IRANIAN JOURNAL OF VETERINARY SURGERY (IJVS)
WWW.IVSA.IR

Ultrasonographic Volumetry of the Canine Thyroid Gland: A Comparison of 2D, 3D Ultrasonography and Real Gland Volume

Alireza Vajhi[*1], DVSc
Masoud Rajabioun[2], DVSc
Mohammad Molazem[1], DVSc
Hamid Sharifi[3], PhD

[1]Department of Clinical Sciences, Faculty of Veterinary Medicine, University of Tehran, Tehran, Iran.
[2]Department of Clinical Sciences, Faculty of Veterinary Medicine, Ferdowsi University of Mashhad, Mashhad, Iran.
[3]Department of Food Hygiene and Public Health, Faculty of Veterinary Medicine, Shahid Bahonar University of Kerman, Kerman, Iran.

Abstract

Objective: to compare the estimated thyroid volume, as determined by two-dimensional (2D) and three-dimensional (3D) ultrasonography, with real volume.
Design: Descriptive Study
Animals: A total of 7 mixed breed dogs
Procedures: On 2D ultrasound, the thyroid volume is estimated by the ellipsoid equation and on 3D ultrasound; it is estimated by outlining the boundaries of the thyroid lobe in image planes and then calculated with the inbuilt software. The real volume was measured after Euthanasia. Correlation between actual and estimated size were computed by using statistical software. All of the dogs must be euthanized because of clinically end-stage condition.
Results: The study demonstrates that there is a high agreement between 3D ultrasound and real volume measured by graduated cylinder method ($r=0.97$, $P<0.000$).
Conclusion and Clinical Relevance: Evaluation of the size of thyroid gland is useful in diagnosis of several situations and in follow-ups monitoring. Ultrasonography is supposed to provide a reliable estimate of thyroid volume. In this study, 3D ultrasound was a useful image method in the estimating of canine thyroid volume.
Keywords: Thyroid lobe, Canine, 3D Ultrasonography, volumetry.

Introduction

Estimation of the canine thyroid volume is generally considered to be important in several pathologic situations such as hypothyroidism, neoplasia, thyroiditis and others.[1] The two major pathologies of the thyroid gland in the adult dog are neoplasia and primary

[*] **Corresponding author:**
Alireza Vajhi, DVSc
Faculty of Veterinary Medicine, University of Tehran, Tehran, Iran
E-mail address: avajhi@ut.ac.ir

hypothyroidism.[2] Evaluation of the size of thyroid gland in follow-ups is also useful in monitoring the response to the treatment.[3,4] A sensitivity of 98% for hypothyroidism was reported using a combination of size and echogenicity of the gland.[5]

Thyroid gland size can be assessed by palpation, scintigraphy and ultrasound. However, evaluation of thyroid gland size with palpation and scintigraphy was inaccurate and had maximum errors between 82% and 90%.[3] Moreoverscintigraphy involves radiation and is invasive which is not suitable for follow-ups.[6]

Because of its superficial location, approximately 1.5–2 cm below the surface of the skin, high-frequency transducers of at least 10 MHz can be used to examine the thyroid gland. This results in a high spatial resolution of the image which makes ultrasonography a very well suited imaging modality for examining the morphology of the thyroid gland. Other advantages of ultrasonography are its widespread availability, its low cost, the absence of ionizing radiation, the short duration of the examination, and the fact that sedation or anesthesia is rarely required. The advent of high-resolution US and fine needle aspirates have decreased the indications for radionuclide thyroid scanning in people.[7]

On ultrasound, the thyroid volume is usually estimated by the ellipsoid equation assuming that the left and right lobes of thyroid gland are ellipse in shape, and the craniocaudal, lateromedial, and dorsoventral dimensions of each lobe are measured in two-dimensional (2D) ultrasound images. However, previous study in human medicine showed that thyroid volume estimation using ellipsoid equation is inaccurate and leads to considerable measurement errors.[8] With the advance in technology, thyroid volume can now be measured with three- dimensional (3D) ultrasound.

The only possibility of receiving correct feedback information about thyroid volume can be obtained measuring the surgical specimen after its removal and comparing it with its preoperative value. This study aims to compare the estimated volume (EV), as determined by preoperative 2D and 3D ultrasonography, with the real gland volume (RV).

Materials and Methods

A total of 7 mixed breed dogs (4 male and 3 female) with no history of thyroid disease were recruited in the study. The mean weight was 22.3Kg (range, 11-32 Kg). On 2D ultrasound, examinations of the thyroid gland were performed using a GE VOLUSON 730-PRO ultrasound unit (GE, Kretz, Zipf, Austria) with a 5-12 MHz linear transducer. On 3D ultrasound, the same ultrasound unit and 3D linear transducer were used. Ultrasonography was performed after optimizing 2D and 3D settings.

