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Case Report

RADIOLOGICAL DIAGNOSIS OF PNEUMOPERITONEUM IN A DOG DUE TO PERFORATION OF THE INTESTINAL WALL

Marko Jumake MITROVIĆ[1*], Anastasija TODOROVIĆ[1]

[1]University of Belgrade, Faculty of Veterinary Medicine, Department of Radiology and Radiation Hygiene, Belgrade, Serbia

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Abstract

Pneumoperitoneum is an urgent condition that requires immediate surgical intervention regardless of the cause. This article presents a three-year-old mixed-breed dog that was diagnosed with pneumoperitoneum by radiological examination. In daily clinical practice, radiological imaging of the abdominal organs is performed with two standard projections (lateral and ventrodorsal). In most cases, however, a pneumoperitoneum cannot be diagnosed with these projections. This article therefore presents radiological imaging with a horizontal X-ray beam, which can be used to diagnose pneumoperitoneum with certainty. It also presents the radiological signs that veterinarians need to look for to diagnose this pathological condition.

Key Words: dog, pneumoperitoneum, radiology, X-ray

CASE PRESENTATION

A 3-year-old mixed breed dog weighing 14.6 kg was brought to the Radiology Clinic, Department of Radiology and Radiation Hygiene of the Faculty of Veterinary Medicine, University of Belgrade, with suspected constipation. Upon admission, the possibility of using the clinical data for publication was discussed with the owner, and informed written consent was obtained prior to submission of this case report.

*Corresponding author – e-mail: markom@vet.bg.ac.rs

According to the owner, the dog had eaten a large amount of bones four days earlier and had not defecated since. The dog squatted to defecate but whimpered and only a small amount of brownish mucus without blood came out of the anus. The owner took the dog to a private veterinary practitioner who performed an enema and a large amount of faeces with bones was discharged. On the same day, a radiological examination of the dog was ordered to determine whether there were any intestinal remnants in the large intestine. On admission, the dog was cheerful and in an unaltered general condition. The abdomen was soft and painless on palpation. Laboratory blood tests (blood count and biochemistry) were not performed.

The radiological examinations were performed with a ZooMax Gold X-ray unit (Control-X Medical, Hungary) with a focus film distance of 60 cm at a voltage of 48 kVp and a current of 16 mAs. In addition to the two standard projections for imaging the abdomen (lateral and ventrodorsal projection), the radiological examination was also performed in an upright body position with a horizontal X-ray beam (Figure 1 A; B and C). For this projection, the dog is positioned vertically, standing only on its hind legs, while the veterinarian holds the front legs upright above the animal's head. The X-ray film is placed behind the animal's body while the horizontal beam runs in a ventrodorsal direction.

The radiographs of the dog's abdomen in lateral and ventrodorsal projection showed a small amount of faecal contents in the final parts of the large intestine, i.e. the rectum. The contents were radiologically consistent with soft tissue opacity, and no bone was observed. The abdominal structures were clearly visible on the radiographs, ruling out the presence of free fluid (Figure 1A-B).

However, on the radiographs, which were taken with the animal in an upright position and a horizontal X-ray beam, a transparent, band-shaped opacity of about 3 cm in diameter was visible between the diaphragm and the diaphragmatic side of the liver (Figure 1 C'). This finding indicates the presence of free gas in the abdominal cavity. Such a change was not seen on the previous radiographs as the gas is diffusely distributed when the animal is radiographed in a recumbent position. However, when the animal is held upright and the radiographs are taken with a horizontal beam, the air moves upwards and can be seen between the liver and diaphragm (the border between the liver and diaphragm is not normally visible on radiographs of healthy animals).

After the radiological diagnosis of pneumoperitoneum, the dog underwent urgent surgery, according to the owner's wishes, which revealed a perforation of the large intestine wall.

