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ULTRASOUND EVALUATION OF COMMON CAROTID ARTERTY BLOOD FLOW IN DOGS

EVALUAREA ULTRASONOGRAFICĂ ÎN FLUXUL SANGUIN DIN ARTERA CAROTIDĂ COMUNĂ LA CÂINI

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ABSTRACT | REZUMAT

Ultrasonography was introduced into clinical veterinary practice in the early 1980's and is currently used for a several clinical indications because is affordable, portable, and capable of high resolution imaging of both tissue and blood flow. Ultrasound modalities used for imaging vascular structures (veins and arteries) and surrounding anatomy include two-dimensional (2D) ultrasound, Doppler color flow (DCF), and spectral Doppler interrogation (PW). For a proper examination, the operator must understand the physics of ultrasound, image display, the probe orientation, mechanisms of image generation and the artifacts. Because the ventral cervical region is anatomically complex, ultrasound is uniquely suited to evaluate the cervical organs, vessels and tissues.

The 2D ultrasound mode examination results in obtaining longitudinal and transverse images of the blood vessels, where it can be evaluated various aspects such as thickness of the wall, luminal content and diameter. DCF examination on a blood vessel not only evaluate the morphology, but also provides information about vessel patency, blood flow direction and velocity. Another important aspect in the examination of a luminal vessel represent the reaction and changes in the blood flow due the pressure applied by the transducer on the vessel walls, especially in those with superficial localization. PW tracing allows through the Doppler waves morphologyto observe the possible pathologic flow pattern and calculate the vascular resistance due the spectral Doppler parameters: peak systolic velocity, early diastolic velocity, peak systolic velocity-to-end diastolic velocity ratio, resistive index, and pulsatility index.

Keywords: ultrasonography, common carotid artery, blood flow

Ultrasonografia a fost introdusă în practica clinică veterinară la începutul anilor 80 și este în prezent utilizată pentru diferite indicații clinice, datorită faptului că este accesibilă din punct de vedere material dar și pentru că este o tehnică capabilă să redea imagini de calitate superioară, atât a țesuturilor cât și a fluxurilor sanguine. Modalitățile ultrasonografice utilizate pentru structurile vasculare (vene și artere) și anatomia din jurul acestora include tehnicile bidemensionale (2D), Doppler color (DCF) și Doppler spectral (PW).

Pentru o examinare corespunzătoare, operatorul trebuie să aibă cunoștințe de principiile de fizică ultrasonografică responsabile de redare imaginilor, orientarea sondei, mecanisme de generare a imaginii și artefactelor. Deoarece regiunea cervicală ventrală reprezintă un complex din punct de vedere anatomic, ecografia este singura tehnică potrivită pentru a evalua organele, venele și țesuturile cervicale.

Modul de examinare bidimensional are ca rezultat obținerea unor secțiuni logitudinale și transversale a vaselor sanguine, prin care se pot evalua aspecte variate precum grosimea peretelui, conținutul luminal și diametrul. Examinarea DCF a vaselor sanguine evaluează nu doar morfologia, dar oferă informații și asupra permeabilității vasului, direcției fluxului sanguin și velocității. Un alt aspect important al examinării unui vas luminal o reprezintă reacția și modificările fluxului sanguin datorită presiuni aplicate de sondă asupra pereților vaselor, mai ales în cazul celor superficiale. PW oferă posibilitatea de a observa tiparul unui flux posibil patologic și de a calcula rezistența vasculară datorată parametrilor Doppler: velocitatea sistolică, diastolică timpurie, raportul dintre velocitatea sistolică și cea diastolică, indicele de rezistivitate și pulsatilitate.

