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Radiographic interpretation of common abdominal affections in dogs

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Abstract

Survey abdominal radiography remains one of the most accessible and widely used first-line imaging modalities in small animal practice for the evaluation of abdominal disease in dogs. Despite the increasing availability of ultrasonography and cross-sectional imaging, plain radiographs continue to provide rapid, cost-effective, and often diagnostic information in emergent and non-emergent abdominal conditions. This article summarizes the characteristic radiographic features of eight commonly encountered abdominal affections in dogs: gastric dilatation-volvulus (GDV), peritoneal effusion, cystoliths, hepatomegaly, splenomegaly (including splenic torsion), renomegaly, megacolon, and pyometra, with additional reference to radiographic pregnancy diagnosis.

Keywords: Abdominal radiography, canine, gastric dilatation-volvulus, splenomegaly, hepatomegaly, pyometra, megacolon, cystoliths

Introduction

Abdominal affections are the most common presenting complaints in canine clinical practice, encompassing conditions ranging from acute, life-threatening emergencies to chronic, insidious disorders of the gastrointestinal, hepatobiliary, urinary and reproductive systems. Survey abdominal radiography served as a first-line imaging tool for evaluating these conditions, owing to its speed, wide availability and ability to reveal characteristic patterns of organ size, position, opacity and mineralization (O'Brien, 1978) ^[14]. Although ultrasonography and cross-sectional imaging have expanded the diagnostic armamentarium, radiography remains central to the initial assessment of the acute abdomen, particularly in emergency settings. Several conditions illustrate the diagnostic value of this modality. Gastric dilatation-volvulus (Mackenzie *et al.*, 2010) ^[11], represents a time-critical emergency in which radiographic recognition directly influences survival. Peritoneal effusion produces a diffuse loss of abdominal detail that radiography detects readily, even though it cannot determine effusion type (Luttwak *et al.*, 1975) ^[10]. Organomegaly involving the liver, spleen, and kidneys presents significant challenges in radiographic interpretation because normal organ size varies among different dog breeds (Choi *et al.*, 2013) ^[4]. Radiographic evaluation is also valuable for diagnosing urinary tract disorders, particularly cystic calculi, which appear as radiopaque mineralized structures within the urinary bladder (Steyn and Lowry, 1991) ^[18]. Survey radiography plays an important role in identifying reproductive conditions such as pregnancy by detecting fetal skeletal mineralization at specific stages of gestation (Haney *et al.*, 2003) ^[8]. Thus, abdominal radiography provides a comprehensive, non-invasive method for evaluating a wide range of hepatosplenic, urinary and reproductive abnormalities, making it an indispensable diagnostic tool in small animal practice. This article reviews these representative radiographic patterns, drawing on the supporting literature to highlight the diagnostic strengths of survey abdominal radiography.

Materials and Methods

This review was compiled through a structured synthesis of the existing veterinary radiology literature pertaining to common abdominal affections in the dog. Radiographic descriptions

were drawn from primary retrospective clinical studies, foundational radiographic reference texts, and peer-reviewed veterinary journals spanning small animal internal medicine, surgery and diagnostic imaging. For each condition, the following parameters were extracted and summarized: (1) underlying pathophysiology relevant to the radiographic appearance, (2) primary and secondary radiographic signs on standard lateral and ventrodorsal projections, (3) recognized quantitative or ratio-based measurement criteria (e.g., organ length relative to vertebral body length). Conditions reviewed included gastric dilatation–volvulus (GDV), peritoneal effusion, cystoliths, hepatomegaly, splenomegaly and splenic torsion, megacolon, pyometra and radiographic pregnancy diagnosis.

