GE Healthcare, Cork, Ireland; 300 mg/kg IV). The patient was scanned at 5, 20, 40 and 190 seconds post injection in order to acquire a multi-phase study. Images were viewed with a dedicated viewing software, with 3D capabilities (Fujifilm Synapse, FujiFilm Medical System USA, Stamford, CT), and multi-planar reformatting (MPR) was used whenever necessary for optimal evaluation. The scans were carried out with the patient in sternal recumbency, with a collimation extending from the cranial border of the heart, caudally to the pelvic canal, approximately up until the coxo-femoral joint.

The scans demonstrated multiple focal air collections in the wall of the descending colon, some rounded and others more linear in appearance. The descending colon was mildly dilated, measuring up to 30 mm in diameter, and the wall was thickened (up to 10 mm) and irregular. This change in the colonic wall was confined only to the descending colon, and with a tendency to be more pronounced on its ventral wall, where there were more intramural air collections than in the thinner dorsal wall (Figure 2 and 3). The rest of the small and large intestinal lumen was also mildly dilated, but with no evidence of pneumatosis. Intraluminal gas within the portal vasculature, or pneumoperitoneum were not observed.

The scan also confirmed the presence of a large left divisional ICPSS between the caudal vena cava (CVC) and the portal vein, at the location where the left hepatic vein and the cranial phrenic vein commonly enter the CVC (Figure 4). No obvious intrahepatic portal vasculature was identified. Additional abnormalities observed on the CT scan included a mildly reduced liver size, mild congestion of the extra-hepatic portal vasculature, mildly enlarged polycystic kidneys, mild enlargement of the spleen and pancreas, multiple mineralized foci in the walls of the aorta and proximal cranial mesenteric artery, a diffused thickened stomach wall (up to 26 mm) and a slight amount of free intraperitoneal fluid. In the lung lobes falling inside the field of view, a few small alveolar infiltrates were observed. No other significant abnormalities were observed in the scan's field of view.

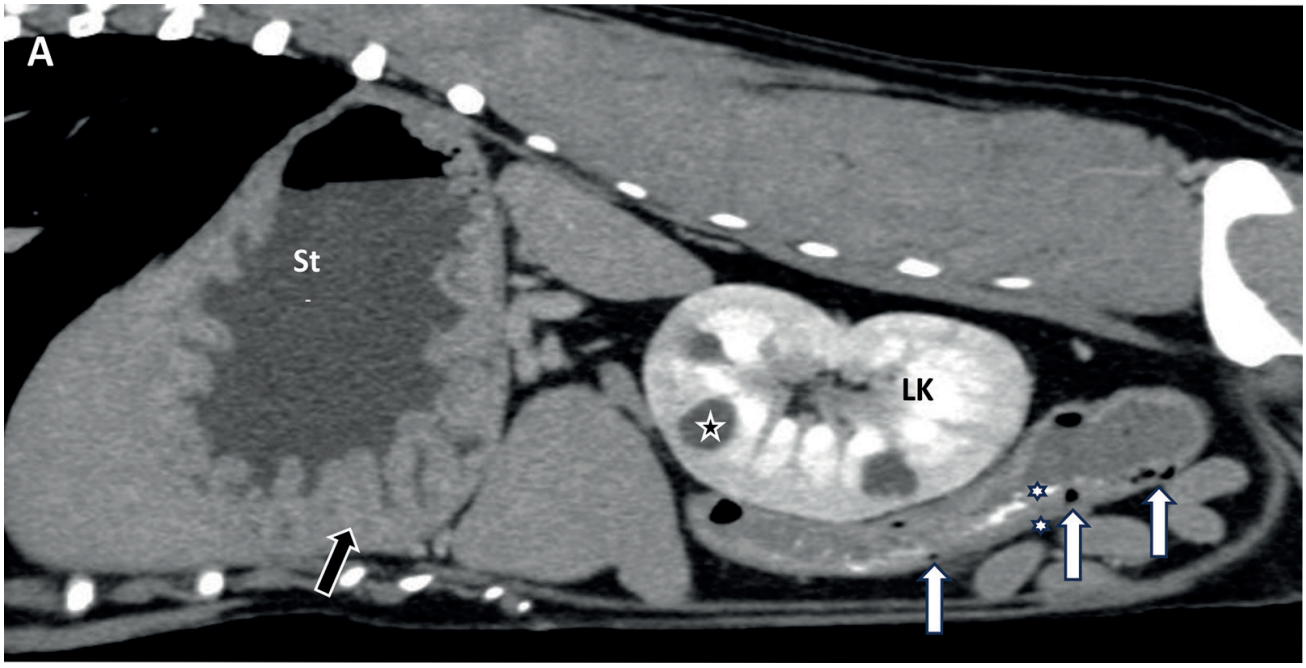
At this point, the dog was discharged with a modified supportive treatment plan tailored to address the persistent elevated ammonia levels despite previous therapy. The updated regimen included a dietary change and antibiotic therapy [metronidazole (10 mg/kg, oral, every 12 hours; Flagil, Sanofi, Yakum, Israel) and amoxicillin-clavulanic acid (10 mg/kg, every 12 hours; Augmentin, Glaxosmithkline, Petah-Tikva, Israel)], in addition to the previous medical treatments.

