Sonographic characteristics of presumptively normal main axillary and superficial cervical lymph nodes in dogs

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Objective—To evaluate the B-mode and Doppler ultrasonographic appearance of presumptively normal main axillary and large superficial cervical lymph nodes (MALNs and SCLNs, respectively) in adult dogs.

Animals—51 healthy adult dogs (data from 1 dog were not analyzed).

Procedures—For each dog, weight, distance from the cranial aspect of the first sternebra to the caudal aspect of the left ischiatic tuberosity, and thoracic height and width at the level of the xiphoid process were recorded. Via B-mode and Doppler ultrasonography, echogenic characteristics, size in relation to body size and weight, and vascular supply of the MALNs and the SCLNs were evaluated (1 SCLN in 1 dog was not ultrasonographically visible).

Results—Most MALNs were clearly margined, solitary, and ovoid; echopatterns were homogenous or cortical and hypo- to isoechoic, compared with surrounding soft tissues. Size measurements of MALNs correlated with dogs' body length, thoracic width and height, and body weight. Most SCLNs were clearly margined, fusiform, and hypoechoic (compared with surrounding soft tissues) with a cortical or homogenous echopattern. Size measurements of SCLNs correlated with dogs' body length, thoracic width and height, and body weight. In 50 of the 100 MALNs, an intranodal vascular supply was detected; in contrast, an intranodal vascular supply in SCLNs was detected infrequently.

Conclusions and Clinical Relevance—Results indicated that, in dogs, anatomically separate lymph nodes have different echogenic and vascular characteristics; body size (skeletal length, height, and width), along with body weight, were correlated with sizes of presumptively normal MALNs and SCLNs. (*Am J Vet Res* 2012;73:1200–1206)

Sonographic imaging of intra-abdominal lymph nodes has been a part of routine abdominal examinations for the detection of disease.[1–3] Equipment resolution and operator skill have improved over time, and regular sonographic evaluation of the medial iliac, jejunal, renal, hepatic, and splenic lymph nodes is now feasible. Sonographic descriptions of nodal size, shape, and echogenicity are routinely used for purposes of disease detection.[4] Such evaluations are especially important when a patient is being screened for the spread of cancer and for oncological treatment planning.[1–3,5–8] Although sonographic evaluation of abdominal nodes to assess neoplastic involvement is routine, initial evaluation of peripheral lymph nodes for disease spread typically involves subjective palpation to determine change in size.[1,3] In addition, some peripheral lymph nodes are not easily palpable nor do they routinely undergo diagnostic imaging, yet the extent of peripheral lymph node disease involvement is important for oncological staging and treatment planning.[1,3,9] In 2 lymph centers in particular, the SCLNs and the MALNs, neoplastic staging for treatment-planning decisions is important.[1,9,10]

Superficial cervical lymph nodes are commonly affected by diseases involving the head, neck, and thoracic mammary glands.[11] The evaluation of these nodes usually involves a subjective assessment of any palpable change in size, compared with the size expected of nondiseased nodes. Following determination of a subjective size change, a clinician then decides whether to further evaluate the node via microscopic examination of fine-needle aspirate or biopsy specimens. Routine imaging of these nodes is not always performed, and the sonographic imaging characteristics of nondiseased nodes have not been described, to our knowledge. The MALNs are often affected by diseases involving the forelimbs, thoracic body wall, and cranial thoracic and cranial abdominal (third) mammary glands.[11] These nodes are not palpable, and detection of disease on

Abbreviations	
AALN	Accessory axillary lymph node
BCS	Body condition score
MALN	Main axillary lymph node
SCLN	Superficial cervical lymph node

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the basis of palpable size change is not feasible. The MALNs also play an important role in neoplastic staging and treatment planning; therefore, identification of means by which disease in these nodes can be detected is vital.[1,9,10] The objective of the study reported here was to characterize the B-mode and color Doppler ultrasonographic appearance of presumptively normal MALNs and large SCLNs in healthy adult dogs.

Materials and Methods

Dogs—Fifty apparently healthy adult dogs owned by students and faculty of the Western College of Veterinary Medicine were enrolled in the study. Informed consent was obtained from the owners. The period of data collection was March 2 to July 2, 2009. Ultrasonographic data for peripheral lymph nodes draining the hind limb were also collected during this study, as previously reported.[8] As an incentive to participate in the study, each owner was offered abdominal ultrasonographic examination of his or her dog at no charge; no abdominal abnormalities were found in the 10 dogs evaluated. The study was approved by the University of Saskatchewan's Animal Research Ethics Board and adhered to the Canadian Council on Animal Care guidelines for humane animal use.

