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TITLE OF CASE ***Do not include "a case report"***

Grass as a linear gastrointestinal foreign body obstruction in four dogs

SUMMARY ***Up to 150 words summarising the case presentation and outcome (this will be freely available online)***

Four dogs presented with linear gastrointestinal foreign body (FB) obstruction caused by impacted grass fibres. The material had become anchored within the pylorus in three dogs, causing necrosis and perforation of the mesenteric border of the affected intestinal segment. Gastrotomy and intestinal resection and anastomosis were performed. The fourth case presented acutely with no intestinal necrosis or perforation with the fibres removed via enterotomy.

One dog suffered severe postoperative ileus that failed to respond to medical management. Continued deterioration prompted euthanasia 12-days post-operatively. The other three dogs survived and were discharged without complication.

Grass has not previously been reported as a cause of linear gastrointestinal obstruction in dogs. It has, however, the potential to cause severe necrosis and perforation of the intestine and should be recognised as a potential linear FB in dogs.

BACKGROUND ***Why you think this case is important – why did you write it up?***

Small intestinal FB obstructions are common in small animals and can be broadly classified as linear (representing 16% to 36.2%[1,2] of all intestinal FB obstructions in dogs) and non-linear. Linear FB's in dogs typically anchor within the pylorus in 67-78% of cases[1,2], with subsequent peristaltic waves causing progressive bunching of the small intestine around the FB. These plicated intestines are susceptible to significant damage and, with continued peristalsis, the FB may erode the mesenteric aspect of the intestinal wall, resulting in necrosis and perforation of large sections of intestine[3,4].

Linear FB's are associated with a higher incidence of postoperative complications compared with non-linear[1,5]. Reported mortality rates for linear FB's are between 2% to 22%[2,5]; similar to those reported for non-linear FB's (1 to 17%)[2,6]. Hobday[7] reported equivocal mortality rates for linear FB obstructions compared with non-linear.

Commonly reported linear FB's in dogs are fabrics, plastics, rope, string, thread and stockings[1,3,4,8]. During the past five years, four patients were presented to a single referral clinic with small intestinal linear FB obstructions caused by a large mass of fibrous grass – a cause of linear FB that has not yet been described in dogs. The aims of this retrospective case series are to describe fibrous grass as a linear gastrointestinal foreign body and to detail the surgical findings and short-term postoperative outcomes in these patients.

CASE PRESENTATION ***Presenting features, clinical and environmental history***

Case one

A six-year-old, female neutered Labrador Retriever was presented with a 24-hour history of vomiting and inappetence. The dog had undergone two previous surgeries for foreign body obstruction, requiring a gastrotomy and two enterotomies. On presentation, the dog was dull with a heart rate of 140 beats/minute. The peripheral pulse quality was poor and bounding femoral pulses were identified. Oral mucus membranes were pink with a capillary refill time of two seconds. The dog was panting with no abnormalities identified during thoracic auscultation. The rectal temperature was 37.1°C and the abdomen was tense when palpated, particularly cranially.

Case two

A nine-year-old, female neutered Labrador Retriever was presented with a five-day history of vomiting, diarrhoea (one episode of melaena), inappetence and abdominal pain which had failed to respond to medical management at the referring veterinary practice. On presentation, the dog was quiet but responsive with a respiratory rate of 20 breaths/minute

and a heart rate of 160 beats/minute. Peripheral pulse quality was poor and the oral mucus membranes were pink and tacky, with a capillary refill time of one second. The rectal temperature was 38.5°C and abdominal palpation revealed cranial abdominal pain and a prominent spleen.

Case three
A five-year-old, female neutered Flat-Coated Retriever was presented with a 48-hour history of vomiting and inappetence. On presentation the dog was quiet but responsive with a heart rate of 128 beats/minute and appropriate peripheral pulse quality. Oral mucus membranes were pink and moist with a capillary refill time of two seconds. The dog was panting with no abnormalities identified during thoracic auscultation. The rectal temperature was not recorded. Abdominal palpation revealed cranial abdominal discomfort and some intestinal loops were palpably fluid-filled.

