pISSN 1598-298X / eISSN 2384-0749
*J Vet Clin* 34(6) : 420-424 (2017)
http://dx.doi.org/10.17555/jvc.2017.12.34.6.420

Journal of Veterinary Clinics
www.ksvc.or.kr

# Radiographic Uterine Diameter Evaluation for the Detection of Uterine Disease in Dogs: A Retrospective Study

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(Received: August 7, 2017 / Accepted: September 22, 2017)

**Abstract :** Cystic endometrial hyperplasia (CEH) and uterine dilation (hydro-, muco-, hemato- and pyometra) are common uterine diseases in intact female dogs. The aim of the present study was to assess the usefulness of digital abdominal radiography in diagnosing uterine disease in intact female dogs. Two hundred and thirteen intact female dogs were included, and were classified into four groups on the basis of radiographic uterine visibility (visible/invisible) and ultrasonographic findings (normal uterus/abnormal uterine condition including CEH and uterine dilation). For each dog, the ratio of the maximum uterine diameter to the height of the fifth lumbar vertebral body (U/L5 ratio) was calculated on radiographs. There were 78 and 135 dogs in the normal and abnormal groups, respectively; 34.6% normal and 53.5% abnormal uteri were visible on abdominal radiographs. Our results suggested that a mean U/L5 ratio of $1.18 \pm 0.53$ (mean $\pm$ 2 SD) indicated a normal radiographic uterus diameter, and that a value of $> 1.60$ should be used as an indicator of uterine disease in clinical practice. However, because false negative results were noted, radiography cannot replace ultrasonography for assessment of the uterus.

***Key words*** **:** abdominal radiography, female dog, ultrasonography, uterine diameter, uterine disease.

## Introduction

Cystic endometrial hyperplasia (CEH) and uterine dilation (hydro-, muco-, hemato-, and pyometra) are common uterine diseases in intact female dogs (6,9,23). In many western countries, most dogs are spayed when young; therefore, evaluation of uterus may have little value. However, intact female dogs prevail in some countries. In this regard, routine assessment of the uterus can present vital information to clinicians, even if the hospital-visit may be for other reasons. Uterine diseases are best diagnosed using ultrasonography, with typical findings including enlarged uterine horns filled with anechoic to echogenic fluid, with or without a thickened endometrium. The presence of cystic structures is diagnostic for CEH (3,21,25).

Although radiography can be used as a diagnostic tool for uterine diseases or pregnancy, the findings are frequently inconclusive (19). The normal uterus is rarely observed radiographically in dogs because of its small diameter and the presence of a soft tissue opacity that mimics the adjacent intestinal loops (1,15,20). Compression abdominal radiography for evaluation of the uterus has been described (2,8,26). It facilitates identification of the uterus by decreasing the superimposition of caudal abdominal structures, although it is rarely used today. There are no other studies on the diameter of the normal uterus on abdominal radiographs. Empirically, however, the uterus can be frequently observed on abdominal radiographs, even in the absence of enlargement.

In veterinary medicine, a transition from analogue radiographic imaging to digital radiographic imaging has rapidly occurred. Contrast optimization, which is the best feature of digital radiography, increases the observability and distinguishability of anatomical structures (16). Therefore, visualization of the uterus may be easier using digital radiography.

The aim of this study was to assess the usefulness of digital abdominal radiography in diagnosing uterine disease in intact female dogs by investigating the frequency of observation of the normal uterus by radiography, and establishing a quantitative radiographic index for the evaluation of uterine disease. The tested hypothesis was that a normal, non-gravid uterus can be frequently observed on abdominal radiographs and the index should be established.

## Materials and Methods

This retrospective study included intact female dogs that presented for various reasons at our hospital between March 2011 and September 2015. All dogs who underwent both abdominal radiography, which included right lateral and ventrodorsal views, and ultrasonography, which provided images of the entire reproductive system (both ovaries, uterine horns and uterine body or cervix), at an interval of less than 1 day were considered eligible. Dogs with poor diagnostic quality of radiographs were excluded, as were dogs with poor serosal detail or abnormal lumbar vertebral columns. A normal lumbar vertebral column was defined as the presence of seven lumbar vertebrae with no transitional vertebra and no vertebral abnormalities affecting the height or length of the verte-

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**Fig 1.** Right lateral abdominal radiograph of an intact female dog. There is a tubular soft tissue opacity within the caudal abdomen, consistent with the uterus (double-headed arrow). This dog was thus classified into the observable group. There were no remarkable findings in the uterus on subsequent ultrasonography examination.

bral body. The basic characteristics of the included dogs (age, sex and body weight) and all the relevant clinical data were obtained from medical records.

**Radiographic measurements**

Abdominal radiographs were acquired using a digital radiography system (EVA-HF 525, COMED medical system, Seongnam, Korea). The kVp and mAs varied depending on the size of the dog, at a focal film distance of 100 cm.

