Research in Veterinary Science 136 (2021) 408–415

Contents lists available at ScienceDirect

Research in Veterinary Science

journal homepage: www.elsevier.com/locate/rvsc

Endoscopic assessment of presumed acquired pyloric narrowing in cats: A retrospective study of 27 cases

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ARTICLE INFO

Keywords:
Pyloric stenosis
Pylorus
Inflammatory bowel disease
Gastritis
Endoscopy
Feline

ABSTRACT

Acquired pyloric narrowing is a rare and poorly-documented condition in cats, but the endoscopic appearance of pyloric narrowing has never previously been reported. The objectives of this study were to describe the clinical, endoscopic and histological features in cats with gastrointestinal signs where the pylorus could not be passed during endoscopy, and to compare these data with a control group.

Medical files of cats that underwent upper GI endoscopy by the same operator between 2006 and 2015 were reviewed. Cats for which the pylorus could not be passed were assigned to the case group, whilst those with an easily-passable pylorus were assigned to the control group.

The case group comprised 27 cats and control group comprised 35 cats. Median age and weight were not different between groups, but there were more Siamese cats in the case group (6/27) compared with the control group (1/35; $P = 0.04$). Chronic vomiting was the main clinical sign in both groups, but the vomitus was more likely to contain food in case group (23/25) than in cats in control group (17/30; $P < 0.01$). Endoscopic findings confirmed gastric inflammation in both groups, whilst histological findings revealed similar lymphoplasmacytic infiltration of the gastric mucosa and the duodenum in most cases, neoplastic features being infrequent.

Acquired pyloric narrowing is probably an underdiagnosed condition in adult cats. A possible association between pyloric narrowing and gastrointestinal inflammatory disease requires further study but, for now, it is recommended that multiple gastric, pyloric, and duodenal biopsies be acquired during the endoscopy.

1. Introduction

Pyloric stenosis is thought to be a rare condition in cats, with only a few congenital cases described in kittens from either domestic shorthair cats or Siamese breeds (Pearson et al., 1974; Syrcle et al., 2013; Twaddle, 1971, 1970). The reported clinical signs are compatible with gastric retention syndrome (*i.e.*, delayed food vomiting after meals), with either radiography or ultrasonography confirming either a full stomach several hours after eating or prolonged retention of radiographic contrast after administration (Pearson et al., 1974; Syrcle et al., 2013). Confirmation of the diagnosis is usually made at coeliotomy, and endoscopy has only been used as a diagnostic tool in one case report (Syrcle et al., 2013; Twaddle, 1971, 1970). Delayed gastric emptying results from several conditions such as gastric obstruction with foreign body or neoplasia, gastric dysmotility, inflammatory or metabolic disease and pyloric stenosis (Washabau and Day, 2013). Endoscopic assessment is required if metabolic disease and focal inflammation (*e.g.* pancreatitis, peritonitis) have been excluded, in order to assess both gastric and duodenal content and mucosa, allowing directed sampling for histopathologic analysis.

To the author's knowledge, acquired pyloric stenosis has never been described in cats. Moreover, although the dimensions of the healthy feline pylorus have been studied ultrasonographically, they have been described in only one study (Couturier et al., 2012). Ultrasonography

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https://doi.org/10.1016/j.rvsc.2021.03.016
Received 17 September 2020; Received in revised form 14 March 2021; Accepted 16 March 2021
Available online 20 March 2021

can be useful to detect muscular hypertrophy, or extraluminal obstruction, however it allows only external and transmural assessment of the pylorus morphology, precluding evaluation of internal diameter and gastric and pyloro-duodenal mucosa. The pyloric sphincter should be readily intubated with an 8.8 mm external diameter video endoscope by an experienced endoscopist (Tams and Rawlings, 2011; Washabau and Day, 2013); therefore, the inability to intubate the pylorus despite several attempts in normal conditions increases suspicion for acquired pyloric narrowing, providing indirect evidence of pyloric stenosis. However, to the authors' knowledge this approach has never been validated in the veterinary literature. Furthermore, endoscopy enables direct examination of both gastric and pyloro-duodenal mucosa and luminal contents in order to identify conditions which might be responsible for delayed gastric emptying, such as chronic foreign bodies, pyloric polyps and pyloric neoplasia (Washabau and Day, 2013).

The aim of this retrospective study was to compare the clinical, imaging, endoscopic and histologic characteristics of two groups of cats with gastrointestinal signs: a group with presumed acquired pyloric narrowing defined by the inability to intubate the pylorus endoscopically, and a control group characterised by the ability to pass an endoscope through the pylorus.

2. Materials and methods

2.1. Case selection and inclusion criteria

This was a retrospective, cross-sectional, cohort study involving cats seen at two referral centres (site 1: Centre Hospitalier Universitaire Vétérinaire d'Alfort, Ecole Nationale Vétérinaire d'Alfort, France; site 2: Clinique Vétérinaire Alliance, Bordeaux, France). To identify eligible cases, the patient medical record files of cats referred to site 1 and site 2 between 2006 and 2015 were retrospectively reviewed. Eligibility criteria included: (1) cats referred to the gastroenterology service at each institution and undergoing gastro-duodenoscopy between 2006 and 2015 in order to investigate chronic gastrointestinal signs (*e.g.*, vomiting, diarrhoea, decreased appetite, weight loss); (2) clinical records available including endoscopic and histologic reports; (3) endoscopy performed by the same experienced endoscopist (VF); and (4) the medical records clearly indicated whether the pylorus could be intubated during endoscopy. Control cases were chosen equally over the whole study period to ensure that group differences did not exist as a result of any improvement of the endoscopist's skill to intubate the pylorus. Cases were excluded if no abdominal ultrasonography was performed or the record not available. All diagnostic investigations were performed for the direct clinical benefit of the case, and owners gave informed written consent.

