Ultrasonographic imaging of the tongue and larynx in normal dogs

Ultrasonographic imaging of the tongue and larynx was performed in 10 dogs with no previous history of upper airway disease. The ultrasonographic findings were compared with the normal canine anatomy of this area and with the results described in the human literature. This study shows that the anatomical features of the canine larynx are adequately detectable using ultrasonography. This finding is in accordance with the findings described in the human literature. It is concluded that ultrasonography may offer a means of investigating canine laryngeal abnormalities.

H. RUDORF

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Division of Companion Animals, University of Bristol, Langford House, Langford, Bristol BS18 7DU

INTRODUCTION

Ultrasonography has recently been used to determine the normal anatomy of the canine neck (Wisner and others 1991), thyroid and parathyroid glands (Wisner and others 1993) and tongue (Solano and Penninck 1996). Examinations of the larynx and vocal cords of animals have so far not been described in the veterinary literature.

In humans, ultrasonographic examination of the larynx and pharynx has been well established since the late 1960s when A-mode was used to display the vibrating vocal cords (Hertz and others 1970). When real time ultrasound appeared, the normal anatomy of the mouth and larynx was described (Ragahvendra and others 1987, Garel and others 1992 , Ueda and others 1993) and the investigation of laryngeal function and laryngeal masses became standard procedure (Ooi 1992, Derchi and others 1992, Erkan and others 1993). Laryngeal paralysis was successfully imaged with colour flow Doppler by Ooi and others in 1995.

The aim of this study in dogs was to relate the normal anatomy of the tongue and larynx described by Miller and others (1964) to that seen with ultrasonography. This should facilitate the diagnosis of laryngeal abnormalities in later studies.

MATERIALS AND METHODS

Normal ultrasonographic anatomy of the larynx and tongue was established by studying five medium to large breed dogs and five cadavers which had no previous history of upper airway disease (Table 1). The larynx of dog 7 was subsequently freed from outside muscles and scanned submerged in a waterbath.

The cadavers were positioned in right lateral recumbency; the unsedated dogs were either standing or in sternal recumbency. The ventral mandibular and laryngeal regions were freed from hair, cleaned with surgical spirit and coupling gel (Henleys Medical) applied. The tongue and floor of the mouth as well as the laryngeal structures were examined in the sagittal and transverse plane. The vocal cords were imaged first by using the thyroid cartilage as an acoustic window. The transducer was then positioned ventrally between the thyroid and cricoid cartilages, scanning cranially towards the thyroid cartilage, along the plane of the vocal cords (Fig 1).

Some dogs exhibited discomfort when scanned through the intercartilage membrane. Breaking the examination into shorter periods, thus decreasing the length of each individual study, solved this problem.

Table 1. Details of dogs used in the study

Dog	Breed	Age (years)	Sex	Status
1	Dobermann	4	M	Alive
2	German pointer	6	MN	Alive
3	Golden retriever	2	FN	Alive
4	Greyhound	5	FN	Alive
5	Greyhound	10	M	Alive
6	Bull mastiff	1	M	Dead
7	Irish setter	4	F	Dead
8	Labrador retriever	9	FN	Dead
9	Lurcher	3	FN	Dead
10	Crossbreed	8	FN	Dead

M Male, F Female, N Neutered

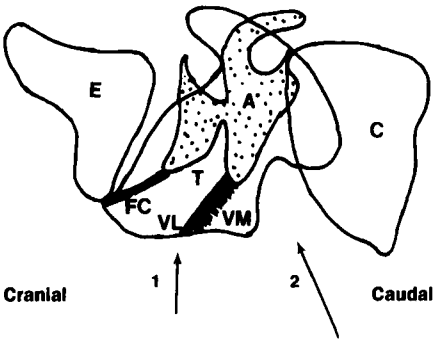


FIG 1. Schematic drawing of laryngeal anatomy. A Arytenoid cartilage, C Cricoid cartilage, E Epiglottis, FC False cord, T Thyroid cartilage, VL Vocal ligament, VM Vocal muscle, Arrow 1 Thyroid cartilage as acoustic window, Arrow 2 Cricothyroid membrane as acoustic window

The studies were performed with an ultrasonic scanner (Apogee 800; ATL) using a 10 MHz linear array probe. Videotapes were recorded and still images taken of these with a video printer (UP-890CE; Sony).