Physical assessments—Distance from the cranial aspect of the manubrium of the sternum to the caudal aspect of the left ischiatic tuberosity and thoracic height and width at the level of the xiphoid process were recorded for each dog. The measurements of body length and thoracic height and width were performed to assess dog size and to minimize the effect of thinness or obesity when body weight alone is used.[12] A BCS was also assigned on a scale from 1 to 9 (1 to 3 = thin, compared with a dog typical of that breed and age; 4 to 5 = ideal body condition for a dog typical of that breed and age; 6 to 9 = heavy, compared with a dog typical of that breed and age).[13]

Ultrasonographic procedures—Each dog was manually restrained in lateral or dorsal recumbency, without the use of sedation, as needed to perform the lymph node examinations. One experienced sonographer (TIS) performed all ultrasonographic procedures with a single ultrasonography system[a] to ensure data collection consistency. A linear 12–5 mHz probe was used to measure the height and length of the MALNs and all measurements, including color Doppler ultrasonographic measurements, of the SCLNs. Because of the equipment used, selection of a specific frequency was not possible; therefore, a predetermined program specific for lymph node evaluation was set up for the probe and was not changed throughout the study. The only adjustments made among dogs or among SCLNs examined were depth and focal point. The small head size of the sector 8–5 MHz transducer was required to obtain the width measurement of the MALNs. All color Doppler ultrasonographic measurements of the MALNs were obtained with the 8–5 MHz sector probe by use of a predetermined program specific for vascular evaluation because selection of specific frequencies was not possible. The only adjustments made among dogs or among MALNs were depth and focal point.

Each nonsedated dog was positioned in dorsal recumbency to evaluate the MALNs and in the appropriate lateral recumbency to evaluate the SCLNs. All node measurements were obtained at the maximum height, length, or width that appeared in the ultrasonographic images. The linear probe was oriented longitudinally in 1 axilla parallel to the thoracic wall to obtain images of the MALNs. The division of the brachial and subscapular vessels was detected caudal to the scapulohumeral joint. The largest lymph node located immediately caudal to the vessel division was assumed to be the MALN.[11] An AALN is usually only present in a few dogs and is smaller than an MALN.[11] The height (dorsal to ventral direction) and length (cranial to caudal direction) of the MALN was measured for each dog and recorded. The sector transducer was then oriented transversely relative to the node to acquire the width measurement. These procedures were then repeated for the other axilla. In lateral recumbency, the SCLN was located by use of a transverse oblique probe position on the caudal lateral aspect of the neck immediately cranial to the supraspinatous muscle. The length (longest axis of node) and height (short axis) were measured. The probe was then oriented transverse relative to the node to acquire the width measurement. The dog was positioned on its other side, and these procedures were then repeated for the other SCLN.

In addition to ultrasonographic measurements of length, height, and width (obtained at the maximum diameter of the lymph node), the following characteristics were recorded for each lymph node: echogenicity relative to surrounding tissues, echotexture, margin shape, margin clarity, and vessel location (intranodal [central parenchymal vessels] vs extranodal [no parenchymal vessels]). The short-axis–to–long-axis ratio for each node was calculated as height divided by length.[2,6] In addition, the interval from placement of the transducer against the skin to visualization of the lymph node and whether the lymph node was palpable were also recorded. The number of lymph nodes present in the area was noted; when > 1 lymph node was present, information was collected only for the largest. A category of corticomedullary echotexture was used to describe lymph nodes in which an outer hypoechoic cortex and an inner hyperechoic medulla were clearly visible. Homogenous, heterogenous, and corticomedullary echotextures were all considered to be normal in the present study. Vascular location was assessed via color Doppler ultrasonography.

Statistical analysis—Statistical analysis was conducted with a standard statistical software package.[b] Significance was set at $\alpha = 0.05$ (2 sided). Differences in size of lymph nodes and time from probe placement to visualization of the lymph nodes between the left and right sides of the body were compared by use of the paired *t* test. Because the measurements obtained from the left and right sides were not considered to be independent, all subsequent analyses were stratified by side of body. Descriptive statistics included determination of the mean, SD, and range when variables were continuous or frequencies and percentages when variables were categorical. The Pearson correlation coefficient was used to assess the linear relationship between independent variables and outcomes. Beta coefficients and SEs obtained from linear regression were also calculated to assess the association between independent variables and outcomes. These analyses included examining the associations of independent variables of age, sex, size, body weight, and BCS with outcomes of lymph node length, height, and width as well as with the outcome of time to visualization of the lymph node. We used an independent-samples *t* test to test the differences in age of the dogs and vascularization type (central vs peripheral).

