PAPER

CT findings in dogs with gastric malposition: 6 cases (2016-2019)

C. White[1,*], H. Dirrig* and E. Fitzgerald[†]

*Department of Clinical Sciences and Services, The Royal Veterinary College, Hawkshead Lane, North Mymms, Hertfordshire, AL9 7TA, UK
[†]North Downs Specialist Referrals, Horley, Surrey, UK

[1]Corresponding author email: crwhite@rvc.ac.uk

Objectives: To describe the computed tomographic (CT) findings of gastric malposition in a group of dogs with suspected chronic gastric instability.

Materials and Methods: A multicentre retrospective study of CT studies of dogs with abnormal gastric position in the absence of clinical signs referable to gastric dilatation and volvulus.

Results: Gastric malposition was identified in six dogs as either an incidental finding or in dogs with histories of chronic and intermittent gastroenteropathy. Gastric malposition was similar in all six cases; the pyloric canal was positioned in the left cranial abdomen in close proximity to the cardia and the pyloric antrum was found either to the left or ventral to the fundus.

Clinical Significance: Recognition of gastric malposition as an incidental or chronic finding may prevent unnecessary emergency intervention on patients presenting for unrelated conditions.

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INTRODUCTION

Chronic gastric instability is defined as a flaccidity of the stomach with resulting intermittent gastric malposition (Czajkowski & Hallman 2018). Dogs with chronic gastric instability can present with a protracted history of non-specific clinical signs including vomiting, lethargy, abdominal discomfort and weight loss (Funkquist & Garmer 1967, Paris *et al.* 2011). Large breed dogs predisposed to acute gastric dilatation and volvulus are also predisposed to chronic gastric instability (Frendin *et al.* 1988). Dogs with acute gastric dilatation and volvulus present with a sudden onset life-threatening condition (Tivers & Brockman 2009), whereas dogs with chronic gastric instability typically present with an insidious history of less severe and sometimes intermittent clinical signs (Funkquist & Garmer 1967, Funkquist 1969, Frendin *et al.* 1988). It has been postulated that the pathogenesis of both acute gastric dilatation and volvulus and chronic gastric instability are similar and that in some cases the former is a continuum of the latter (Funkquist & Garmer 1967, Funkquist 1969). Dogs with gastric dilatation and volvulus require emergency surgical management (Tivers & Brockman 2009), whereas dogs with chronic gastric instability typically do not (Paris *et al.* 2011).

There is a plethora of terminology used within the literature to describe the same or similar disease process as chronic gastric instability, these include partial gastric torsion, partial or chronic gastric dilatation and volvulus, chronic gastric volvulus, gastric malpositioning and gastric displacement without acute dilatation (Boothe & Ackerman 1976, Mathiesen 1983, Leib & Blass 1984, Leib *et al.* 1987, Frendin *et al.* 1988, Paris *et al.* 2011). In all these cases the patient presents with similar clinical signs, diagnostic imaging and surgical findings.

A case series has described the radiographic, ultrasonographic and endoscopic findings of seven dogs with chronic gastric instability (Paris *et al.* 2011). This series documented the dynamic component of this disease whereby the position of the stomach in several dogs changed between and during imaging modalities or between imaging and exploratory laparotomy.

The authors have noted gastric malposition in CT studies of several patients presenting for reasons not suggestive of acute gastric dilatation and volvulus. Following a search of the databases, Pubmed and Science Direct, for the keywords CT, gastric instability and gastric malposition on the 20/08/2020 only one case report was found that described the CT findings of chronic gastric instability in a Great Dane (Czajkowski & Hallman 2018). The purpose of this paper was to describe the CT findings in six dogs diagnosed with suspected chronic gastric instability and to identify consistent imaging features between these patients.

All authors adhere to all four criteria based on the ICMJE definition of authorship.

