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Radiographic Evaluation of Small Intestinal Diameter in Small Breed Dogs

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Abstract : The purpose of the present study was to prove our empirical tendency of relatively high small intestinal diameter (SI) to fifth lumbar vertebral height (L5) ratio, which has been used in dogs. In this study, the ratio of SI/L5 was determined in small breed dogs weighing less than 5 kg. In addition, the effect of large volume of contrast media on the intestinal dilation was determined by performing upper gastrointestinal contrast study. Abdominal radiography and upper gastrointestinal series were performed in twelve healthy dogs weighing less than 5 kg. Small intestinal diameter (SI), fifth lumbar vertebral height (L5), and twelfth rib diameter were measured on abdominal radiographs. The range of values of SI/L5 is from 1.03 to 2.26 in plain radiography, and from 1.55 to 2.5 in contrast studies. Contrast agent significantly increased small intestinal diameter, and could be considered as mildly dilated intestinal model. Therefore, a value of 2.1 for SI/L5 is recommended as the upper limit of the normal range suggesting nonobstructive intestinal dilation.

Key words **:** intestinal diameter, upper GI series, small breed dogs.

Introduction

Intestinal dilation is an important radiographic finding for diagnosis of intestinal obstruction or functional ileus in the dog presented with vomiting (8). Survey abdominal radiographs and the barium upper gastrointestinal study (UGI) are often the most helpful and readily available diagnostic methods. The radiological signs associated with intestinal obstruction include intestinal dilation, a visible foreign body, retention of ingesta proximal to the lesion, stacking of bowel loops, squared-off dilated loops, multiple fluid levels on standing lateral films and increased peritoneal fluid (1,2,8). Of these, intestinal dilation and the visualization of the foreign body are the most important signs of obstruction. However, the cause of the obstruction is frequently radiolucent or obscured by superimposed gas shadows and hence intestinal dilation is usually the only sign even though it could not be shown just after vomiting.

Therefore, normal range of intestinal diameter is very important for evaluation of functional or mechanical ileus. The upper limit for normal small intestinal size of the cat has been defined as 12 mm (11), and in man as 3 cm (4). In a previous report, the normal size for the canine duodenum was determined in relation to the length of the second lumbar vertebra (10). In another report (5), Graham *et al.* estimated a ratio of the maximum small intestinal diameter (SI) and the height of the body of the fifth lumbar vertebra at its narrowest point (L5). They recommended a value of 1.6 for SI/L5 as the upper limit of normal intestinal diameter for clinical use. Their model showed that obstruction is very unlikely if the SI/L5 value is less than this, and higher values were significantly associated with obstruction (5). Another method for evaluation of small intestinal diameter has been applied in the dog, which is that normal loops will not usually exceed the height of an endplate of a lumbar vertebral body, or twice the width of the 12th rib (1). To our experience, small breed dogs have relatively small lumbar than that of large breed dogs compared to the size difference of small intestine between large and small breed dogs. The purpose of the present study was to prove our empirical tendency of relatively high SI/L5 ratio in small breed dogs by relating intestinal diameter to lumbar and rib and to determine applicable index for small dogs weighing less than 5 kg. Additionally, the effect of large volume of contrast media on the intestinal dilation was determined.

Materials and Methods

Twelve (2 male and 10 female) healthy various breeds small dogs, ranging from 3 to 5 years old (mean age: 3.6 years) in weight from 2.5 to 5 kg (mean weight: 3.75 kg) were used. All dogs were screened for signs of gastrointestinal and systemic disease by physical examinations and clinical laboratory analysis including complete blood count, serum biochemistry and urinalysis. Thoracic and abdominal radiography (XPLORER-900®, Medien international co., Ltd. Korea) and abdominal

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ultrasonography (SONOACE 8800®, MEDISON, Korea) revealed no significant findings for gastrointestinal tract. All experimental animals were fasted for approximately 12 hours before the experiment.

30% barium sulfate (EasySB®, Taejoon Pharm., Seoul, Korea) was used for contrast media without additional dilution procedure. Conventional upper gastrointestinal (GI) studies were performed using the following technique. Before administration of contrast medium, survey radiographs were made to confirm an empty GI tract. Twelve dogs received 12 ml/kg of 30% barium. The contrast medium was administered through an orogastric tube directly into the stomach, and each dog was then radiographed serially at intervals of 10 minutes until the contrast reached the cecum. Right lateral and ventrodorsal abdominal projections were made in all the groups.