2.2. Case definition and study groups

Cats were assigned to the presumed acquired pyloric narrowing group when the pylorus could not be intubated successfully despite multiple attempts (*e.g.*, pyloric intubation was classified as "severe" (3) or "moderate" (2) according to the World Small Animal Veterinary Association [WSAVA] criteria during endoscopic evaluation). Cases were eligible for inclusion in the control group when the pylorus was easily intubated during endoscopy (*e.g.*, pyloric intubation classified as "normal" (0) or "mild" (1) according to the WSAVA criteria). Controls were ultimately included according to the same inclusion criteria over the same period to ensure that the size of both groups was approximately equal.

2.3. Clinical signs, laboratory, and imaging data

Information was recorded on signalment, dietary and medication history, clinical signs, and physical examination findings (*e.g.*, body weight, temperature, thoracic auscultation findings and abdominal palpation). Details of clinicopathological investigations were recorded when present; a serum biochemistry profile was usually performed as part of the screening test and previous the anaesthesia. Similarly, findings from abdominal ultrasonography were recorded, cases without an ultrasound report available were excluded.

2.4. Endoscopy

Prior to endoscopy, cats were fasted for at least 16 h, and no premedication was used before anaesthesia. General anaesthesia was induced with either propofol (Propovet Multidose, Zoetis) at 4–6 mg/kg IV or thiopental (Nesdonal, Merial) at 20–22 mg/kg, and anaesthesia was maintained using 2% isoflurane (Vetflurane, Virbac) with oxygen, after tracheal intubation. Endoscopy was performed using a GIF 160 pediatric video gastroscope (Olympus), with an external diameter of 8.8 mm. Cats were positioned in left lateral recumbency as previously recommended (Tams and Rawlings, 2011; Washabau and Day, 2013), with a mouth gag placed immediately before intubation and left in place for as short a time as possible to minimise the risk of amaurosis (Martin-Flores et al., 2014).

The duration of most procedures was about 20 min. The insertion tube was first advanced into the oesophagus, through the mouth, and then advanced into the stomach through the cardia. The stomach was partially insufflated (*i.e.*, the minimum amount of insufflation possible to identify the position of the antrum and pylorus) to enable the endoscope to be advanced towards the pylorus. A macroscopic evaluation of the antrum and the pylorus was then performed before pyloric intubation was attempted, by advancing the tip of the endoscope to the pylorus and applying gentle pressure. Four-to-six attempts were made (pressure applied to the pylorus gradually increased) to pass the pyloro-duodenal junction. For cases where the pylorus was not successfully passed, no further attempts were made in order to prevent any proximal duodenal damage.

If the pylorus was passable, the proximal duodenum was macroscopically observed, gross changes were scored and biopsy samples were collected. Thereafter, the endoscope was withdrawn until the tip was back in the stomach, and other parts of the stomach were then examined, their appearance scored, and biopsies collected. The diameter of the pyloric sphincter was compared to the open biopsy forceps diameter (6 mm) to estimate the internal pyloric diameter in some cases, as previously described (Syrcle et al., 2013). At the end of the procedure, a standardised endoscopic report was completed, which included grading of various macroscopic findings (Washabau et al., 2010).

2.5. Histopathological analysis

During endoscopy, multiple biopsies were collected from the region of the pylorus, antrum, body, fundus and duodenum, with reusable biopsy forceps with oval fenestrated jaws (PE202300, Optomed). In cases where the pylorus could not be intubated, duodenal biopsies were collected blind by pyloric catheterisation as previously described (Willard et al., 2008). Biopsies were placed in 10% neutral-buffered formalin (pH 7.4) in preparation for histopathological analysis; those collected from cats seen at site 1 were submitted to the Biopôle (Maisons-Alfort, France) whilst those collected from cats seen at site 2 were submitted to the LAPVSO (Laboratoire d'Anatomie Pathologique Vétérinaire du Sud-Ouest, 31201 Toulouse, France). All samples from the stomach were processed together, rather than assessing separate regions individually. Samples were processed by routine methods for histological examination, and sections were stained with haematoxylin and eosin before being interpreted by one EBVS® European Specialist in Veterinary Pathology, according to the WSAVA recommendations (Washabau et al., 2010).

2.6. Therapy and outcome

When available, information about treatment (drug, time and dosage) clinical improvement and follow-up were gathered. If the cat died, the date and cause of the death were recorded.

2.7. Statistical analysis

All data were entered into a spreadsheet, and statistical software (BiostatGV, https://marne.u707.jussieu.fr/biostatgv) was used to assist with data analysis. Quantitative variables (*e.g.*, age and weight) were described using median and range, and Mann-Whitney *U* tests were used to compare age and weight between groups. Qualitative variables were described using percentages and compared between groups using either χ^2 tests, or Fisher's exact tests when sample size was small (*e.g.*, when the expected values in any cell within a contingency table was <5). Statistical significance was assumed when $P < 0.05$ for two-sided analyses.

3. Results

3.1. Study population and signalment

During the study period, 27 cats met the eligibility criteria, whilst 35 cats were assigned to the control group. Signalment and clinical signs are summarised in Table 1. Most of the cats were domestic shorthair (cases: 18/27, 66%; controls: 26/35, 74%), with a range of other breeds represented (Table 1). Siamese cats were over-represented in the case group (6/27 *vs.* 1/35, $P = 0.04$). There were 12 males and 15 females, respectively, in the case group and 21 and 14 males and females, respectively, in the control group, with no significant difference between groups ($P = 0.22$). All cats were neutered except for one cat in each group. The median age of cases and controls was 8.0 years [range 2.0–14.5 years] and 9.0 years [range 0.7–18.0 years], respectively, with no significant difference between groups ($P = 0.47$). The median weight of cases and controls was 4.0 kg [range 2.3–6.0 kg] and 4.5 kg [range 2.4–7.1 kg], respectively, with no significant difference between groups ($P = 0.25$).