Case four
A one-year-old, female entire Dobermann was presented with a 12-hour history of restlessness and two episodes of vomiting. The dog had shown signs of pica since she was a puppy and previously had emesis induced following ingestion of two socks and a handkerchief that had been observed by the owner, all on separate occasions. An enterotomy had been performed on two occasions for foreign body removal – the first foreign body was a glove and the second was twisted, fibrous grass. The second foreign body obstruction had occurred just three weeks prior to presentation and the referring veterinarian had reported severe intestinal adhesions during exploratory coeliotomy. On presentation the dog was bright, alert and responsive. The respiratory rate was 16 breaths/minute and the heart rate was 132 beats/minute with appropriate peripheral pulse quality. Oral mucus membranes were pink and moist, with a capillary refill time less than two seconds. Rectal temperature was 37.8°C. Abdominal palpation revealed a firm mass within the mid abdomen which was associated with a pain response on palpation.

INVESTIGATIONS *If relevant*

Case one
Results of haematology, biochemistry and electrolyte analysis were within the normal parameters.
Abdominal ultrasound revealed fluid distension of the stomach (figure 1D) and a solid mass of hyperechoic material (with acoustic shadowing) was identified within the pylorus and extended throughout the length of the duodenum. There were multiple areas of plication of the proximal duodenum and contraction of the pylorus was evident around the hyperechoic material. No free peritoneal fluid was observed.

Case two
Results of haematology, biochemistry and electrolyte analysis were within the normal parameters.
Abdominal ultrasound revealed marked fluid distension of the stomach with an irregularly marginated hyperechoic structure within the gastric lumen (figure 1: A,B and E) that extended throughout the entire length of the duodenum. Multiple areas of plication of the proximal duodenum around the hyperechoic material were identified and small segments of the duodenal lumen were fluid-filled (figure one). The duodenum and jejunum were hypomotile. No free peritoneal fluid was identified.

Case three
Results of haematology, biochemistry and electrolyte analysis were within normal parameters.
Three-view abdominal radiographs revealed an irregular soft tissue opacity within the pyloric antrum, and mottled heterogeneous soft tissue opacity within the proximal small intestine with areas of small intestinal bunching (figure 2: B and C).
Abdominal ultrasound revealed a mass of hyperechoic material with associated acoustic shadowing within the gastric lumen, extending through the pylorus and throughout the length of the duodenum. Multiple areas of plication of the duodenum around the hyperechoic material were identified and the duodenal lumen was fluid-filled. A single region of the duodenal wall was thickened, with loss of layering (figure 1C). No free peritoneal fluid was identified.

Case four

Haematology and biochemistry analysis revealed leukocytosis ($23.4x10^9$/l, ref 6-15), neutrophilia ($21.384x10^9$/l, ref 3.6-12) and lymphopaenia (4%, ref 10-36). Creatine kinase was elevated (615U/l, ref 50-200) and triglycerides were low (0.50mmol/l, ref 0.57-1.14). The remainder of the biochemistry results were within normal limits. No electrolyte abnormalities were identified.

Three-view abdominal radiographs revealed distension of a portion of small intestine with mottled heterogeneous soft-tissue opacity within the lumen (figure 2A). Abdominal ultrasound revealed a linear structure within the jejunal lumen with acoustic shadowing. A small peritoneal effusion was present.

DIFFERENTIAL DIAGNOSIS ***If relevant***

The findings of abdominal imaging were consistent with linear gastrointestinal foreign body obstruction.

TREATMENT ***If relevant***

Case one

Exploratory coeliotomy revealed a linear foreign body within the pylorus, extending through the duodenum into the proximal jejunum. There was plication of the duodenum around the linear foreign body, which was particularly marked at the mesenteric border, where there were three distinct areas of serosal tearing and intestinal wall compromise. No free peritoneal fluid was identified. A gastrotomy and two enterotomies revealed a large mass of fibrous grass which had become twisted and lodged within the pylorus. The compromised portions of duodenum and jejunum were resected, and a functional stapled end-to-end anastomosis was performed.