The height of the body of the fifth lumbar vertebra (L5) was measured at its narrowest point on the lateral radiograph (Fig 1). The maximum small intestinal external diameter (SI) was measured, either on a lateral or ventrodorsal survey radiograph. The diameter of twelfth rib was measured at its widest point on the lateral radiograph (Fig 1). All measurements were preformed three times on precontrast and contrast radiographs using internal caliper of picture archiving & communication system (PACS) viewer after magnification of radiography to make boundaries of intestine be clear, and averaged values were used as data for analyses.

The data were analyzed by one sample t-test and Wilcoxon signed rank test of variance using Graphpad Prism® software.

Result

Minimal diameter of small intestine is 6.83 mm and maximum value is 10 mm in plain radiography, and 9.07 to 11.5 mm in contrast radiography, respectively. The mean diameters of the small intestines, the diameters of 12th ribs and the height of the body of the 5th lumbar vertebrae in small breed dogs are summarized in Table 1.

Analyses for SI/L5 and SI/rib ratio were summarized in Table 2. The range of values of SI/L5 is from 1.03 to 2.26 in plain radiography, and from 1.55 to 2.5 in contrast studies. The ranges of SI/rib ratio are from 2.85 to 4.52 in plain radiogra-

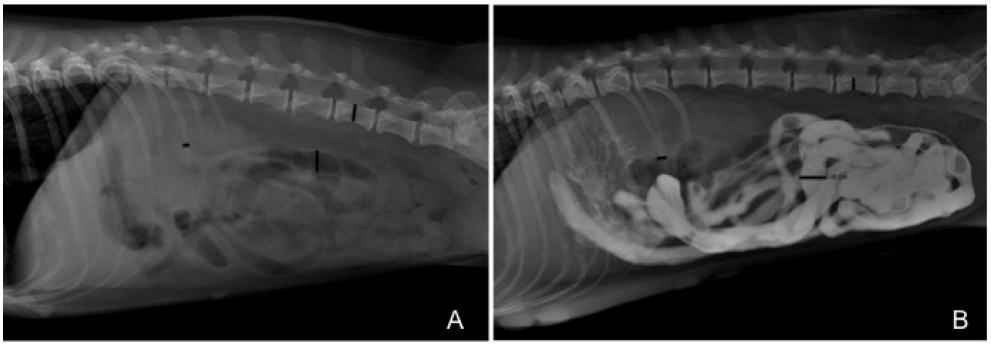

Fig 1. Lateral abdominal plain radiography (A) and upper GI series (B) showing the measurements of the small intestine diameter, 12th rib width, and the fifth lumbar vertebral height (black lines) in the experimental dogs.

Table 1. The diameters (mm) of small intestine, 12th rib, and height of 5th lumbar vertebra and their relative ratios in plain abdominal radiography

Dog	SI	L5	12th Rib	SI/L5	SI/Rib
1	8.83	4.3	2.3	2.05	3.84
2	9.93	4.4	2.2	2.26	4.52
3	4.97	4.8	2.3	1.03	2.16
4	7.57	4.8	1.8	1.58	4.20
5	9.17	5.6	2.3	1.64	3.99
6	7.23	4.4	2.5	1.64	2.89
7	10.00	5.4	2.3	1.85	4.35
8	8.57	6.4	2.1	1.34	4.08
9	6.83	5.4	1.9	1.27	3.60
10	7.07	6.6	2	1.07	3.53
11	7.90	5.1	1.9	1.55	4.16
12	8.27	6.4	2.9	1.29	2.85
Mean ± SD	8.03 ± 1.43	5.3 ± 0.82	2.21 ± 0.3	1.55 ± 0.38	3.68 ± 0.71

Table 2. The diameters (mm) of small intestine, 12th rib, and height of 5th lumbar vertebra and their relative ratios in contrast studies

