

Radiographic diagnosis of small intestinal obstruction in pet rabbits (*Oryctolagus cuniculus*): 63 cases

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OBJECTIVES: To identify radiographic features that can be used to aid in the diagnosis of small intestinal obstruction in pet rabbits.

MATERIALS AND METHODS: Retrospective study comparing radiographic features of 63 cases of confirmed intestinal obstruction with 50 abdominal radiographs taken of rabbits without gastrointestinal disease. Abdominal radiographs were examined for gastric size, gastric contents, small intestinal dilatation and gas within the large intestine and caecum.

RESULTS: Gastric size, gastric contents, small intestinal dilatation and gas within the large intestine and caecum were all features that differed between rabbits with small intestinal obstruction and rabbits without gastrointestinal disease. Radiographic features associated with small intestinal obstruction included severe gastric dilation, gastric contents primarily consisting of liquid and gas, small intestinal dilation and absence of large amounts of gas in the caecum and large intestine.

CLINICAL SIGNIFICANCE: Observation on gastric size, small intestinal dilatation and gas within the large intestine and caecum aid in radiological diagnosis of small intestinal obstruction in rabbits and so can guide appropriate treatment.

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INTRODUCTION

Small intestinal obstruction (also referred to as “intestinal obstruction,” “gastrointestinal obstruction,” “gastric dilation,” “gastric dilatation” and “bloat”) is an acute, life-threatening condition of pet rabbits (Harcourt-Brown 2007a, Oglesbee & Jenkins 2011, Schuhmann & Cope 2014). Any physical obstruction of the small intestines causes build-up of fluid and gas oral to the obstruction (Lennox 2013, Harcourt-Brown 2014). Because rabbits have a well-developed lower oesophageal sphincter they are unable to vomit and so, in cases of complete small intestinal obstruction, the progression of gastric/intestinal dilation is rapid (Harcourt-Brown 2013). The most common cause of small intestinal obstruction in rabbits is a pellet of compressed hair (not to be confused with gastric trichobezoars) found to be responsible for 82% (49/60) of cases in one study (Harcourt-Brown 2007a). Other less common causes of obstruction include ingested foreign

material, strictures, intussusception, abscesses, adhesions, herniation and neoplasia (Harcourt-Brown 2007a, Schuhmann & Cope 2014). The most common sites of obstruction are the proximal duodenum and the ileocaecocolic junction but obstruction can occur at any point along the small intestine (Harcourt-Brown 2007a, Oglesbee & Jenkins 2011). It is important for veterinarians to be able to distinguish between this physical obstruction of the small intestine and gastrointestinal hypomotility (also referred to as “gut stasis,” “gastrointestinal stasis”) – another common gastrointestinal condition (Varga 2014). Gastrointestinal hypomotility involves a functional slowing or stopping of the peristaltic movements along the small and large intestines (Varga 2014). Some authors have used the term rabbit gastrointestinal syndrome, which encompasses both these pathologic conditions together with others (Lichtenberger & Lennox 2010).

Rabbits with small intestinal obstruction present with variable clinical signs, ranging from inappetence to depression to sudden

death (Oglesbee & Jenkins 2011). Progression along this spectrum can be rapid because the obstruction causes compromised intestinal circulation and accumulation of liquid and gas within the stomach. In these rabbits, the distended stomach causes compression of the caudal vena cava and aorta, leading to hypovolaemic shock, electrolyte imbalances and severe pain (Oglesbee & Jenkins 2011). As such, rapid diagnosis and appropriate treatment is critical to ensure a favourable outcome in these patients. Of particular importance is distinguishing between small intestinal obstruction and gastrointestinal hypomotility because the treatment of these two conditions differs (Harcourt-Brown 2013, Varga 2014). Diagnosis of intestinal obstruction is generally based on a consistent history and physical examination (acute onset of anorexia, signs of pain, lethargy, depression, bloated abdomen, hypothermia), laboratory analysis (marked hyperglycaemia, haemoconcentration) and abdominal radiographs (Harcourt-Brown & Harcourt-Brown 2012).