A percutaneous coil embolization of the shunt was recommended as the next step in treatment. Prior to the planned intervention, a blood PCR test for *Ehrlichia canis* was submitted to investigate the cause of thrombocytopenia, and doxycycline therapy (10 mg/kg orally once daily; Doxylin, DEXCEL, Or Akiva, Israel) was initiated as a precautionary measure. The PCR result was negative; however platelet count increased. One month after presentation, an attempt at coil embolization was performed but was unsuccessful. Despite recommendations, the owners declined the option of open surgery for shunt attenuation. The dog's medical treatment remained unchanged throughout this follow-up period.

At the three-month recheck examination following initial presentation, the dog exhibited clinical improvement, with previously soft stools becoming more formed and notable weight gain observed. Ultrasonography at this time revealed no signs of pneumatosis coli (PC) or any other gastrointestinal tract abnormalities. Additionally, portal vein mean velocity (Vmean) measurements were found to be within normal limits. At this point, surgical intervention was recommended again; however, the owners opted to continue with medical management instead. Seven months following the initial presentation, the dog was doing well and remained asymptomatic with regard to the shunt. No gastrointestinal-related signs were present. The dog was receiving lactulose, omeprazole and a hepatic supplement. The owners had discontinued antibiotics for several weeks, with no impact on the dog's well-being. Ammonia levels at this point were 74 μg/dL. The owners were still not willing to pursue surgical intervention.

DISCUSSION

This report describes a unique case of pneumatosis coli in a dog with intrahepatic congenital portosystemic shunt, that presented without specific clinical signs directly attributable to the PC. Unlike most documented cases of pneumatosis intestinalis in veterinary medicine, which often exhibit severe clinical signs or a fulminant disease, this case appeared to be benign and potentially incidental. The absence of severe gastrointestinal or systemic manifestations, supports the



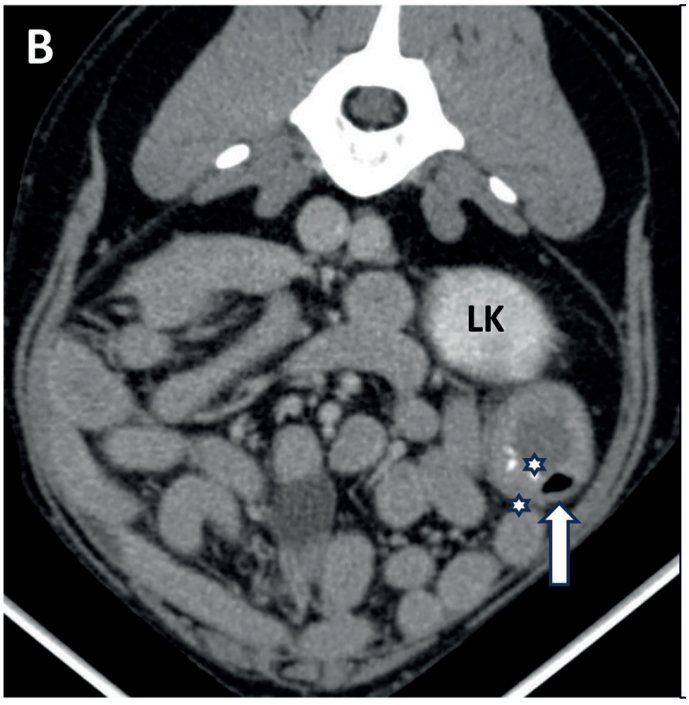


Figure 2: Sagittal (A) and transverse (B) late post contrast abdominal computed tomography images, done with the dog in sternal recumbency.