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MATERIALS AND METHODS

This study was a multicentre retrospective descriptive case series. The archives from the two referral institutions, between January 2016 and June 2019, were searched for patients with the following keywords; gastric malposition, partial torsion, chronic gastric volvulus or chronic gastric dilatation and volvulus. Inclusion criteria for participation in the study consisted of an available complete abdominal CT study of diagnostic quality, CT finding of a displaced pyloric antrum to the left of the fundus and absence of clinical signs referable to acute gastric dilatation and volvulus. Decision on inclusion study criteria and collection of the data were made by two board-certified veterinary radiologists and a first year resident in veterinary radiology.

Patients were sedated using anaesthetic protocols chosen by the attending clinician or anaesthetist. The studies were performed with one of the following CT scanners; Aquilion ONE™/GENESIS Edition 320-slice (Canon Medical Systems), Mx8000 IDT 16-slice (Philips, Best, The Netherlands) or Aquilion Lightning, 16-slice multidetector helical scanner (Canon Medical Systems).

Patients were scanned in sternal recumbency using variable acquisition parameters. Abdominal CT DICOM images were reviewed by the three authors using an imaging processing software (OsiriX Imaging Software, Pixmeo, Switzerland). Multiplanar reconstructions were utilised as needed. The identification of a malpositioned stomach and the ensuing CT description were recorded based on consensus opinion. Additional pertinent imaging findings, notably the position of the spleen, were also recorded. Patient clinicopathological details including history, clinical signs, other diagnostic tests, treatment and outcomes were also recorded.

RESULTS

Signalment, clinical presentations and initial non-diagnostic imaging finding

Six dogs fulfilled the inclusion criteria (Table 1). Breeds included two great Danes, one boxer, one St Bernard, one Newfoundland and one Flat-Coated retriever. Ages ranged between 3 and 10 years. There were three entire males, two neutered males and one entire female. Case 1 presented for a work-up of haemorrhagic pericardial effusion, chronic vomiting, weight loss and polyuria and polydipsia. Case 2 presented with a 24 hour history of vomiting, haemorrhagic diarrhoea, lethargy and inappetence. Case 3 presented for a 3-week history of vomiting, retching, hypersalivation and a 5-kg weight loss. Case 4 presented for chronic coughing and lethargy. Two months prior this patient had been diagnosed with a pulmonary mass in the left caudal lung lobe and a meningioma within the rostral cranial fossa, for which the patient was receiving radiation therapy at the time of presentation. Case 5 presented for management of a previously diagnosed malignant melanoma in the rostral mandible. Case 6 presented for syncope and hyperthermia following cluster seizures. Cases 2, 4 and 5 had long-term histories of gastroenteropathy and were on specially formulated diets. Abdominal CT was performed 2 months previously in case 5 for investigation of a 3-week history of haemorrhagic diarrhoea and vomiting. The CT, along with haematology, biochemistry, canine pancreatic lipase immunoreactivity test, adrenocorticotropic hormone stimulation test, cobalamin assay, faecal parasitology and urinary analysis were consistent with pancreatitis. A CT was also performed 1 year previously in case 6 for anaemia, however, no cause was found. In both these cases with previous CTs, the stomach

Table 1. Signalment, presenting clinical signs, final diagnosis and further work-up of gastric malposition in each of the six cases