There are few studies on the normal radiographic anatomy of pet rabbits (Hinton & Gibbs 1982, Balikci Dorotea *et al.* 2016) and no guidelines on the objective interpretation of abdominal radiographs to aid diagnosis of intestinal obstruction. In dogs, measurement of intestinal diameter can be useful in diagnosis of physical obstruction (Finck *et al.* 2014). Several radiographic features have been suggested to be useful indicators of intestinal obstruction in rabbits, including contact of the stomach with the ventral abdominal wall, gas and liquid within the stomach, as well as serial radiographs that demonstrate changes in stomach size, small intestinal dilatation and gas movement along the gastrointestinal tract (Harcourt-Brown 2007a, Harcourt-Brown 2007b, Harcourt-Brown 2013, Lennox 2013). However, there are no data on how specific or sensitive these features are for this condition. The aim of this study was to provide data on the radiographic features of intestinal obstruction by comparing abdominal radiographs of rabbits with confirmed small intestinal obstruction with abdominal radiographs from rabbits presented without gastrointestinal disease.

MATERIALS AND METHODS

Case selection

Medical records from a referral exotics service were reviewed for rabbits presenting between 2008 and 2018 that had been diagnosed with intestinal obstruction. Case files were found through a keyword search within the species “rabbit,” using the key words “obstruction,” “orogastric” or “milked.” The term “milked” was included because this is a term used almost exclusively for the massage of obstructions along the small intestine during exploratory laparotomy. For inclusion, cases had to have had the diagnosis of small intestinal obstruction confirmed through exploratory laparotomy. Cases were excluded if they did not have diagnostic quality radiographs that included the entire abdomen in lateral view (left or right), extending from the cranial diaphragm cranially, the coxofemoral joint caudally, the ventral abdominal wall ventrally and the dorsal lumbar musculature dorsally. Evaluation was only made of the single lateral abdominal view, not the orthogonal ventrodorsal projection.

Rabbits with non-gastrointestinal disease

Fifty rabbits that presented with disease not relating to the gastrointestinal tract and where abdominal radiographs had been taken, were found through a keyword search after selecting species as “rabbit,” using the keyword “urolith.” This search was used to source abdominal radiographs of rabbits where it was deemed unlikely that the animals were suffering from intestinal obstruction. This was important to minimise inclusion of unconfirmed intestinal obstruction cases in this group. Cases were excluded if there was any suspicion of primary gastrointestinal disease based on the medical records (*e.g.* anorexia, no faecal output, hyperglycaemia, distended stomach). Cases were also excluded if they did not meet the radiographic specifications listed above.

Radiographic examination

All radiographs were viewed directly on *E-Film Digital Radiology Viewer* (®). For each case we measured: gastric length, gastric height, and length L1 to coxofemoral joint (Fig. 1). Gastric length and height were measured at 90° angles to each other, with length parallel to the thirteenth thoracic vertebra and height perpendicular. For each case it was also recorded whether the stomach extended caudal to the caudal aspect of L2 vertebra and whether the stomach was in direct contact with the

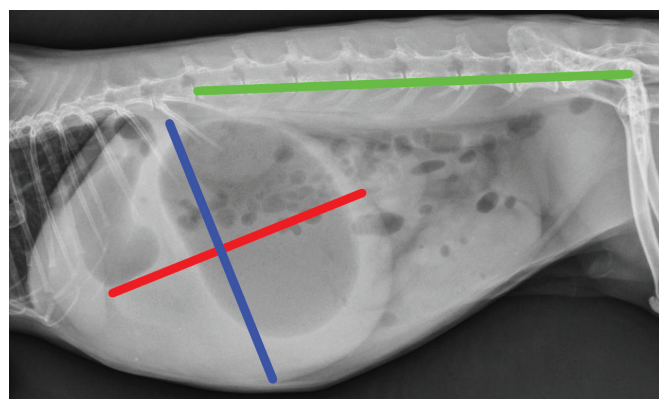


FIG 1. Measurement of gastric length (blue line) and width (red line), at 90° to each other, as well as length between the cranial aspect of the first lumbar vertebrae (L1) and the coxofemoral joint (green line)

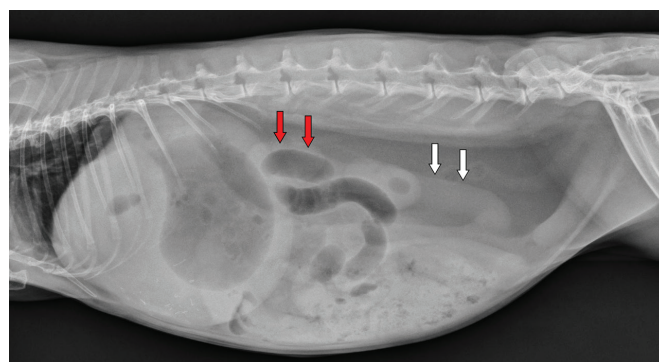


FIG 2. Abdominal radiograph of a rabbit with confirmed intestinal obstruction showing distention of the small intestine with likely liquid (white arrows) and gas (red arrows)