Case two

Exploratory coeliotomy revealed marked gastric distension and confirmed the presence of a linear gastrointestinal foreign body obstruction. There was marked plication of the duodenum and proximal jejunum around the linear foreign body and four distinct areas of mesenteric border perforation with associated serosal bruising (figure 3. There was generalised peritonitis, however no free peritoneal fluid was identified. A gastrotomy and enterotomy were performed and a large linear mass of fibrous grass which had become twisted and lodged within the pylorus and extended to the proximal jejunum was retrieved. The distal duodenum and proximal jejunum were resected, and a functional stapled end-to-end anastomosis was performed. Due to concerns of hypomotility on the pre-operative abdominal ultrasound scan, the resected small intestine and a gastric biopsy were submitted for histopathology. Histopathology of the resected duodenum revealed moderate diffuse, subacute enteritis with multifocal, subacute ulceration, perforation and granulation tissue formation. Plant material and bacteria were also identified.

Case three

A linear foreign body extending from the pyloric antrum to the proximal jejunum was identified during exploratory coeliotomy. Focal areas of serosal tearing and signs of intestinal compromise were identified on the mesenteric border of the distal duodenum and proximal jejunum. A gastrotomy and two enterotomies were performed to retrieve a large amount of fibrous grass which had become twisted and lodged within the pylorus. The compromised distal duodenum and proximal jejunum were resected, and a sutured end-to-end anastomosis was performed.

Case four

Exploratory coeliotomy revealed multiple abscesses within the subcutaneous fat and abdominal wall which appeared to be associated with the recent coeliotomy closure. The abscessed tissue was surgically debrided, and a tissue sample was submitted for bacterial culture and sensitivity. A linear foreign body was identified within the pylorus, extending to the proximal jejunum. Multiple small intestinal adhesions were present, many of which were chronic and were not broken down due to concern of further compromising the intestinal wall. More recent jejuno-jejunal adhesions were identified and gently released. The enterotomy site from the surgery performed three weeks previously was inspected and no significant abnormalities were identified. A gastrotomy and an enterotomy were performed to retrieve a large linear mass of fibrous grass which had become twisted and lodged within the pylorus. A biopsy was taken from the jejunal enterotomy site prior to closure to further investigate for an underling cause of pica. Histopathology revealed moderate, diffuse, subacute, neutrophilic, eosinophilic and erosive enteritis within the jejunum. Escherichia coli was cultured from the abscessed abdominal wall. The isolate was susceptible to most antibiotics.

After surgery, all four dogs received intravenous fluids, opioid analgesia (methadone and subsequently buprenorphine) and broad-spectrum antibiosis. Dogs two and three received gastroprotectants (omeprazole) and anti-emetics (maropitant). Dog two also received a prokinetic (metoclopramide) due to the preoperative ultrasound finding of intestinal hypomotility.

OUTCOME AND FOLLOW-UP

Case one
After surgery, the dog remained inappetent and began regurgitating. Abdominal ultrasound revealed fluid accumulation within the stomach and reduced intestinal motility. A diagnosis of postoperative ileus was made and treatment consisting of prokinetic therapy (metoclopramide continuous rate infusion and ranitidine), a gastroprotectant (omeprazole) and an anti-emetic (maropitant) was initiated. The dog was discharged after four days with oral ranitidine and tramadol, however re-presented the following day due to recurrence of regurgitation. Abdominal ultrasound was repeated and confirmed ongoing ileus. The dog was re-admitted for continued prokinetic therapy (metoclopramide continuous rate infusion) and oral ranitidine. Opioid analgesia was discontinued at this stage. The dog responded well to further medical treatment and was discharged four days later.

Case two
The dog remained inappetent after surgery and began to regurgitate. Following initiation of medical management, the dog started eating and the regurgitation improved, however signs did not fully resolve. The dog was initially discharged on postoperative day five with oral medications (tramadol, omeprazole, metoclopramide, potentiated amoxicillin and metronidazole) but was re-admitted to the hospital two days later due to lethargy, inappetence and continued regurgitation. Abdominal ultrasound revealed fluid accumulation within the stomach and absent intestinal motility. Four days following re-admission, the frequency of regurgitation had reduced, however the dog remained inappetent, so an oesophageal feeding tube was placed to facilitate enteral nutrition. Following initiation of oesophageal tube feeding, the frequency of regurgitation increased. Additional prokinetic (ranitidine) and anti-emetic (ondansetron) therapy was initiated, however the dog was euthanased three days later due to continued regurgitation and a progressively worsening demeanour.