Case	Breed	Age	Sex	Clinical signs	Final diagnosis	Further diagnostics or interventional procedures
1	Flat coated retriever	10 years	Female entire	Haemorrhagic pericardial effusion, polyuria, polydipsia, weight loss and 3 week history of vomiting.	Right atrial appendage haemangiosarcoma	Gastropexy. Stomach in normal position at time of surgery.
2	great Dane	4 years	Male entire	24 hours of vomiting, diarrhoea, lethargy and inappetence. Chronic history of intermittent gastroenteritis.	Gastroenteritis	Normal position of the stomach at time of follow-up ultrasound (48 hours)
3	great Dane	6 years	Male entire	3 week history of vomiting, retching, hypersalivating and a 5 kg loss of weight.	Megaoesophagus and aspiration pneumonia	None
4	boxer	8 years	Male neutered	Coughing and lethargy. Meningioma and pulmonary mass diagnosed 2 months prior. Chronic history of intermittent gastroenteritis.	Pulmonary carcinoma and cranial meningioma	Gastropexy. Stomach in normal position at time of surgery.
5	Newfoundland	3 years	Male neutered	Staging for rostral mandibular melanoma. Chronic history of intermittent gastroenteritis. Previous normally positioned stomach on CT.	Rostral mandibular melanoma	Normal position of the stomach at follow-up ultrasound (72 hours)
6	St Bernard	6 years	Male neutered	Syncope and hyperthermia following cluster seizures. Previous normally positioned stomach on CT.	Idiopathic epilepsy with secondary hyperthermia and suspected myocarditis	None

was correctly positioned. Following admission, patients underwent various diagnostic procedures to determine the cause of their clinical signs. These tests varied between dogs but included a minimum data set of haematology and serum biochemistry in all dogs.

CT findings

The major CT findings of the malpositioned stomach were similar in all six cases, notably with the pyloric canal and the pyloric antrum located in the left cranial abdomen (Fig 1). The pyloric antrum was dorsal and to the left of the fundus in five cases and ventral to the fundus in one case. In all cases there was a fold at the junction of the pyloric antrum and gastric body resulting in a more acute angle of the lesser curvature of the stomach and reduced distance between the pylorus and cardia. The pyloric canal was consistently ventral and to the left of the cardia.

The stomach was slightly to moderately distended with gas and ingesta. The proximal duodenum in all cases followed a similar course within the cranial abdomen. The duodenum exited the pylorus left of the midline, extending ventral to the fundus or cardia towards the right cranial quadrant. The duodenum was consistently mildly to moderately dilated with a fluid ingesta.

One dog had a moderately gas distended oesophagus (case 3). Although the dorsal aspect of the spleen was consistently found within the left abdomen, its position relative to the left kidney and stomach was abnormal in all cases. In four dogs the dorsal aspect of the spleen was abnormally positioned ventral to the left kidney with the ventral aspect either cranially traversing the left ventral peritoneal cavity to terminate caudal to the visceral surface of the liver (cases 1, 4 and 6) or caudally traversing the left ventral peritoneal cavity (case 5). In the other two dogs (case 2 and 3) the dorsal aspect was positioned ventral to the fundus and extended cranially along the left ventral aspect of the peritoneal cavity before forming a U shaped bend to the right, caudal to the visceral surface of the liver, and continuing caudally along the right ventral aspect of the abdomen (Fig 2).

In all cases the body and right lobe of the pancreas was located left of the midline and the gastroduodenal vein entered the portal vein from the left (Fig 3).

Additional pertinent findings included a right atrial appendage mass, pericardial effusion and a small volume of peritoneal fluid in case 1 and a cranial meningioma and pulmonary mass