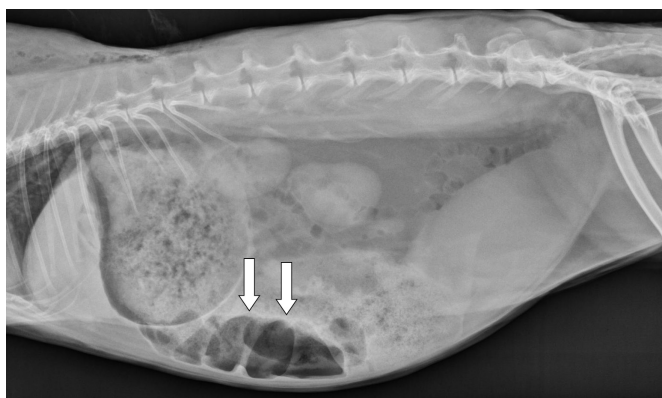


FIG 3. Abdominal radiograph of a rabbit with no suspicion of intestinal obstruction showing a large amount of gas in the caecum (white arrows)

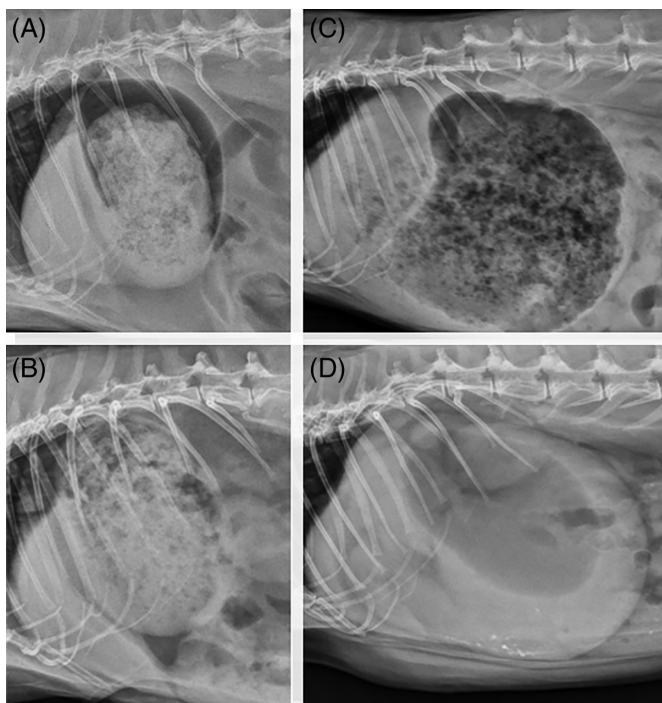


FIG 4. Abdominal radiographs of four rabbits showing different gastric contents. (A) ingesta with gas silhouette, (B) ingesta, (C) ingesta with large amount of gas, (D) liquid with gas cap. Note: stomach is dilated in (C) and (D)

ventral abdominal wall. In addition, a subjective interpretation was made of whether small intestine was distended with liquid or gas (Fig. 2), and whether there were large amounts of gas in the large intestine and caecum (Fig. 3). Small intestine was distinguished from large intestine by the lack of haustral folds, a central position within the abdomen and by not continuing into the pelvis (like the descending colon does). Finally, the radiographic appearance of the gastric contents was categorised as: (1) normal heterogenous ingesta with or without a gas silhouette, (2) ingesta with large amount of gas or (3) homogenous soft tissue opacity with a gas cap (Fig. 4). In addition, medical records were reviewed to identify the cause of obstruction and the location of the obstruction along the small intestine [pylorus, proximal (descending) duodenum, jejenum and ileum].

All radiographs were reviewed by the same two observers: a final year veterinary student and an experienced rabbit veterinarian. The student, blinded to the diagnosis of each radiograph, made the gastric measurements and then both observers made a consensus agreement on the gastric contents, small intestinal dilation and large intestinal gas.

Statistics

Prevalence of different radiographic features was calculated for both obstruction cases as well as non-obstruction cases.

RESULTS

A total of 63 cases of confirmed intestinal obstruction and 50 cases of non-gastrointestinal related disease met our inclusion and exclusion criteria.