Case three
The dog had an uncomplicated recovery from surgery and was discharged three days postoperatively. No short-term complications were reported; however, she re-presented one year later and was diagnosed with jejunal perforation as a result of a penetrating stick injury. A small intestinal resection anastomosis was performed at that time, and the dog recovered uneventfully.

Case four
The dog recovered uneventfully from surgery and was discharged after two days. No immediate complications were encountered, however the dog re-presented five months later with a further gastrointestinal foreign body obstruction (a piece of ball plus marrow bone fragments) with duodenal perforation and septic peritonitis. A gastrotomy and small intestinal resection and anastomosis were performed, and the dog was subsequently discharged without complication.

DISCUSSION *Include a very brief review of similar published cases*

This report describes the ability of grass fibres to cause linear gastrointestinal FB obstruction with the potential to cause significant damage including deep mucosal ulceration on the mesenteric border of the affected intestinal segment. Fibrous grass has not yet been reported as a cause of linear gastrointestinal FB obstruction in dogs.

Although grass ingestion was not observed by the owners of any of the four dogs in this case series, Hayes[1] reported that in 26% of cases with gastrointestinal FB obstructions, ingestion of the foreign material was observed by the owner. It is therefore important that grass is considered a possible linear FB and that dogs with clinical signs of gastrointestinal obstruction following recent grass ingestion are promptly assessed for possible obstruction.

Fibrous plant material admixed with rope has been reported as a cause of twenty-two gastrointestinal linear foreign body obstructions in a population of sixteen Silver Leaf Langurs in captivity[9]. Two of the Langurs had plication and perforation of the mesenteric border of the small intestine, requiring resection and anastomosis. Nine Langurs were diagnosed with linear foreign body obstructions during post-mortem examination, where

plication, perforation and septic peritonitis were frequent findings. The authors report that once aware of the severity of damage caused by such obstructions, early surgical intervention was instigated, and no further Langurs required intestinal resection.

The imaging modalities utilised in the four cases described included abdominal radiography (two cases) and ultrasound (four cases) and was based on the preference of the clinician managing each case. Ultimately, for all four cases, the decision to proceed with surgical intervention was based on the ultrasound findings of a linear gastrointestinal foreign body with intestinal plication and, in case three, suspicion of perforation due to loss of intestinal wall layering which was subsequently confirmed during surgery. The diagnosis of grass fibres acting as a linear foreign body was made intra-operatively and could not have been predicted based on the pre-operative imaging in the four cases described.

Three of the four dogs had severe compromise of the mesenteric border of the affected portion of small intestine, with necrosis and perforation of the intestinal wall, demonstrating the potential for grass to cause severe intestinal injury as a linear FB. All three dogs underwent resection and anastomosis of a significant portion of small intestine. The owner of the fourth dog had experience with previous gastrointestinal obstructions and this dog was presented promptly, enabling early surgical intervention. This dog did not have severe intestinal wall damage, did not require enterectomy and had an uncomplicated recovery from surgery. This may indicate that early surgical intervention is associated with a better outcome in patients with fibrous grass linear foreign body obstructions, consistent with reports of other linear FB[1]. Aronson[3] reported that intestine may not resume normal function post-operatively following linear FB obstruction. This may be related to the chronicity of obstruction as demonstrated by cases one and two, which had a longer duration of clinical signs prior to presentation. Both of these dogs suffered postoperative ileus and required prolonged hospitalisation for medical management.

Dog four had a history of frequent foreign body ingestion and a presumptive diagnosis of pica was made. Histopathology findings of a jejunal biopsy were suggestive of inflammatory bowel disease. Further investigations were recommended to the owner; however these were not pursued. Dog two had a protracted history of vomiting, with intestinal hypomotility observed on preoperative ultrasound. Gastric and small intestinal biopsies were taken to rule out an underlying cause, however the results were consistent with physical damage as a result of linear foreign body obstruction. Histopathology was not performed in cases one and three as the surgical findings were consistent with foreign body obstruction and some financial constraints were present. Dogs one, two and three did not have any known underlying cause of foreign body ingestion.