Results

Dogs—Fifty dogs were initially enrolled in the study. However, lymph nodes in 1 dog were considered abnormal; that dog was removed from the study, and no data from that dog were analyzed. Another dog was subsequently included to replace that dog. Therefore, data were analyzed for 31 females (4 sexually intact and 27 neutered) and 19 neutered males. Age ranged from 1.0 to 14.0 years (mean ± SD age, 5.1 ± 3.2 years). Mean weight, body length, thoracic width, and thoracic height were 22.6 ± 12.5 kg, 55.1 ± 12.2 cm, 16.9 ± 3.3 cm, and 22.0 ± 5.2 cm, respectively. Thirty dogs were purebred (17 breeds), and 20 were crossbred. Body condition scores were distributed as follows: 3 (n = 2 dogs), 4 (14), 5 (15), 6 (9), and 7 (10). No dog had any clinical sign of illness during the 8-week period preceding the study.

For all 50 dogs, MALNs on the right and left sides were easily detected via ultrasonography. The SCLNs were easily detected on the right side in all dogs; and on the left side, SCLNs were detected in 49 (98%) dogs. The MALN on either body side was not palpable in any of the dogs. The right and left SCLNs were palpable in 48 (96%) and 46 (92%) dogs, respectively.

The MALNs appeared ovoid in sagittal images; mean short-axis–to–long-axis ratio was 0.7 on the right side and 0.5 on the left side (**Figure 1**). For MALNs, the width was less than the height in all 50 dogs, giving each node a flattened ovoid conformation that allowed it to lie against the thoracic body wall. The SCLNs were all fusiform in shape with short-axis–to–long-axis ratios < 0.22 (**Figure 2**). The mean width of the SCLNs was approximately twice the mean node height (**Table 1**). With the exception of a larger mean width of the MALN on the right side of the body, compared with the MALN on the left side ($P < 0.05$), there were no significant differences in either the MALN or the SCLN node sizes between the right and left sides of the body. The differences in time to visualization of the node were not significantly different between the left and right sides of the body. The time to visualization of the lymph node following placement of the transducer against the skin increased with higher BCS, which was especially noticeable for the SCLNs; however, this correlation was not significant ($P > 0.05$).

For both the right and left MALNs, there were significant ($P < 0.01$) positive associations of node size measurements (height, width, and length) with body length, body weight, thoracic depth, and thoracic width (**Table 2**). Although age and MALN size measurements appeared inversely related in general, these relationships were not significant, with the exception of the correlation between age and the length of the left or right MALN.

For the SCLNs on each side of the body, there were significant ($P < 0.05$) positive associations of node size measurements (height, width, and length) with body length and body weight (**Table 3**). Body condition score was positively associated with SCLN height on both the left ($P < 0.001$) and right ($P = 0.02$) side of the

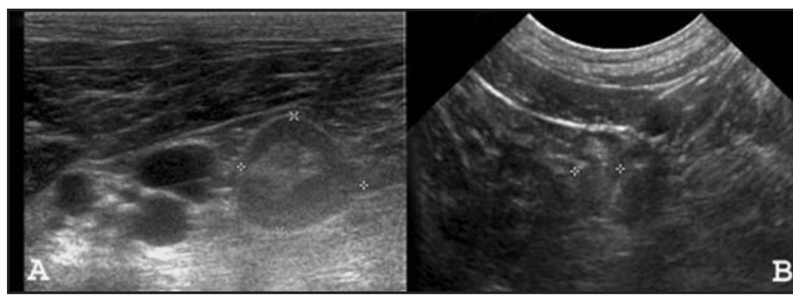

Figure 1—Representative grayscale ultrasonographic images of the presumptively normal left MALN of a healthy dog obtained by use of sagittal (A) and transverse (B) probe positions. Note the hypoechoic cortical and hyperechoic medullary distinction. Height (distance between the x cursors), length (distance between the + cursors in panel A), and width (distance between the + cursors in panel B) of the lymph node are indicated.