Results

Gastric Dilatation–Volvulus (GDV)

Gastric dilatation–volvulus (GDV) is an acute, life-threatening condition characterized by severe gastric distension followed by rotation of the stomach along its mesenteric axis (Mackenzie *et al.*, 2010, 2014) ^[11, 16]. The hallmark radiographic finding is compartmentalization of the gas-distended stomach into two distinct gas-filled compartments separated by a soft-tissue band, producing the classic "double bubble" or "Popeye arm" appearance (Sharp, 2014) ^[16] (Fig. 1). This characteristic appearance occurs because the pylorus is displaced dorsally and cranially, folding over the gas-filled gastric fundus and body (Frendin *et al.*, 1988) ^[7]. Marked gastric distension with gas, fluid, and ingesta is consistently present, while the pylorus, which normally occupies the ventral right cranial abdomen, becomes displaced dorsally and frequently toward the left side of the abdomen (Sharp, 2014) ^[16]. Additional radiographic findings may include splenic displacement or congestion secondary to gastric rotation, narrowing of the caudal vena cava indicative of hypovolemic shock, and free abdominal gas in cases of gastric perforation (Mackenzie *et al.*, 2010; Soederer, 2008) ^[11, 17].

Peritoneal Effusions

Peritoneal effusion refers to the abnormal accumulation of free fluid within the peritoneal cavity and may develop secondary to right-sided congestive heart failure, portal hypertension, hypoalbuminemia, neoplasia, uroabdomen, hemoabdomen, or septic peritonitis (Luttwak *et al.*, 1975) ^[10]. Radiographically, peritoneal effusion produces a generalized loss of abdominal serosal detail, resulting in the characteristic ground-glass appearance due to the loss of normal fat–soft tissue contrast outlining the abdominal organs (Fig. 2). As a result, the margins of the liver, spleen, kidneys, and intestinal loops become indistinct or impossible to identify.

Overall abdominal soft-tissue opacity is increased, accompanied by generalized abdominal distension and a rounded, pendulous abdominal contour. Intestinal loops are displaced toward the center of the abdomen, where they appear to float within the surrounding fluid. In severe cases, outward splaying of the costal arch and marked abdominal wall distension may also be observed. Although survey radiography is effective in detecting moderate to large volumes of peritoneal fluid, it is relatively insensitive for identifying small fluid accumulations and cannot distinguish between transudates, exudates, blood, urine, or septic effusions, necessitating further diagnostic procedures such as ultrasonography and abdominocentesis (Luttwak *et al.*, 1975) ^[10].

Cystoliths

Cystoliths are mineral concretions that develop within the urinary bladder as a result of metabolic abnormalities, dietary factors, urinary tract infections, or alterations in urine pH (Buffington *et al.*, 1997) ^[3]. Radiographically, radiopaque calculi such as struvite and calcium oxalate appear as well-defined mineral-opacity structures within the urinary bladder lumen (Steyn and Lowry, 1991) ^[18]. These calculi may be single or multiple and vary considerably in size and shape, ranging from smooth, rounded stones to faceted or irregularly shaped calculi (Fig. 3). Because urinary bladder calculi are freely movable, they typically settle in the most dependent portion of the bladder, and changes in patient positioning between lateral and ventrodorsal projections help confirm their intravesical location while differentiating them from mineralized masses or superimposed fecal material (Steyn and Lowry, 1991) ^[18]. Radiolucent calculi, including many urate and cystine uroliths, are frequently not visible on survey radiographs and therefore require double-contrast cystography or ultrasonography for accurate detection (Buffington *et al.*, 1997) ^[3]. Secondary radiographic findings may include diffuse or focal urinary bladder wall thickening associated with chronic cystitis and marked urinary bladder distension in cases of urethral obstruction (Zotti *et al.*, 2007) ^[21]. Thus, although survey radiography remains the primary imaging modality for detecting radiopaque cystoliths, complementary imaging techniques are often necessary to identify radiolucent uroliths and associated urinary bladder abnormalities (Zotti *et al.*, 2007) ^[21].