Foci cystic to linear intramural gas collections are present on the ventral wall of the descending colon (white arrows). Note the irregular thickening of the colonic wall, slightly more evident on the ventral wall (between the cursors).

In the sagittal plane image (A), a mildly enlarged polycystic left kidney (star), and a mild thickening of the stomach wall (black arrow) can be also noted.

(LK, Left Kidney; St, Stomach).

classification of this case as non-aggressive and suggests that PC can occur as a mild or asymptomatic condition in dogs, paralleling benign forms of pneumatosis cystoides coli reported in human medicine.

The precise cause of PC in this case remains unclear, though several potential mechanisms warrant consideration. Gastrointestinal disturbances associated with ICPSS, including altered portal blood flow, intestinal wall hypoxia, and bacterial overgrowth, may predispose affected dogs to the mechanical and infectious mechanisms implicated in the pathogenesis of PI. Approximately 30% of dogs with portosystemic shunts exhibit nonspecific gastrointestinal signs,

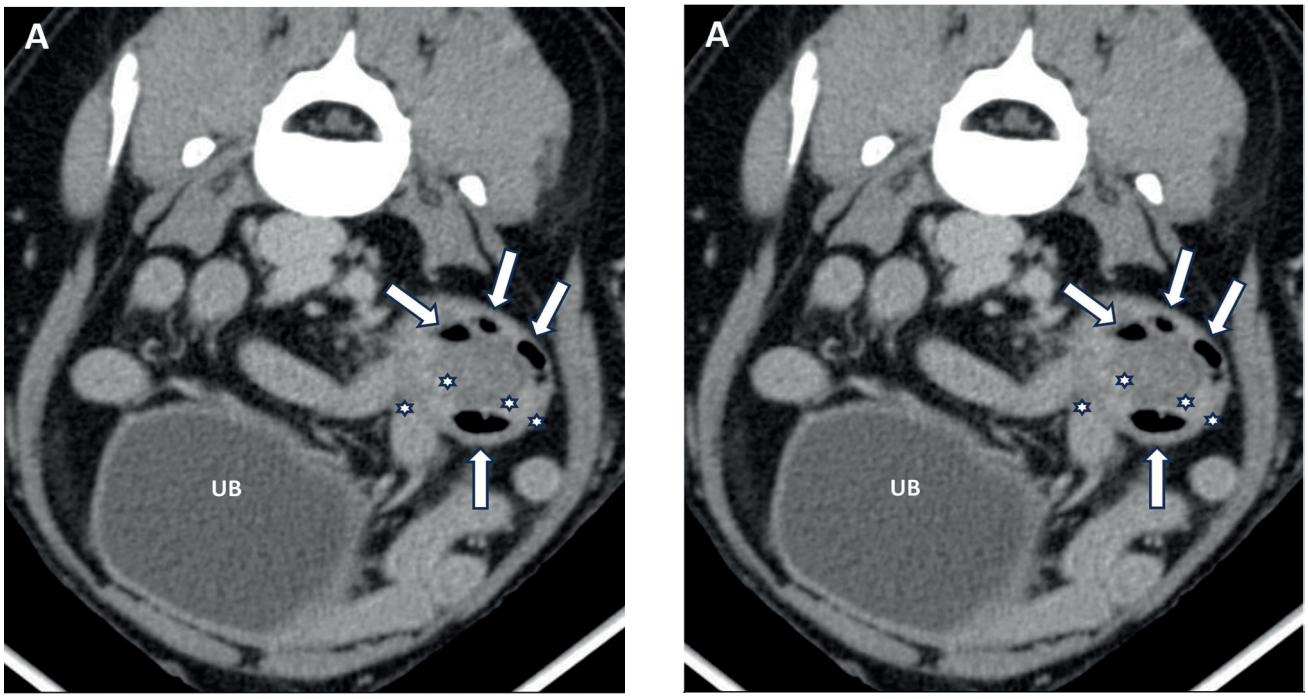


Figure 3: Transverse (A) and dorsal (B) late post contrast abdominal computed tomography images, done with the dog in sternal recumbency. Both images show the presence of irregular to cystic intramural gas collections in the wall of the descending colon (white arrows). Note the irregular thickening of the colonic wall (between the cursors). (Li, Liver; UB, Urinary Bladder).

providing a plausible link between the underlying condition and the development of PC (31). Additionally, Lactulose therapy, commonly used in the management of ICPSS, has been associated with PC in human medicine through the production of carbon dioxide and hydrogen, which may increase intraluminal pressure and allow gas migration through a compromised intestinal wall (6, 10). However, the resolution of PC in this case despite the continued administration of lactulose argues against a direct causal relationship. While antibiotic administration coincided with clinical improvement and imaging resolution, the mild nature of the clinical signs observed makes it unlikely that antibiotics played a definitive role in resolving the PC.