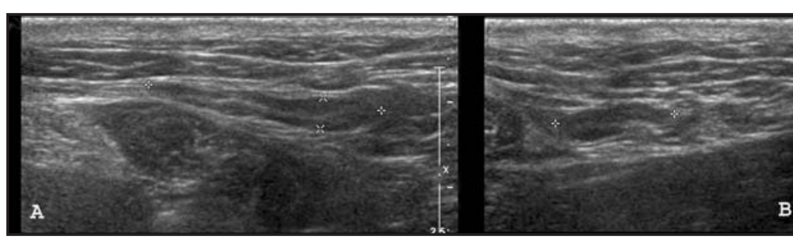

Figure 2—Representative grayscale ultrasonographic images of the presumptively normal left SCLN of another healthy dog obtained by use of sagittal (A) and transverse (B) probe positions. In panel A, the vertical line bar on the right side of the image denotes the location of the probe focal zone and the vertical incremental scale represents 0.5 (short) and 1.0 cm (long) distances. *See* Figure 1 for remainder of key.

Table 1—Length, height, and width (determined ultrasonographically) of right and left presumptively normal MALNs and SCLNs and time from probe placement to visualization of the lymph nodes in 50 healthy dogs.

	Right side of the body		Left side of the body	
Variable	**Mean ± SD**	**Range**	**Mean ± SD**	**Range**
MALN				
Length (cm)	1.57 ± 0.47	0.66–3.05	1.61 ± 0.52	0.61–2.82
Height (cm)	0.81 ± 0.28	0.30–1.35	0.77 ± 0.29	0.26–1.54
Width (cm)	0.65 ± 0.21*	0.22–1.28	0.60 ± 0.21	0.26–1.09
Time (s)	12 ± 14	1–79	14 ± 28	2–177
SCLN				
Length (cm)	2.26 ± 0.85	0.87–4.16	2.13 ± 0.70	0.96–3.79
Height (cm)	0.46 ± 0.18	0.22–0.92	0.42 ± 0.14	0.13–0.75
Width (cm)	0.91 ± 0.38	0.29–1.89	0.95 ± 0.41	0.34–2.02
Time (s)	39 ± 49	2–240	23 ± 31	1–270

*Within a row, value is significantly ($P < 0.05$) different from the mean value for the left node.

Table 2—Pearson correlation coefficient (*r*) and strength of association (β) for length, height, and width (determined ultrasonographically) of presumptively normal right and left MALNs with independent variables of interest evaluated in 50 healthy dogs.

Variable	Right MALN (n = 50)			Left MALN (n = 50)		
	Length (cm)	Height (cm)	Width (cm)	Length (cm)	Height (cm)	Width (cm)
Age (y)						
r	−0.30	−0.13	0.07	−0.35	−0.16	−0.08
β ± SE	−0.04 ± 0.02	−0.01 ± 0.01	0.005 ± 0.01	−0.06 ± 0.02	−0.01 ± 0.01	−0.005 ± 0.01
P value	0.04	0.36	0.62	0.01	0.28	0.59
Weight (kg)						
r	0.60	0.64	0.54	0.65	0.58	0.48
β ± SE	0.02 ± 0.004	0.01 ± 0.002	0.009 ± 0.002	0.03 ± 0.005	0.01 ± 0.003	0.008 ± 0.002
P value	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.001
BCS*						
r	0.20	0.26	0.02	0.10	0.28	0.22
β ± SE	0.08 ± 0.06	0.06 ± 0.03	0.004 ± 0.03	0.04 ± 0.06	0.07 ± 0.03	0.04 ± 0.03
P value	0.18	0.07	0.88	0.48	0.05	0.14
Thoracic depth (cm)						
r	0.60	0.63	0.52	0.70	0.54	0.41
β ± SE	0.06 ± 0.01	0.03 ± 0.006	0.02 ± 0.005	0.07 ± 0.01	0.03 ± 0.007	0.02 ± 0.006
P value	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.004
Thoracic width (cm)						
r	0.51	0.63	0.48	0.55	0.56	0.40
β ± SE	0.07 ± 0.02	0.05 ± 0.009	0.03 ± 0.008	0.09 ± 0.02	0.05 ± 0.01	0.03 ± 0.009
P value	< 0.001	< 0.001	0.001	< 0.001	< 0.001	0.005
Body length (cm)						
r	0.60	0.59	0.58	0.70	0.54	0.45
β ± SE	0.02 ± 0.004	0.01 ± 0.003	0.01 ± 0.002	0.03 ± 0.004	0.01 ± 0.003	0.008 ± 0.002
P value	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.002
Sex						
β ± SE	0.02 ± 0.14	−0.09 ± 0.08	−0.01 ± 0.06	0.20 ± 0.15	−0.10 ± 0.09	−0.05 ± 0.06
P value	0.90	0.27	0.82	0.19	0.25	0.44

The reference category for sex was female.