Hepatomegaly

Hepatomegaly refers to enlargement of the liver, which may be diffuse or focal and commonly occurs secondary to hepatic congestion associated with right-sided heart failure, inflammatory liver disease, infiltrative disorders such as lymphoma or mast cell disease, primary or metastatic hepatic neoplasia, nodular hyperplasia, or endocrine disorders including hyperadrenocorticism (Liptak *et al.*, 2004) ^[9]. Radiographically, hepatomegaly is characterized by caudal extension of the liver beyond the costal arch with rounding of the normally sharp ventral hepatic margins (Liptak *et al.*, 2004) ^[9]. The enlarged liver displaces the stomach caudally and dorsally, increasing the distance between the gastric silhouette and the diaphragm and altering the normal gastric axis, particularly through displacement of the pyloric antrum (Fig. 4). Additional displacement of adjacent abdominal organs, including the right kidney, spleen, and small intestinal loops, may also be evident (Nickel *et al.*, 1973) ^[13]. On the lateral radiographic projection, the ventral hepatic border appears rounded rather than maintaining its normal wedge-shaped contour. An objective radiographic method for assessing hepatic size has been described by measuring the ratio of liver length on right lateral radiographs—from the caudoventral liver margin to the ventral aspect of the caudal vena cava just cranial to the diaphragm—to the length of the 11th thoracic vertebra (T₁₁) (Choi *et al.*, 2013) ^[4]. Using this method, the normal liver length is approximately 5.4–5.5 times the length of T₁₁ in most dogs, 5.16 times in brachycephalic breeds, and approximately 4.64 times in Pekingese dogs, highlighting important breed-related variations in hepatic size (Choi *et al.*, 2013) ^[4].

Splenomegaly

Splenomegaly denotes enlargement of the spleen and may occur as either diffuse enlargement or focal nodular

expansion. Common causes include splenic neoplasia such as hemangiosarcoma or lymphoma, extramedullary hematopoiesis, vascular congestion associated with sedation, anesthesia, splenic torsion, right-sided heart failure and various infectious or inflammatory disorders (Wilson *et al.*, 2003; Baldo *et al.*, 2012) ^[20, 21]. Radiographically, generalized splenomegaly in dogs, and to a lesser extent in cats, is characterized by thickened, rounded, and blunted splenic margins with dorsal and caudal displacement of the jejunum on lateral projections (Neer, 1996) ^[12] (Fig. 5). On the ventrodorsal projection, displacement of adjacent abdominal organs depends on the portion of the spleen affected and the degree of enlargement; the jejunum may be displaced to either side, whereas enlargement of the splenic head results in cranial displacement of the stomach (Neer, 1996) ^[12]. In cases of splenic torsion, the spleen becomes markedly enlarged and displaced from its normal anatomical location owing to rotation around its mesenteric axis, causing venous obstruction followed by arterial compromise (DeGroot *et al.*, 2016) ^[15]. Radiographically, the torsed spleen may assume a characteristic reverse C-shaped appearance on the lateral projection or appear as a large ventral abdominal mass, while the splenic head may no longer be visible in its normal left craniodorsal position.

Pyometra

Pyometra is a life-threatening uterine infection characterized by the accumulation of purulent material within the uterine lumen. It typically develops in intact female dogs during diestrus, approximately two months after estrus, as a consequence of progesterone-induced cystic endometrial hyperplasia followed by secondary bacterial infection (Fossum, 2013; Prasad *et al.*, 2017) ^[6, 15]. Radiographically, pyometra is characterized by one or more tubular, fluid-filled, soft-tissue opaque structures occupying the caudal to mid-abdomen, representing markedly distended uterine horns (Fig. 6). The enlarged uterus usually exhibits a convoluted or looping configuration and may extend cranially depending on the degree of uterine distension. On lateral radiographs, enlargement of the uterine body is characteristically observed as a soft-tissue structure positioned between the urinary bladder and the colon (Fossum, 2013) ^[6]. Progressive uterine enlargement results in cranial and dorsal displacement of adjacent small intestinal loops and alteration of the normal abdominal organ position. In cases complicated by uterine rupture, generalized loss of abdominal serosal detail due to septic peritonitis and free peritoneal fluid may also be evident (Fossum, 2013) ^[6].