Cuvinte cheie: ultrasonografie, arteră carotidă comună, flux sanguin

The common carotid arteries (CCA) in dogs finishes near a transverse plane, passing throughout the hyoid bone body, originating on the both sides, the right and left external carotids (ECA) as well as the right and left internal carotid arteries (ICA). The major afferent blood supply to the brain arises from the ICA's and vertebral arteries. In human medicine, the ICA's

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and the basilar artery are joined on the ventral surface of the brain into an vascular ring, named circle of Willis. The arterial brain's supply in dogs is radically different from that in humans. In humans, the ICA is the most important source of blood to the brain, whereas in dogs the cerebral arterial circle receives a substantial contribution from anastomotic vessels, derived from numerous extensive branches of the ECA (Jewell, 1952). Also, compared with humans, the vertebral arteries in dogs assume a greater importance in terms of the total blood supply to the brain. In dogs, because of the numerous intra-and extracranial anastomoses, the brain "is protected" against the effects of cerebral arterial occlusion. These differences may explain why cerebrovascular diseases are less common in dogs than in humans. The brain is a complex and heterogeneous organ, dependent on its blood supply. Cerebrovascular disease describes any pathological condition of the brain caused by an abnormality of blood flow. Pathological processes that may result in cerebrovascular disease include: occlusion of the lumen by thrombus or embolus, rupture of the blood vessel wall, lesion or altered permeability of the vessel wall and increased viscosity or other changes in the quality of the blood. Knowledge of the routes of arterial blood flow to the brain represent an important factor for clinicians in understanding disease pathophysiology and appropriate therapeutic intervention.

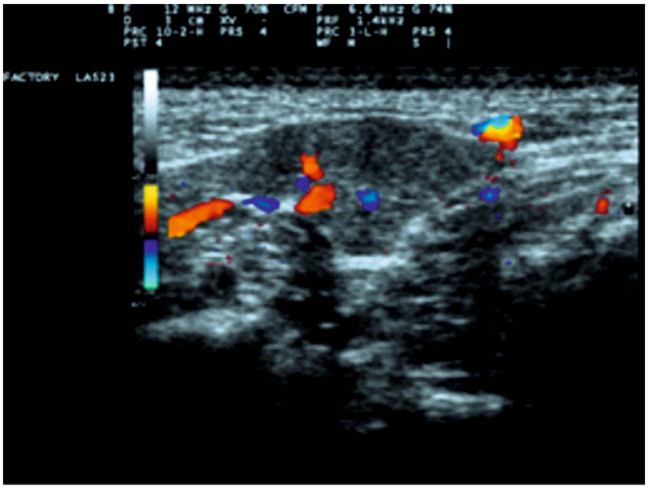

Fig. 1. Carotid body tumor

In human medicine, cerebrovascular disorders are frequent and are very often related to atherosclerotic plaques and carotid artery stenosis. People with neurological signs are often subjected to carotid artery Doppler ultrasound examination. For this reason, examination of CCA arteries has become a regular practice in the prevention of stroke or brain ischemia.

In dogs, atherosclerotic disorders do not occur with the same frequency as in humans. However, stenosis may occur because of other causes, such as neoplasia,aneurysms, arterio-venous malformations, trauma, and iatrogenic causes secondary to surgical procedures. Carotid body tumors (Fig. 1) appear rarely and are usually more malignant than aortic body tumors. These tumors are usually non-functional (chemodectomas or paragangliomas) and generally they cause clinical symptoms as they affect the surrounding structures. Carotid body tumors usually tend to splay to the carotid bifurcation as they enlarge.

Scanning preparation.

No specific preparation is required, but the patient must be capable to lie down (right/left recumbence) and sitting still during the examination with the maximum neck extension. The examination site (right and left jugular fossa) should be clipped and cleaned with alcohol and after that acoustic gel it's applied. The examination can be performed with a medium to high frequency (4–7 or 5–12 MHz) flat linear array transducer. The higher the frequency, the better the resolution of the vessel wall structure; however, in some cases the carotid bifurcation lies deep in the neck, requiring a lower frequency transducer for visualization.

CCA is located in close association and parallel to the trachea. The major neck vessels that can be examined with ultrasound are the jugular veins, and their primary tributaries, and the CCA and their major branches. In addition to defining gross anatomy of the neck, high-resolution ultrasound can also be used to examine very small structures such as the thyroid and parathyroid glands. The examination should also demonstrate the presence and direction of flow in the vertebral arteries. Blood flow velocities detected in most of the normal and diseased carotid arteries are reasonably high, so the scanner should be configured to visualize high-velocity pulsatile flow. A small spectral Doppler sample volume (Fig. 2) is usually used to interrogate the CCA's, as it allows for more selective investigation of areas of velocity increase or flow disturbance.