A line drawing was made of each area to facilitate recognition of the structures depicted on the ultrasound scan.

RESULTS

Caudoventral mouth and larynx

Normal anatomy

The muscular support of the tongue runs between the mandibular rami and the hyoid apparatus. It consists of two muscles: the mylohyoid and the geniohyoid muscles. The rami of the mylohyoid muscle, which have their origin on the medial surface of each mandibular ramus, insert in the midline at a fibrous raphe and caudally at the basihyoid bones. The geniohyoid muscle is also paired and runs midline from the mandibular symphysis to the basihyoid. Both muscle bellies are in close contact with each other and are located just dorsal to the mylohyoid muscles.

The genioglossus muscle lies in the intermandibular space, in and beneath the tongue. Its caudal fibres run caudally and dorsally to insert fan-like into the tongue.

The larynx is an unpaired, midline musculocartilaginous organ of about 6 cm in length. The epiglottis occupies half of this length. The false vocal cord represents the caudal limit of the aryepiglottic mucosa and it extends between the ventral projection of the cuneiform process of the arytenoid cartilage and the epiglottis. The vocal fold, or true vocal cord, extends from the vocal process of the arytenoid cartilage on either side to the luminal aspect of the ventrocaudal part of the thyroid cartilage.

The vocal ligament is a strap of elastic fibres which is enclosed in the true vocal cord. It is covered by mucous membrane, is approximately 2 mm thick and has a

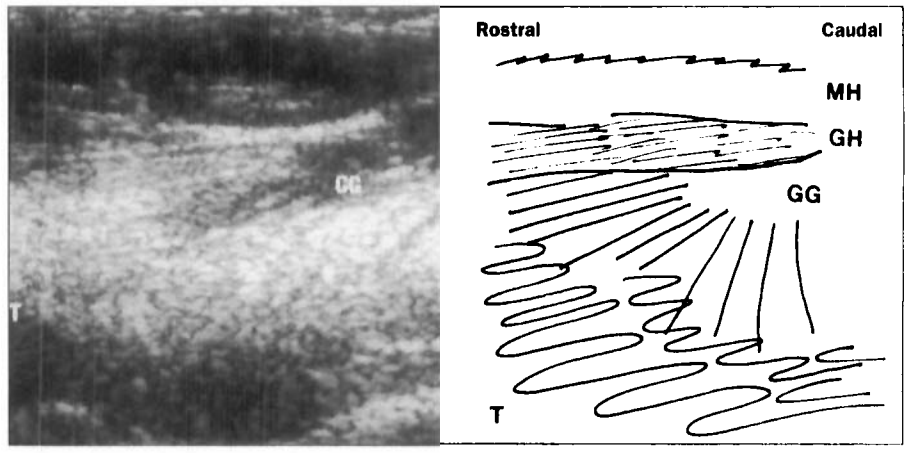


FIG 2. Sagittal view of the root of the tongue. MH Mylohyoid muscle, GH Geniohyoid muscle, GG Genioglossus muscle, T Tongue