Table 1
Signalment and clinical findings in cats with pyloric narrowing (cases; n = 27) and cats with gastrointestinal signs without pyloric narrowing (controls; n = 35).[1]

	Cases	Controls	P-value
Age (years)	8 (2.0–14.5)	9 (0.7–18)	0.473
Type of food			0.199
Dry food	12/17 (70%)	9/24 (38%)	
Wet food	2/17 (12%)	5/24 (20%)	
Mix	3/17 (18%)	9/24 (38%)	
Home-made	0/17 (0%)	1/24 (4%)	
Breed			0.037[1]
Domestic Shorthair	18/27 (66%)	26/35 (74%)	
Birman	1/27 (4%)	4/35 (11%)	
Siamese	6/27 (22%)	1/35(3%)	
Maine Coon	0/27 (0%)	1/35 (3%)	
Angora	0/27 (0%)	1/35 (3%)	
British Shorthair	0/27 (0%)	1/35 (3%)	
Persian	0/27 (0%)	1/35 (3%)	
Abyssinian	1/27 (4%)	0/35 (0%)	
Rex Devon	1/27 (4%)	0/35 (0%)	
Weight (kg)	4.0 (2.3–6.0)	4.5 (2.4–7.1)	0.253
Sex			0.22
Female	15/27 (55%)	14/35 (40%)	
Male	12/27 (45%)	21/35 (60%)	
Neuter status	26/27 (96%)	34/35 (97%)	1.000
Duration of signs (m)	4 (0.1–42)	5.5 (0.1–60)	0.496
Chronic (>3 weeks)	18/22 (82%)	28/34 (82%)	1.000
Content of vomiting			0.005
Food	23/25 (92%)	17/30 (57%)	
Liquid	2/25 (8%)	13/30 (43%)	
Frequency of vomiting			<0.001
No vomiting	0/21 (0%)	3/28 (11%)	
1-3/month	0/21 (0%)	8/28 (29%)	
1–3/week	9/21 (43%)	13/28 (46%)	
Daily	12/21 (57%)	4/28 (14%)	
Time of vomiting after meal			0.487
No clear pattern	4/16 (25%)	5/17 (29%)	
Always within 30 min	7/16 (44%)	4/17 (24%)	
Between 30 min and 4 h	2/16 (12%)	2/17 (12%)	
Always longer than 4 h	3/16 (19%)	6/17 (35%)	
Dysorexia	4/27 (15%)	11/35 (31%)	0.149
Diarrhoea	6/27 (22%)	10/35 (29%)	0.232
Weight loss	10/27 (37%)	16/35 (46%)	0.606

[1] P-value corresponds to comparison between the proportion of Siamese cats between groups (Fischer's test).

3.2. Clinical signs, laboratory and imaging data

Chronic vomiting was the most frequent clinical sign in both groups (cases: 18/22, 82%; controls: 28/34, 82%), with no significant difference between groups ($P = 1$). Median duration of chronic clinical signs was calculated (among precisely quantified data available) and was not different between groups (cases: median 4 months [0.1–42 months]; controls: median 15.5 months [0.1–60 months]; $P = 0.49$). Time of vomiting was recorded when available and was variable among cats; vomiting could occur a few minutes to a few hours from meals. However, vomiting food was more common in cases (23/25, 92%) compared with controls (17/30, 57%; $P < 0.01$). Other clinical signs included diarrhoea (cases: 6/27, 22%; controls: 10/35, 29%, $P = 0.23$), decreased appetite (cases: 4/27, 15%; controls: 11/35, 31%, $P = 0.15$) and weight loss (cases: 10/27, 37%; controls: 16/35, 46%, $P = 0.61$). Serum biochemistry and haematology results are presented in Table 2 and Table 3, respectively. None of the results for any cat were consistent with a systemic (*i.e.*, non-gastrointestinal) origin for the clinical signs, and there were no significant differences between groups.

3.3. Ultrasonographic examination

Abdominal ultrasound findings are presented In Table 4 and Fig. 1. Despite food withdrawal for 16 h, gastric contents were evident in 4 cats in each group ($P = 0.72$). Pyloric muscular layer thickening was present in only 2 cats in case group and in 4 cats in control group ($P = 0.69$), whilst muscular-layer thickening was also evident in other regions in 8 cats in case group and 13 cats in control group ($P = 0.60$). Other ultrasonographic abnormalities included signs of chronic nephropathy (cases: 4/27, 15%; controls: 7/35, 20%; $P = 0.74$), hepatomegaly or

Table 2
Biochemical findings in cats with pyloric narrowing (cases; n = 27) and cats with gastrointestinal signs without pyloric narrowing (controls; n = 35) – median [range].