B-Mode Imaging.

The normal vessel walls will often appear as a double-layer structure when imaged in longitudinal section. This represents the intima/media layer and adventitia and is most clearly seen on the posterior wall in the CCA, when the vessel lies at right angles to

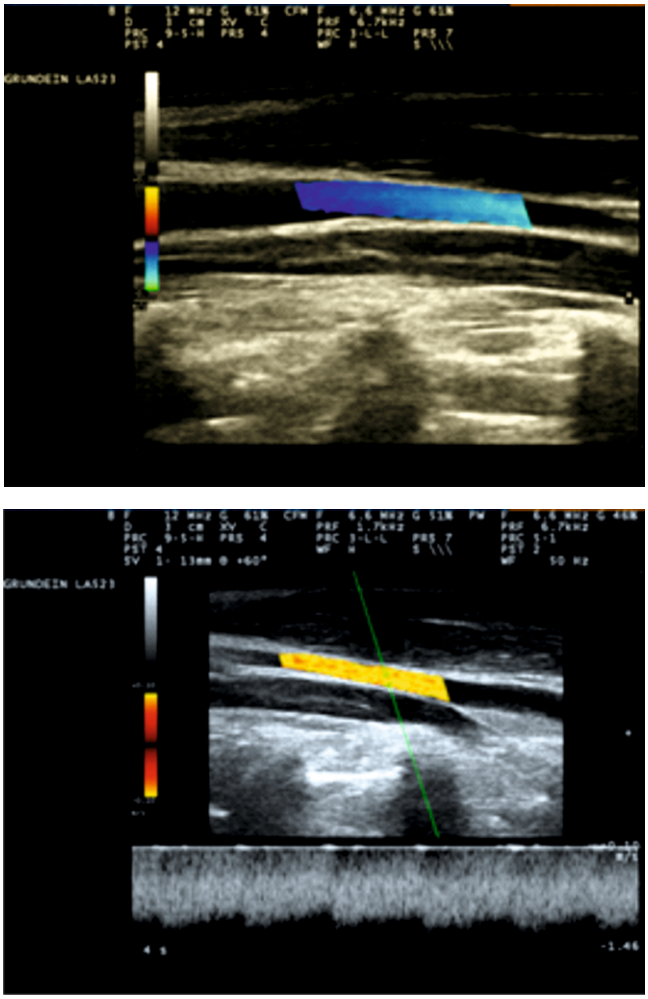

Fig. 2. Doppler color flow (above) and spectral Doppler interrogation (below) of left jugular vein - characteristic continuous spectral blood flow