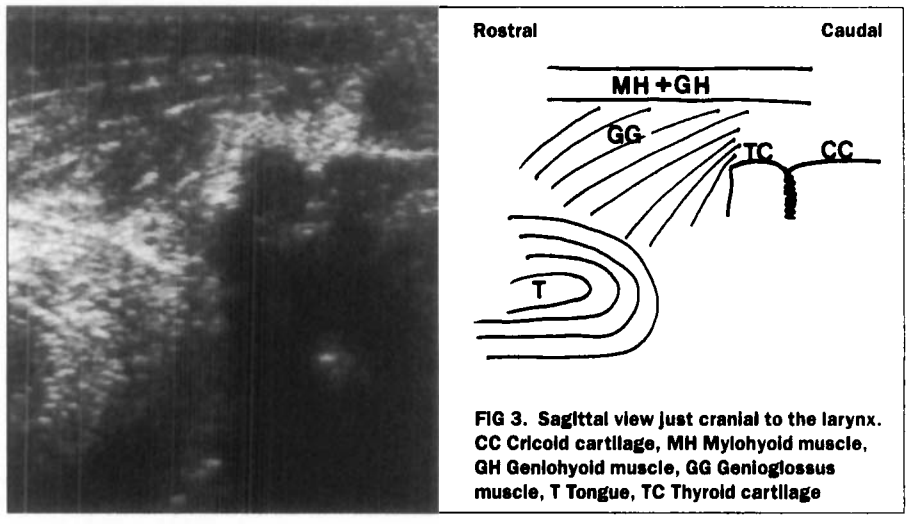


FIG 3. Sagittal view just cranial to the larynx. CC Cricoid cartilage, MH Mylohyoid muscle, GH Geniohyoid muscle, GG Genioglossus muscle, T Tongue, TC Thyroid cartilage

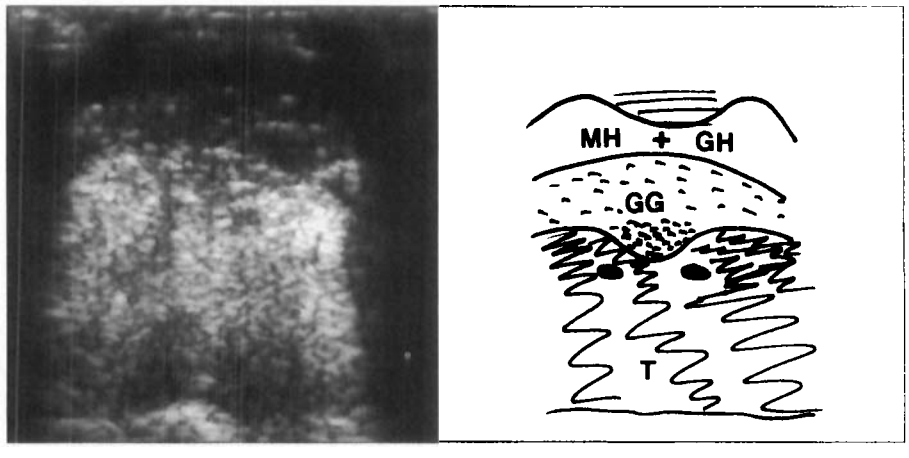
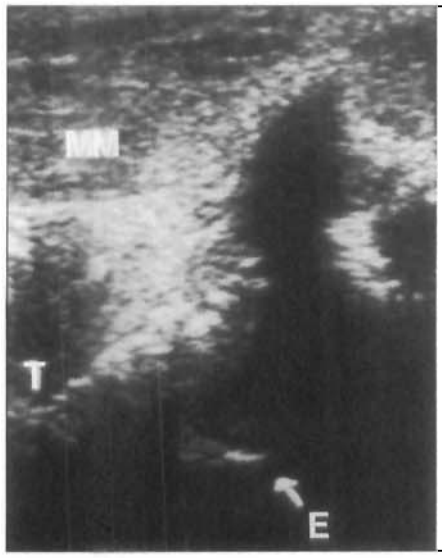


FIG 4. Transverse section of the mid-tongue region. MH Mylohyoid muscle, GH Geniohyoid muscle, GG Genioglossus muscle, T Tongue with blood vessels (●)



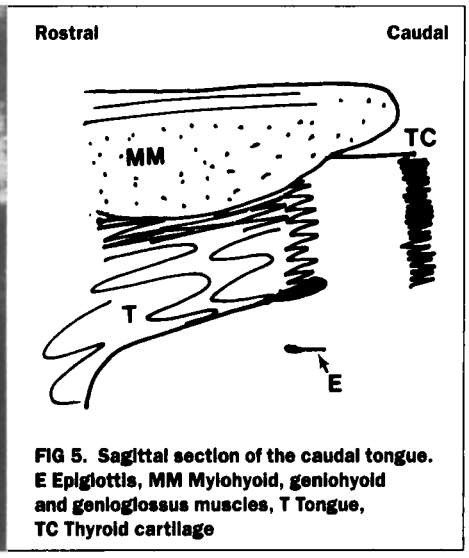
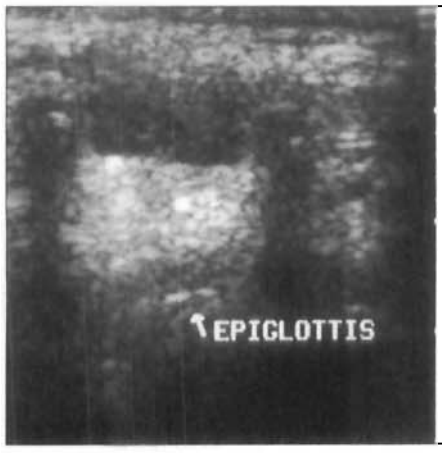