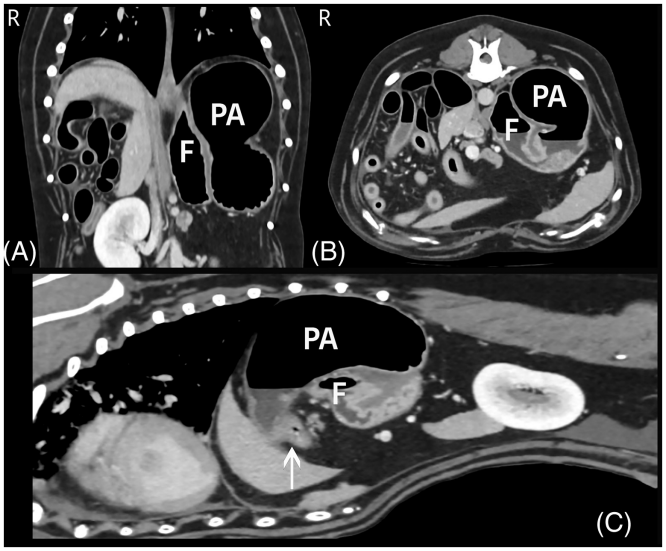

FIG 1. Postcontrast soft tissue dorsal (A), transverse (B) and sagittal (C) CT reconstructions (window width: 400; window level: 40) of the cranial abdomen in case 1. Malpositioned pyloric antrum (PA) in the left craniodorsal aspect of the abdomen, positioned dorsal and to the left of the fundus (F). The pylorus (arrow) is abnormally positioned within the left cranial abdomen. This malposition of the stomach was similar in all six cases. R indicates right side of the patient

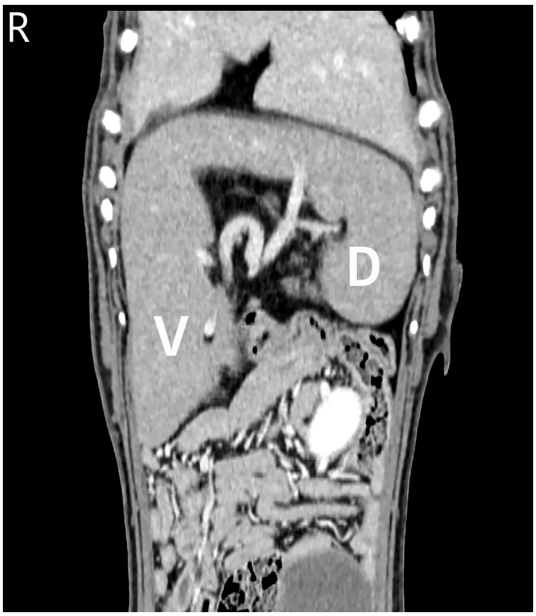

FIG 2. Postcontrast soft tissue dorsal CT reconstruction (window width: 400; window level: 40) of the abdomen in case 3. The dorsal aspect of the spleen (D) is on the left and traverses the abdomen cranially to the visceral surface of the liver. Caudal to the liver the spleen crosses the abdomen to the right before curving caudally. (Ventral aspect of the spleen (V)). R indicates right side of the patient

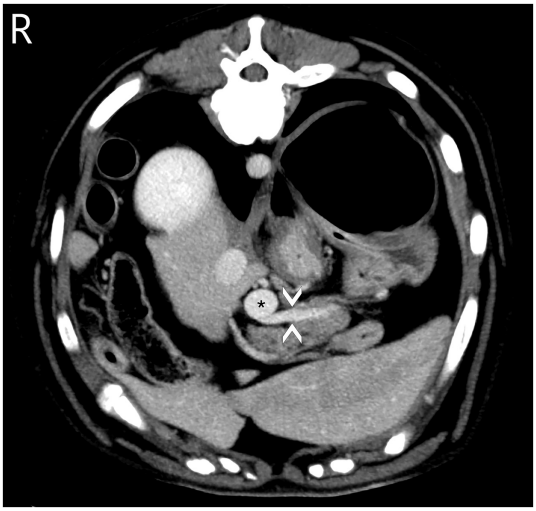

FIG 3. Postcontrast soft tissue transverse CT (window width: 400; window level: 40) of the cranial abdomen in case 4. The gastroduodenal vein (between the arrowheads) is identified abnormally entering the portal vein (asterisk) from the left. R indicates right side of the patient

in case 4. Case 3 with the moderately distended oesophagus had lesions within the right cranial, right middle and left caudal lung lobes compatible with aspiration pneumonia.

Radiographic findings

Standing horizontal beam thoracic radiography performed the following day after CT confirmed a true pathological megaoesophagus in case 3.