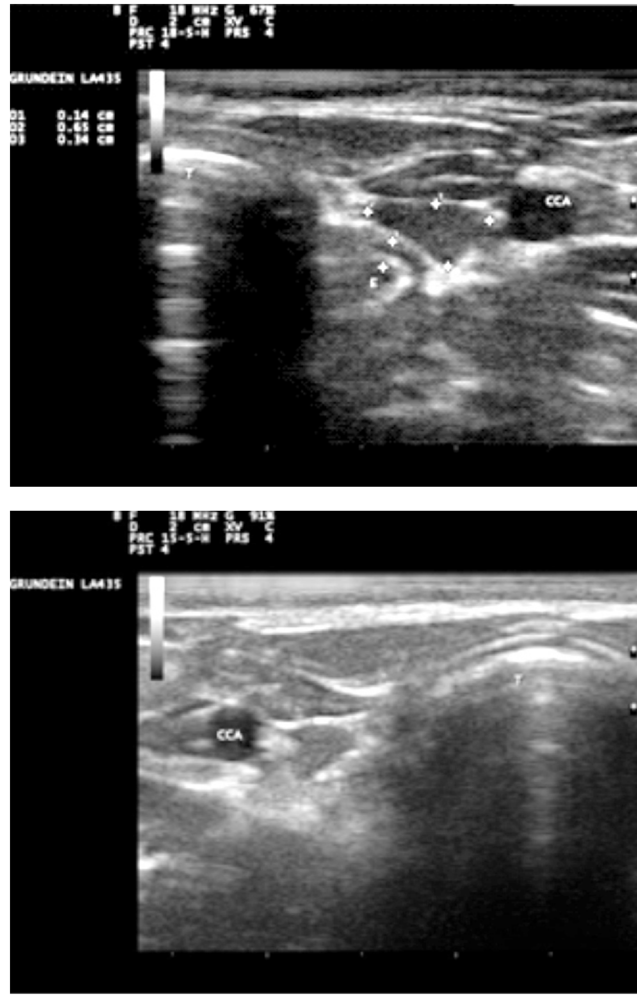

Fig. 3. Transverse B-mode images: Right (above) and left CCA (below) and the thyroid and esophagus (18MHz frequency)

the ultrasound beam. The normal thickness of the intima-media layer is of the order of 0.5 mm. A normal vessel lumen should appear anechoic, but it is possible for the sonographer to remove echoes from within the lumen by reducing the time gain compensation, so careful use of the imaging controls is important. Reverberation artifacts can also give the appearance of structures within the lumen. Occasionally, it is difficult to obtain adequate B-mode images of the bifurcation. In this case, color flow imaging may help locate the vessels and enable spectral Doppler measurements to be made. (Fig. 3, 4, 5)

Color imaging

Flow in normal carotid arteries is pulsatile, with forward flow present throughout the cardiac cycle. With the appropriate PRF selected, color should continually fill the vessel lumen up to the walls.

The flow may appear more pulsatile in the ECA than in the ICA and CCA. At the bifurcation, changes in the vessel geometry often lead to areas of flow reversal within the bifurcation, on the opposite side of the vessel to the ECA origin. Increased velocity within a stenosis usually causes a change in the color displayed on the image, often associated with aliasing and sometimes with flow recirculation. The color flow image can help to locate the area of greatest narrowing within a diseased segment of a vessel, which should then be investigated with the spectral Doppler. High-velocity jets may be seen within and just beyond a stenosis and the path of the flow may no longer be parallel to the vessel wall. In this case, the color image allows more accurate angle correction for velocity measurements. The complete absence of color Doppler filling within a vessel could indicate that the vessel is occluded, but this should be confirmed by optimizing