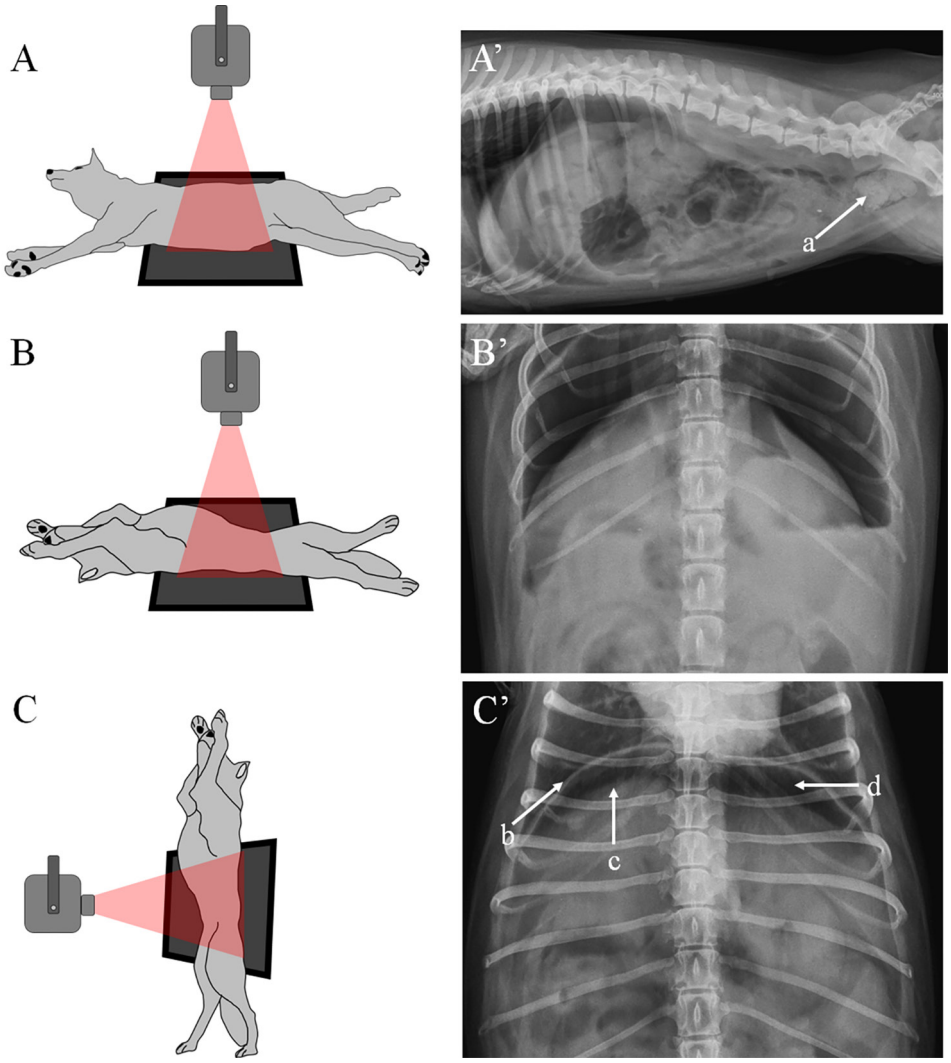

Figure 1. Schematic views and radiographs of the dog in lateral **(A, A')**, ventrodorsal **(B, B')** projection and with horizontal X-ray beam **(C, C')**: soft tissue contents – faeces in the large intestine **(a)**; diaphragm **(b)**; diaphragmatic side of the liver **(c)** and free gas between diaphragm and liver **(d)**.

DISCUSSION

The presence of free intraperitoneal gas, or pneumoperitoneum, can have both iatrogenic and pathological causes. Iatrogenic pneumoperitoneum most commonly occurs after recent invasive procedures, such as celiotomy, laparoscopy or abdominocentesis, where the detection of intraperitoneal air is generally expected and not considered clinically significant (Simmonds et al., 2011). In contrast, pathological pneumoperitoneum is usually categorised as either spontaneous or traumatic.

Retrospective studies have identified gastrointestinal perforation as the main cause of spontaneous pneumoperitoneum, most commonly associated with gastric dilatation-volvulus or gastrointestinal neoplasia (Saunders and Tobias, 2003; Smelstoys et al., 2004).

Tension pneumoperitoneum is a condition in which excessive gas accumulates in the peritoneal cavity, leading to significant cardiorespiratory problems (Joo et al., 2020; Bernabe et al., 2021). This gas accumulation increases the intra-abdominal pressure and pushes the diaphragm upwards, leading to shortness of breath and rapid breathing (tachypnoea). In addition, the increased pressure compresses the inferior vena cava, which reduces venous return to the heart and can lead to low blood pressure (hypotension) and accelerated heart rate (tachycardia) (Joo et al., 2020). Therefore, urgent decompression is required to reduce intra-abdominal pressure.

Traumatic pneumoperitoneum is often due to external injuries that compromise the integrity of the body wall, such as dog bites, gunshot wounds or vehicular trauma. One case has been reported in which a dog developed pneumoperitoneum secondary to pneumomediastinum following blunt thoracic trauma (Simmonds et al., 2011). Two mechanisms have been proposed to explain the displacement of air from the thoracic to the abdominal cavity: (1) direct migration through pleural and diaphragmatic defects, including natural microscopic fenestrations or the epiploic foramen; and (2) indirect spread via the mediastinum by following perivascular pathways or large diaphragmatic openings such as the aortic and oesophageal hiatus and entering the retroperitoneal space and subsequently the peritoneal cavity (Karaman and Demirbilek, 2005; Sreevathsa, 2009).