FIG 5. Sagittal section of the caudal tongue. E Epiglottis, MM Mylohyoid, geniohyoid and genioglossus muscles, T Tongue, TC Thyroid cartilage



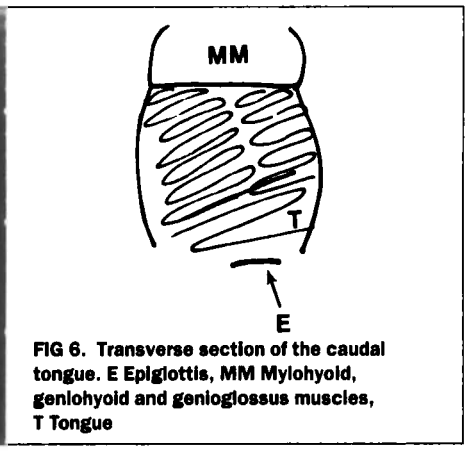
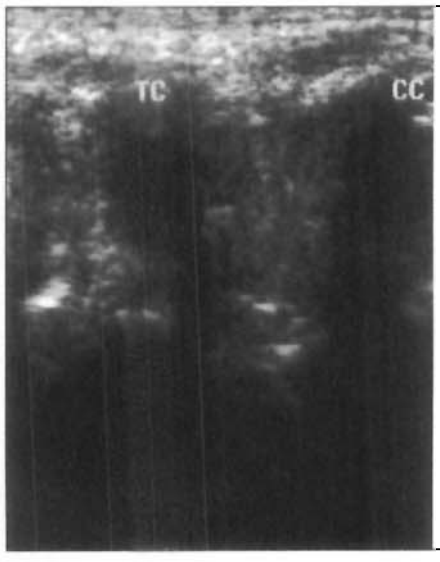


FIG 6. Transverse section of the caudal tongue. E Epiglottis, MM Mylohyoid, geniohyoid and genioglossus muscles, T Tongue



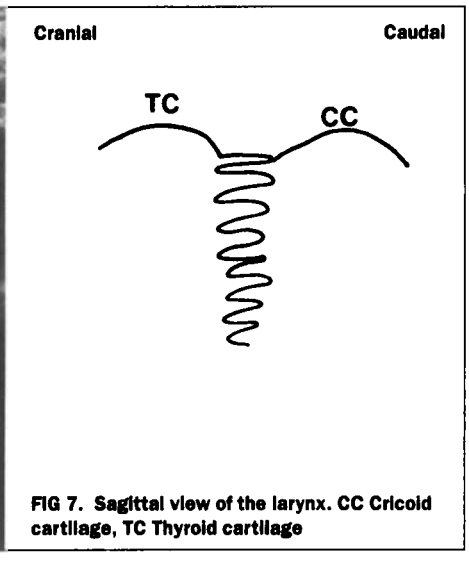


FIG 7. Sagittal view of the larynx. CC Cricoid cartilage, TC Thyroid cartilage

thin cranial border. It forms the supporting framework for the cranial border of the vocal cord and is continuous caudally with the vocal muscle which is a portion of the thyroarytenoid muscle mass. The opening between the true vocal cords is termed the rima glottis.

Ultrasonographic anatomy

The hypoechoic, homogeneously speckled mylohyoid and geniohyoid muscles were separated by an echogenic line, best seen in the sagittal plane (Fig 2). The genioglossus appeared layered in its caudal aspect and radiated into the propria linguae muscle fibres (Figs 2 and 3). The tongue appeared more echogenic than the hyoid and genioglossus muscles (Figs 2, 4 and 6).