	Case group	Control group	P-value
Urea (mmoL/L)	8.49 [5.16–36.6] N = 23	8.4 [5.99–14.8] N = 26	0.756
Creatinin (μmoL/L)	124 [70.4–220] N = 23	14.3 [70.7–194] N = 27	0.969
Total Plasmatic Protein (g/L)	70 [53–90] N = 21	70.1 [54–88] N = 21	0.734
Albumin (g/L)	29.5 [24–35] N = 20	29 [24–40] N = 19	0.297
ALP (UI/L)	55 [20–119] N = 22	58.5 [14–214] N = 24	0.538
ALAT (UI/L)	52.5 [9–162] N = 22	45 [27–248] N = 25	0.856
Glucose (mmoL/L)	7.05 [5.1–12.5] N = 22	6.61 [2.94–14.4] N = 23	0.162
fPli (μg/L)	135 [1.1–2.9] N = 6	2.1 [0.6–8.5] N = 11	0.417
T4 (nmoL/L)	28.4 [16–37] N = 11	32 [12–49.8] N = 17	0.588

Table 3
Hematological findings in cats with pyloric narrowing (cases; n = 27) and cats with gastrointestinal signs without pyloric narrowing (controls; n = 35) – median [range].

	Case group	Control group	P-value
Ht (L/L)	0.360 [0.206–0.455] n = 15	0.352 [0.218–0.460] n = 20	0.701
Hb (g/L)	126 [74–143] n = 14	117 [88–143] n = 18	0.676
Leucocyte count (10^9/L)	10.3 [4.48–15.4] n = 14	9.12 [4.79–33.3] n = 18	0.587
Neutrophils (10^9/L)	6.69 [2.03–11.9] n = 14	6.01 [1.19–25.9] n = 17	0.921
Eosinophils (10^9/L)	0.520 [0.150–1.42] n = 14	0.495 [0.160–3.26] n = 18	0.790
Monocytes (10^9/L)	0.300 [0.100–1.114] n = 14	0.555 [0.060–4.97] n = 18	0.057
Lymphocytes (10^9/L)	2.12 [0.570–3.34] n = 14	1.87 [0.420–4.54] n = 17	0.921
Platelet count (10^9/L)	249.5 [52–383] n = 14	294 [29–885] n = 18	0.342

change in liver echogenicity (cases: 7/27, 26%; controls: 10/35, 29%; $P = 1.0$), pancreas abnormality (cases: 1/27, 4%; controls: 5/35, 14%; $P = 0.22$) or digestive (mesenteric, ileo-colic, gastric or hepatic) mild adenomegaly (cases: 8/27, 30%; controls: 10/35, 29%; $P = 1.00$).

3.4. Endoscopy

Details of the gross endoscopic inspection of the stomach are provided in Table 5. Macroscopic findings included oedema, hyperaemia, erosions, discolouration of the gastric mucosa, and were present in both cases and controls, with no significant difference between groups (Table 5). Such changes were present in any gastric region including fundus, corpus, antrum, cardia and lesser curvature but not specifically at the pylorus level. Findings consistent with inflammation were common and not statistically different between groups ($P > 0.05$ for all). Other endoscopic lesions identified included gastric foreign body (cases: 1/34, 3%; controls: 1/37, 3%; $P = 1.0$), abnormal gastric content (cases: 1/27, 4%; controls: 1/35, 3%; $P = 1.0$) and gastric mass or polyp (cases; 1/27, 4%; controls 4/35, 11%; $P = 0.37$) localised in the body or antrum and not obstructing the pylorus. An additional mucosal fold was reported in 5/27 (19%) cats in case group, beside the pylorus. Besides the lesions described and the presence of a narrowed pyloric aperture (pyloric intubation graded 2 to 3 in all cases), no other endoscopic findings were noted. Examples of endoscopic appearance of narrowed pylorus are illustrated in Fig. 2.

3.5. Histopathological analysis

A summary of the histological findings in both cases and controls is given in Table 6. The most common finding reported in the gastric mucosa was lymphoplasmacytic infiltration graded from mild (score 1) to severe (score 3) according to WSAVA guidelines, but there was no difference in the presence of such an infiltration between cases (18/27, 67%) and controls (21/35, 60%; $P = 0.96$). More specifically, there was no significant difference in the number of cats presenting mild, moderate or severe lymphoplasmacytic infiltration between groups. Other histopathological findings included eosinophilic infiltration of the gastric mucosa (cases: 2/27, 7%; controls: 1/35, 3%; $P = 0.58$), fibrosis (cases: 11/27, 41%; controls: 10/35, 29%; $P = 0.42$), mucosal hypertrophy (cases: 3/27, 11%; controls: 5/35, 14%; $P = 1.00$), glandular atrophy (cases: 2/27, 7%; controls: 3/35, 9%; $P = 1.00$), the presence of spiral-shaped bacteria resembling *Helicobacter* species (cases: 3/27, 11%; controls: 9/35, 26%; $P = 0.20$). Records of duodenal histology were available from 19/27 cats in the case group and from 30/35 cats in the control group. In the duodenum, there was lymphoplasmacytic infiltrate of the duodenal mucosa in 15/19 cases (79%) cases and 23/30 controls (77%; $P = 0.69$). Gastric or duodenal neoplasia was also identified in 2/27 (7%) and 8/35 (23%; $P = 0.16$) of cases and controls, respectively, with the histopathological diagnosis being lymphoma in all cases (either gastric high-grade lymphoma localised in the fundic area or small-cell duodenal lymphoma).

Overall, final diagnosis in the case group was inflammatory bowel disease (IBD) in 23/27 cases (85%), neoplasia in 2/27 cases (7%), food hypersensitivity in one case (4%) and trichobezoar in one case (4%). Final diagnosis in the control group was IBD in 21/35 cases (60%), acute gastritis in two cases (5%), adenomatous polyps in one case (3%), diffuse adenomatous lesions in one case (3%), lymphoma in 7 cases (20%), megaoesophagus in one case (3%), ulcerative gastritis in one case (3%), and trichobezoar in one case (3%).

