Association of intestinal disorders in cats with findings of abdominal radiography

William M. Adams, DVM, DACVR; Laura A. Sisterman, DVM; Julia M. Klauer, BS; Barbara M. Kirby, DVM, MS, DACVS; Ting-Li Lin, MS

Objective—To compare the radiographic appearance of small and large intestines of cats with various medical conditions and create a quantitative index for interpretation of intestinal diameters on radiographic views of the abdomen.

Design—Retrospective cohort study.

Animals—74 cats that underwent abdominal radiography.

Procedures—Cats were assigned to 1 of 4 diagnosis categories: nonobstructive gastrointestinal tract disease (n = 20), nonobstructive gastrointestinal tract disease (32), linear foreign body (LFB; 11), and small intestinal mechanical obstruction not caused by an LFB (11). Abdominal radiographs were evaluated without knowledge of history or diagnosis. Maximum and minimum external small intestine diameter (SID) and colon diameter (CD) were compared; dorsoventral and mediolateral measurements of the cranial end plate of L2 (VEL2) and L5 vertebrae were compared. Dorsoventral height of VEL2 from lateral radiographic views was used to determine maximum-SID/VEL2 and maximum-CD/VEL2 ratios. Gas patterns were evaluated.

Results—Nonobstructive gastrointestinal tract disease was more likely than obstruction until a maximum-SID/VEL2 ratio > 2.0. At a maximum-SID/VEL2 ratio of 2.5, probability of a disease not related to the intestinal tract was < 4%. At a maximum-SID/VEL2 ratio of 3.0, probability of mechanical intestinal obstruction was 70%. When the maximum-CD/VEL2 ratio was 2.0, probability of LFB was 50%; as the maximum-CD/VEL2 ratio increased beyond 2.0, likelihood of LFB decreased. Both gas pattern and CD correlated with diagnosis category.

Conclusions and Clinical Relevance—Normalizing ratios of maximum-SID/VEL2 and maximum-CD/VEL2 obtained from measurements on lateral radiographic views of the abdomen in cats were related to diagnosis category. (J Am Vet Med Assoc 2010;236:880–886)

Mechanical intestinal obstruction, LFB, lymphocytic plasmacytic enteritis, and intestinal lymphosarcoma are important differential diagnoses for cats with acute or persistent vomiting. The diagnosis of intestinal obstruction is often made on the basis of findings on survey radiographic views of the abdomen. Although LFB is classically evidenced radiographically by a characteristic bunching of the small intestines, other mechanical obstructions can be harder to identify in the absence of a radiopaque foreign body; often, dilation of the small intestines orad to the obstruction becomes the most telling radiographic sign. Recognition of intestinal segments of varying diameter coupled with abnormal dilation of a segment depends on the experience of the observer and published reference range values for SID. In dogs, a quantitative index for SID has been established by relating SID to lumbar vertebral body measurements on survey radiographic views of the abdomen. This index can be used as an indicator of small intestinal obstruction. The amount of small intestinal gas, gas patterns, and plication of intestines have been used as radiographic indicators of intestinal disease in dogs and cats. Little is known of any secondary effects of small intestinal diseases on CD. The purpose of the study presented here was to compare the radiographic appearance of the small and large intestine, including the amount and patterns of intestinal gas, and create a quantitative index for interpretation of intestinal diameters on radiographic views of the abdomen from cats with various medical conditions.

Materials and Methods

Case selection—Abdominal radiographic images of cats that underwent abdominal radiography at the Animal Emer-
...gery Center of Glendale, Wis, and the University of Wisconsin Veterinary Medical Teaching Hospital from January 1995 through June 2005 were retrospectively identified by a search of medical, surgical, and radiology records. Records of all cats that underwent exploratory laparotomy were searched at the Animal Emergency Center, whereas records of all cats that underwent abdominal radiography were searched at the veterinary medical teaching hospital. Criteria for inclusion were that each cat had diagnostic-quality, orthogonal radiographic views (ie, 1 lateral view and 1 ventrodorsal view) of the abdomen and a confirmed diagnosis.

procedures—Cats were assigned to 1 of 4 groups on the basis of having the following diagnoses as recorded in the medical records: group A, no signs of gastrointestinal tract disease (but survey radiographic images of the abdomen available) or a diagnosis unassociated with the intestinal tract; group B, nonobstructive gastrointestinal tract disease; group C, intestinal LFB; and group D, small intestinal obstruction not caused by an LFB. Diagnoses recorded for cats in group A (ie, those without gastrointestinal tract disease) had been confirmed by use of ultrasonography or laparotomy, or necropsy.