Abdominal radiography performed within 24 hours of the CT study in cases 1 and 4 revealed a craniodorsally positioned gas distended pyloric antrum with a soft tissue band separating the pylorus from the fundus (compartmentalisation) (Fig 4). The combination of gastric compartmentalisation and an abnormally positioned pyloric antrum was highly suggestive of gastric malposition but the degree of gas distension was not consistent with a typical case of gastric dilatation and volvulus. Consistent with the malposition seen in the CT, the spleen in case 1 had an abnormal reverse C appearance (Fig 4).

Outcome

An exploratory coeliotomy was performed within 24 hours of the CT study in two of the six cases. In case 4 the stomach was reported to be correctly positioned but the spleen was rotated. A preventative right incisional gastropexy was performed. Under the same anaesthetic the dog had a left caudal lung lobectomy performed. Histology confirmed the pulmonary mass to be a carcinoma. The dog continued to lose weight and was euthanased 4 months later as a result of an episode of acute onset respiratory distress and discovery of numerous pulmonary metastases. Case 1 underwent resection of the right atrial appendage and exploratory coeliotomy 24 hours after the CT study. The stomach and spleen were confirmed to be in the correct position and a preventative right incisional gastropexy was performed. The atrial mass was histologically confirmed to be haemangiosarcoma. The peritoneal fluid evident on the CT and radiographs was cytologically confirmed to be a transudate suspected to be secondary to cardiac tamponade. After discharge, this patient was lost to follow-up.

A focal gastric and splenic ultrasound was performed 48 hours after the CT study in case 2 which revealed a normal location, shape, size and echogenicity of the stomach and spleen; the clinical signs in this dog improved on conservative treatment alone.

Cortisol, TSH/T4 and acetylcholine receptor antibody serum titre levels were within normal limits for case 3 and conservative management was initiated for treatment of idiopathic megaoesophagus. At the 4-week follow-up the owner reported the dog continued to vomit intermittently. Thoracic radiographs taken at the time of revisit revealed on-going megaoesophagus. No procedure was carried out to treat the reported gastric malposition.

The final two cases were treated for their initial presenting complaints. Case 5 had a rostral mandibulectomy for a melanoma and case 6 was treated medically for arrhythmia and seizures. It was suspected that the arrhythmia in case 6 was secondary to myocarditis caused by the seizure-induced hyperthermia. A focal ultrasound of the stomach performed 72 hours after the CT in case 5 revealed a correctly positioned pylorus and fundus within the right and left cranial abdomen, respectively. Both cases were discharged without complication and no procedure was carried out to treat the reported gastric malposition.

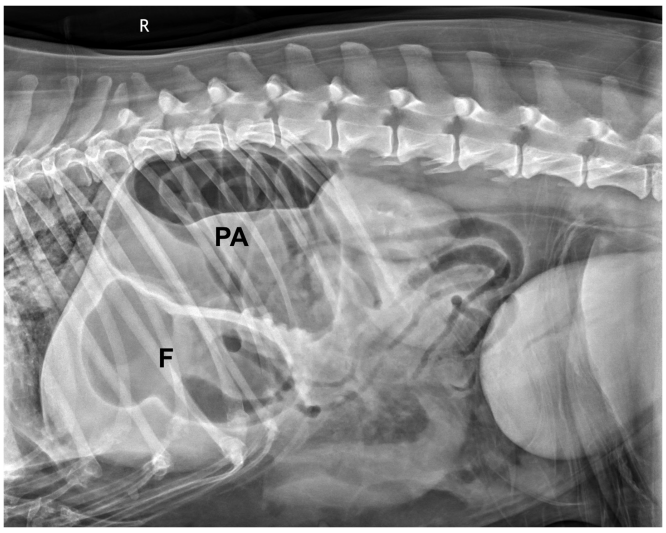

FIG 4. Post CT right lateral abdominal radiograph from case 1. The pyloric antrum (PA) is dorsal to the fundus (F). A soft tissue band separates the fundus from the pyloric antrum (compartmentalisation). The spleen has a reverse C shape consistent with malposition. There is a reduction in serosal detail and soft tissue streaking throughout the peritoneal cavity consistent with peritoneal fluid. Iodinated contrast material is visible within the urinary tract

DISCUSSION

This case series describes the CT findings of gastric malposition identified in six dogs incidentally or with clinical signs consistent with chronic gastric instability. The abnormally positioned stomach was similar in all six cases; the pyloric canal was positioned in the left cranial abdomen in close proximity to the cardia and the pyloric antrum was found to the left or ventral to the fundus. The duodenum consistently exited the pylorus on the left of the midline and the pancreas along with the gastroduodenal vein were also identified left of midline.