Gastric size

Several measurements of gastric size were different in rabbits with small intestinal obstruction compared to rabbits without obstruction (Table 1). Of the obstruction cases, 62 of 63 (98%) had a “gastric length + gastric height” summed length greater than or equal to the length from L1 to the coxofemoral joint, which was a higher proportion than in the non-obstruction cases (6/50). Similarly, amongst the obstruction cases, 58 of 63 (92%) had direct contact between the gastric wall and the ventral abdomen, while this was only observed in (6/50) of the non-obstruction cases. The stomach extended beyond the caudal aspect of L2 in 41 of 63 (65%) obstruction cases but this was not observed in any non-obstruction cases.

Gastric contents

Fifty-eight of 63 (92%) obstruction cases had gastric contents consisting primarily of liquid with a gas cap, which was found in only one non-obstruction case. Normal ingesta was observed in a single case of intestinal obstruction but identified in 46 of 50 (92%) non-obstruction cases.

Table 1. Radiographic features of the stomach, small intestine and large intestine in pet rabbits with small intestinal obstruction and without small intestinal obstruction

Measure of gastric size	Obstruction (n = 63)	Non-obstruction (n = 50)
Gastric length+width greater than or equal to length L1 to coxofemoral joint.	62 (98%)	6 (12%)
Caudal aspect of stomach extends beyond caudal aspect of L2	42 (65%)	0 (0%)
Direct contact between gastric wall and ventral abdomen.	58 (92%)	6 (12%)
Gastric contents		
Liquid with gas cap	58 (92%)	1 (2%)
Normal ingesta with large amounts of gas	4 (6%)	3 (6%)
Normal ingesta (with or without gas silhouette)	1 (2%)	46 (92%)
Radiographic feature		
Small intestinal dilation with likely liquid/gas	30 (48%)	2 (4%)
Large amounts of gas in large intestine	4 (6%)	19 (38%)

Cause of obstruction

Overall, pellets of compressed hair were responsible for 29 of 36 (81%) obstructions (where the cause of obstruction was recorded) in this study. Other causes included synthetic material ($n = 5$), omental entrapment, raw bean, seeds, dried food material and adhesions. Non-hairpellet causes of obstruction were more common (*i.e.* in four of five cases) when gastric contents consisted primarily of gas and heterogenous soft tissue opacity consistent with ingesta (Fig. 4), than where the gastric contents were primarily gas and homogenous soft tissue opacity consistent with liquid (3/31).

Small and large intestine features

Small intestinal distention with liquid and/or gas was noted in 30 of 63 (48%) obstruction cases but in only in two of 50 non-obstruction cases. In contrast, large amounts of gas in the caecum or large intestines were observed in 19 of 50 non-obstruction cases compared with four of 63 (6%) obstruction cases. Small intestine was dilated in two of 21 (10%) cases in which the obstruction was located in the pylorus or proximal duodenum, whereas it was dilated in 28 of 42 (67%) obstructions that were located distal to the proximal duodenum.

DISCUSSION

The only way to confirm intestinal obstruction in a rabbit is either through *post mortem* examination or surgery and so intestinal obstruction is only a suspected diagnosis if it is treated medically (Harcourt-Brown 2007b, Schuhmann & Cope 2014). In dogs and cats, studies have found certain clinical, laboratory and diagnostic imaging features that support the diagnosis of mechanical intestinal obstruction, and these are clinically useful when deciding whether to treat a case surgically or medically (Finck *et al.* 2014). Guidelines on clinical, laboratory and imaging features consistent with intestinal obstruction in rabbits are currently lacking, but must be species-specific, since the anatomy and physiology of rabbits varies from other domestic species. For example, sonographic diagnosis of intestinal obstruction is difficult in rabbits because of their small size and the large amount of gas within the gastrointestinal tract. The present study aimed to investigate whether there were radiographic features present in rabbits with small intestinal obstruction that were absent in those without, which could thus be used as a diagnostic tool for this disease.

