Lymph nodes are essential structures to be evaluated in an ultrasonographic examination of the feline abdomen. It was hypothesized that current technical proficiency would allow all feline abdominal lymph nodes to be identified ultrasonographically. Ten clinically normal, adult, domestic shorthair cats were examined using real-time compound ultrasonographic imaging. The medial iliac lymph nodes were visible in 100% of the cats, the jejunal lymph nodes in 90%, the hepatic lymph nodes in 70%, the aortic lumbar, the splenic, and the pancreaticoduodenal lymph nodes in 60% each, the ileocecal and the colic lymph nodes in 50% each, and the renal, the gastric, the sacral and the caudal mesenteric lymph nodes in 40%, 30%, 20%, and 10% of the cats, respectively. The inconsistent presence of lymph nodes, their poor echocontrast and interposed gas of the gastrointestinal tract explain the lower percentages of identification. The ultrasonographic length and diameter of the lymph nodes were determined. The majority of these measurements corresponded to those in the literature. We conclude that ultrasonography is a valuable tool for the identification and evaluation of most abdominal lymph nodes in the normal cat. Average ultrasonographic measurements are presented as a preliminary guideline for normal feline abdominal lymph nodes.

Key words: abdomen, cat, lymph nodes, ultrasonography.

Introduction

The anatomy of abdominal lymph nodes in the cat has been described, and minor variations exist concerning presence, location, size, and shape of the lymph nodes.1–4 Ultrasonographic information on the appearance of normal feline and canine lymph nodes is available: they have an elongated shape and homogeneous echotexture, and are slightly hypoechoic compared with mesenteric fat.5 In the dog, the ultrasonographic examination of normal abdominal lymph nodes has been described.6 Criteria have been defined to differentiate normal and diseased canine superficial lymph nodes, using B-mode and Doppler ultrasonography (US).7

We hypothesized that advances in ultrasonographic technology might enable to obtain more information regarding ultrasonographic imaging of abdominal lymph nodes in the cat. Hence, the aim of this study was to further describe the ultrasonographic anatomy of the abdominal lymph nodes in the normal cat as well as the frequency one succeeds in identifying them.

Materials and Methods

Ten cats were imaged. All cats had a clinical problem other than abdominal disease. The general condition, clinical examination, and complete blood count were normal, and tests for FIV and FeLV were negative. All cats were adult, domestic shorthair cats with age between 1 and 10 years. Gender was not a selection criterion. Four uncooperative cats were sedated with medetomidine (100 mg/kg intramuscular). The ultrasonographic examinations were performed by one and the same observer (J.H.S.), who scanned the abdomen of all cats. Real-time compound US with a 7–14 MHz linear transducer was used.* Machine settings were adjusted for optimal image quality.

During the examination, particular attention was given to identification of the abdominal lymph nodes, based on available anatomic description (Fig. 1a and b).1 Aortic lumbar, renal, hepatic, splenic, gastric, pancreaticoduodenal, jejunal, ileocecal, colic, caudal mesenteric, medial iliac, and sacral lymph nodes were evaluated. The aortic lumbar lymph nodes are oriented along the abdominal aorta and caudal vena cava, spread between the diaphragm and the deep circumflex iliac arteries. One to four of these lymph nodes are associated with the renal vessels and are named renal lymph nodes. The hepatic lymph nodes are located at