Previously published literature describing the radiographic findings of chronic gastric instability has reported a chronic history of non-specific clinical signs, including weight loss, vomiting and inappetence (Boothe & Ackerman 1976, Leib & Blass 1984, Frendin *et al.* 1988, Paris *et al.* 2011). Similarly, five of the six dogs in this case series presented histories of chronic (3 weeks or more) or intermittent gastrointestinal signs. All dogs in this study demonstrated a dynamic component in which the position of the stomach changed between the different imaging studies or between imaging and exploratory coeliotomy. Two of the dogs (cases 1 and 4) had coeliotomies performed within 24 hours of the CT, revealing normal gastric position. Two dogs (case 2 and 5) underwent an abdominal ultrasound 48-72 hours post CT that revealed a normal position of the stomach. The spleen was also noted to be correctly shaped and positioned in case 2 during the ultrasound examination, but the spleen in case 5 was not assessed. Prior to the CT studies demonstrating gastric malposi-

tion, CT studies had also been performed 2 months previously in case 5 and 1 year previously in case 6. On these previous CTs the pylori were positioned on the midline and the gastric body, fundus and spleen were correctly positioned. These findings are similar to that described by Frendin *et al*. 1988 where an "upside down" radiographic appearance of the gastric axis was seen in three dogs that were later discovered during coeliotomy to have a correctly positioned stomach. Dynamic gastric position has more recently been described in a case series of seven dogs with chronic gastric instability that underwent radiographic, ultrasonographic and endoscopic investigations (Paris *et al*. 2011). Similar to what has been described previously, the six cases of suspected gastric instability in this study appear to be dynamic, in which the stomach intermittently assumes an abnormal position. This may explain the intermittent and chronic clinical signs.

Case 6 had no previous or current signs of gastrointestinal disease and although cases 4 and 5 had histories of intermittent gastroenteritis, similar to previous reports of chronic gastric instability, they were not symptomatic for this at the time of presentation. These cases highlight the important point that gastric malposition may be detected as an incidental finding on CT in patients presenting for non-related conditions, and, although gastropexy may benefit these patients, the identification of gastric malposition does not necessarily warrant immediate surgical intervention. Awareness that a malpositioned stomach on CT may be an incidental finding in some patients may also prevent deflection from the more current issue of the patient.

The displacement of the stomach in all six cases was similar; when viewed from a caudal to cranial direction, the pyloric antrum rotated approximately 90-180° ventral to the fundus in a clockwise direction with a final position between the fundus and the left abdominal wall (5/6) or ventral to the fundus (1/6). When viewed from a cranial to caudal direction, as is the convention on transverse plane CT images (Fig 1), this is seen as a 90-180° anticlockwise rotation. The fundus was medially displaced in all cases. During a gastric dilatation and volvulus episode the stomach is rotated through 180 to 360° (Tivers & Brockman 2009), therefore, a rotation of 90-180°, as seen in the dogs in this study, may represent a partial torsion. Partial gastric torsions were first described in Boothe & Ackerman 1976. The torsions described in the dogs in this paper are similar to those of the dogs in this case series, with the pylorus positioned ventral to the cardia in the left abdomen and the rotation approximately 90-130° in the same direction.