Dog two suffered severe and intractable ileus which ultimately resulted in euthanasia. An oesophageal feeding tube had been placed eight days after surgery to facilitate enteral nutrition, however following initiation of tube feeding, regurgitation re-developed and became more frequent. The decision to place an oesophageal feeding tube in favour of a gastrostomy tube was based on almost complete resolution of regurgitation at the time of tube placement and the presence of intra-operative peritonitis and postoperative gastrointestinal inflammation. Although prokinetic therapy was administered and a feeding tube placed, factors such as opioid administration and prolonged postoperative inappetence could have contributed to persistent and refractory ileus[10]. There are currently no specific protocols for managing postoperative ileus, however in general terms: prokinetic therapy should be administered; opioid analgesia should be avoided or antagonised where possible and other forms of analgesia considered; electrolyte and acid-base disturbances should be corrected and fluid balance maintained; early ambulation should be encouraged and; early enteral nutrition, within 48 hours of surgery should be facilitated[10].

In conclusion, grass should be considered a cause of linear foreign body obstruction in dogs. It has the potential to cause significant damage to the small intestinal wall, including necrosis and perforation of the mesenteric border and therefore early surgical intervention is likely to result in a better outcome. Where postoperative ileus occurs, a proactive multi-modal approach is recommended, however ileus may be refractory to interventions.

LEARNING POINTS/TAKE HOME MESSAGES ***3 to 5 bullet points – this is a required field***

- Grass fibres can act as a linear gastrointestinal foreign body and should be considered in the differential diagnosis for linear foreign bodies
- Grass fibre linear foreign body obstructions may cause extensive damage to the gastrointestinal tract
- Early surgical intervention is recommended for linear gastrointestinal foreign body obstructions caused by grass fibres
- Postoperative ileus should be considered in dogs which have undergone gastrointestinal surgery that are vomiting, regurgitating or lack borborygmi on abdominal auscultation
- Early recognition and active management of postoperative ileus may improve outcomes following linear gastrointestinal foreign body obstruction. Management is multimodal, however there are currently no specific recommendations regarding therapeutic interventions.

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FIGURE/VIDEO CAPTIONS ***figures should NOT be embedded in this document***

Figure one:
Abdominal ultrasound images of dogs (A and B: dog 2, C: dog 3, D: dog 1, and E: dog 2). Cranial is to the left of the images and ventral at the top of the images. Image A and B show the duodenum containing a linear hyperechoic structure (white arrow) with bunching of the intestine around it consistent with a linear foreign body and associated small intestinal plication. The duodenal lumen is mildly fluid dilated adjacent to the linear foreign body (white star). In C a small intestinal loop shows loss of normal layering of the small intestinal wall. In D and E the stomach is dilated with anechoic fluid content and heterogeneous hyperechoic foci, some of which display a linear shape (white arrows) and may reflect grass strands found at surgery. Additionally, in E a hyperechoic interface with strong distal acoustic shadowing (white arrowhead) is visible within the gastric lumen, likely consistent with the fibrous mass of grass found at surgery.

Figure two:
Examples of right lateral (A: dog 4, and B: dog 3) and left lateral (C: dog 3) radiographs of dogs showing the typical heterogeneous, mottled, granular soft tissue opacity of fabric or cloth-like foreign material within small intestine (black arrows). Within the pyloric antrum and proximal duodenum of radiograph A there are small mineralised opacities (black arrowhead) suggestive of a "gravel sign" seen in chronic partial mechanical obstruction (another differential for this would be non-obstructing gastric foreign bodies). In radiograph B bunching of the small intestine in the central abdomen (black star) is also visible which is found with small intestinal linear foreign bodies. In radiograph C the pyloric antrum is mildly gas dilated and contains irregular, heterogeneous soft tissue opacity (black circle), likely the fibrous grass mass found at surgery.

Figure three:
Intra-operative images from case two. The upper image shows two enterotomies within the distal duodenum with a mass of fibrous grass protruding from one of the enterotomy sites (arrow). The lower image shows four distinct areas of mesenteric border perforation with associated serosal bruising (arrows).