First, each radiograph was evaluated for the visibility or non-visibility of the uterus. A positive result was defined as the identification of a well-defined, tubular soft tissue opacity between the descending colon and the urinary bladder (Fig 1). Accordingly, the dogs were classified into observable and unobservable groups. Then, the maximum uterus diameter (U) was measured on right lateral views for the observable group. Finally, the height of the fifth lumbar vertebral body (L5) was measured at its narrowest point on right lateral views. The U/L5 ratio was then derived from these measurements. All radiographic measurements were performed three times using an electronic calliper in DICOM images (Infinite PACS, Infinite Healthcare, Seoul, Korea) and the mean values for each measurement were used to calculate the ratio.

**Ultrasonographic uterine diameter**

Abdominal ultrasonography was performed using one of three ultrasound machines (Prosound α7, Hitachi Aloka Medical Ltd., Wallingford, CT, USA; Accuvix XG, Samsung Medison, Seoul, Korea; SA-9900, Medison, Seoul, Korea) equipped with 4-11 MHz linear or curvilinear transducers. The ultrasonography findings of all dogs were reviewed. The maximum diameter of the right or left uterine horns measured using the electronic calliper of the ultrasound device on either transverse or longitudinal sections were recorded. On the basis of these findings, the dogs were classified into normal and abnormal groups. The normal group included dogs with no dilatation, thickening, cysts, or mass lesions in the uterine wall. The abnormal group included dogs with dilated uterine horns filled with anechoic to echogenic fluid (hydro-, muco-, hemato-, or pyometra) or cystic structures embedded in the uterine wall. Dogs that were pregnant, or had uterine neoplastic or congenital anomalies, were excluded.

**Groups**

Subsequently, the dogs were classified into four groups: normal-invisible (group 1), normal-visible (group 2), abnormal-invisible (group 3) and abnormal-visible (group 4) groups.

**Intra- and inter-observer reliabilities**

Sixty-five of the 213 radiographs were randomly selected and evaluated by two observers. On each radiograph, identification of the uterus was recorded as yes or no, and the maximum diameter, L5, and the U/L5 ratio were independently measured three times by each observer, by repeating the measurements 7 days apart. The means were compared to evaluate the inter-observer reliability.

**Statistical analyses**

Statistical tests were selected and performed by using SPSS (IBM SPSS Statistics for Windows, Version 23.0, IBM Corp., Armonk, NY). Normality of data was assessed using the Shapiro-Wilk test. Age, body weight, and radiographic and ultrasonographic measurements were compared among groups using Kruskal-Wallis, and Mann-Whitney tests. The correlation between the radiographic and ultrasonographic uterine diameter was assessed using Spearman's correlation co-efficient. Receiver operating characteristic (ROC) analysis was performed, and the area under the curve (AUC) was calculated to determine cut-off values of the U/L5 ratio for overall accuracy, optimum sensitivity (100% sensitivity), and optimum specificity (100% specificity) for the detection of uterine disease. Intra- and inter-observer reliabilities were evaluated using intra-class correlation coefficients (ICCs). All data are presented as means ± standard deviations (SDs). For all analyses, a $p < 0.05$ was considered statistically significant.

## Results

A total of 213 intact female dogs were included in this study. A normal uterus was observed using ultrasonography in 78 dogs (36.6%) (normal group), while there were 135 dogs (63.4%) with an abnormal uterus (abnormal group). The uterus could be identified on abdominal radiographs for 27 dogs (34.6%) in the normal group (normal-visible; group 2) and 72 dogs (53.3%) in the abnormal group (abnormal-visible; group 4). On the other hand, the uterus was not visible in 46.7% dogs in the abnormal groups (Fig 2).

Twenty-one breeds were represented and most were small-breed dogs (Table 1). The mean age of all dogs was 9.5 ± 3.3 years (range, 1-17 years). There was a significant difference in age between group 1 (normal-invisible) and groups 3 (abnormal-invisible) and 4 (abnormal-visible; $p = 0.048$ between groups 1 and 3; and $p = 0.011$ between groups 1 and 4). There was no significant difference between group 1 and 2. The

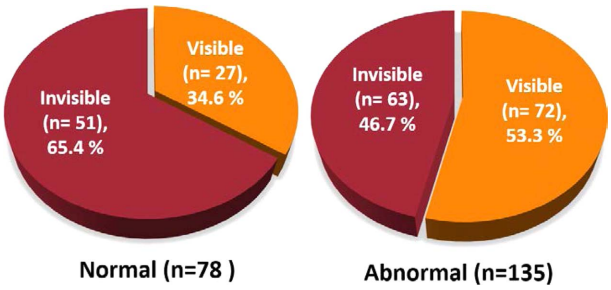


**Fig 2.** Classification of 213 intact female dogs included in this study. The uterus could be identified on abdominal radiographs for 27 dogs (34.6%) in the normal group and 72 dogs (53.3%) in the abnormal group. Furthermore, the uterus was not visible in 46.7% dogs in the abnormal groups.

mean body weight was 5.60 ± 6.34 kg (range, 1.4-43.0 kg), with no significant differences among groups (Table 2).