In approximately 74–77% of dogs with spontaneous pneumoperitoneum, the presence of free gas is associated with perforation of a hollow organ, usually in the gastrointestinal tract (Saunders and Tobias, 2003). As a result, pneumoperitoneum usually requires urgent exploratory surgery, as a leak in the gastrointestinal tract often leads to bacterial contamination and subsequent sepsis. This emphasises the critical need for early and accurate recognition of pneumoperitoneum (Ng et al., 2020). In veterinary practise, pneumoperitoneum is usually treated by immediate surgical intervention, regardless of its aetiology (Saunders and Tobias, 2003; Smelstoys et al., 2004). Early surgical treatment aims to eliminate the source of air ingress and reduce the risk of intestinal contamination in the peritoneal cavity (Karaman and Demirbilek, 2005).

The diagnosis of septic peritonitis is based on an increased white blood cell count, increased total protein concentrations and low glucose levels in the peritoneal fluid. Bonczynski et al (2003) found that the white blood cell count exceeded 17×10^9 cells/L (normal range: 7×10^9 cells/L), the total protein concentration was 3.6 g/dL (normal < 2.0 g/dL) and the glucose in the peritoneal fluid was consistently below 55 mg/dL (with a sensitivity of 57 % and a specificity of 100 %). A glucose difference of more than 20 mg/dL between the peritoneal fluid and blood glucose values (with a

sensitivity and specificity of 100 %) further supports the diagnosis of septic peritonitis. The blood abnormalities, such as pronounced neutrophilia, monocytosis, elevated C-reactive protein and elevated D-dimer values, indicate a pronounced inflammatory reaction (Kim et al., 2024).

For the radiological diagnosis of the pneumoperitoneum, we chose a ventrodorsal projection with the animal in a standing position and a horizontal X-ray beam. In this position, all abdominal organs shift downwards (i.e. caudally) due to gravity, while the less dense gas rises upwards (i.e. cranially) and accumulates between the liver and diaphragm, where it is clearly visible. Imaging is performed immediately. However, Ng et al. (2020) report that imaging in a lateral recumbent position with a horizontal X-ray beam is more effective. In this technique, the animal is placed in the left lateral position with the X-ray beam orientated horizontally in a ventrodorsal direction. On the radiograph, gas typically accumulates beneath the caudal ribs. Although the authors describe this method as the most effective for detecting pneumoperitoneum, even in cases with minimal free gas, one of its disadvantages is the need to wait at least 2 to 10 minutes after positioning the patient before the radiograph can be taken.

Although radiography is often used to detect free intraperitoneal gas, its diagnostic value is limited due to the possible superimposition of gas bubbles with abdominal organs, which can produce a false image of intraluminal gas in the intestines. In contrast, ultrasound, especially when performed by experienced operators, not only helps to detect free gas, but can also contribute to a more precise localisation of the lesion. Computed tomography (CT), however, has been shown to be a more sensitive diagnostic method, especially in the assessment of gastrointestinal perforations in animal patients. CT has been shown to be superior to radiography and ultrasound in detecting perforated ulcers and small amounts of free air in the peritoneum, especially in post-operative patients. Several studies confirm the advantage of CT diagnostics over radiography in the detection of subtle intraperitoneal gas accumulations (Marwood et al., 2022). However, this case report highlights the diagnostic value of horizontal beam radiography in confirming pneumoperitoneum, a condition requiring urgent surgical intervention. The inclusion of this imaging technique in routine diagnostic imaging protocols may improve the detection of free abdominal gas when standard projections prove inconclusive.

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Authors' contributions

Both authors contributed equally to the preparation of this case report.

Competing interests

The authors declare that they have no competing interests.

ORCID iDs

Marko Jumake Mitrović https://orcid.org/0000-0002-0416-0103
Anastasija Todorović https://orcid.org/0000-0002-7315-5578

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RADIOLOŠKA DIJAGNOSTIKA PNEUMOPERITONEUMA PSA UZROKOVANOG PERFORACIJOM ZIDA CREVA

Marko Jumake MITROVIĆ, Anastasija TODOROVIĆ

Kratak sadržaj

Pneumoperitoneum je hitno stanje koje, bez obzira na uzrok, zahteva trenutnu hirurško intervenciju. Ovaj rad prikazuje trogodišnjeg psa mešanca kod kojeg je pneumoperitoneum dijagnostikovan radiološkim pregledom. U svakodnevnoj kliničkoj praksi, rendgensko snimanje abdominalnih organa vrši se pomoću dve standardne projekcije (lateralna i ventrodorzalna). Međutim, upotrebom ovih projekcija pneumoperitoneum se ne može dijagnostikovati u većini slučajeva. Stoga, ovaj rad prikazuje radiološko snimanje sa horizontalnim zračnim snopom, na osnovu kojeg se pneumoperitoneum može dijagnostikovati sa sigurnošću. Takođe, prikazani su radiološki znakovi na koje veterinari moraju obratiti pažnju kako bi dijagnostikovali ovo patološko stanje.

Ključne reči: pas, pneumoperitoneum, radiologija, rendgensko zračenje