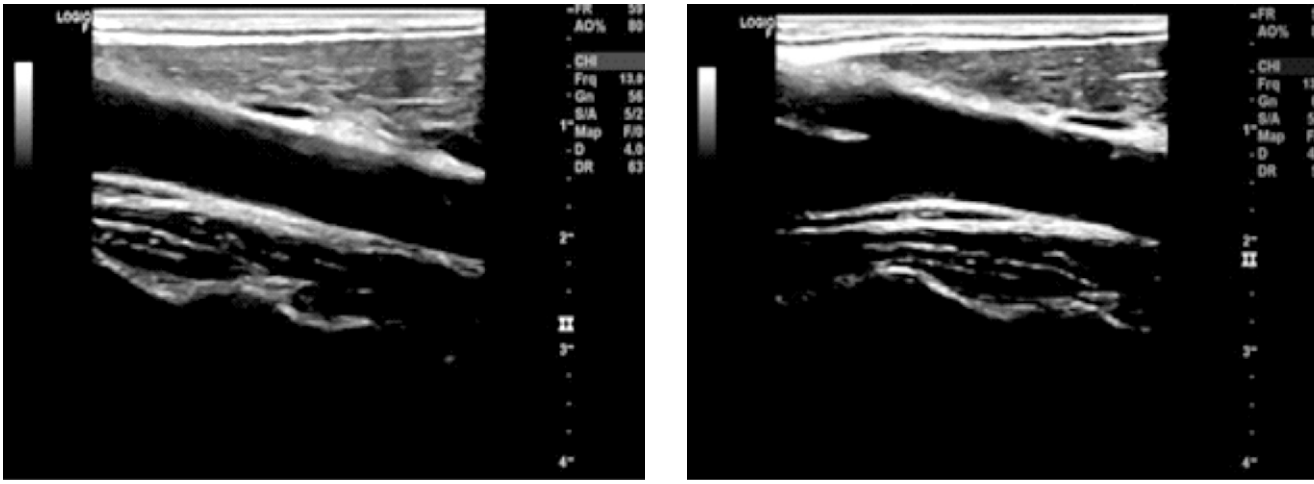

Fig. 4. Longitudinal B-mode image of the CCA (left) and bifurcation with the ICA and ECA seen in the same plane (right) (13 MHz frequency)

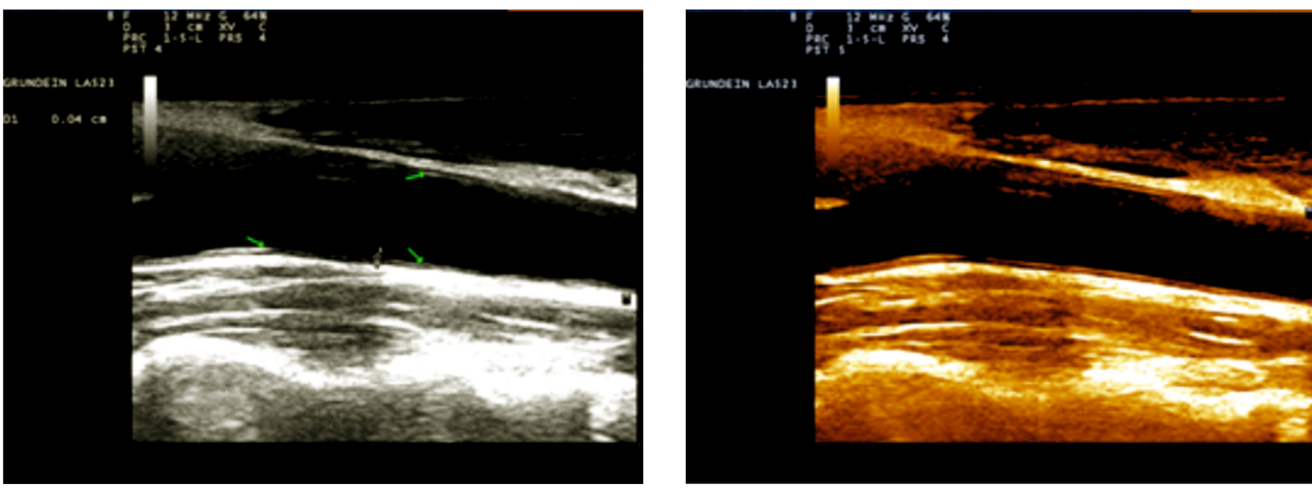

Fig. 5. Longitudinal B-mode images of the CCA and the normal thickness of the intima-media layer without filter (left) and Orange Gray filter (right) (12 MHz frequency)

the color controls for detection of low velocity flow to rule out the presence of a very tight stenosis some-where along the vessel.

The apparent lack of color filling within the CCA or ICA during diastole may indicate high-resistance flow due to an occlusion or tight stenosis distally.

Spectral Doppler should be used to confirm the absence of diastolic flow, and both color and spectral Doppler should be used to investigate the distal vessels carefully. (Fig. 6, 7, 8)

Spectral doppler waveforms.

Spectral Doppler recordings obtained from the ECA show a high-resistance flow pattern with a pulsatile waveform shape and low diastolic flow compared with the low-resistance waveform shape seen in the ICA. The normal CCA waveform has a shape some-where between that of the ICA and the ECA.

The peak systolic velocities seen in the carotid arteries depend on the relative size of the vessel but are typically less than 100 cm/s in the normal ICA.

The flow profiles in the normal bifurcation seen in color flow imaging will affect the spectral Doppler waveform shapes detected in the ICA origin, which may appear disturbed or demonstrate areas of reverse flow. Distal to the bifurcation, the waveform shapes should no longer appear disturbed. Therefore, it is necessary to keep the Doppler angle of 60° or less, because small changes in the Doppler angle above 60° result in significant changes in the calculated speed.