All radiographic views of the abdomen were reviewed by 1 author (LAS), under the supervision of a diplomate of the American College of Veterinary Radiologists (WMA); both authors were unaware of the history, clinical signs, and diagnosis for each cat. The following measurements were made from radiographic views of the abdomen: dorsoventral height and lateromedial width of the cranial epiphyses (ie, end plates) of L2 and L5 vertebrae, max-SID and mini-SID, and maxCD and miniCD (Figure 1). In addition, the length of L7 was measured from lateral radiographic views of the abdomen of 10 cats randomly chosen from this study for comparison with maxCD. All measurements were taken with a caliper and were recorded in millimeters. Vertebral end plate measurements from both radiographic views of the abdomen (ie, lateral and ventrodorsal views) were compared for consistency for each cat. Dorsoventral height of the VEL2 was chosen for analyses. The SID-VEL2 ratios were calculated on the basis of maxSID and miniSID, and the CD-VEL2 ratios were calculated on the basis of maxCD and miniCD. For each radiographic view of the abdomen, the portion of the small intestines that contained gas was subjectively assessed as <25%, 25% to 50%, and >50%. Gas patterns were defined from ventrodorsal and right lateral radiographic views of the abdomen as a linear (noncircumscribed), bubble (locally circumscribed), or comma-shaped gas pattern, and incidence of each pattern or a combination of patterns was recorded. Presence or absence of a plicated (ie, bunched) appearance of small intestines was recorded. Amount of feces that filled the colon was subjectively assessed as <25%, 25% to 50%, and >50%.

Statistical analysis—Multinomial logistic regression models were used to evaluate the correlation of SID, max-SID, miniSID ratio, SID-VEL2 ratio, CD-VEL2 ratio, gas pattern, amount of gas, amount of feces, and bunching of intestines with diagnosis category. Analysis of deviance was performed to assess the clinical importance of the relationship between each measurement and diagnosis group of cats. Values of P < 0.05 were considered significant.

Results

Medical record review—Seventy-four cats met the inclusion criteria for this study. Of the 74 cats, 20 were included in group A because they either did not have clinical signs of gastrointestinal tract disease or had a diagnosis unassociated with the intestinal tract (eg, urolithiasis, pancreatitis, and hepatopathy). 32 were included in group B because they had nonobstructive gastrointestinal tract diseases (inflammatory bowel disease [n = 15], gastritis [7], intestinal lymphoma [6], gastric foreign bodies not involving the small intestine [3], and gastric parasites [1]), 11 were included in group C because they had an intestinal LFB, and 11 were included in group D because they had a small intestinal obstruction not caused by an LFB (non-LFB [7] or an intraluminal neoplastic mass [4]).

Domestic shorthair (n = 43) was the most common of the 10 breeds represented. Neutered males (n = 36) were slightly overrepresented, compared with spayed females (30), and there were 4 male and 4 female cats that were sexually intact. Body weights were available for 69 cats, ranging from 1.44 to 7.80 kg (3.17 to 17.20 lb) with a median of 4.22 kg (9.30 lb). Ages ranged from 2.5 months to 17.5 years, with mean and median ages of 7.2 years and 4.9 years, respectively. Median ages for cats in groups A, B, C, and D were 9.8, 7.8, 2.3, and 4.0 years, respectively.

Vertebrae measurements—Although end plate heights for all cats ranged from 6.5 to 11 mm, there was no significant difference between VEL2 and VEL5 heights on the lateral radiographic view of the abdo-

![Figure 1](image-url)
men. However, there was a significant difference between widths of VEL2 and VEL5 on the ventrodorsal radiographic view. Widths of VEL2 and VEL5 for all cats ranged from 9.5 to 17.5 mm, and VEL2 widths were significantly ($P < 0.001$) less than VEL5 widths. There was also a significant ($P < 0.001$) difference between VEL2 width measured from the ventrodorsal radiographic view and VEL2 height measured from the right lateral view. This difference caused a marked disparity when SID:VEL2 ratios were compared between ventrodorsal and lateral radiographic views; median ratios were 0.93 when measured from the ventrodorsal radiographic view and 1.35 from the right lateral radiographic view. Similar significant differences were found when SID: VEL5 ratios were compared between those obtained from ventrodorsal and lateral radiographic views. Because of similarities in VEL2 and VEL5 heights, only measurements involving VEL2 height are reported. The median height of VEL2 on the right lateral view for all cats was 8.5 mm (range, 6.5 to 10.5 mm).