The animals were input into general anesthesia using Acepromazine (0.1mg/Kg, IM) and Ketamine hydrochloride (10 mg/Kg) and placed in dorsal recombency on the examination table with the neck hyper-extended. Ventral part of the neck was shaved in both side of the trachea and caudal to the larynx. The skin was prepared by cleaning and applying enough acoustic gel. The thyroid lobes were scanned separately in longitudinal and transverse planes and the volume of the thyroid lobes was measured by 2D and 3D ultrasound. On 2D ultrasound, the thyroid lobe volume was estimated by measuring the craniocaudal (CC), lateromedial (LM), and dorsoventral (DV) dimensions of the thyroid lobe, and calculating the volume using the ellipsoid equation as described by Zimmermann et al.[9] and Vitti et al.[10]:

$$\text{Thyroid volume} = л/6 \times CC \times LM \times DV$$

The LM dimensions were measured in the transverse scan with a maximum cross-sectional area of the thyroid lobe (Fig. 1). The CC and DV dimension was measured in the longitudinal

scan of the thyroid lobe (Fig. 2). All measurements were obtained by using the built-in electronic calipers.

Figure 1. Transverse sonogram shows the measurement of the lateromedial dimension of the left lobe of the thyroid gland. CC, Common Carotid; Es, Esophagus; LCa, Longus Capitis; LCo, Longus Coli; Sc, Sternocephalicus muscle; Sh, Sternohyoidus muscle; St, Sternothyroidus muscle; TH, Thyroid lobe; Tr, Trachea.

Figure 2. A longitudinal extended field-of-view sonogram shows the measurement of the craniocaudal (horizontal line) and dorsoventral (vertical line) dimensions of the left lobe of the thyroid gland.

For 3D ultrasound, a longitudinal scan of the entire thyroid lobe was performed through a single sweep from the lateral border to the medial border. After the examination, the stored images were retrieved, and the boundaries of the thyroid lobe in the 20 image planes were outlined. The volume of the thyroid glands was then calculated with the inbuilt software (Fig.3).

Figure 3. Sonograms show the 3D ultrasound volumetric measurement of the left lobe of the thyroid gland. The boundaries of the thyroid were outlined in the upper left, upper right and lower left sonograms which correspond to the longitudinal, transverse and coronal planes of the thyroid, respectively. The thyroid volume was calculated by the inbuilt software and was demonstrated in the lower right image.

All of the animals were undergone euthanasia, because they were in end-stage condition clinically and must be euthanized, both thyroid lobes were removed and their volume was measured by a graduated cylinder. The amount of water added was considered to be the real thyroid volume; the isthmus is not taken into account in volume calculation in all of the methods.

Data were expressed as mean and standard deviation; correlation between actual and estimated size were computed by using SPSS/PC-15.0 statistical software (SPSS Inc., Chicago, IL).

Results

The mean volume of thyroid lobes were measured based on 2D, 3D and graduated cylinder method (Table1). In the volumetric measurement of thyroid lobes, there is a high agreement between 3D ultrasound and graduated cylinder method (r=0.97, P<0.0002, Fig. 4). The range of measurement variations between 3D ultrasound and graduated cylinder method was -0.04 to -0.05 ml (mean ± SD=0.097±0.274). According to the results of 3D ultrasound and on the basis of the mean volume, the right thyroid lobes tend to be larger than the left thyroid lobe. The mean thyroid lobe volume based on 3D ultrasound, not according to the side of the lobes, is 0.671±0.29 ml (mean ± SD, range: 0.35-1.08 ml), and it is 0.679 ml (range: 0.415-0.963 ml) and 0.661 ml (range: 0.350-0.960 ml) for the right and left lobes, respectively.