### Radiographic measurements

On radiographic measurements, L5 was not significantly different among groups. Both uterine diameter and U/L5 ratio were significantly higher in group 4 than in group 2 (Table 2). The mean U/L5 ratio in group 2 was 1.18 ± 0.27, suggesting a normal radiographic uterine diameter, which was 1.18 ± 0.53 (12).

### Ultrasonographic uterine diameter

There was a significant difference ($p < 0.001$) in the uterine diameter on ultrasonography between all groups except groups 1 and 2. The uterine diameter was greater in the abnormal groups, compared to the normal groups, and greater in group 4 than in group 3. However, there was no significant difference between groups 1 and 2 ($p = 0.265$; Table 2).

### Correlation between radiographic and ultrasonographic uterine diameter

There was a strong positive linear relationship between radiographic and ultrasonographic uterine diameter. Spearman's correlation coefficient was 0.851 ($p < 0.001$).

**Table 1.** Breed distribution for the intact female dogs

| Breeds | Groups | | | | Total (%) |
|---|---|---|---|---|---|
| | 1* | 2 | 3 | 4 | |
| Shih Tzu | 7† | 12 | 13 | 14 | 46 (21.6) |
| Maltese | 11 | 4 | 16 | 14 | 45 (21.1) |
| Yorkshire Terrier | 10 | 1 | 15 | 10 | 36 (16.9) |
| Poodle | 5 | 1 | 2 | 6 | 14 (6.6) |
| Mixed breed | 4 | 2 | 2 | 2 | 10 (4.7) |
| Cocker Spaniel | 4 | 3 | 1 | 2 | 10 (4.7) |
| Miniature Schnauzer | 1 | 0 | 5 | 4 | 10 (4.7) |
| Pomeranian | 3 | 1 | 1 | 2 | 7 (3.3) |
| Pekingese | 0 | 1 | 1 | 5 | 7 (3.3) |
| Chihuahua | 1 | 0 | 0 | 5 | 6 (2.8) |
| Golden Retriever | 0 | 0 | 0 | 4 | 4 (1.9) |
| Jindo Dog | 1 | 1 | 1 | 0 | 3 (1.4) |
| Dachshund | 1 | 0 | 1 | 1 | 3 (1.4) |
| Miniature Pinscher | 0 | 0 | 3 | 0 | 3 (1.4) |
| Others | 3 | 1 | 2 | 3 | 9 (4.2) |
| Total | 51 | 27 | 63 | 72 | 213 (100.0) |

*Group 1, normal-invisible; group 2, normal-visible; group 3, abnormal-invisible; group 4, abnormal-visible
The groups were created on the basis of radiographic (uterus visible and invisible) and ultrasonographic (normal and abnormal uterus) findings.
†Number of dogs

### ROC analysis

The AUC was 0.915 (95% CI, 0.862-0.968). A U/L5 ratio of > 1.40 showed the best accuracy (sensitivity, 83%; specificity, 85%) for the detection of uterine disease, a ratio of > 1.60 showed the optimum specificity (100%) for the presence of uterine disease, and a ratio of < 1.01 showed the optimum sensitivity (100%) for the absence of uterine disease.

### Intra- and inter-observer reliabilities

Intra- and inter-observer ICCs for all measurements indicated excellent reliability (ICCs > 0.8; $p < 0.001$).

**Table 2.** Age, body weight, radiographic and ultrasonographic measurements for the four groups of intact female dogs included in this study

| Group | Patient information | | Radiographic measurements | | | | Ultrasonographic measurements |
|---|---|---|---|---|---|---|---|
| | Age (year) † | Body weight (Kg) | L5 (mm) ‡ | Uterus (mm) † | U/L5 ratio†§ | | Uterus (mm) † |
| | | | | | Mean ± SD | Range | |
| 1* (n = 51) | 8.10 ± 4.09 | 4.86 ± 3.69 | 5.36 ± 1.52 | ND** | ND | ND | 4.38 ± 1.44 |
| 2 (n = 27) | 9.54 ± 3.12 | 6.30 ± 4.90 | 6.19 ± 1.69 | 6.99 ± 1.08 | 1.18 ± 0.27 | 0.55-1.59 | 4.73 ± 0.94 |
| 3 (n = 63) | 9.92 ± 2.84 | 4.61 ± 3.51 | 5.45 ± 1.42 | ND | ND | ND | 8.72 ± 3.34 |
| 4 (n = 72) | 10.21 ± 2.74 | 6.73 ± 9.40 | 5.87 ± 2.35 | 19.17 ± 15.58 | 3.27 ± 2.10 | 1.02-11.35† | 16.88 ± 10.61 |