Small intestine measurements—There was no significant relationship between maxSID or minSID and cat group. The duodenum could be confidently identified on radiographic images of only 4 of the 74 (5%) cats. The maxSID of all cats ranged from 7 to 37 mm. The median maxSID for cats in groups A, B, C, and D was 11, 11, 12, and 13 mm, respectively. The minSID of all cats ranged from 6 to 11 mm (median, 8 mm). Median maxSID: minSID ratios for cats in groups A, B, C, and D were 1.29, 1.40, 1.41, and 2.08, respectively. For group D cats (ie, those with small intestinal obstruction not caused by an LFB), the maxSID: minSID ratio ranged from 1.45 to 2.52. No significant relationship was found between the maxSID: minSID ratio and cat group.

A significant ($P = 0.009$) correlation was found between the maxSID: VEL2 ratio and cat group. The maxSID: VEL2 ratio ranged from 0.85 to 4.15 (mean, 1.47; median, 1.39). Range of maxSID: VEL2 ratios for cats of groups A, B, C, and D was 0.85 to 1.89, 0.93 to 4.15, 1.03 to 1.91, and 1.24 to 2.75, respectively. Of the 20 group A cats (ie without clinical signs of gastrointestinal tract disease), 4 had a maxSID: VEL2 ratio > 1.5, although all had a ratio < 1.9 and the median was 1.23. The estimated probability of nonobstructive gastrointestinal tract disease was greater than LFB or obstructive intestinal disease up to a maxSID: VEL2 ratio of 2.0, and probability of intestinal obstruction exceeded 0.5 only above a ratio of 2.5 (Table 1). Median maxSID: VEL2 ratio for cats with small intestinal obstruction (group D) was 1.93 (3/11 group D cats had a ratio ≥ 2.0), with 95% confidence in a diagnosis of small intestinal obstruction at a maxSID: VEL2 ratio > 4.0. Little correlation was seen between LFB and the maxSID: VEL2 ratio. There was no significant relationship between the minSID: VEL2 ratio and cat group.

The highest maxSID: VEL2 ratio (4.15) was not associated with mechanical obstruction. That cat had a maxSID of 37 mm as a result of severe segmental distal jejunal ulcerative lymphoplasmacytic enteritis, which was subsequently resected. The next 3 highest maxSID: VEL2 ratios among group B cats (ie, those with nonobstructive gastrointestinal tract disease) ranged from 1.67 to 1.9.

Colon measurements—There was a significant ($P = 0.005$) relationship between maxCD and cat group. The maxCD of all cats ranged from 11 to 37 mm, with both a mean and median value of 23 mm. Five of 11 group C cats (ie, those with an LFB) had a maxCD < 20 mm. When maxCD was < 20 mm, probability of LFB was the highest (up to 0.6); as the CD increased, the estimated probability of LFB decreased sharply (as low as 0.05). The colon could be measured in 10 of the 11 group D cats (ie, those with intestinal obstruction). MaxCD for 8 of those 10 cats was between 20 and 23 mm. One cat in group C and 2 in group D had a maxCD > 22 mm (< 15% of those 2 diagnosis groups, combined). Although group B cats (ie, those with nonobstructive gastrointestinal tract disease) had the widest range of values for maxCD (15 to 38 mm), 20 of the 31 cats in this group for which the colon could be measured had a maxCD > 23 mm. Of the 6 cats with a maxCD of 32 to 37 mm, 4 were in group B and 3 of these cats had colitis. Idiopathic megacolon was not diagnosed among the 74 cats studied. The middle 50% of maxCD values was nearly identical for group A and B cats. The maxCD range for group A cats (ie, those without gastrointestinal signs) was 16 to 32 mm, with a median of 24 mm. The mean and median lengths of L7 of 10 randomly chosen cats from this study were 17.4 and 18.5 mm, respectively. Fifteen of 20 group A cats had maxCD measurements that exceeded the 18.5-mm median length of L7. The minCD ranged from 5 to 31 mm (median minCD, 14 mm).