Gastric dilatation has been described as a hallmark of intestinal obstruction in rabbits in numerous texts (Harcourt-Brown 2007b, Lennox 2013, Varga 2014) and supported by our study which found several measures of gastric size that were more common in cases of obstruction (Table 1). Notably, a comparison between the summed length and width of the stomach with the length from the first lumbar vertebrae to the coxofemoral joint was highly sensitive for intestinal obstruction, although this feature will need to be evaluated in another sample population to confirm its validity. It is noteworthy that there is considerable variation in the vertebral formula in rabbits (Proks *et al.* 2018), and that the number of lumbar vertebra will impact the distance

from L1 to the coxofemoral joint. Our study also found a more specific association with small intestinal obstruction based on the caudal extent of the gastric wall. This was found to be beyond the caudal extent of L2 in 65% of intestinal obstruction cases, and in none of the non-obstruction cases. Clinically, this gives a high positive predictive value of this feature for diagnosing intestinal obstruction but, again, requires validation in an independent sample population. It is important to note that gastric dilation can also occur with other conditions such as mucoid enteropathy, engorgement and paralytic ileus (Harcourt-Brown 2013).

In a healthy rabbit, the gastric contents form a large mat of hair and fibrous plant material. Radiographically this has the appearance of a heterogenous mixture of ingesta, which has a soft tissue opacity, interspersed with fine pockets of gas (Hinton & Gibbs 1982, Lennox 2013, Balicki Dorotea *et al.* 2016). There will sometimes be a layer of gas around the outside of this food/hair mass, which is termed a gas silhouette on radiographs. As discussed above, if there is a mechanical obstruction of the small intestine in a rabbit, there is accumulation of liquid and gas in the stomach, in addition to the usual hair/food ball. The liquid causes a loss of the radiographic detail and, when the rabbit is placed in lateral recumbency, the gas, if present, moves up towards the non-dependent side, and so is seen as a “gas cap” on radiographs. In right lateral recumbency this will be gas within the fundus, and in left lateral recumbency it is gas within the pylorus. This radiographic feature was found to be a useful feature of obstruction cases, being present in 92% of cases compared to just 2% of non-obstructed rabbits (Table 1).

Pellets of compressed hair were the primary cause of intestinal obstruction in this study, responsible for 81% of cases in which a cause of was identified, consistent with other reports (Harcourt-Brown 2007a). It was thus interesting that of the five cases of intestinal obstruction that did not have radiographic evidence of liquid plus gas cap in the stomach only one was caused by a pellet of compressed hair with the remaining four consisting of fibrous material ($n = 2$), omental entrapment and a raw whole bean. Other reported causes of intestinal obstruction include neoplasia, adhesions, seeds, hernias, intestinal torsions and cysts (Harcourt-Brown 2007a).

The radiographic appearance of the small and large intestine, including caecum, has also been suggested to have predictive value in the diagnosis and characterisation of intestinal obstruction in rabbits. Small intestinal dilatation, particularly segmental, has been shown to be correlated with physical obstruction in dogs, but not cats (Adams *et al.* 2010, Finck *et al.* 2014). Nevertheless, even in dogs, this feature has an overlap between obstructive and non-obstructive ileus (Finck *et al.* 2014). Interestingly, while such objective measurements are relevant, some studies have shown them to be no more accurate in the diagnosis of physical obstruction than subjective assessment alone, irrespective of the examiner’s experience (Ciasca *et al.* 2013). In the present study, small intestinal dilatation was more common in obstruction cases (48%) compared to non-obstruction cases (4%) (Table 1).

If there is an obstruction in the pylorus or proximal duodenum, it is logical to assume that there will not be any dilation

of the small intestines aborad to this. If there is an obstruction in the distal duodenum, jejunum or ileum, then it is logical to assume that there will be a build-up of ingesta/liquid/gas orad to this, and that this may cause a distention that is visible radiographically. This study found that small intestinal dilatation was predictive of where the obstruction was located, with dilatation more common if the obstruction was aborad to the proximal duodenum. One of the two radiographs that had small intestinal dilatation and an obstruction at the proximal duodenum only had a short segment of dilatation corresponding to the location of the proximal duodenum, and so it was suspected that this represented dilatation of the first segment of the duodenum orad to the obstruction. The explanation for the other case is unknown, although it may have been due to multiple obstructions with the most aborad one passing into the caecum before surgery.