P values were obtained from correlation and simple linear regression analyses to test the null hypothesis that the correlation coefficient and regression coefficient equal zero.

*For each dog, a BCS was assigned on a scale from 1 to 9 (1 to 3 = too thin; 4 to 5 = ideal body condition; 6 to 9 = too heavy).

body as well as with SCLN width on the left side of the body ($P = 0.002$). On the right side of the body, thoracic depth and thoracic width were positively associated ($P < 0.001$) with both SCLN length and height. On the left side of the body, thoracic depth and thoracic width were positively associated ($P < 0.01$) with SCLN length, height, and width.

Sonographic characteristics of MALNs and SCLNs were summarized **(Table 4)**. The 100 MALNs were predominantly hypoechoic (67%) to isoechoic (26%), compared with the ultrasonographic appearance of surrounding soft tissues. The echogenicity was generally homogenous (49%); however, many MALNs had either a heterogenous (22%) or corticomedullary (29%) appearance. The margins were usually clearly defined and smooth. Vascular supply was minimally visible and central (intranodal) in 50 of the 100 nodes **(Figure 3)**; in the remaining nodes, no intranodal vessels were evident. Among the 50 dogs, only 1 MALN on the right side of the body was detected in 44 (88%) and only 1 MALN on the left side of the body was detected in 47 (94%). A single AALN on the right side was detected in 4 dogs, and a single AALN on the left side was detected in 2 dogs. Two AALNs on the right side were detected in 2 dogs, and 2 AALNs on the left side were detected in 1 dog. There was no significant association between the age of the dog and the presence of central (intranodal) or extranodal vascularization (data not shown).

The 99 SCLNs were predominantly hypoechoic (92%), compared with the ultrasonographic appearance of surrounding soft tissues. Only 8 nodes were isoechoic or hyperechoic, compared with the ultrasonographic appearance of surrounding soft tissues. Most of the SCLNs nodes had a corticomedullary echotexture (74%) and smooth, clearly defined margins (Figure 2; Table 4). A heterogenous echopattern was detected only in the right SCLN and only in 3 dogs. More than 80% of the dogs had a solitary SCLN on each side of the body. Two SCLNs nodes on the right side of the body were detected in 8 dogs, and 2 SCLNs nodes on the left side were detected in 7 dogs. Three SCLNs on the right side were detected in only 1 dog; no dogs had 3 SCLNs on the left side. The detection of a minimally visible centrally located vessel was only possible in 7 of the 49 (14%) left SCLNs examined and in 15 of the 50 (30%) right SCLNs examined. The remaining nodes had no visible intranodal blood supply. There was no significant association between the age of the dog and the presence of central (intranodal) or extranodal vascularization (data not shown).

The dogs' weights were classified into 3 categories (low weight = ≤ 16.5 kg; medium weight = > 16.5 to 29.8

Table 3—Pearson correlation coefficient (*r*) and strength of association (β) for length, height, and width (determined ultrasonographically) of presumptively normal right and left SCLNs with independent variables of interest evaluated in 50 healthy dogs.

	Right SCLN (n = 50)			Left SCLN (n = 49)		
Variable	Length (cm)	Height (cm)	Width (cm)	Length (cm)	Height (cm)	Width (cm)
Age (y)						
r	−0.007	−0.17	−0.18	−0.006	0.03	−0.13
β ± SE	−0.002 ± 0.04	−0.009 ± 0.008	−0.02 ± 0.02	−0.001 ± 0.03	0.001 ± 0.006	−0.02 ± 0.02
P value	0.96	0.23	0.23	0.97	0.85	0.39
Weight (kg)						
r	0.72	0.62	0.29	0.58	0.61	0.51
β ± SE	0.05 ± 0.007	0.009 ± 0.002	0.009 ± 0.004	0.03 ± 0.007	0.007 ± 0.001	0.02 ± 0.004
P value	< 0.001	< 0.001	< 0.05	< 0.001	< 0.001	< 0.001
BCS						
r	0.26	0.48	0.05	0.26	0.34	0.43
β ± SE	0.19 ± 0.10	0.07 ± 0.02	0.02 ± 0.05	0.15 ± 0.08	0.04 ± 0.02	0.15 ± 0.05
P value	0.07	< 0.001	0.72	0.08	0.02	0.002
Thoracic depth (cm)						
r	0.71	0.55	0.24	0.62	0.55	0.46
β ± SE	0.12 ± 0.02	0.02 ± 0.004	0.02 ± 0.01	0.08 ± 0.02	0.01 ± 0.003	0.04 ± 0.01
P value	< 0.001	< 0.001	0.10	< 0.001	< 0.001	0.001
Thoracic width (cm)						
r	0.71	0.58	0.23	0.61	0.61	0.51
β ± SE	0.18 ± 0.03	0.03 ± 0.006	0.03 ± 0.02	0.13 ± 0.02	0.03 ± 0.005	0.06 ± 0.02
P value	< 0.001	< 0.001	0.11	< 0.001	< 0.001	< 0.001
Body length (cm)						
r	0.76	0.55	0.29	0.62	0.53	0.51
β ± SE	0.05 ± 0.006	0.008 ± 0.002	0.009 ± 0.004	0.04 ± 0.006	0.006 ± 0.001	0.02 ± 0.004
P value	< 0.001	< 0.001	< 0.05	< 0.001	< 0.001	< 0.001
Sex						
β ± SE	0.04 ± 0.25	−0.005 ± 0.05	0.13 ± 0.11	−0.24 ± 0.21	−0.04 ± 0.04	−0.12 ± 0.12
P value	0.89	0.92	0.25	0.25	0.30	0.32