Pregnancy Diagnosis

Pregnancy diagnosis in dogs can be performed radiographically during the latter half of gestation after fetal skeletal mineralization has occurred. Although ultrasonography permits earlier pregnancy detection and assessment of fetal viability, radiography remains the preferred imaging modality for accurate fetal counting and estimation of parturition timing during late gestation (Haney *et al.*, 2003) ^[8]. Radiographic confirmation of pregnancy becomes possible after fetal skeletal mineralization, which begins at approximately 43 days of gestation in dogs and 38 days in cats, corresponding to approximately 20–22 days and 25–29 days before parturition, respectively (Haney *et al.*, 2003) ^[8]. As gestation advances, progressive mineralization makes the fetal skulls, vertebral columns, ribs and long bones increasingly distinct on radiographs (Fig. 7). Estimation of

litter size is most accurately achieved by counting individual fetal skulls, although overlapping fetuses or superimposition may occasionally reduce accuracy. During the final week of gestation (approximately 58–63 days), complete mineralization of the fetal dentition together with increased mineral density of the fetal skeleton indicates fetal maturity and impending parturition. As delivery approaches, fetal skulls may be visualized entering the maternal pelvic canal, providing additional evidence of imminent whelping. Radiography is also useful for identifying indirect signs of fetal death, including the presence of gas within fetal tissues or the uterine lumen. However, because radiographs cannot assess fetal cardiac activity or viability, abdominal ultrasonography remains the imaging modality of choice for early pregnancy diagnosis, fetal heart rate evaluation, assessment of fetal movement, and continuous monitoring of fetal well-being. Consequently, radiography and ultrasonography are complementary imaging techniques that together provide comprehensive evaluation throughout canine pregnancy (Haney *et al.*, 2003) ^[8].

Discussion

Survey abdominal radiography remains an essential first-line imaging modality in small animal practice despite the widespread availability of ultrasonography. As described by O'Brien (1978) ^[14], interpretation of abdominal radiographs relies on systematic assessment of organ size, shape, position, opacity, and number, enabling recognition of characteristic radiographic patterns that form the basis of differential diagnosis. The conditions reviewed in this article demonstrate the continuing diagnostic relevance of these principles across a wide spectrum of canine abdominal diseases.

Among acute abdominal emergencies, gastric dilatation–volvulus (GDV) remains one of the most time-critical conditions in which survey radiography plays a pivotal role. Recognition of the characteristic compartmentalized "double bubble" or "Popeye arm" appearance allows rapid differentiation of GDV from simple gastric dilatation and facilitates immediate surgical intervention, an important determinant of survival (Mackenzie *et al.*, 2010) ^[11]. Nevertheless, gastric displacement without clinical GDV has been reported (Freundin *et al.*, 1988) ^[7], emphasizing that radiographic findings should always be interpreted in conjunction with clinical examination.

For diffuse abdominal diseases such as peritoneal effusion, radiography serves primarily as a screening tool by demonstrating generalized loss of abdominal serosal detail and increased soft-tissue opacity. However, because radiographs cannot differentiate the nature of the accumulated fluid, further evaluation using ultrasonography and abdominocentesis is necessary for definitive diagnosis, consistent with the principles of peritoneal fluid dynamics described by Luttwak *et al.*, (1975) ^[10].

Evaluation of organomegaly, including enlargement of the liver, spleen, and kidneys illustrates another important application of abdominal radiography. Because organ size varies considerably with breed and body conformation, objective vertebral ratio-based measurements are more reliable than subjective assessment. Breed-specific hepatic size variations reported by Choi *et al.*, (2013) ^[4] support the anatomical observations of Nickel *et al.*, (1973) ^[13], while hepatic enlargement identified radiographically frequently requires further characterization to distinguish inflammatory, congestive, endocrine, and neoplastic disorders (Liptak *et al.*, 2004) ^[9]. In contrast, splenic torsion represents a true

pathological emergency characterized by marked splenic enlargement, abnormal anatomical position, and occasionally intraparenchymal gas formation (DeGroot *et al.*, 2016) [5], complementing the broader clinical approach to splenomegaly proposed by Neer, (1996) [12].