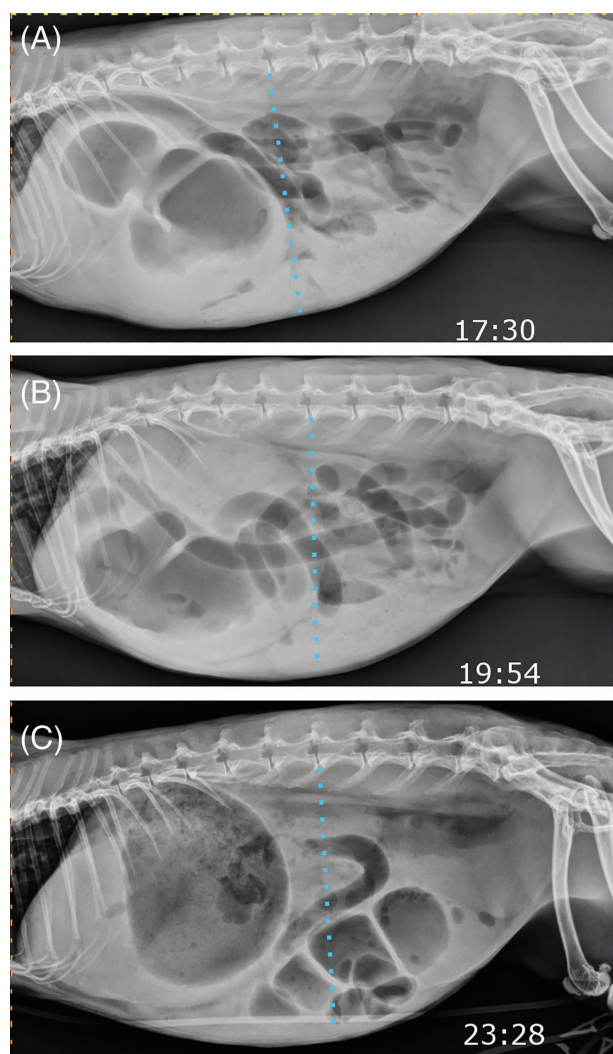


FIG 5. Serial radiographs of a rabbit with suspected intestinal obstruction. (A) initial radiograph showing gastric distention, gastric contents are mainly liquid with a gas cap, small intestinal dilatation, and little gas in the large intestine; (B) A radiograph 2 hours later showing enlargement of the stomach, which now extends caudal to L2; (C) radiograph after another 3.5 hours showing reduction in gastric size and large amounts of gas in the caecum. Blue dotted line; ventral extension of caudal extent of L2

In cases of intestinal obstruction, the choice of medical or surgical management may be dependent on obtaining serial radiographs, which can aid identification of the passage of a partial obstruction through the small intestine. Such passage may be indicated by a reduction in gastric size, appearance of small intestinal dilatation not previously present (indicating an obstruction had moved from the proximal duodenum or pylorus to a more aborad location), or the appearance of large amounts of gas into the caecum, indicating that the obstruction has passed into the caecum, allowing gas from the stomach to move through (Fig. 5). Notably, large amounts of gas in the caecum and large intestine can also be seen in other gastrointestinal conditions in the rabbit, such as gastrointestinal hypomotility.

The original aim of this study was to compare radiographic features of the rabbit abdomen in cases of intestinal obstruction with those in cases of gastrointestinal hypomotility, as this was considered to have the greatest clinical value. However, distinguishing between cases of gastrointestinal hypomotility and cases of intestinal obstruction that resolve spontaneously or due to medical treatment, is too uncertain. This is particularly evident because rabbits commonly develop gastrointestinal hypomotility secondary to the pain, stress and tissue damage associated with intestinal obstruction. Additionally, there are a number of other abdominal diseases not investigated in this study, such as liver lobe torsion, and some of these may have radiographic similarities to small intestinal obstruction.

This study was based on the case archives of a single large referral hospital, and so may be susceptible to sampling bias. Classification of the radiographs had inherent subjectivity because, even when using digital measurement tools, judgment would still be required to define the limitations of the organ of interest. For gastric size, this is often quite clear dorsally, caudally and ventrally, but can be difficult on the cranial aspect because of border effacement against the liver. Likewise, to determine whether intra-luminal gas is located within a loop of small or large intestine can be difficult, particularly if there is only a short segment affected. The use of a singular radiographic projection was also a limitation, as a more complete three-dimensional understanding can be obtained through the use of orthogonal views.

This study presents radiographic features of 63 cases of confirmed physical small intestinal obstruction in pet rabbits, and compares them with those in 50 rabbits with non-gastrointestinal disease. The findings indicate that gastric size, small and large intestinal appearance and gastric contents are all useful radiographic features when diagnosing intestinal obstruction.

Conflict of interest

None of the authors of this article has a financial or personal relationship with other people or organisations that could inappropriately influence or bias the content of the paper.

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