*Group 1, normal-invisible; group 2, normal-visible; group 3, abnormal-invisible; group 4, abnormal-visible
The groups were created on the basis of radiographic (uterus visible and invisible) and ultrasonographic (normal and abnormal uterus) findings.
†Significant difference ($p < 0.001$) between groups
‡The body height of the fifth lumbar vertebra
§Ratio of the maximum uterus diameter to the height of the fifth lumbar vertebral body
**not determined

## Discussion

In clinical circumstances, radiography is generally used as an important screening tool for abdominal conditions. Several studies have quantitatively evaluated abdominal organs on radiographs of normal dogs and cats cats (10,13,17,24). However, a normal uterus was considered to be elusive on radiographs. Contrary to popular belief, however, we found that the normal uterus could be observed in 34.6% intact female dogs using abdominal radiography, even in the absence of uterine disease or pregnancy. In a previous study on female cats, the sensitivity of digital radiography for the accurate identification of the reproductive status was 28% (26), which is slightly lower than the rate in the present study. This difference is likely attributable to differences in species, size, and/or observers.

Not surprisingly, considering that uterine disease is more prevalent in older dogs, the dogs in the abnormal groups were older compared with those in the normal-invisible group (group 1). With regard to breed distribution, Shih Tzus were most common in group 2. We speculate that body conformation or breed may affect identification of the uterus, although the number of dogs in group 2 was less than that of the other groups. Therefore, these results may not accurately reflect the actual tendency for radiographic uterus identification with regard to breed, and further studies are necessary to clarify this issue.

There were strong correlation between radiographic and ultrasonographic uterine diameter and significant difference between normal and abnormal groups, representing abdominal radiography can be used as a valuable diagnostic tool to determine uterine dilatation. At the same time, however, radiography should not be used to exclude uterine diseases, because the uterus was not identified in 46.7% dogs in the abnormal groups. It is also supported by the findings of comparisons between the normal and abnormal groups with regard to the U/L5 ratio. In the present study, we found that a mean U/L5 ratio of $1.18 \pm 0.53$ (mean $\pm$ 2 SD) can be used as a normal reference range on radiographs of dogs. Although the ratio was significantly higher in the abnormal groups (U/L5 ratio of $3.27 \pm 2.10$), the ranges overlapped to some degree; furthermore, two cases of pyometra were actually included in the suggested normal range. Therefore, radiography cannot be promoted over ultrasonography for first line assessment of the uterus.

In ROC analysis, the best cut-off U/L5 ratio for the detection of uterine diseases was 1.40 (sensitivity, 83%; specificity 85%). In the clinical setting, however, this value is not very useful. Instead, a cut-off value of $> 1.60$ showed the optimum specificity (100%) for the presence of uterine disease. In such cases, ultrasonography can be used for further assessment of the uterine wall and contents.

This study has several limitations. First and most important, the diagnosis of uterine diseases was only based on ultrasonography findings. Histological, cytological, and bacteriological evaluations of the uterus were not performed or considered. Although it is well known that ultrasonography has a high diagnostic accuracy for the detection of pyometra-CEH complex (5,19), it was found that 38% (10/26 dogs) of infertile, but ultrasonographically normal dogs were positive for endometritis via cytological and bacteriological evaluations (11). Second, the normal groups included critically ill patients (cancer, immune-mediated diseases, cardiorespiratory diseases, etc.); therefore, the normal group in the present study may have included dogs with subclinical uterine diseases. Third, the uterine morphology changes depended on the stage of the estrous cycle or a history of a previous pregnancy (4,7,14, 18,22). The uterine diameter is slightly increased (approximately 1-3 mm) during the proestrus and estrous stages (27). Unfortunately, however, we could not retrieve this information for all dogs considering the retrospective nature of the study. Finally, the majority of dogs in the study were small breeds and the body condition score was not considered of each dog. Body size, conformation, and/or obesity may influence the rate of detection of the uterus on radiographs.

In conclusion, it is found that the normal uterus can be identified on abdominal radiographs, and therefore, simple radiographic identification of the uterus does not necessarily indicate the presence of uterine disease. If a uterus is visible, the U/L5 ratio on abdominal radiographs could be considered as a quantitative index for detecting uterine disease. The mean ratio of $1.18 \pm 0.53$ (mean $\pm$ 2 SD) is suggested for normal radiographic uterine diameter in intact female dogs and a ratio of $> 1.60$ for high likelihood of uterine disease in a clinical setting. However, not all abnormal uteri were identified, and therefore, radiography cannot replace ultrasonography for the assessment of uterine disease.

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