The transverse section showed the mylohyoid and geniohyoid muscles as a hypoechoic band in the near field. Dorsal to that, the genioglossus muscle showed a speckled echogenicity. The tongue appeared moderately hyperechoic (Fig 4).

The epiglottis was seen as a hyperechoic line on the sagittal view, just cranial and dorsal to the shadow cast by the thyroid cartilage (Fig 5). In the transverse section, the epiglottis was just visible as a mildly hyperechoic line, dorsal to the tongue, in the far field of the transducer (Fig 6). The detection of the epiglottis was easiest during the act of deglutition because of the associated movement.

The thyroid and cricoid cartilages appeared as hyperechoic lines on the sagittal view, reflecting the beam, leaving an acoustic shadow in the far field (Fig 7). On the transverse view, the false and true vocal cords could be assessed in all the animals with the transducer placed caudal to the thyroid cartilage onto the cricothyroid membranes (Figs 9 to 11). In eight of the 10 animals examined, the vocal cords could also be assessed with the transducer positioned onto the thyroid cartilage directly and the beam angled slightly cranially. Figs 10 and 11 were obtained in this fashion from dog 4. The two cases in which it was not possible to view the

vocal cords using the thyroid cartilage as an acoustic window were the older dogs (5 and 10).

The cuneiform processes of the arytenoid cartilages were seen in the most cranial aspect of the larynx as paired, hyperechoic lines about 1·5 cm from the transducer surface (Fig 8). A moderately hypoechoic echo was detected medial to the hyperechoic thyroid cartilage on either side (Fig 9). This was presumed to represent the false vocal cords. The vocal processes of the arytenoid cartilage could be seen just dorsal to the vocal ligaments, about 2·3 cm from the transducer surface. They appeared as elongated lines with dorsal enhancement, resulting in two roughly circular structures, each apparently connected to one of the vocal ligaments (Fig 10). The vocal ligaments were visible on either side of the rima glottis as a hyperechoic band of about half the thickness of the vocal muscles, apparently touching in the ventral midline (Figs 10 and 11). The subepiglottic area, filled with air, caused a reverberation artefact through the rima glottis. The air artefact between the two vocal ligaments appeared hyperechoic and complicated the detection of the ligaments (Fig 11).

Figs 10 and 11 show the slightly pyramidal hyperechoic thyroid cartilage, followed axially by two separate triangular to ovoid, anechoic structures, which represent the vocal muscles. The image obtained in the waterbath (Fig 12) showed the same anatomical configuration, although the thyroid cartilage in water appeared much more hyperechoic than the vocal ligaments.

Vocal cord motion

The vocal cords were abducted during inspiration but very little change of position was evident during normal breathing. The position of the arytenoid cartilage (cuneiform and vocal process) was easier to observe and the symmetry of the movement could be judged.

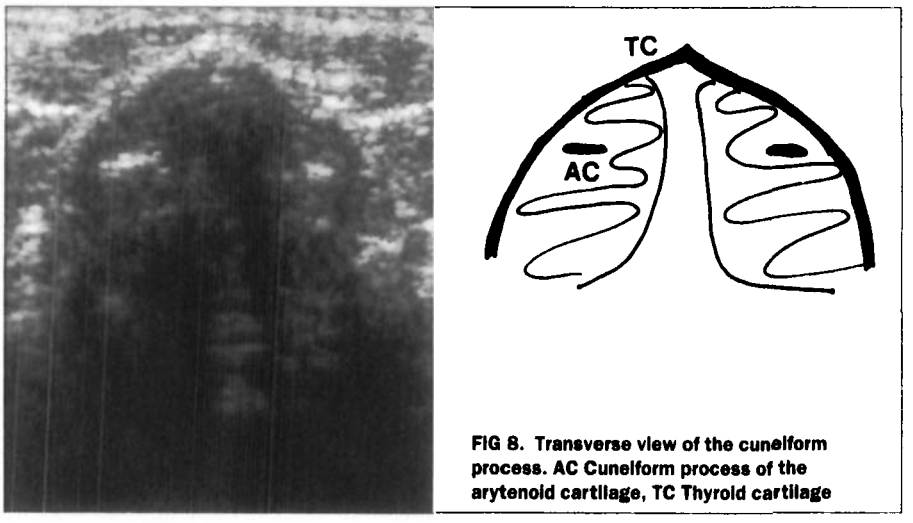


FIG 8. Transverse view of the cuneiform process. AC Cuneiform process of the arytenoid cartilage, TC Thyroid cartilage