Table1. Mean volume of thyroid lobes

	Volume based on 3D method (cm^3)	**Volume based on 2D method** (cm^3)	**Volume based on graduated cylinder** (cm^3)
Right lobe	0.679	0.449	0.644
Left lobe	0.661	0.399	0.602

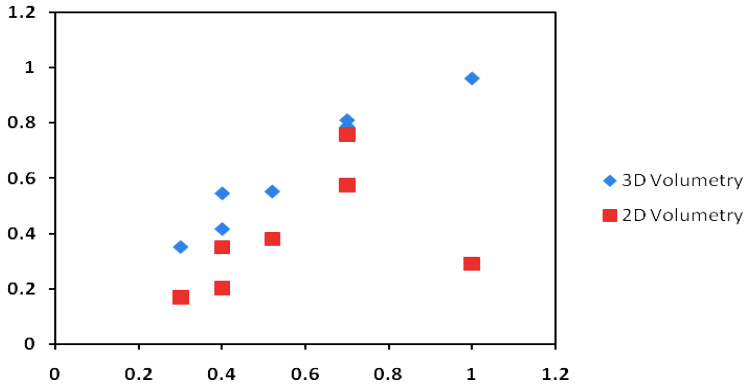

Figure 4. Scatter plot showing the correlation comparison of the volume of the thyroid lobe measured with 3D and 2D ultrasound with graduated cylinder after surgery.

Discussion

Measurement of the size of canine thyroid gland is important in diagnosing and monitoring of thyroid diseases. Thyroid gland size can be estimated by palpation and scintigraphy; however, on the basis of the human study, the accuracy of these two methods in the assessment of thyroid gland size is low. Ultrasound is a useful imaging tool for assessment of thyroid glands and measurement of thyroid size.[3] Results in this study showed that 3D ultrasound had a high accuracy in volumetric measurement compared with real size. Ying et al showed that there was moderate agreement between the thyroid volume measured with 2D and 3D ultrasound. They suggested that it was due to lower accuracy of 2D ultrasound which assumed irregular-shaped thyroid glands as elliptical in shape and higher accuracy of 3D ultrasound in thyroid volume measurement is because the 3D system calculated the volume by outlining the boundaries of the thyroid gland .[6] Thyroid lobe in dogs has ellipsoid shape similar to human

thyroid lobes; therefore the above suggested cause for accuracy of 3D compared to 2D in thyroid volumetry is also reliable in this study. Riccabona et al also reported that 3D ultrasound (mean: 5.6%) had a lower volumetric measurement error than 2D ultrasound (mean: 2.7%).[11,12] Three-dimensional ultrasound is a useful and precise image method in the measurement of thyroid volume as compared with 2D ultrasonography, and this method enables to exactly detect the alteration of the thyroid lobe volume in a relatively short time.

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چکیده

اندازه‌گیری حجم غده تیروئید با استفاده از اولتراسونوگرافی: مقایسه‌ای بین روش دوبعدی و روش سه‌بعدی با حجم واقعی

علیرضا وجهی*[1]، مسعود رجبیون[2]، محمد ملازم[1]، حمید شریفی[3]

[1] گروه علوم درمانگاهی، دانشکده دامپزشکی دانشگاه تهران، تهران، ایران.
[2] گروه علوم درمانگاهی، دانشکده دامپزشکی دانشگاه فردوسی مشهد، مشهد، ایران.
[3] گروه بهداشت و مواد غذایی، دانشکده دامپزشکی، دانشگاه شهید باهنر کرمان، کرمان، ایران.

هدف- مقایسه حجم تخمینی بدست آمده از روش‌های اولتراسونوگرافی دوبعدی، سه‌بعدی با حجم واقعی.

طرح مطالعه- مطالعه توصیفی

حیوانات- ۷ قلاده سگ نژاد مخلوط

روش بررسی- در روش دو بعدی حجم غده تیروئید با استفاده از معادله الیپسوئید و در روش سه‌بعدی با دنبال کردن محدوده غده در تصاویر بدست آمده با کمک نرم افزار دستگاه محاسبه گردید. حجم واقعی بعد از کشتن حیوانات محاسبه شد. ارتباط بین حجم واقعی و حجم‌های تخمین زده شده با اولتراسونوگرافی با استفاده از بسته نرم‌افزاری محاسبه شد. سگ‌های مورد مطالعه از نظر بالینی در شرایطی بودند می بایست کشته می‌شدند.

نتایج- این مطالعه نشان داد که بین حجم تخمین‌زده شده با روش اولتراسونوگرافی سه‌بعدی و حجم واقعی تخمین زده شده با روش استوانه مدرج ارتباط معنی‌داری وجود دارد ($r=0.97, P<0.000$) .

نتیجه‌گیری و کاربرد بالینی- ارزیابی اندازه غده تیروئید در تشخیص بیماریها و مانیتور کردن بیمار کمک کننده است. اولتراسونوگرافی روشی برای تخمین حجم غده تیروئید است و در این مطالعه مشخص شد که روش اولتراسونوگرافی سه‌بعدی یک روش مفید برای تخمین حجم غده تیروئید می‌باشد.

واژه‌های کلیدی: تیروئید، سگ، اولتراسونوگرافی سه‌بعدی، تعیین حجم.