3.6. Therapy and outcome

Most of the cats were treated medically with small doses of prednisolone (0.2–0.3 mg/kg/day) and were exclusively fed one of two highly digestible wet foods (either Gastrointestinal Diet or Hypoallergenic Diet, Royal Canin) over 3 to 5 meals. Balloon dilation was necessary in one refractory case with inflammatory enteropathy, using a pediatric pyloric balloon (Olympus Swift BP-2 Pyloric Balloon Dilator WA95093A 10x30mm, Olympus Winter & Ibe GmbH) inserted in the pyloric lumen, and repeated several times. Another cat with IBD required pyloroplasty. The clinical signs improved in all cats with medical therapy (and the balloon dilation for one cat), with decreased frequency of vomiting. Cats with small-cell lymphoma were treated with

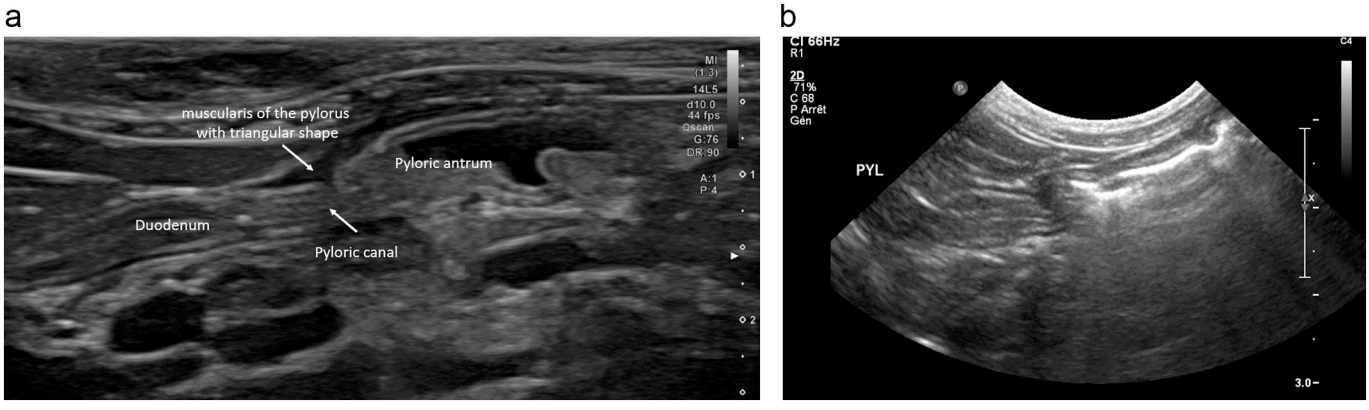

Fig. 1. Ultrasonographic appearance of a normal feline pylorus (a) and the similar appearance of the pylorus in a cat identified with pyloric narrowing (b), showing the absence of muscularis layer hypertrophy or loss of layering at the pyloric level.

Table 4
Ultrasonographic findings in cats with pyloric narrowing (cases; n = 27) and cats with gastrointestinal signs without pyloric narrowing (controls; n = 35).

Ultrasonographic findings	Cases	Controls	P-value
Digestive tract			
Abnormal gastric content	4/27 (15%)	4/35 (11%)	0.719
Pyloric thickening	2/27 (7%)	4/35 (8%)	0.689
Thickening of other regions	8/27 (30%)	13/35 (37%)	0.596
Stomach other than pylorus	1	3	
Duodenum	0	4	
Jejunum	5	4	
Ileum	2	1	
Colon	0	1	
Other abdominal organs			
Pancreas (hyperechogenicity or nodular appearance)	1/27 (4%)	5/35 (14%)	0.220
Liver	7/27 (26%)	10/35 (29%)	1.000
Hepatomegaly	1	4	
Hyperechogenicity	5	3	
Biliary sludge	1	3	
Kidneys	4/27 (15%)	7/35 (20%)	0.742
Signs of chronic nephropathy	4	6	
Nephromegaly	0	1	
Spleen	2/27 (8%)	2/35 (6%)	1.000
Mild splenomegaly	0	1	
Nodule	1	0	
Mild heterogenicity	1	1	
Lymph node (LN) enlargement	8/27 (30%)	10/35 (29%)	1.000
Gastric	0	0	
Hepatic	1	2	
Jejunal	1	4	
Ileo-colic	3	2	
Colic	2	0	
>2 different LNs	1	2	

a combination of prednisolone (tapering protocol) and chlorambucil (15 mg/m^2 four days every three weeks; Lingard et al., 2009). Finally, cats with high grade gastric lymphoma were offered conventional chemotherapy but the owners elected palliative treatment with prednisolone.

3.7. Estimated pyloric diameter

The pyloric diameter was subjectively evaluated (by comparing with the size of the biopsy forceps, as shown in Fig. 3) in 18/27 cats in the case group, with a median size of 6.0 mm (range 3.0–8 mm). Given that the pylorus was easily intubated in control cats, the pylorus could not be measured accurately, suggesting that the pyloric diameter was over 8.8 mm in all cases.

4. Discussion

To our knowledge, this is the first study describing signalment, clinical, and specific endoscopic findings in adult cats presumed to have acquired pyloric narrowing, suggested by the endoscopic appearance and inability of an experienced endoscopist to intubate the pylorus with an 8.8 mm external diameter flexible video gastroscope despite several attempts and despite the absence of any mechanical obstruction. The entity described here is likely to reflect pathological consequences of several underlying diseases, and the main objective was to describe the associated clinicopathological findings. Endoscopy is known to be a safe tool for the investigation of various gastrointestinal diseases in cats, and the results of the current study suggest that this procedure is well suited to classifying disorders of the pylorus.