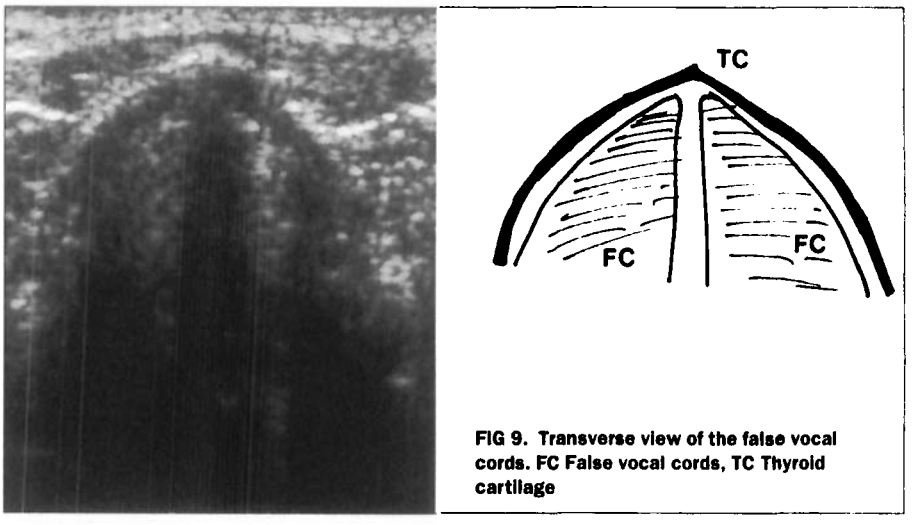


FIG 9. Transverse view of the false vocal cords. FC False vocal cords, TC Thyroid cartilage

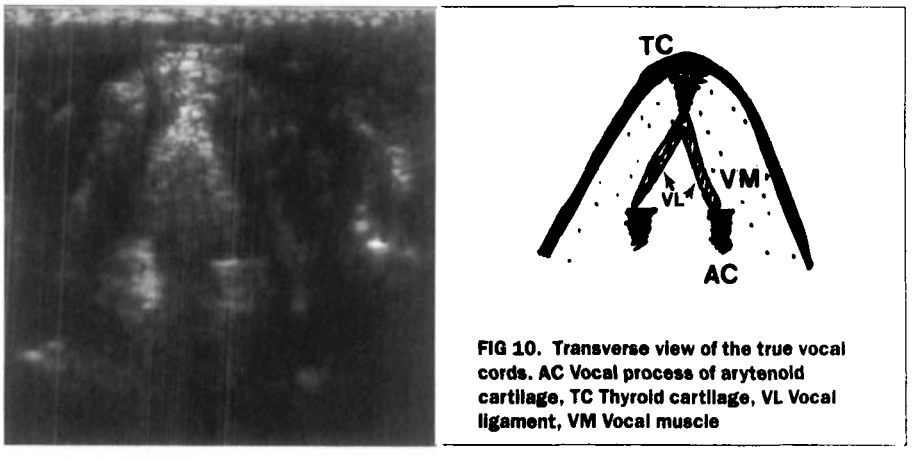


FIG 10. Transverse view of the true vocal cords. AC Vocal process of arytenoid cartilage, TC Thyroid cartilage, VL Vocal ligament, VM Vocal muscle