Several cases of PC have been reported in dogs, but only three cases have specifically involved dogs with portosystemic shunts, some of which were treated with lactulose therapy. While both PSS and lactulose are theorized to predispose dogs to pneumatosis intestinalis, no definitive causal association has been established.

The intramural gas pattern observed in this dog's CT scan does not correspond to any of the gas patterns described in human medicine for distinguishing benign pneumatosis intestinalis (PCC) from fulminant pneumatosis intestinalis (PLC) (1, 5). Subjectively, the gas distribution in this case appeared to fall somewhere between the "cystic" or "bubble-like" morphology typically associated with PCC and the "linear" and circumferential morphology characteristic of PLC (Figures 2 and 3). Additional imaging features often reported in PLC, such as bowel dilation, colonic wall thickening, and free intraperitoneal fluid (1), were also present in this case. However, these findings were nonspecific and may have alternative explanations unrelated to PLC.

Radiographic characterization of pneumatosis coli in veterinary medicine remains poorly defined, with limited reports available for comparison. Of the seven veterinary reports describing CT findings of gastrointestinal pneumatosis with imaging of intramural gas (2, 3, 7, 15, 17, 24, 26), only three reports specifically document cases of pneumatosis coli CT imaging (2, 24, 26). The remaining reports either describe pneumatosis in the esophagus and stomach or do not specify the location of the intramural gas. The CT descriptions provided in the three veterinary reports of pneumatosis coli (2, 24, 26) offer limited detail and make it challenging to identify patterns comparable to those described in pneumatosis cystoides coli and