Despite being a sphincter with elasticity and contractility provided by the mucosal and muscular layers, the pyloric opening has limited capacity to dilate (Biancani et al., 1980). To our knowledge, neither acquired pyloric narrowing nor stenosis have ever previously been reported in adult cats, perhaps, because a definitive diagnosis is not easy to establish given the lack of any standardised approach for evaluating the internal diameter of the pylorus. Instead, cases can only ever be 'presumed' (rather than definitely confirmed) based upon the clinical signs (*e.g.*, vomiting of food, variable delayed vomiting after eating) and the exclusion of other conditions responsible for gastric delayed emptying (Washabau and Day, 2013).

One limitation of the current study is that the classification of cases and controls was made subjectively, after inability to intubate the pylorus at endoscopy, since it is assumed that the pylorus should be easily passable at endoscopy (Tams and Rawlings, 2011; Washabau and Day, 2013). However, factors other than narrowing might have influenced success of intubation, such as being a small-statured cat, over-insufflation (which leads to a reflex closure of the pylorus), the use of prokinetic drugs (metoclopramide), operator experience, breed (*i.e.*, Siamese and Burmese cats are suspected to have a narrower pyloric canal) and endoscopic diameter (Tams and Rawlings, 2011; Washabau and Day, 2013). Various steps were taken to minimise the influence of these factors. For example, the same endoscopist performed all endoscopic procedures, and was already experienced at the beginning of the study period, making variations in endoscopic skills meaningless during the study. The same 8.8 mm external diameter flexible gastroscope was used throughout, with care taken not to over-insufflate the stomach during the procedure. Other causes of delayed gastric emptying (*e.g.* pyloric polyp, pyloric foreign body or pyloric mass) were ruled out during the procedure although some cases did have neoplasia not affecting the pylorus. Further, prokinetic drugs were not used and, in any case, the authors are not aware of any pharmacological agents that has been shown to modify pyloric tone in cats (Smith et al., 2004).

Although domestic shorthair cats were the most common breed affected, Siamese cats were over-represented; this is not surprising

Table 5
Endoscopic findings of the stomach in cats with pyloric narrowing (cases; n = 27) and cats with gastrointestinal signs without pyloric narrowing (controls; n = 35).

	Cases				Controls				P-value[1]
	0	1	2	3	0	1	2	3	
Hyperaemia	9 (33%)	16 (59%)	2 (7%)	0 (0%)	7 (20%)	17 (49%)	11 (31%)	0 (0%)	0.062
Oedema	10 (37%)	11 (41%)	4 (15%)	2 (7%)	10 (29%)	14 (40%)	9 (26%)	2 (5%)	0.736
Discolouration	12 (44%)	12 (44%)	3 (12%)	0 (0%)	9 (26%)	21 (60%)	5 (14%)	0 (0%)	0.303
Erosions/ulcers	22 (82%)	2 (7%)	3 (11%)	0 (0%)	27 (77%)	2 (6%)	5 (14%)	1 (3%)	0.803
Content	27 (100%)	0 (0%)	0 (0%)	0 (0%)	34 (97%)	1 (3%)	0 (0%)	0 (0%)	1.000
Pylorus intubation	0 (0%)	0 (0%)	2 (7%)	25 (93%)	33 (94%)	2 (6%)	0 (0%)	0 (0%)	(discrimination criterion)
Mass/polyp	1 (4%)				4 (11%)				0.376
Foreign body	1 (4%)				1 (3%)				1.000

Endoscopic findings graded according to the WSAVA guidelines. Code: Normal = 0; Mild = 1; Moderate = 2; Severe = 3.
[1] Variables tested either with a Fischer's test (mass/polyp and foreign body) or Cochran-Armitage trend test (all other variables).

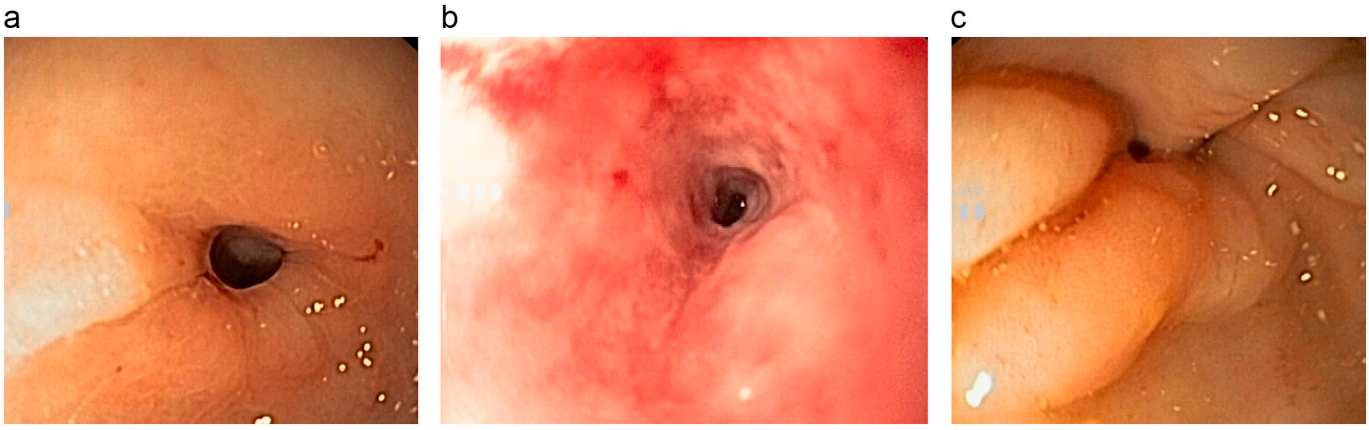

Fig. 2. Illustrations of narrowed pylorus. (a): narrowed pylorus with surrounding mucosal oedema. (b): narrowed pylorus with surrounding mucosal erosions and erythema. (c): narrowed pylorus with surrounding additional mucosal fold.