The SCLNs were detected on the right side in all dogs; on the left side, SCLNs were detected in 49 dogs.

See Table 2 for remainder of key.

Table 4—Sonographic characteristics of the right and left MALNs and SCLNs in 50 healthy dogs.

Characteristic	Right MALN (n = 50)	Left MALN (n = 50)	Right SCLN (n = 50)	Left SCLN (n = 49)
Echogenicity				
Hypoechoic	31 (62)	36 (72)	46 (92)	45 (92)
Isoechoic	15 (30)	11 (22)	3 (6)	2 (4)
Hyperechoic	4 (8)	3 (6)	1 (2)	2 (4)
Echogenic pattern				
Homogenous	25 (50)	24 (48)	10 (20)	13 (27)
Heterogenous	12 (24)	10 (20)	3 (6)	0 (0.0)
Corticomedullary	13 (26)	16 (32)	37 (74)	36 (73)
Margin shape				
Smooth	34 (68)	36 (72)	46 (92)	47 (96)
Irregular	16 (32)	14 (28)	4 (8)	2 (4)
Margin clarity				
Clear	32 (64)	40 (80)	45 (90)	47 (96)
Unclear	18 (36)	10 (20)	5 (10)	2 (4)
Vessel location				
Intranodal	23 (46)	27 (54)	15 (30)	7 (14)
Extranodal	27 (54)	23 (46)	35 (70)	42 (86)
No. of nodes detected/body side				
1	44 (88)	47 (94)	41 (82)	42 (86)
2	4 (8)	2 (4)	8 (16)	7 (14)
3	2 (4)	1 (2)	1 (2)	0 (0)

Data are expressed as No. (%).

kg; high weight = > 29.8 kg). This was done to provide usable values of lymph node length, height, and width, having accounted for the size of each dog. For each measurement (length, height, and weight) for both the MALNs and SCLNs, as the category of dog's weight increased, the mean lymph node size also increased ($P < 0.01$). The only exception was the width of the right SCLN. When the independent variables (ie, body length, body weight, thoracic depth, thoracic width, and BCS) and MALN and SCLN sizes (ie, length, height, and width of the left and right nodes) were evaluated in association with the dogs stratified by age grouping (< 6 years old vs ≥ 6 years old), no significant associations were identified (data not shown).

Discussion

The size, shape, and echo characteristics of lymph nodes are frequently investigated in veterinary medicine via ultrasonography to detect lymph node involvement in diseases in dogs or to assist in staging and treatment assessments in canine cancer patients. In the 50 healthy dogs of the present study, we were able to ultrasonographically characterize the size, shape, margin, echopattern, echogenicity, and vascular supply of presumptively normal MALNs and SCLNs. Specific descriptions of these normal nodes and their ultrasonographic characteristics are minimal in previous reports,[1,2] to our knowledge.

Most dogs had clear-margined, solitary MALNs that were ovoid, hypo- to isoechoic, and homogenous or cortical in echopattern. The MALN size measurements correlated significantly with body length, body weight, thoracic width, and thoracic height of the dogs. The ultrasonographic detection rate for the MALNs was quite high and higher than that previously reported.[2] Minimal success in detecting MALNs via ultrasono-graphy has been reported.[2] There was a learning curve for MALN detection in the present study, but once the MALN appearance was established, detection was efficient and repeatable.