The lack of accuracy in the measurements results in larger errors in the estimation of speed than similar errors in the angles for measuring levels of impedance, such as resistance index, as these measures are based only on the amplitude ratio between systolic and diastolic. (Fig. 9, 10)

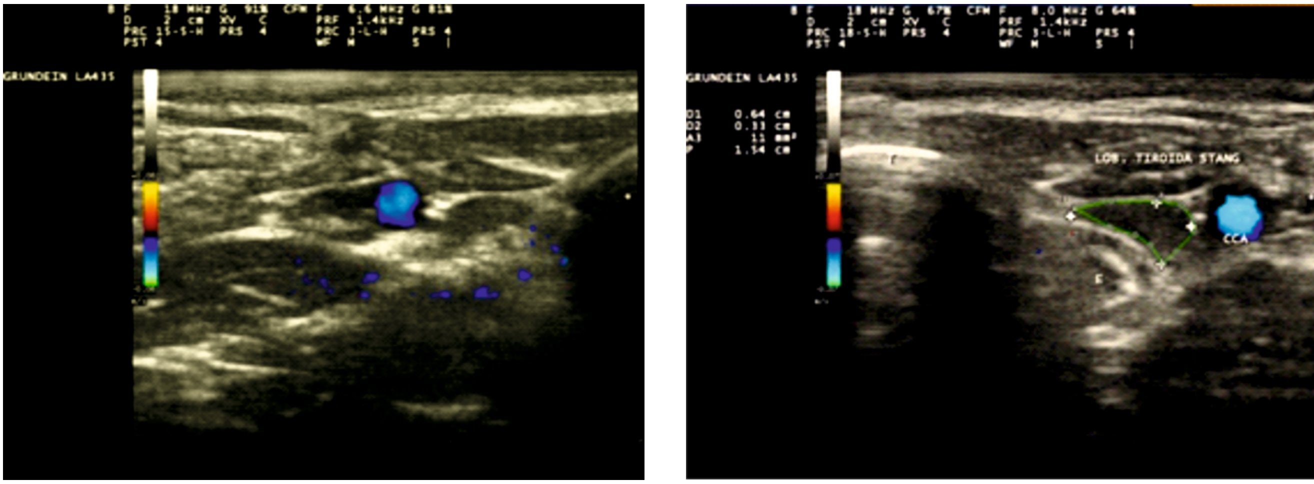

Fig. 6. Transverse Color Doppler mode images
- right and left CCA -

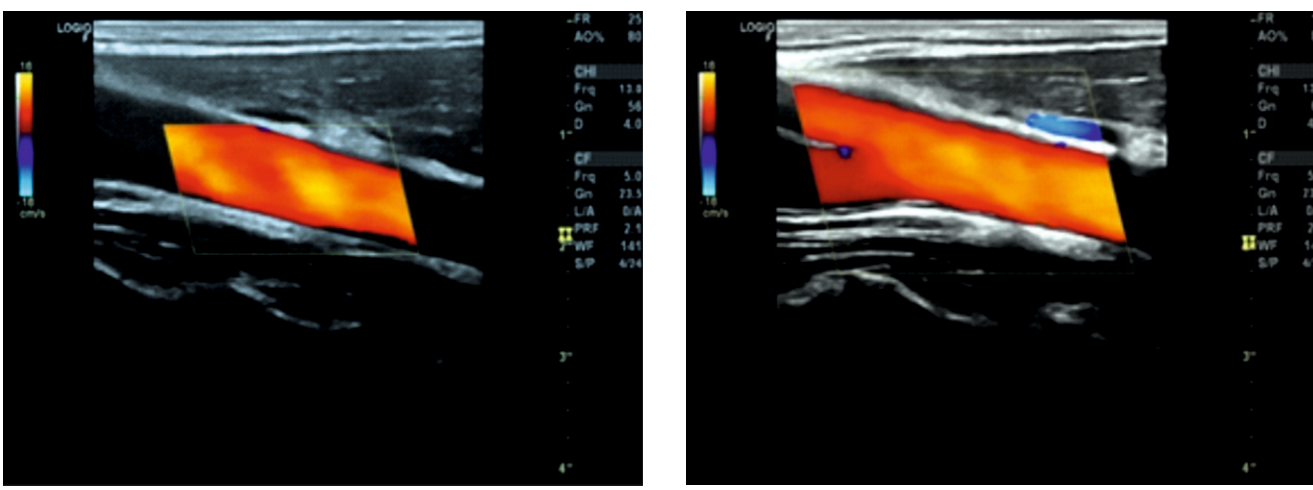

Fig. 7. Longitudinal color Doppler mode image of the CCA (left)
and bifurcation with the ICA and ECA seen in the same plane (right)

Normal blood flow in the CCA's of small animals may show wide variations.

In general, larger dog breeds present bidirectional blood flow, whereas smaller dog breeds and cats present unidirectional blood flow.