Table 6
Histological findings in gastro-duodenal biopsies of cats with pyloric narrowing (cases; n = 27) and cats with gastrointestinal signs without pyloric narrowing (controls; n = 35).

Histological findings	Cases				Controls				P-value[1]
	0	1	2	3	0	1	2	3	
Stomach									
Lymphocytic-plasmacytic infiltrate	9 (33%)	12 (44%)	5 (19%)	1 (4%)	14 (40%)	13 (37%)	5 (14%)	3 (9%)	0.959
Eosinophilic infiltrate	25 (93%)	2 (7%)	0 (0%)	0 (0%)	34 (97%)	1 (3%)	0 (0%)	0 (0%)	0.575
Mucosal hypertrophy	24 (89%)	3 (11%)	0 (0%)	0 (0%)	30 (86%)	5 (14%)	0 (0%)	0 (0%)	1.000
Fundic gland atrophy	25 (93%)	2 (7%)	0 (0%)	0 (0%)	32 (91%)	3 (9%)	0 (0%)	0 (0%)	1.000
Fibrosis	16 (59%)	11 (41%)	0 (0%)	0 (0%)	25 (71%)	10 (29%)	0 (0%)	0 (0%)	0.418
Helicobacter	24 (89%)	3 (11%)	0 (0%)	0 (0%)	26 (74%)	9 (26%)	0 (0%)	0 (0%)	0.202
Duodenum									
Lymphocytic-plasmacytic infiltrate	4 (21%)	10 (52%)	3 (16%)	2(11%)	7 (23%)	12 (40%)	7 (23%)	4 (14%)	0.690
Gastric or duodenal neoplasia									0.164
Gastric high grade	2 (7%)				8 (23%)				
lymphome (fundus)	1				4				
Duodenal small-cell	1				3				
lymphoma	0				1 (antrum)				
Polyp									

Lesions were graded according to the WSAVA guidelines. Code: Normal = 0; Mild = 1; Moderate = 2; Severe = 3.
[1] Variables tested either with a Fischer's test (neoplasia) or Cochran-Armitage trend test (all other variables).

because pyloric stenosis has previously been reported in this breed (Pearson et al., 1974; Syrcle et al., 2013; Twaddle, 1971, 1970). Either this would confirm that Siamese cats are predisposed to pyloric stenosis or, given the method of diagnosis, it might instead suggest that Siamese cats simply have a narrower pyloric internal diameter. Thus, further studies are needed comparing pyloric diameter in healthy Siamese cats and other breeds. Pyloric narrowing was not associated with sex in the current study, which contrasts with two previous case reports where most cases were female (Twaddle, 1971, 1970), but is similar to the findings from another report where male and female cats were equally represented (Pearson et al., 1974).

Chronic vomiting was the most common clinical sign observed in both groups, although food was more likely to be present in cases compared with controls. Thus, clinicians should be aware that the presence of food in vomitus could be used the index of suspicion for pyloric narrowing. Other clinical signs were only sporadically present, and the frequency did not differ between cases and controls.

The ultrasonographic appearance of the pylorus was rarely abnormal in the cats of this study, in contrast to canine pyloric gastropathy where thickening of the pylorus muscularis is observed (Biller et al., 1994). Endoscopically, findings consistent with gastric inflammation (*e.g.*, oedema, erythema, erosions, discolouration) were noted in many cats, whilst gastric ulceration and antral polyps were rare. However, there were no significant differences between groups, suggesting that these would not be useful discriminating signs for the diagnosis of presumed acquired pyloric narrowing. Differential diagnosis of delayed gastric emptying or gastric obstruction was supported by endoscopic procedure. Gastric retention was not commonly seen, possibly because of the prolonged (>16 h) fast prior to the procedure itself and because of the lack of real obstruction of the stomach. Therefore, the degree of pyloric narrowing was less marked in our cases compared with reported cases of congenital pyloric stenosis, therefore a complete gastric obstruction was not expected.

As previously discussed, pyloric diameter was visually estimated, by comparing it with the width between the jaws of the biopsy forceps when fully open; this suggests that, subjectively, pyloric diameter of the cases was narrower than of the control cats, and might explain why the pylorus could not be intubated. Pyloric antrum diameter was similarly endoscopically estimated in a case of congenital pyloric stenosis (Syrcle et al., 2013). In a recent prospective study in healthy cats, median pyloric diameter was 9 mm (interquartile range 9–10 mm), consistent with our suspicion of abnormal pyloric narrowing when it cannot be catheterised with an 8.8 mm gastroscope (Lamoureux et al., 2019). However, given that no guidelines were currently available for measurement of the feline pyloric diameter in cats, further studies are needed.