Most dogs in the present study had clearly margined, fusiform SCLNs that were hypoechoic with a cortical or homogenous echopattern. The SCLN size measurements were significantly correlated with body length, body weight, thoracic width, and thoracic height. Shape change is reported as an important criterion for node assessment in terms of disease infiltration.[6,7] Previous studies[6,7] have determined that apparently normal superficial lymph nodes have short-axis–to–long-axis ratios < 0.50 (as determined by assessment of height relative to length), whereas abnormal lymph nodes have a higher mean ratio. By use of the same measurements in the present study, the ratio for all SCLNs was < 0.22, consistent with previous study findings. The SCLN centers were repeatedly detected; however, increased body condition did increase the time from placement of the transducer against the skin to visualization of the lymph node.

Most SCLNs examined ultrasonographically in the present study did have a visible hypoechoic cortex. The presence of a cortical pattern in both peripheral and abdominal lymph nodes has been described as normal, although a higher incidence of cortical distinction in jejunal nodes in dogs < 6 years of age has been reported.[2,4] The correlation of age with echopattern was not determined in the present study. The cortical characteristics such as size or thickness were also not measured and analyzed. In humans, a change in cortical thickness, in combination with other nodal characteristic changes, has been used to help determine whether a node is affected with benign or malignant disease.[4] Investigation into cortical characteristics in dogs that are affected by age or disease presence needs to be performed.

In the dogs of the present study, the vascular supply of all the nodes examined was minimal, which is consistent with findings of previous studies[2,7] of apparently normal nodes. If a central supply was evident, it consisted either of a single or a few small vessels. This is similar to findings of other studies,[2,4,7] which indicated that visualization of a central vascular supply in normal peripheral and abdominal lymph nodes was uncommon. The central supply was detectable in 50 of the 100 MALNs examined in the present study, which is a higher proportion than that previously reported for apparently normal lymph nodes in dogs.[2,4] In contrast, in the present study, detection of a central vascular supply in the SCLNs was consistently infrequent. One possibility for the difference in central vascular supply detection may be a primary anatomic difference between the 2 types of lymph centers. The size or velocity of the vessels supplying the MALNs may be more detectable with the color Doppler ultrasonographic function because these node vessels branch immediately off the very large-volume, high-velocity brachial and subscapular vessels.[11] Node and therefore vessel orientation relative

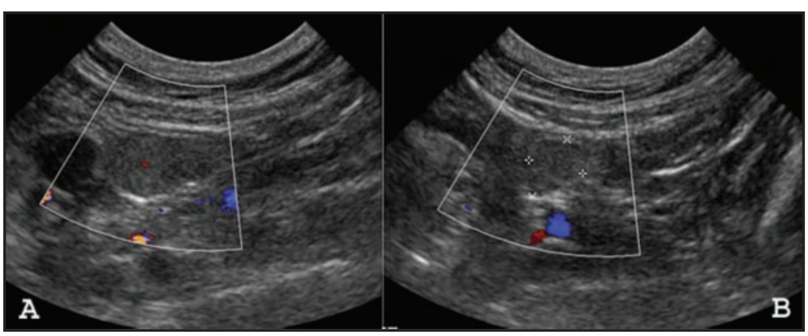

Figure 3—Representative color Doppler ultrasonographic images of the presumptively normal right MALN of a third healthy dog obtained by use of sagittal (A) and transverse (B) probe positions. Outlined area is the area in which color Doppler ultrasonography was applied. Notice the intranodal vascular supply indicated via color Doppler ultrasonography. In panel B, height (distance between the x cursors), and width (distance between the + cursors in panel B) of the lymph node are indicated.

Table 5—Mean (95% confidence interval) length, height, and width of right and left MALNs and SCLNs of 50 healthy dogs by weight category.

Lymph node	Variable	Body weight category* Low	Medium	High
Right MALN (n = 50)	Length (cm)	1.22 (1.03–1.40)	1.69 (1.52–1.86)	1.80 (1.53–2.08)
	Height (cm)	0.60 (.049–0.70)	0.82 (0.71–0.93)	1.02 (0.89–1.15)
	Width (cm)	0.51 (0.41–0.61)	0.68 (0.57–0.79)	0.76 (0.68–0.85)
Left MALN (n = 50)	Length (cm)	1.18 (1.02–1.34)	1.70 (1.47–1.94)	1.96 (1.72–2.20)
	Height (cm)	0.58 (0.50–0.66)	0.75 (0.66–0.84)	0.98 (0.79–1.18)
	Width (cm)	0.48 (0.41–0.55)	0.57 (0.48–0.67)	0.73 (0.61–0.85)
Right SCLN (n = 50)	Length (cm)	1.50 (1.22–1.78)	2.45 (2.12–2.78)	2.88 (2.51–3.25)
	Height (cm)	0.34 (0.30–0.39)	0.48 (0.41–0.55)	0.57 (0.46–0.68)
	Width (cm)	0.79 (0.61–).97)	0.98 (0.78–1.18)	0.96 (0.74–1.18)
Left SCLN (n = 49)	Length (cm)	1.53 (1.30–1.76)	2.35 (2.07–2.62)	2.51 (2.15–2.88)
	Height (cm)	0.33 (0.27–0.39)	0.43 (0.38–0.48)	0.51 (0.43–0.58)
	Width (cm)	0.66 (0.55–0.77)	0.98 (0.79–1.17)	1.21 (0.97–1.44)