In 2004, Lee et. al., observed an average systolic peak velocity of 115±17cm/s and an average final diastolic velocity of 39±7cm/s in the CCA of 1-year-old beagles. They observed that the caudal velocity was generally higher than the cranial velocity (Table 1).

One limitation for any Doppler-based technique, attention should be given to minimizing user-related variations and errors.

In the same animal, the hemodynamic vascular indexes shouldn't be observed big differences between right and left CCA blood flow.

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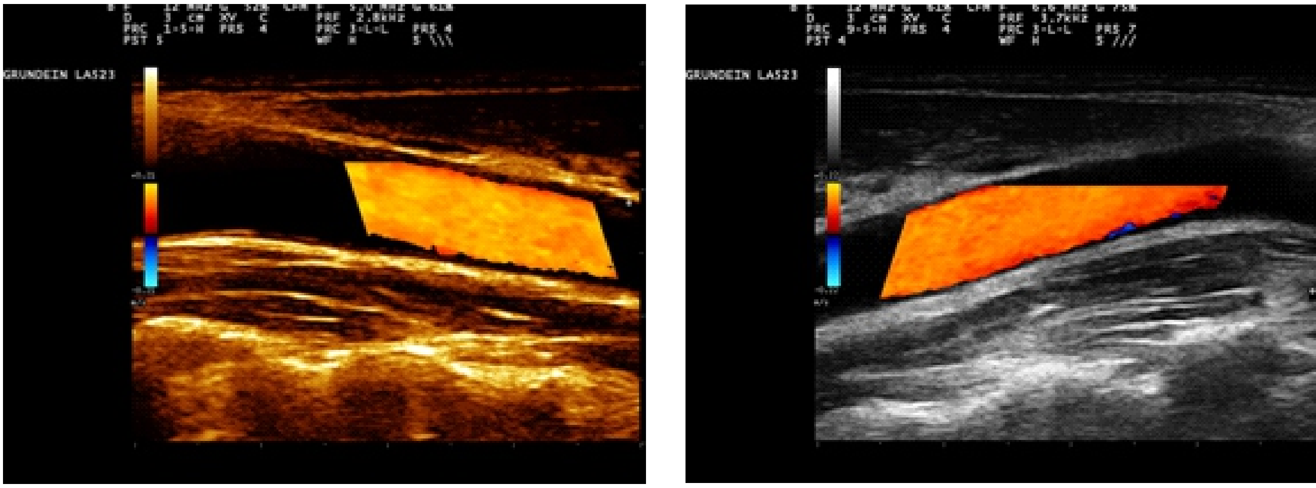

Fig. 8. Longitudinal color Doppler flow mode image of the CCA - with orange and blue Gray filters for better evidence of blood flow and vessel wall