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*Logiq 7, GE Medical Systems, Milwaukee, WI.
the junction of the splenic and gastroduodenal veins with the portal vein and in the hilus of the liver. The splenic lymph nodes can be found adjacent to the splenic vessels in the hilus of the spleen. The gastric lymph nodes are embedded in the lesser omentum along the lesser curvature of the stomach, adjacent to the cardia or occasionally adjacent to the pylorus. The pancreaticoduodenal lymph nodes are oriented at the caudal aspect of the pylorus, where the cranial pancreaticoduodenal and the right gastroepiploic veins meet. One or two pancreaticoduodenal lymph nodes may be present adjacent to the right pancreatic lobe. Multiple jejunal lymph nodes are located adjacent to the cranial mesenteric artery and the origin of the jejunal arteries at the root of the mesentery. In 50% of the cats, some lymph nodes can be found along the jejunal vessels in the more distal part of the mesentery, near the jejunum and the ileum. The ileocecal lymph nodes are embedded in the ileocecal fold at both sides of the concavity of the cecum. The mesocolon contains the colic lymph nodes near the ascending and transverse colon, and the caudal mesenteric lymph nodes near the descending colon. The medial iliac lymph nodes are found adjacent to the abdominal aorta and the caudal vena cava. They are caudal to the deep circumflex iliac artery and vein, and cranial to the external iliac artery and common iliac vein. The sacral lymph nodes are located caudal to the origin of the internal iliac arteries and at the origin of the median sacral artery. They may follow the course of these vessels.

A normal lymph node was recognized ultrasonographically as a hypoechoic, homogeneous, elongated structure in its expected anatomic location. A record was made of the number of cats in which a particular lymph node could be identified. For each lymph node, the maximal length and the maximal diameter were measured once in each cat. The maximal diameter was defined to be perpendicular to the maximal length. Depending on where the parameters were largest, length and diameter were identified on the same image or on two separate images. Subsequently, the mean maximal length and the mean maximal diameter of each lymph node were calculated by averaging the measurements of the 10 cats. If more than one lymph node was identified in one location, the largest one was measured. If only one lymph node was visible, it was considered representative of the group of lymph nodes. As soon as one lymph node was identified during the ultrasonographic examination, no further attempt was made to find other lymph nodes of the same group.

Results

The results are summarized in Table 1 and compared with the range of normal anatomic values.1–4

The medial iliac and the jejunal lymph nodes were the most frequently identified lymph nodes, visible, respectively, in 100% and 90% of the cats. The caudal mesenteric and the sacral lymph nodes had the lowest detection frequencies, which were 10% and 20%, respectively. Other detection frequencies ranged between 30% and 80%.

The length of all lymph nodes was in accordance with the anatomy literature,1–4 except for one ileocecal lymph node. This lymph node had a length of 23.2 mm, which exceeds the reported 15 mm.
The ranges for normal lymph node diameters are available in anatomy texts for aortic lumbar, splenic, jejunal, ileocecal, caudal mesenteric, and medial iliac lymph nodes\textsuperscript{1–4} and matched the measured diameter in 23/36 individual lymph nodes (diameter of one ileocecal lymph node was lost during the procedure). In 11/36 lymph nodes, the diameter was below the anatomic range, and 2/36 lymph nodes had a diameter above the anatomic range. While the reported approximate diameters of the hepatic and the pancreaticoduodenal lymph nodes are 10 and 5 mm, respectively, the corresponding ranges in our study were 2.5–3.6 mm, for six hepatic lymph nodes (diameter of one hepatic lymph node was lost during procedure), and 3.6–6.2 mm, for six pancreaticoduodenal lymph nodes.

### Discussion

Real-time compound imaging, a technique based on multiple angles of insonation per scan plane, was used in this study. Compared with conventional B-mode US, it produces superior border definition of rounded structures, less image speckle and improved soft tissue contrast.\textsuperscript{8} These advantages are beneficial in imaging lymph nodes, known for having poor contrast with surrounding tissue.

Few reports are available on the ultrasonographic characteristics of normal abdominal lymph nodes in the cat. The appearance of feline gastric lymph nodes has been described in connection with the normal pancreas.\textsuperscript{9} In that study, only one gastric lymph node was found cranio-median to the pylorus. Its largest size was 10 × 6 mm, while our largest measurement was 6.4 × 1.9 mm. In the same study, the gastric lymph node was identified in six of 20 normal cats, which is similar to our study.

Regarding the ileoceccolic region in normal cats, all of 31 cats had at least two colic lymph nodes identified in this area.\textsuperscript{10} This is higher than the 50% frequency reported in our study. Nevertheless, the diameter of both lymph nodes ranged between 1.9 and 4.9 mm, which was similar to our range of maximal diameter, 1.9–5.2 mm.