Dog	SI	L5	12th Rib	SI/L5	SI/Rib
1	10.73	4.3	2.3	2.5	4.67
2	9.77	4.4	2.2	2.22	4.44
3	10.97	4.8	2.3	2.29	4.77
4	10.87	4.8	1.8	2.26	6.04
5	9.50	5.6	2.3	1.7	4.13
6	9.17	4.4	2.5	2.08	3.67
7	9.50	5.4	2.3	1.76	4.13
8	9.90	6.4	2.1	1.55	4.71
9	9.70	5.4	1.9	1.8	5.11
10	10.73	6.6	2	1.63	5.37
11	9.07	5.1	1.9	1.78	4.77
12	11.50	6.4	2.9	1.8	3.97
Mean ± SD	10.12 ± 0.8	5.3 ± 0.82	2.21 ± 0.3	1.95 ± 0.31	4.65 ± 0.65

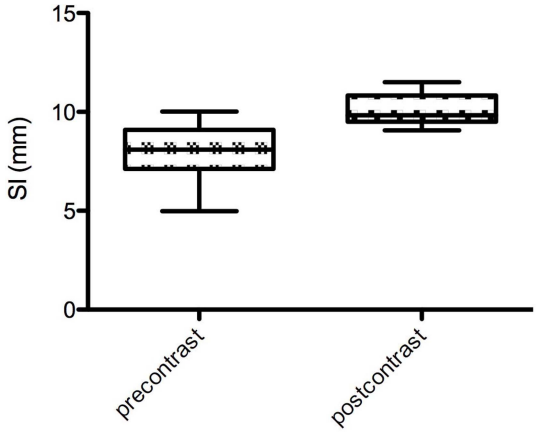

Fig 2. Small intestinal diameters (SI) are significantly different between precontrast and postcontrast values (p = 0.0034).

Table 3. Distribution of SI/L5 ratio and SI/rib ratio in precontrast (Pre SI/L5 and Pre SI/Rib) radiography and upper GI contrast study

	Pre SI/L5	Pre SI/Rib	SI/L5	SI/Rib
Minimum	1.03	2.16	1.6	3.67
25%	1.23	3.05	1.72	4.13
50%	1.57	3.92	1.8	4.69
75%	1.8	4.19	2.25	5.03
Maximum	2.26	4.52	2.5	6.04
Mean ± SD	1.55 ± 0.38	3.68 ± 0.71	1.95 ± 0.31	4.65 ± 0.65
Upper 95% CI	1.79	4.13	2.14	5.06

CI: confidence interval

phy, and from 3.67 to 6.04 in contrast radiography. The small intestinal diameters are significantly different between before and after contrast media administration (p = 0.0034) (Fig 2).

Discussion

Intestinal dilation has been used as a major factor indicating intestinal obstruction or functional ileus in the vomiting dogs. In discussing the radiological signs seen in gastrointestinal disease, some authors fail to define intestinal dilation while indicating that recognition of this is very important in the diagnosis of obstruction (3,8). However, others have suggested parameters for the normal upper limit of intestinal diameter, which range from one to two times of 12th rib widths (1,12) to three times of 12th rib widths (14) and one lumbar vertebral body height (7). An intestinal diameter equaling or exceeding four caudal rib widths has been considered dilated (11,13). In Graham's study (5), 86% of experimental animals had SI/L5 ratio less than 1.6 in normal group. Based on that study, a value of 1.6 was recommended as the upper limit of the normal range and animals with lower values are unlikely to have intestinal obstruction, and animals with values greater than 2.0 have a very high probability of obstruction.

In this study, the 95% confidence interval values were calculated as the normal range. Therefore, the value of 1.8 is the upper limit of SI/L5 ratio in this study. This value is relatively higher than the 1.6 of the previous study. The discrepancy between this study and the previous one is likely caused by the difference of experimental animals; i.e. large breed dogs versus small breed dogs.

30% commercially made barium sulfate (EasySB®) were used to evaluate the effect of contrast media administration on the small intestinal diameter. This product composed of barium and methylcellulose could be used without additional dilution procedure. One of the advantages of using barium product containing methylcellulose was the greatly improved visualization of bowel loops (6). The ability to visualize deep loops through overlying loops was significantly better than when barium alone was used despite the inherent difficulty of visualizing numerous loops of an actively contracting bowel

(6). Also, the visualization of the bowel loops in regions of overlap with the ribs and lumbar vertebra was improved, therefore the maximal diameter of intestine overlapped by other bowel loops or skeletal structures could be measured. It had been reported that barium with methylcellulose consistently increased small bowel distensibility. The value of 2.1 could be the strong evidence of mechanical obstruction in small breed dogs, considering fluid retention in obstructive intestinal diseases or large volume of contrast media administration of upper GI series.