A significant ($P = 0.02$) relationship was found between maxCD: VEL2 ratio and cat group. MaxCD: VEL2 ratios of all cats ranged from 1.4 to 4.5, with a mean of 2.75 and median of 2.81. Median maxCD: VEL2 ratio

<table>
<thead>
<tr>
<th>Groups</th>
<th>No. of cats</th>
<th>Median maxSID:VEL2 ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>20</td>
<td>1.28</td>
</tr>
<tr>
<td>B</td>
<td>32</td>
<td>1.31</td>
</tr>
<tr>
<td>C</td>
<td>11</td>
<td>1.47</td>
</tr>
<tr>
<td>D</td>
<td>11</td>
<td>1.95</td>
</tr>
</tbody>
</table>

Table 1.—Estimated probability of diagnosis category (ie, cat group) versus maxSID: VEL2 ratio as determined from measurements made from right lateral radiographic views of the abdomen in 74 cats.*

* A significant ($P = 0.009$) correlation was found between the maxSID: VEL2 ratio and cat group. Group A = Cats without gastrointestinal tract disease (but survey radiographic images of the abdomen available) or a diagnosis unassociated with the intestinal tract. Group B = Cats with nonobstructive gastrointestinal tract disease, Group C = Cats with intestinal LFB. Group D = Cats with small intestinal obstruction not caused by an LFB.
for group A, B, C, and D cats was 2.8, 3.0, 2.3, and 2.6, respectively. When the maxCD:VEL2 ratio was 1.5, probability of LFB was 0.5; as maxCD:VEL2 ratio increased, likelihood of an LFB steadily decreased to 0.04 at a ratio of 4.5. Conversely, when maxCD:VEL2 ratio was 1.5, probability of nonobstructive gastrointestinal tract disease was 0.14; as maxCD:VEL2 ratio increased, likelihood of nonobstructive gastrointestinal tract disease steadily increased to 0.76 at a ratio of 4.5 (Table 2). A decreased incidence of obstructive disease with increased maxCD:VEL2 ratios was not significant. There was no relationship between maxCD:VEL2 ratio and lack of gastrointestinal tract disease.

When results of the maxSID:VEL2 ratio and maxCD:VEL2 ratio were combined, a significant ($P = 0.005$) correlation was found between the combined ratios and cat group. For example, if the maxSID:VEL2 ratio was $\leq 2.0$ and the maxCD:VEL2 ratio was $> 2.5$, there was low probability (0.11) of small intestinal obstruction and high probability (0.57) of nonobstructive gastrointestinal tract disease.

There was no significant ($P = 0.93$) relationship between the length of colon containing feces and cat group. For groups A, B, C, and D, 10 of 20, 13 of 32, 4 of 11, and 5 of 11 cats, respectively, had feces in $> 50\%$ of the descending colon. Of the 74 cats, 7 had no feces in the colon; all cats without signs of gastrointestinal tract disease (group A) and 9 of 11 cats with an LFB (group C) had some feces in the colon.

Small intestinal gas—The amount of gas detected radiographically throughout the small intestines was quite variable, with no significant ($P = 0.19$) relationship between the amount of gas and cat group. Of the 74 cats, only 1 had no observable gas in the small intestines, although nearly half ($n = 34$) of the cats had gas in $< 25\%$ of the small intestines. Nearly a quarter ($n = 18$) of the cats had gas in 25% to 50% of the small intestines, and another 28% ($21$) of cats had gas in $> 50\%$ of the small intestines. In cats with no gastrointestinal tract disease (group A cats), 1 cat had no gas and 6, 6, and 7 cats had gas in $< 25\%$, 25% to 50%, and $> 50\%$ of the small intestines, respectively.