Previous authors have theorised gastric instability may be a predisposing factor for gastric dilatation and volvulus (Funkquist & Garmer 1967). Supporting this theory, the five breeds in this case series were typical of those commonly presenting with gastric dilatation and volvulus. Both intrinsic and extrinsic factors (*e.g*. diet and postprandial exercise) have a proven role to play in the pathogenesis of gastric dilatation and volvulus (Brockman *et al*. 1995). Body conformation, notably large breeds dogs and those with large thoracic height-to-width ratios, is acknowledged as an important predisposing intrinsic factor (Schellenberg *et al*. 1998). Therefore, an association between conformation in these breeds and the degree of mobility of the stomach is possible. This instability may manifest as dynamic malposition of the pyloric canal and pyloric antrum as seen in this group of dogs, which may then lead to complete torsion as seen in cases of gastric dilatation and volvulus. It is unknown if chronic gastric instability is a separate entity or the prodromal stage of gastric dilatation and volvulus (Funkquist & Garmer 1967, Funkquist 1969). Prospective studies assessing the prevalence of gastric dilatation and volvulus in a cohort of dogs with chronic gastric malposition findings may prove useful. Should an association be found, there may be benefit in performing prophylactic gastropexy in these patients with chronic gastric instability to reduce the possible progression to gastric dilatation and volvulus.

An additional finding in these cases was an abnormally positioned spleen. In four dogs in this study the dorsal aspect was found in an abnormal caudoventral position ventral to the kidney. In the other two cases the dorsal aspect was found in a ventral position ventral to the fundus with the ventral aspect forming a cranial bend caudal to the liver. In the normal anatomy, the dorsal aspect of the spleen is closely associated with the greater curvature of the stomach due to the gastrosplenic ligament. This results in the dorsal aspect having a relatively fixed position between the fundus and the cranial pole of the left kidney (Evans & Lahunta 2013). As the stomach rotates during gastric dilatation and volvulus, the fundus along with the spleen are displaced to the right. The splenic displacement seen in these six cases may be the result of the malpositioned stomach and a possible feature of chronic gastric instability. Gastrosplenic ligament laxity is another possible cause of splenic displacement and there is a proposed theory that repeated episodes of gastric dilatation, or partial gastric dilatation and volvulus, may stretch the gastrosplenic and splenocolic ligaments sufficiently to allow splenic hypermobility (Goldmid *et al*. 1994). Splenic displacement is also seen with splenic torsion and interestingly the radiographs of case 1 demonstrated a reverse C shape to the spleen which is a feature described in cases of splenic torsion (Stickle 1989). However, it is unlikely the patient in case 1 had a splenic torsion at the time the radiographs were acquired, as the CT performed immediately before the radiographs show only displacement and no torsion. The reverse C shape in this case is likely the result of a displaced spleen which is consistent with the CT findings.

Based on the literature search there is no report of chronic gastric malposition or gastric dilatation and volvulus being associated with an abnormal left-positioned gastroduodenal vein. The gastroduodenal tributaries drain the duodenum, pancreas and right aspect of the stomach and are therefore anatomically closely associated with these structures. The authors propose that the left position of the gastroduodenal vein is due to axial rotation of the portal vein following displacement of the pyloric antrum, right pancreas and the duodenum rather than a congenital malformation.

There are several limitations to this study including the retrospective study design which resulted in variability in the level of detail provided in the clinical history and in the diagnostic investigations performed for each case. A second limitation is the small sample size; having only six cases precludes the possibility of preforming statistical assessment and therefore the identification of factors that may predispose to this condition. Although

certain trends have been identified in this series, a larger sample size is necessary to see if these findings could be extrapolated to the general population.

In conclusion gastric malposition was identified in six dogs with either a history of chronic or intermittent gastroenteropathy or as an incidental finding. The CT findings in all cases were similar, with the pylorus identified in the left cranial abdomen and the dorsal aspect of the spleen occupying an atypical ventral position. Recognition of gastric malposition as an incidental or chronic pathological finding may prevent unnecessary emergency intervention on patients presenting for an unrelated condition.

Conflict of interest

No conflicts of interest have been declared.

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