SI/12th rib ratio was suggested less than twice the widest of 12th rib (1). However, SI/12th rib ratios are higher than 4.0 in 50% of even precontrast values. It was thought that the ratios of small intestinal diameter and rib width are useful only in large breed dogs.

In the previous studies, the measurements on radiographic film are usually performed manually with hand-held calipers. Therefore, intra- and interobserver variability is relatively high (9). The development of digital radiography and PACS system made electronic measurements possible, which could result in more accurate and precise measurements with less observer variability. Digital radiography could overcome mild serosal detail decrease by control of window level and widths. This is useful because the application of the test requires that the maximum small intestinal external diameter be measured accurately. If serosal detail is reduced because of poor radiographic quality, lack of abdominal fat due to immaturity or cachexia, or the presence of peritoneal effusion or peritonitis, the intestine will be hard to measure. In the previous study (5), the widest small intestinal gas bubble was measured in case of the peritoneal detail loss, which resulted in some underestimation of the degree of dilation present. The post-exposure control of digital radiography could have serosal margin of small intestine visualize, which result in the more precise measurments. Small breed dogs weighing less than 5 kg have relatively small lumbar vertebra and intestine. Therefore, the measurements of these small structures were not easy. The magnification function of PACS viewer system also allows the margin of lumbar and small intestine to be remarkably shown in radiography.

Conclusion

The SI/L5 ratio is a useful index of small intestinal size in small breed dogs. Approximately SI/L5 ratio of 1.8 could be used as upper limit of small intestinal diameter in small breed dogs weighing less than 5 kg. Contrast agent significantly increased small intestinal diameter, and the upper limit of SI/L5 ratio was 2.1. Therefore, the higher values of SI/L5 ratios than 2.1 might suggest intestinal mechanical obstruction.

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소형견에서 소장 직경의 방사선학적 평가

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요 약 : 기초 검사를 통해 위장관계와 위장관 운동에 영향을 줄 수 있는 전신 질환이 없는 12 두의 5 kg 이하의 소형견들을 선별하여 사용하였다. 조영 전 단순 방사선 검사를 실시한 후, 30% 바륨을 체중 kg 당 12cc 를 위관 튜브를 통해 주입하였다. 그 후 일련의 방사선 사진을 촬영한 후, 우측횡와상과 복배상을 촬영하여 소장에 조영제가 골고루 분포된 사진을 선별하여 분석하였다. PACS viewer에서 우측횡와상 방사선 사진을 확대하고 대비도를 조정하여 조영된 장과 비교하고자 하는 해부학적 구조인 5번째 요추의 윤곽선이 뚜렷이 영상화되도록 한 후, 내장된 전자 caliper를 이용하여 최대 장직경과 5번째 요추의 가장 좁은 부분의 높이를 측정하였다. 복배상에서 역시 장직경과 12번째 늑골의 가장 넓은 부위의 경을 측정하였다. 위의 측정치를 소장과 요추 비율 (SI/L5 ratio) 그리고 소장과 늑골 비율 (SI/Rib ratio)로 명명하여 주로 대형견의 자료인 이전 연구와 비교평가하였다. 소형견에서의 SI/L5 ratio의 범위는 조영전 1.03-2.26 그리고 조영후 1.55-2.5 였으며, SI/Rib ratio는 조영전 2.16-4.52, 그리고 3.67-6.04 였다. 이는 이전부터 사용되어 오던 상위 한계인 SI/L5 ratio 1.6과 SI/Rib ratio 2 보다 높은 수치이며, 이러한 차이는 대형견에 비해 상대적으로 작은 골격구조 때문인 것으로 생각된다. 따라서 소형견에서는 정상 소장과 요추 비율의 상위 한계가 1.8배이며, 2.1배 이상일 경우 기계적 폐색을 의심할 수 있을 것으로 생각된다.

주요어 : 장직경, 위장관 조영, 소형견