Intestinal gas pattern and a combination of gas patterns were significantly ($P = 0.001$) related to cat group. Linear, bubble, and comma-shaped gas patterns were seen in radiographic images of 67, 19, and 12 cats, respectively. A linear gas pattern was seen exclusively in 49 cats, of which 13 were cats with no intestinal disease (ie, group A cats). The bubble gas pattern was seen exclusively in only 3 cats, and all had gastrointestinal tract disease. However, 6 cats had a bubble gas pattern combined with a linear gas pattern and no intestinal disease. No cat had a comma-shaped gas pattern exclusively. Of the 12 cats in which a comma-shaped gas pattern was identified, 11 had gastrointestinal tract disease, of which 7 had an LFB (ie, 7/11 group C cats). All 5 cats that had a combination pattern of linear and comma-shaped gas had surgical disease. The combination of a linear gas pattern and bubble gas pattern seen in 9 cats did not correlate with gastrointestinal tract disease, as over half of the cats ($n = 6$) with that combination of gas patterns were from group A (ie, those with no gastrointestinal tract disease). There was no significant relationship between the amount of small intestinal gas or intestinal gas pattern and cats with infiltrative intestinal lymphosarcoma ($P = 0.66$) or inflammatory bowel disease ($P = 0.55$).

Plication of the small intestines was noted on radiographic images of 10 of the 72 cats for which it could be evaluated; radiographic appearance of the small intestines could not be evaluated for 2 cats with pancreatitis; 1 cat was markedly obese with a fecal filled colon, and the other was thin, with mild abdominal effusion found on abdominal ultrasonography. Plication of the small intestines was significantly ($P < 0.001$) related to LFB, as this radiographic finding was identified for 7 of the 11 group C cats (estimated probability 0.64). Estimated probability of intestinal plication was 0.00 to 0.05 for the other 3 cat groups. All 10 cats with plication of the small intestines had conditions that required abdominal surgery.

A significant ($P < 0.001$) relationship was found between plication of the small intestines and various gas patterns. There was a very low likelihood of only a linear gas pattern if plication of the small intestines was present (an incidence of 0 in this series of cats). Conversely, if a linear gas pattern was combined with a comma-shaped gas pattern or a combination of linear, comma, and bubble patterns, the likelihood of plication of the small intestines was highest (estimated probability of 0.33 for each of these 2 gas patterns). Eight of 10 cats with small intestinal plication had a comma-shaped gas pattern.

**Discussion**

Evaluation of abdominal radiographs in the series of cats presented here revealed that when the maxSID:VEL2 ratio was $\geq 2.0$, gastrointestinal tract disease was present. At a maxSID:VEL2 ratio of $\geq 2.5$, the most likely abnormality was intestinal obstruction. Findings

<table>
<thead>
<tr>
<th>Groups</th>
<th>No. of cats</th>
<th>Median maxCD:VEL2 ratio</th>
<th>Probability values based on maxCD:VEL2 ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>1.5</td>
</tr>
<tr>
<td>A</td>
<td>20</td>
<td>2.79</td>
<td>0.19</td>
</tr>
<tr>
<td>B</td>
<td>31</td>
<td>3.02</td>
<td>0.14</td>
</tr>
<tr>
<td>C</td>
<td>11</td>
<td>2.30</td>
<td>0.50</td>
</tr>
<tr>
<td>D</td>
<td>10</td>
<td>2.55</td>
<td>0.17</td>
</tr>
</tbody>
</table>

* A significant ($P = 0.02$) correlation was found between the maxCD:VEL2 ratio and cat group. See Table 1 for remainder of key.

<table>
<thead>
<tr>
<th>No.</th>
<th>P</th>
<th>P</th>
<th>P</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>2.55</td>
<td>2.0</td>
<td>2.5</td>
<td>3.0</td>
</tr>
<tr>
<td>B</td>
<td>3.5</td>
<td>1.5</td>
<td>2.30</td>
<td>2.6</td>
</tr>
</tbody>
</table>

Table 2—Estimated probability of diagnosis category (ie, cat group) versus maxCD:VEL2 ratio as determined from measurements made from right lateral radiographic views of the abdomen in 72 cats.*

---

For the table above, the figures represent probabilities based on the maxCD:VEL2 ratio. The table lists the number of cats in each group, the median maxCD:VEL2 ratio, and the probability values for different maxCD:VEL2 ratios. The probabilities were calculated using a significant ($P = 0.02$) correlation between the maxCD:VEL2 ratio and cat group. The table highlights the likelihood of various gastrointestinal conditions based on the radiographic findings.