Radiographic evaluation of the urinary and reproductive systems similarly demonstrates both the strengths and limitations of survey imaging. Radiopaque cystoliths are readily identified and localized using positional radiography (Steyn and Lowry, 1991) [18], whereas radiolucent uroliths require contrast studies or ultrasonography for detection. The atypical mineralization associated with chronic cystitis reported by Zotti *et al.*, (2007) [21] and the limited radiographic findings in many lower urinary tract disorders described by Buffington *et al.*, (1997) [3] further emphasize the complementary role of advanced imaging and laboratory investigations. Likewise, although pyometra typically produces characteristic tubular soft-tissue opacities within the caudal abdomen, early disease may closely resemble fluid-filled intestinal loops, making ultrasonography the preferred modality for definitive diagnosis.

Survey radiography also provides valuable information in gastrointestinal and reproductive disorders. In megacolon, radiographs accurately demonstrate the severity of colonic dilation and fecal retention, while objective measurements described by Trevail *et al.*, (2011) [19] and the broader observations of Adams *et al.*, (2010) [1] improve diagnostic consistency. For pregnancy diagnosis, radiography remains the most accurate technique for fetal enumeration and estimation of parturition during late gestation after fetal skeletal mineralization, complementing the superior ability of ultrasonography to assess fetal viability and early pregnancy (Haney *et al.*, 2003) [8].

Collectively, the conditions reviewed highlight the enduring clinical value of survey abdominal radiography as a rapid, accessible and cost-effective diagnostic technique. Although radiography is highly effective for detecting organ enlargement, displacement, alterations in abdominal opacity, gastrointestinal obstruction, mineralized lesions, and fetal skeletal mineralization, its inability to evaluate tissue architecture, vascular perfusion, organ function, and small-volume lesions limits its diagnostic specificity. Consequently, abdominal radiography should be regarded as the initial imaging modality that guides subsequent diagnostic investigations, including ultrasonography, contrast radiography, computed tomography, magnetic resonance imaging and image-guided sampling when indicated. Used in conjunction with clinical examination and complementary imaging techniques, survey abdominal radiography continues to play a fundamental role in the diagnosis and management of canine abdominal disorders.

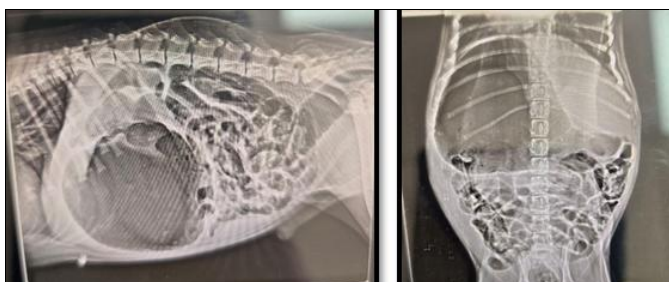


Fig 1: Right lateral and ventrodorsal abdominal radiographs showing marked gas-filled gastric distension with compartmentalization of the stomach, producing the characteristic “double bubble” “Popeye arm” appearance, consistent with gastric dilatation–volvulus (GDV).

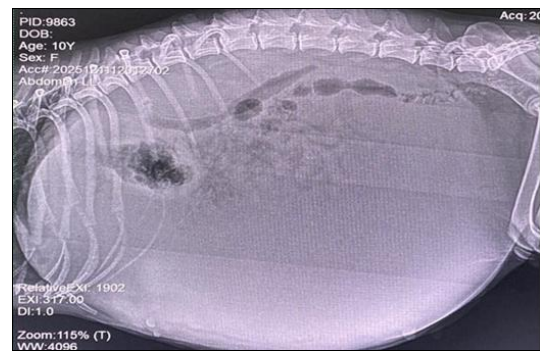


Fig 2: Left lateral abdominal radiograph of a dog showing marked peritoneal effusion characterized by generalized loss of abdominal serosal detail and increased soft-tissue opacity, producing a ground-glass appearance.



Fig 3: Left lateral abdominal radiograph of a dog showing a Multiple, radiopaque cystolith (urinary bladder calculus) within the urinary bladder lumen.