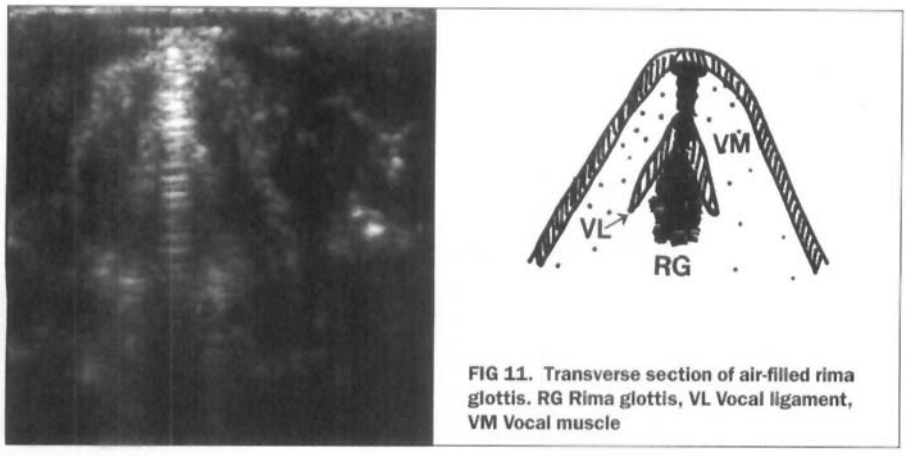


FIG 11. Transverse section of air-filled rima glottis. RG Rima glottis, VL Vocal ligament, VM Vocal muscle

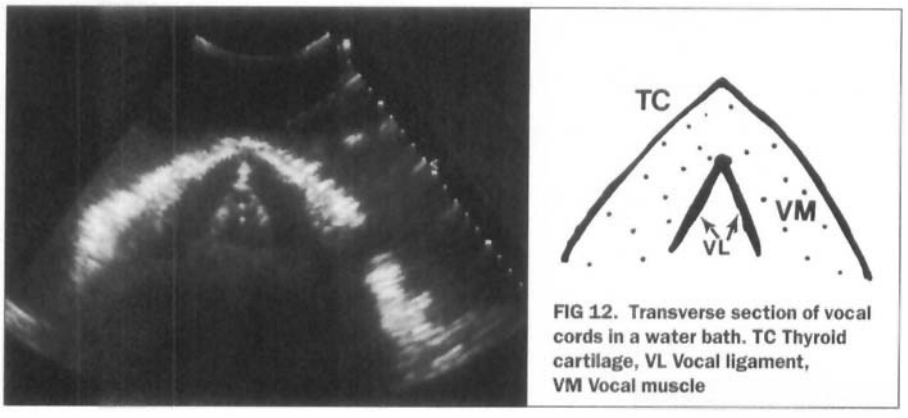


FIG 12. Transverse section of vocal cords in a water bath. TC Thyroid cartilage, VL Vocal ligament, VM Vocal muscle

DISCUSSION

By using a high frequency, linear transducer it was possible to recognise the mylohyoid, geniohyoid and genioglossus muscles in dogs as described in humans (Ueda and others 1993). Their separation was best seen in the sagittal plane. The use of a high frequency sector scanner in animals, as described by Solano and Penninck (1996), complicates the assessment of these muscles because of near field artifacts.

The appearance of the genioglossus muscle resembled the anatomical description of Miller and others (1964) and the ultrasonographic description in horses (Solano and Penninck 1996) and people (Ueda and others 1993). It merged with the relatively hyperechoic body of the tongue and was seen to be striated in the sagittal and speckled in the transverse plane.

The epiglottis appeared brightly hyperechoic and was most consistently seen in the sagittal plane during deglutition. The use of the 10 MHz transducer made it more difficult to obtain a good image because the beam narrowed dramatically, when focusing on this structure 3·5 cm from the transducer surface. For the evaluation of the epiglottis, a 7·5 MHz transducer with stand-off would undoubtedly be more useful.

The thyroid and cricoid cartilages, because of their shadow-casting abilities, were detected in the sagittal plane. This was in accordance with the findings of Carp and Bundy (1992). In eight of the 10 animals it was possible to view the vocal cords using the thyroid cartilage as an acoustic window. This method is well documented in the human literature and has been used in children (Ueda and others 1993) and adults up to the age of 73 years (Ragahvendra and others 1987, Ooi 1992, Ooi and others 1995). On the other hand, Derchi and others (1992) state that only 40 per cent of subjects over 70 years of age could be examined, because of calcification of the thyroid cartilage in the other 60 per cent. Garel and others (1992) noted that calcification following surgery also creates an acoustic shadow which prevents the detection of structures. It appears, therefore, that calcification rather than age is the preventing factor for sound transmission in the laryngeal region. It was not possible to comment on the degree or homogeneity of the laryngeal cartilage calcification in the group of dogs in the present study because no radiographs were taken to assess cartilage calcification.