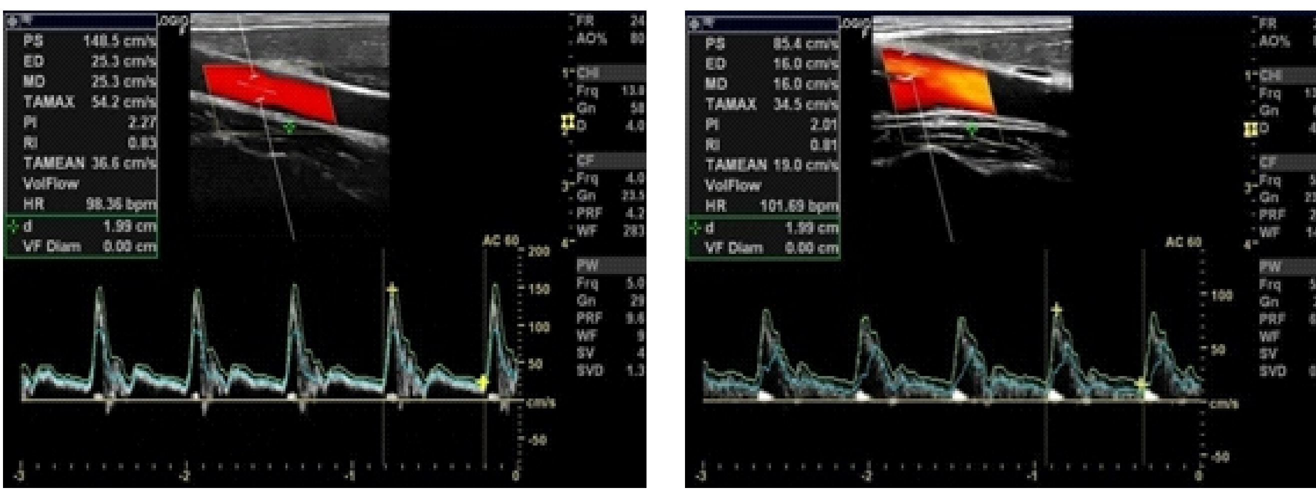

Fig. 9. Typical normal Doppler spectral obtained from the right CCA (left) and right ICA (right)

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Table 1

Spectral waveform analysis and diameter of normal profile in dogs divided by gender and side

Animal (n=14)		**Female**	**Male**
Right CCA	Minimum diastolic velocity	10.5 ± 3.23	11.5 ± 2.42)
	Maximum systolic velocity	72.24 ± 10.40	78.5 ± 19.08
	Diameter (cm)	0.53 ± 0.06	0.55 ± 0.06
	Pulsatility index	1.49 ± 0.20	1.48 ± 0.15
	Resistance index	0.85 ± 0.06	0.85 ± 0.05
Left CCA	Minimum diastolic velocity	13.33 ± 5.60	12.83 ± 3.86
	Maximum systolic velocity	71.5 ± 21.6	81.16 ± 13.64
	Diameter (cm)	0.5 ± 0.06	0.56 ±0.07
	Pulsatility index	1.34 ± 0.24	1.45 ± 0.18
	Resistance index	0.8 ± 0.10	0.84 ± 0.06

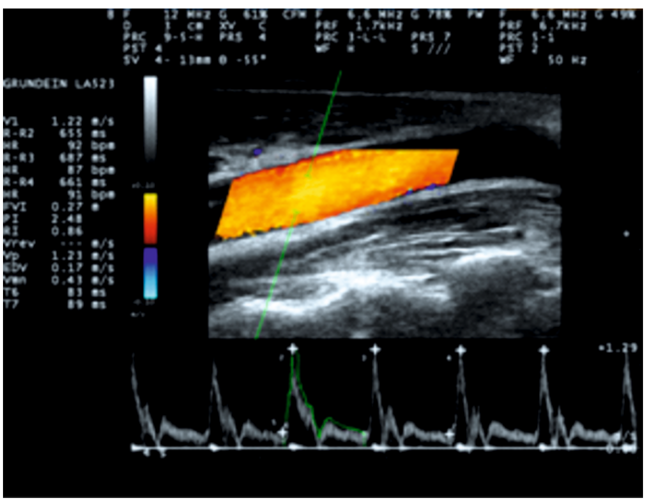

Fig. 10. Normal Doppler spectral of left CCA

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