---

The Statistical Analysis System (SAS) is a software suite for advanced analytics, business intelligence, data management, and predictive analytics. It provides a comprehensive set of tools for data analysis, data management, and data visualization. SAS is widely used in various fields, including medicine, research, and business, for statistical analysis and data management.

---

The radiographic images of the cats were analyzed to determine the presence and type of gas patterns, as well as other diagnostic signs. The findings were correlated with the clinical and diagnostic data to provide insights into gastrointestinal tract disease.
in the present study indicate that a maxSID:VEL2 ratio of \( \geq 2.0 \) is abnormal in cats. It has been previously suggested that the SID of cats without gastrointestinal disease should not exceed twice the height of the central portion of L4.\(^2\)\(^,\)\(^6\) The central portion is approximately 0.8 the height of the L4 vertebral end plate. For cats presented here without gastrointestinal tract disease (group A), the median maxSID:VEL2 ratio was 1.23, but 4 of the 20 group A cats had maxSID:VEL2 ratios that ranged from 1.0 to 1.9. In another study\(^2\) on 20 clinically normal cats from which food had been withheld for 24 hours prior to abdominal radiography, the SID was consistently \(< 12 \text{ mm}. \) In the present study, although the minSID in the 20 cats without gastrointestinal tract disease (group A cats) did not exceed 12 mm, 5 group A cats had a maxSID that ranged from 13 to 17 mm and the median maxSID for all group A cats was 11 mm. Compared with previous studies,\(^2\),\(^6\) data from the present study indicate that a more generous maxSID:VEL2 ratio of \(< 2.0 \) may be appropriate for cats without gastrointestinal disease. This correlates with the larger maxSID found in group A cats in the present study, compared with clinically normal cats in a previous report.\(^2\)

In a study\(^6\) on 5 clinically normal cats that had food withheld for 12 hours and underwent an enema at least 1 hour prior to abdominal radiography, the SID ranged from 5.5 to 8.0 mm. However, in the present study, 8 of 19 cats without gastrointestinal tract disease for which the minimum intestinal diameters could be measured (group A cats) had a minSID of \(> 8 \text{ mm} \) and 19 of 20 group A cats had a maxSID of \(> 8 \text{ mm} \). In the present study, no significant relationship was found between maxSID and gastrointestinal tract disease. Contrasted with other studies,\(^2\)\(^,\)\(^6\) the present study included cats (\( n = 6 \)) that were \(< 1 \text{ year old}, \) food was not intentionally withheld from any cats prior to abdominal radiography, cats were not administered an enema prior to radiography, and all cats were being evaluated for some medical condition (although the 20 group A cats had no evidence of gastrointestinal tract disease). Inclusion of immature cats in the present study may have confounded analysis of intestinal diameter, but is justified by the recognition that this subpopulation is more prone to idiopathic indiscernition than mature cats, a notion verified by the median age being quite young in group A cats (ie, those with an LFB), consistent with a previous report.\(^6\) Median age of group D cats (ie, those with small intestinal obstruction) was also younger than the median age of the total study population (despite the inclusion of 4 mature group D cats that had obstruction caused by intestinal neoplasia). Testing a measurement method for determining gastrointestinal tract disease on the basis of a cross section of feline patients may be more clinically appropriate than measurements from clinically normal cats from which food has been withheld in a research setting.

In the present study, overlap in the range of intestinal diameters (maxSID, 7 to 36 mm; minCD, 3 to 31 mm) of cats emphasizes the importance of distinguishing the small intestine from the colon when interpreting abdominal radiographs and measurement results. Comparing intestinal distribution on both left and right lateral views as well as the ventrodorsal view of the abdomen can be helpful. When a question remains as to whether an intestinal segment is the small intestine or colon, insufflation of room air into the rectum to create a pneumocolon and repeating 3-view abdominal radiography may also be helpful.\(^10\)

The CD is reported to be 2 to 3 times the SID in cats.\(^11\) Similarly, in the present study, the median maxCD was 24 mm and the median maxSID was 11 mm for the 20 cats without gastrointestinal tract disease (group A cats). On the basis of end plate ratios calculated from cats without gastrointestinal tract disease, median values for the maxSID:VEL2 ratio and maxCD:VEL2 ratio were 1.3 and 2.8, respectively, suggesting that the CD may be approximately 2.2 times the SID in cats without gastrointestinal tract disease. Normal CD is also reported to be less than the length of the body of L7.\(^12\) As 15 of 20 group A cats exceeded that reported maximum CD threshold, findings in the present study do not support that comparison.