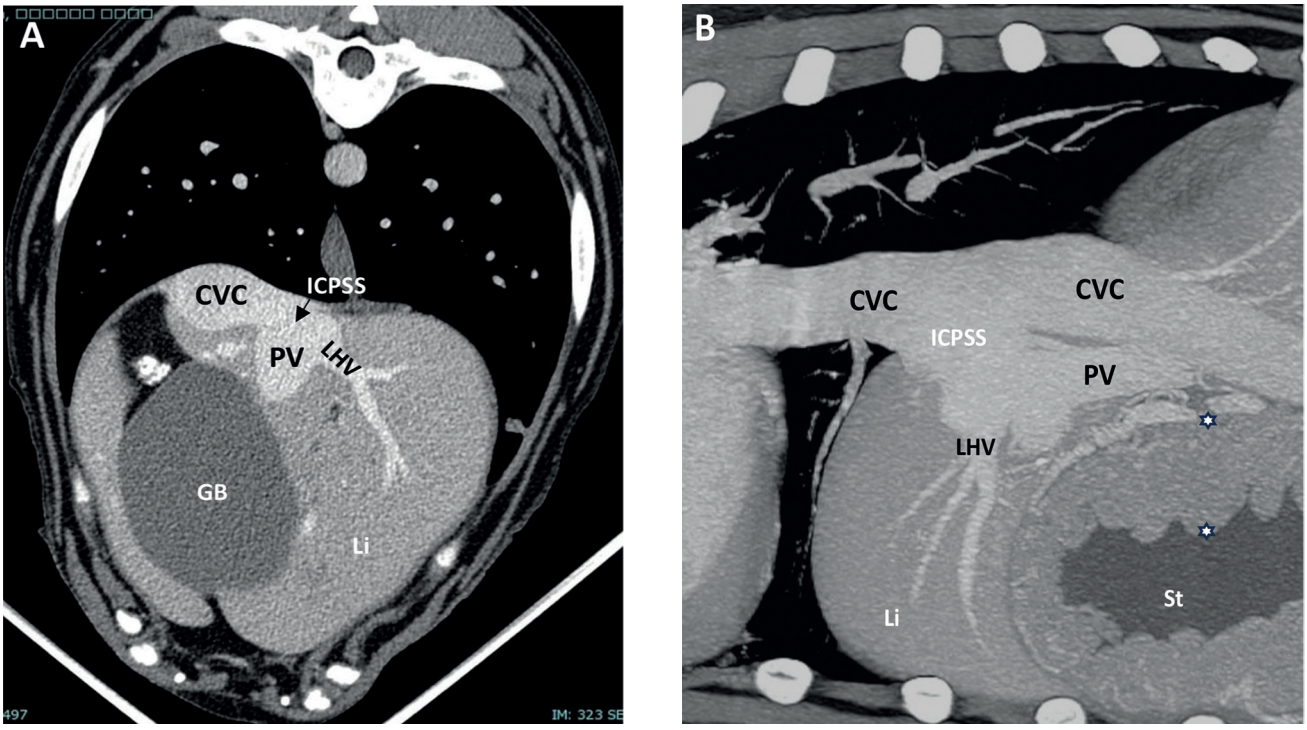


Figure 4: Transverse (A) and sagittal (B) late post contrast abdominal computed tomography images, done with the dog in sternal recumbency. Both images show the presence of a large left divisional intrahepatic congenital portosystemic shunt (ICPSS) between the caudal vena cava (CVC) and the portal vein (PV), at the location where the left hepatic vein (LHV) and the cranial phrenic vein usually enter the CVC. Note the thickening of the stomach wall identified on the sagittal view (between cursors). The sagittal image is of thin-maximum intensity projection (MIP). (Li, Liver; St, Stomach; GB, Gall Bladder).

pneumatosis linearis coli in human medicine. In one case (26), the intramural gas is described as "linear," but no additional characteristics were noted. The accompanying figures depict an extensive circumferential extraluminal air pattern along the large bowel, which appeared non-specific and did not match the linear gas patterns typically reported in human cases (1). Another case (2) includes only a general reference to extraluminal gas tracking along the colon, with no further descriptive detail. The single figure presented also displays extensive and circumferential extraluminal air without a distinctive pattern. The third case (24) lacked any detailed description of the intramural gas and provideed just one figure showing a focal intramural gas pattern with a linear orientation. However, this isolated image may not adequately represent the exact intramural gas distribution pattern which may be better defined on the complete scan. These reports highlight the current limitations in veterinary literature regarding the radiographic characterization of PC and underscore the need for more systematic imaging analysis and standardized descriptions to establish clear diagnostic patterns and improve the clinical interpretation of PC findings in veterinary patients.

The relatively low number of reported PC cases in veterinary medicine, as compared to human medicine, may result from several factors. Computed tomography (CT) imaging, widely used as a screening tool in human medicine due to its availability, lower cost, and ability to be performed without anesthesia, is less commonly employed in veterinary medicine. In addition, technical differences in imaging protocols, such as the lack of oral contrast in veterinary CT studies, may impair the detection of intramural gas, leading to underdiagnosis. Furthermore, radiological awareness of PC may be lower in veterinary medicine, particularly when clinical signs are mild, non-specific, or absent. Subtle patterns of intramural gas may be overlooked, especially when masked by intraluminal gas or confounded by other gastrointestinal findings. The low number of reported PC cases could explain why PC is rarely identified as an incidental finding in veterinary medicine.

In conclusion, this report describes the first case of pneumatosis coli (PC) in a dog as a potentially incidental and benign finding, with no severe clinical manifestations. While potential predisposing factors, including ICPSS and lactulose therapy, were present, no direct causal relationship could be confirmed. This case underscores the need for increased radiological awareness of PC in veterinary medicine and highlights the importance of distinguishing benign forms of PC from more fulminant types, thus correlating the radiographic findings to morbidity and mortality, as is done in human medicine. Further investigation into the etiology, classification, and clinical significance of PC is warranted to improve diagnostic accuracy and guide clinical management in veterinary patients.

It is important to recognize that gastrointestinal pneumatosis represents a radiographic finding rather than a specific clinical diagnosis. As such, it should be interpreted with the same caution and clinical context applied to any other diagnostic finding. Automatic assumptions of aggressive pathology should be avoided, however, disregarding its potential significance would also be inappropriate. Future advancements in radiographic categorization and pattern classification of gastrointestinal pneumatosis may improve clinical assessments and support the development of more targeted diagnostic and therapeutic approaches for affected patients.

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