In the dog, normal abdominal lymph nodes are difficult to identify due to their small size and as their echogenicity is similar to those of the surrounding tissues.\textsuperscript{6} Only the medial iliac and the jejunal lymph nodes are regularly identified. In another study, the medial iliac lymph nodes were identified in 45% (left) and 82% (right) of 11 normal dogs.\textsuperscript{11} In our study, at least one medial iliac lymph node was found in each cat and a jejunal lymph node was visible in nine of 10 cats.

Not all abdominal lymph nodes were consistently found in cats in the present study. According to anatomic descriptions, most abdominal lymph nodes are present in individual cats, although their number may be variable. Individual cats may occasionally be missing the aortic lumbar, renal, splenic, gastric, ileocecal, or sacral lymph nodes.\textsuperscript{1–3} However, in this study, they were identified, respectively, in 60\%, 40\%, 60\%, 30\%, 50\%, and 20\% of the cats. It is not known if the lymph nodes that could not be seen in our 10 cats were actually absent or just not detected during the ultrasonographic examination, as no gold standard for deciding on the presence or absence of the nodes is available. There was no tendency for the lymph nodes with the lowest detection frequencies to be identified within the same individual cat, which would suggest a better visibility of the abdominal lymph nodes in these specific cats.

Visceral and vascular landmarks can be used to locate abdominal lymph nodes ultrasonographically. In the literature, an ultrasonographic map of abdominal vessels is available for the dog, but not for the cat.\textsuperscript{12} In our study, we used both visceral and vascular landmarks. Color or power Doppler sonography was used whenever necessary (Figs. 2–6).

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<th>Table 1. Ultrasonographic Frequency of Detection and Measurements of Feline Abdominal Lymph Nodes</th>
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<td>Frequency (%)</td>
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Results of the ultrasonographic examination of the abdomen of 10 cats. The ultrasonographically measured maximal length and diameter are represented as mean and range. The ranges of anatomic measurements out of literature are available for comparison.

*Ultrasonographic.
In humans, interposed gas makes perigastric and perisplenic lymph nodes difficult to access ultrasonographically. A similar problem was noted in our study, with gas obscuring lymph nodes near the stomach, cecum, and colon (gastric, pancreaticoduodenal, ileocecal, colic, and caudal mesenteric lymph nodes). Small intestinal loops were not detrimental to lymph node identification, as they mostly contained mucus and could be displaced during scanning.

Apart from one ileocecal lymph node, all lymph nodes had their lengths falling within the published range. Not all diameters of the individual lymph nodes were in harmony with the literature, although the mean diameters of lumbar aortic, splenic, jejunal, and medial iliac lymph nodes were. The maximal diameters of the individual ileocecal and the caudal mesenteric lymph nodes were consistently lower than those of the anatomic references. Also, the maximal diameter of the individual hepatic lymph nodes did not approach the reference value of 10 mm. No anatomic reference values are available for diameters of renal, gastric, colic, and sacral lymph nodes.

To our knowledge, the accuracy of ultrasonographic measurement of lymph nodes has not been validated. We propose our measurements as a preliminary guideline of the expected sizes of abdominal lymph nodes in normal
Pathologic abdominal lymph nodes are easier to image ultrasonographically because they are usually enlarged, have decreased echogenicity and are more rounded.\textsuperscript{5,6,14} In advanced disease, they may become irregularly shaped, heterogeneous, and poorly margined.\textsuperscript{15} A good optimal knowledge of the lymph node drainage pattern is important to increase specificity of detected abdominal abnormalities.\textsuperscript{1–4} Attempts to characterize abnormal lymph nodes as benign or malignant have lead to numerous ultrasonographic parameters in humans and animals.\textsuperscript{7,16} It is concluded that in humans the Doppler characteristics described for superficial lymph nodes are difficult to apply to abdominal lymph nodes because of the deeper location of the latter ones.\textsuperscript{17}

To conclude, most of the abdominal lymph nodes in the normal cat can be assessed ultrasonographically. We suggest using the proposed ultrasonographic measurements as a guideline for the assessment of abdominal lymph nodes in normal cats.

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REFERENCES