*The dogs' body weights were classified into 3 categories: low, ≤ 16.5 kg; medium, > 16.5 to 29.8 kg; and high, > 29.8 kg.

to transducer angle may have contributed to differences in sensitivity of the color Doppler vessel detection.[14] The transducer angle relative to the SCLN long axis was usually 90°, which would result in decreased detection sensitivity, compared with the transducer angle of 30° to 60° used during ultrasonographic examination of the MALNs.[14] Transducer shape will also affect color Doppler sensitivity in that the sound wave array with the linear probes are strictly linear in alignment, whereas the sector probe array differs in wave angle from the probe.[14] When a linear probe is used, all sound waves leave the probe in a linear orientation and, if the probe is oriented 90° with the vessel, all the waves would interact with the vessel at 90°. By use of a sector probe oriented 90° to a vessel, only the central sound waves are linear and the outer sound waves change in orientation to the vessel and may align more with the vessel, allowing detection via color Doppler mode. This probe characteristic increases the sensitivity of the sector probes. Also, for the MALNs and SCLNs, the technical settings differed between transducer programs when color flow Doppler was used. In theory, higher-frequency transducers have increased Doppler frequency and therefore better Doppler sensitivity.[14] In practice, however, a compromise exists between better sensitivity to flow and penetration because increased imaging depth lowers frame rates, which decreases sensitivity.[14] In the machine used in the present study, the overall frame rate range for the 12–5 MHz linear probe in color Doppler mode was lower than the rate range for the 8–5 MHz sector probe in color Doppler mode, which would contribute to comparatively decreased sensitivity. In addition, the relative depth of the MALNs from the body wall was less than that of the SCLNs, which would also contribute to Doppler sensitivity differences. For these reasons, the sector probe has much better sensitivity in the color Doppler mode. Given that only the vascular supply of MALNs was assessed by use of the sector probe, comparison of the presence of intranodal vessels between SCLNs and MALNs may not be appropriate and could be a potential limitation of the present study. However, it should be considered that the differing vessel characteristics detected by use of the respective probes were repeatable and specific for the individual lymph center.

To the authors' knowledge, the present study is the first in which skeletal body size (skeletal length, height, and width), along with body weight, was related to lymph node size.[12] There was a significant correlation of skeletal body size with node size, a finding that may help clinicians further characterize normal node size ranges. Body weight and BCS are influenced by level of obesity, whereas skeletal size is not. The degree to which body condition influences lymph node size in dogs has yet to be determined.

In the present study, an inverse relationship between dog age and lymph node size was identified, which was similar to the finding for jejunal lymph nodes in a population of 57 dogs[4]; however, the results of the present study were significant only for age and the height of the MALNs when data were not stratified by age group. Unlike the findings of the previous study,[4] there was no significant association between age groups (< 6 years or ≥ 6 years) and any of the independent variables (ie, body weight, body length, thoracic depth, thoracic width, or BCS) and sizes of MALNs or SCLNs (ie, length, height, and width of the left and right nodes) in the present investigation.

The present study revealed sonographic characteristics of MALNs and the largest SCLNs in dogs that were both consistent with results of previous studies and apparently unique to individual lymph centers. The findings could be incorporated into routine scanning procedures and used to aid disease detection, monitoring, and staging. Both of these lymph centers are major drainage sites and commonly affected by primary or metastatic disease. Knowledge of the sonographic characteristics of normal MALNs and SCLNs will assist in disease detection and enable inclusion of an affected node in the radiation therapy field.

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a. iU22 Doppler ultrasonic flow detector, Philips Healthcare, Andover, Mass.
b. Statistical Package for the Social Sciences, version 16.0, IBM-SPSS, Chicago, Ill.

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