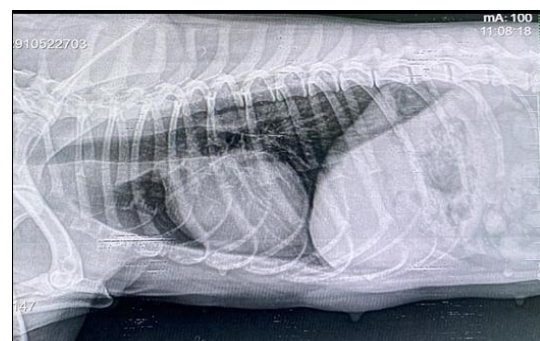


Fig 4: Lateral thoracic/cranial abdominal radiograph showing hepatomegaly, with an enlarged liver extending caudally beyond the costal arch and rounded hepatic margins

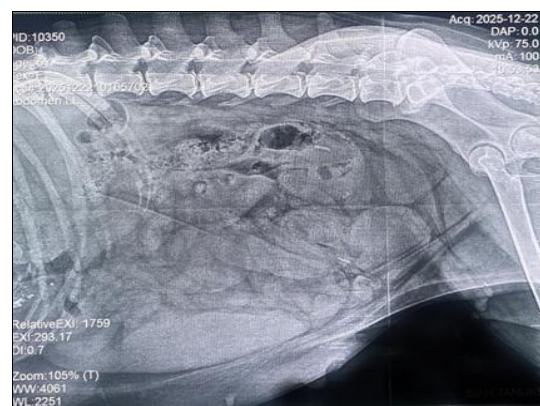


Fig 5: Lateral abdominal radiograph of a dog showing generalized splenomegaly, characterized by marked enlargement of the splenic silhouette with rounded and blunted splenic margins.

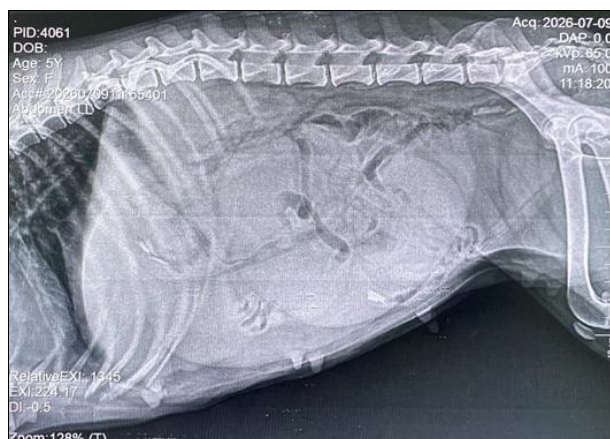


Fig 6: Lateral abdominal radiograph showing markedly enlarged, tubular soft-tissue opaque structures in the caudal and mid-abdomen, consistent with fluid-distended uterine horns and suggestive of pyometra

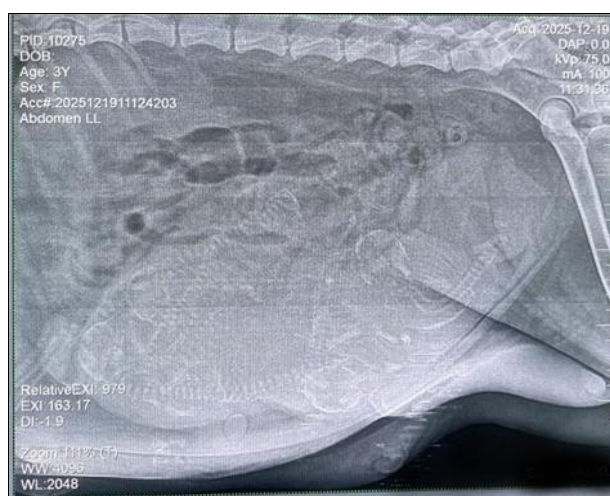


Fig 7: Lateral abdominal radiograph of a 3-year-old female dog showing multiple mineralized fetal skeletal structures within the gravid uterus, consistent with late-stage pregnancy.

Conflict of Interest

Not available

Financial Support

Not available

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