The larynx is essentially an air-filled structure; because of the scattering of the ultrasound beam, it is not easy to evaluate the laryngeal air column. The vocal cords project into the laryngeal lumen and displace the air column. This permits the ultrasonographic detection of the vocal cords (Ragahvendra and others 1987).

The laryngeal lumen was best imaged in the transverse section. The thyroid cartilage appeared as a mildly hyperechoic, cone-shaped structure with the almost anechoic vocal muscles at its axial surface. The axial boundary of this muscle, the vocal ligament, was hyperechoic and detectable only with the beam directed through it. It was easier to achieve this position through the transcartilage window. The appearance of vocal muscle and vocal ligament is as described in the human literature (Ragahvendra and others 1987, Garel and others 1992, Ueda and others 1993, Fanucci and others 1994) and, given that the histological components of these structures are the same in animals (Nickel and others 1973) and humans (Bloom and Fawcett 1968), it can be assumed that the reasoning for this

appearance given in the human literature can be extrapolated into the veterinary world. It is stated therein that, owing to their muscular component, the vocal cords appear anechoic, whereas the vocal ligaments, containing elastic fibres, appear hyperechoic.

The false vocal cords described in the human literature as having an increased echogenicity (Ragahvendra and others 1987, Garel and others 1992, Ueda and others 1993, Fanucci and others 1994), owing to their fatty tissue and mucous gland components (Ragahvendra and others 1987), were probably represented by the aryepiglottic mucosa just cranial to the vocal ligaments.

It was difficult to observe the vocal ligaments over longer periods because of the laryngeal air column, and it can be assumed that this will be complicated even further in animals with dyspnoea. The position and movement of the cuneiform and vocal processes of the arytenoid cartilage might, therefore, prove to be a better landmark when trying to evaluate vocal cord motion as suggested by Garel and others (1992) in cases of laryngeal stenosis.

The pictures obtained from thin breeds such as the greyhound and the Irish setter were of better quality than the ones obtained from breeds with a large amount of soft tissue or fat around the larynx.

Conclusion

This study demonstrates that high resolution ultrasonography is a non-invasive, consistently reproducible technique that enables the investigation of the tongue and the laryngeal structures. It also facilitates the assessment of vocal cord motion during respiration. Ultrasonography may, therefore, offer a means of investigating laryngeal abnormalities, but further studies on clinical cases are required to support this theory.

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ABSTRACTS

Pathological factors affecting survival in dogs after splenectomy

The pathological findings of spleens removed from 500 dogs during a four-year period were correlated to their survival. Gross and microscopic examination was performed allowing classification of disease as neoplastic or non-neoplastic and then into further categories according to the gross appearance, malignancy and so on. The case outcome was established by a written questionnaire completed by the veterinarian four to 30 months after splenectomy. Only 12 cases were lost to follow-up. Of the 500 spleens, 51 per cent were classified as non-neoplastic. Nodular splenomegalies were present in 81 per cent of these as a result of conditions such as nodular hyperplasia, haematoma and splenic abscess, while 18 per cent were uniformly enlarged on gross examination – causes included torsion, infarction and lymphoid hyperplasia. Forty-eight per cent of the spleens were classified as neoplastic, 89 per cent of which contained malignant neoplasms. Fourteen types of malignant neoplasms were reported, with haemangiosarcoma accounting for the largest number (more than 50 per cent). A significant predilection for this condition was noted in German Shepherd dogs and golden retrievers. Sixty-four per cent of dogs with splenic hyperplasia or haematoma were alive one year after splenectomy. Survival times for dogs with benign splenic neoplasms were similar: 31 per cent of those with splenic haemangiosarcoma were alive one month after surgery with 7 per cent alive one year after surgery, and 25 per cent of dogs with splenic lymphoma were alive one year after surgery.

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