The most common histological finding in cases was

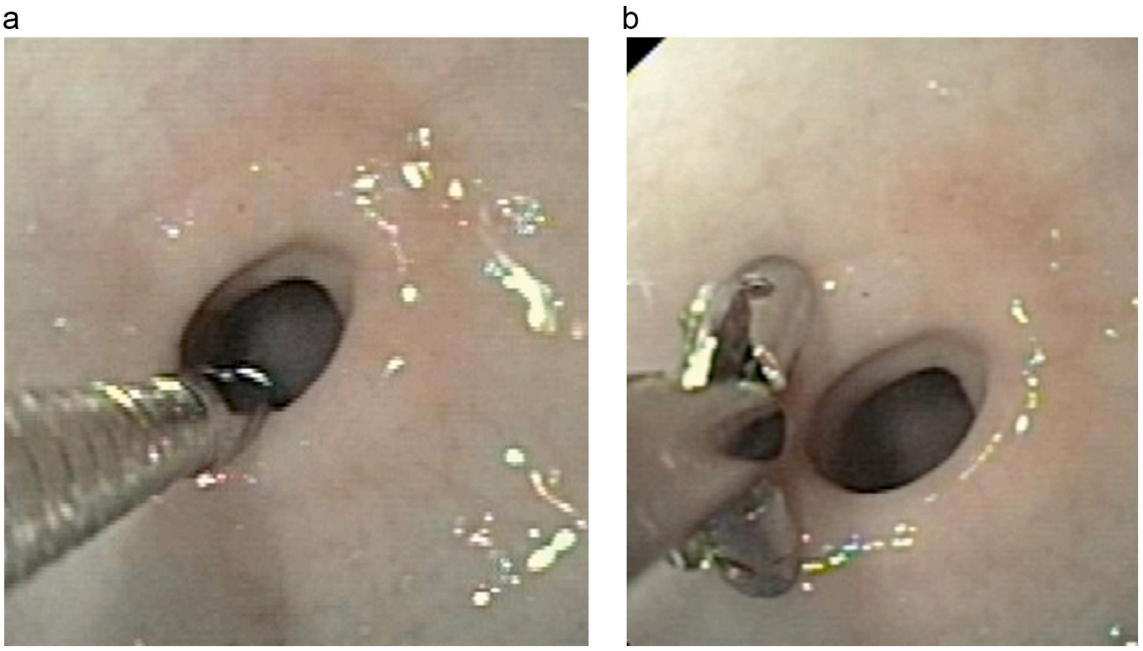

Fig. 3. Endoscopic appearance of a narrowed pylorus: the diameter is compared to the closed (a) and opened (b) biopsy forceps.

lymphoplasmacytic infiltration of the gastric mucosa. Whilst these findings could suggest that an inflammatory process might be responsible for a lack of elasticity leading to pyloric narrowing, the significance is not clear, given that a similar proportion of controls had the same inflammatory findings. In dogs, enlarged folds surrounding the pylorus are a common finding of pyloric hypertrophic gastropathy during endoscopic procedure (Leib et al., 1993). This was not recorded in the cats of the current study, despite a thickened mucosal fold which was observed for some cases. Moreover, in dogs, a hypertrophy of the smooth muscular layer surrounding is another common histological finding, which was not reported in the current study. However, histological features in our study were based upon endoscopic biopsies of a small number of cases and muscular layers could therefore not be assessed; full-thickness surgical biopsies or necropsy data would have been required to assess more precisely the modifications of the muscular layers. In the absence of such biopsies, muscular layer hypertrophy could only be considered unlikely based on the combination of endoscopic and ultrasonographic appearance that were not suggestive for it. Based on this hypothesis, this might suggest the aetiology of the apparent pyloric narrowing in cats is different from that seen in dogs. Instead of muscular hypertrophy, mucosal fibrosis in a chronic inflammatory context could explain a reduction in pyloric diameter along with loss of its elasticity. Semi-quantitative evaluation of pyloric mucosal fibrosis, using Masson's Trichrome staining for instance, would be an interesting approach to test this hypothesis. Indeed, mucosal inflammation and secondary fibrosis were also suspected to be involved in acquired inflammatory rectal strictures in a recent study (Lamoureux et al., 2019), where chronic mucosal changes finally impair sphincter elasticity and opening capacity. Further studies should now be conducted to confirm these findings and explore aetiology in more detail.

Besides the limitations described above, others should be considered. First, the study was retrospective in nature and we lacked specific tools to enable objective measurement of pyloric diameter. Second, collection of gastric biopsies was not standardised among cases, in terms of number of biopsies and sites sampled even if multiple biopsies were systematically performed, which might have affected histopathological interpretation. Third, case numbers were relatively small and some clinical details were incomplete. For example, some laboratory data were not available, if performed by the practitioner prior to referral, and duodenal biopsies were not available in each case. This might have led to underestimation of metabolic diseases and duodenal diseases. Finally, given the lymphoplasmacytic inflammation commonly identified, prednisolone was often trialled at anti-inflammatory doses. However, follow-up was not available in all cases meaning that response to this therapy cannot be determined precisely. Given these listed limitations, it is suggested that prospective studies-including an appropriate pyloric measuring tool-should be considered to examine cases of presumed acquired pyloric narrowing more completely. Prospective studies would enable the outcome of such cases to be elucidated, as well as the response to therapy determined.

5. Conclusion

In summary, in this preliminary study, we have described a series of 27 cases with presumed acquired pyloric narrowing. Compared with 35 cats without this condition, the vomitus of these cats was more likely to contain food, and Siamese cats were over-represented. One possible explanation for acquired pyloric narrowing could be peri-pyloric cicatricial fibrosis secondary to an inflammatory process. However, further studies are needed to better describe and understand this syndrome.

Author's note

These results were presented as an oral communication at the ECVIM-CA congress in September 2016.

Conflict of interest declaration

AJG's academic post at the University of Liverpool is financially supported by Royal Canin.

FD's clinical position at CHUVA-Ecole Nationale Vétérinaire d'Alfort was financially supported by Royal Canin.

Funding

The authors received no financial support for the research, authorship, and/or publication of this article.

Ethical approval and informed consent statement

This retrospective study involved the use of client-owned animal only, and followed internationally recognized high standards of individual veterinary clinical patient care. Ethical Approval from a committee was not therefore needed. The owners gave written informed consent for all the procedures.

Acknowledgments

The authors greatly thank all the clinicians and the diagnostic imaging service for their implication in this study.

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