In a study\(^1\) on dogs, an SID:L5 (vertebral body height rather than end plate height) ratio of \(> 2.19 \) in that species provided 95% confidence in a diagnosis of intestinal obstruction. By comparison in the present study, a maxSID:VEL2 ratio of \(> 4.0 \) in cats provided 95% confidence in a diagnosis of intestinal obstruction. Also, in the study on dogs,\(^1\) an SID:L5 (vertebral body height ratio) of 1.6 was suggested as the upper limit for clinically normal dogs. Because 10 of 20 group A cats (ie, without gastrointestinal tract disease) had a maxSID:VEL2 (vertebral end plate height) ratio \(> 1.2 \) and as high as 1.89, there is likely a substantial species difference to be accounted for in applying vertebral ratio measurement methods. Discrepancy in lumbar ratio measurements between dogs and cats could be attributable to a difference in the lumbar vertebral body length-to-dorsventral height ratio, which appears greater in cats than in dogs. Although cats do not vary in size as much as dogs, there was considerable size variation in this series of cats, with immature cats included. The use of measurements of L2 to normalize intestinal diameter measurement can correct for differences in cat body sizes, similar to the normalizing concept reported with L5 in dogs.\(^3\)

Successful application of the intestinal diameter-to-vertebral end plate ratio in determining intestinal enlargement requires attention to several details. First, either VEL2 or VEL5 vertebral bodies can accurately be used, but only on the lateral radiographic views. Because of the significant difference in width of these 2 vertebrae when viewed in the ventrodorsal projection, separate standards would have to be determined for individual vertebrae to use the ventrodorsal radiographic view of the abdomen. Second, there was a significant difference between width and height as measured on ventrodorsal and lateral radiographic views, respectively, for both VEL2 and VEL5, indicating an ellipsoid cross-sectional shape of the lumbar vertebral bodies. Because of this ellipsoid shape, true lateral positioning is required for accurate application of these presented standards. Finding that measurements from these 2 lumbar vertebral end plates were essentially identical is advantageous, in the event that 1 of them is malformed or has degenerative
changes. A third detail required for accurate application of these findings is to accurately identify the small intestine. As the median CD:VEL2 ratio was more than twice that of the small intestine, misidentification could lead to clinically relevant misdiagnoses.

A potential shortcoming of the study was the inability to identify the duodenum in > 90% (70/74) of cats studied. The duodenum not being identifiable on radiographs of the abdomen of cats has been reported. The proximal portion of the duodenum is frequently identifiable on abdominal radiographs of dogs and is reported to be slightly greater in diameter than the jejunum. This may have affected the results of the present study if the duodenum was larger than and mistaken for the jejunum in some measurements. That possibility was taken into consideration, as intestinal loops were chosen for measurement. A loop was consciously chosen in the mid to caudal portion of the abdomen for measuring maxSID, whenever possible.

For cats in groups A, B, and D, there were clear changes in probability of disease with increasing maxSID:VEL2 ratios. Although infiltrative disease has been noted by others to cause increased intestinal diameter, the limited data in the present study did not confirm this. For example, 21 of 32 group B cats (ie, those with nonobstructive gastrointestinal tract disease) had infiltrative or inflammatory bowel disease, yet 23 of 32 group B cats had maxSID:VEL2 ratios < 1.5, similar to the number of cats (16/20) without gastrointestinal tract disease. This finding is in agreement with that of a study on 9 cats with inflammatory bowel disease that did not have increased intestinal diameter. Conversely, only 2 of 11 group D cats with small intestinal obstruction had a maxSID:VEL2 ratio < 1.5, and 5 of the group D cats had a maxSID:VEL2 ratio > 2.0. When evaluating the probability of LFB on the basis of maxSID:VEL2 ratio, no correlation was found. This may be because most cats with an intestinal LFB have partial obstruction and only mildly distended small intestines.

Plication of the intestines was an important radiographic finding in 7 of 11 (64%) cats with an LFB in the present study. Previously, the radiographic finding of plication of the small intestine has been reported for 21% to 52% of cats with LFB. Three cats had the radiographic appearance of plication of the small intestines, but did not have an LFB. Accumulation of fat in the omentum and falciform ligament in obese cats can displace the small intestine into the mesogastric area, giving the appearance of bunching of the intestine without the presence of an LFB. The significant relationship between diagnosis category and maxCD:VEL2 ratio was distinctly different from that found for the maxSID:VEL2 ratio. Of the 32 cats with nonobstructive gastrointestinal disease (group B cats), 17 had a maxCD:VEL2 ratio ≥ 3.0; high maxCD:VEL2 ratios were correlated with nonobstructive gastrointestinal tract disease. Conversely, only 1 group C cat with an LFB and 2 group D cats with a small intestinal obstruction had a maxCD:VEL2 ratio ≥ 3.0; incidence of both LFB and obstruction decreased as the maxCD:VEL2 ratio increased. The significantly smaller CD of cats with an LFB may relate to observations that in mechanical obstruction, intestinal evacuation occurs aboral to the obstruction.

There was no correlation between presence of gas in the small intestine and disease. Over half (40/74) of the cats had gas in at least 25% of their small intestines, and 8 of 20 cats without gastrointestinal tract disease had gas in > 50% of their small intestines. In a previous report of 26 cats that had normal findings on upper gastrointestinal contrast studies, 83% had no observable gas in the small intestines. In another study, it was reported that radiographic detection of gas in the small intestines of clinically normal cats is rare. These reported differences in incidence of gas in the small intestines may be attributable to the fact that none of the cats in the present study had food withheld for 24 hours or had an enema prior to abdominal radiography, as has been done in previous studies.

There was a much higher probability of having an abnormal gas pattern (bubble gas pattern or comma-shaped gas pattern) with intestinal plication associated with an LFB. As intestinal loops become plicated, gas is trapped in pockets formed by the pleats. The result is an abnormal pattern of round, tapered, or short tubular gas shapes. Root and Lord found an increase in the bubble gas pattern in the small intestinal lumen of 62% of cats with an LFB. Felts et al found a comma-shaped (tapered) gas pattern in the small intestines of 32% of cats with an LFB. In the present study, the finding that 7 of 11 (64%) cats with an LFB had a comma-shaped gas pattern in the small intestines is consistent with findings in these previous reports; however, 5 of 12 cats that had a comma-shaped gas pattern did not have an LFB. This suggests that although a comma-shaped gas pattern is nearly always an abnormal radiographic finding, it is not pathognomonic for an LFB.

References


Objective—To determine the spectrum and frequency of abnormalities for low-field magnetic resonance imaging (MRI) examinations of clinically normal Doberman Pinschers and Foxhounds.

Animals—37 clinically normal dogs (20 Doberman Pinschers and 17 Foxhounds).

Procedures—For each dog, MRI of the cervical vertebrae (sagittal, dorsal, and transverse T1- and T2-weighted images) was performed. Variables assessed were intervertebral disk degeneration, disk-associated compression, compression of the dorsal portion of the spinal cord, vertebral body abnormalities, and changes in intraparenchymal signal intensity. Associations between these variables and age, breed, sex, and location of the assessed intervertebral disk spaces were evaluated.

Results—Severe MRI abnormalities were detected in 17 dogs, including complete disk degeneration (n = 4 dogs), spinal cord compression (3), or both (10). Vertebral body abnormalities were detected in 8 dogs, and hypertense signal intensity was detected in 2 dogs. Severity of disk degeneration and disk-associated compression was significantly associated with a higher age. There was a significant association between disk degeneration, disk-associated compression, and compression of the dorsal aspect of the spinal cord and location of the assessed intervertebral disk space, with the intervertebral disk spaces in the caudal portion of the cervical region being more severely affected.

Conclusions and Clinical Relevance—Abnormalities on MRI examinations were commonly seen in the caudal portion of the cervical vertebral column and spinal cord of clinically normal Doberman Pinchers and Foxhounds. Such lesions were probably part of the typical spinal cord degeneration associated with the aging process of dogs. (Am J Vet Res 2010;71:428–434)