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Doppler sonographic study of common carotid artery and jugular vein blood flow in Labrador dogs

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In the present study, Doppler sonographic findings of common carotid artery (CCA) and external jugular vein (EJV) blood flow in normal as well as neurological deficit Labrador dogs were evaluated. In the first part of the study, 12 apparently healthy adult Labrador dogs (in two groups; group I animals aged 2-6 yr, group II animals aged 6-10 yr) were subjected to B-mode and Doppler ultrasonography of the CCA and EJV. Doppler ultrasonography was performed in all animals without sedation in lateral decubitus position using 7.5 MHz linear transducer. The mean values CCA diameter (D), peak systolic velocity (PSV), end diastolic velocity (EDV), pulsatility index (PI), resistive index (RI) and velocity (V) differed significantly between the groups I and II. No differences were found between genders or vessel sides of same age group animals. In the second part of the study, five dogs showing variable neurologic signs were subjected to Doppler sonographic examination; the neurological conditions were broadly categorized as inflammatory conditions, upstream stenosis of CCA, downstream stenosis of CCA and jugular venous reflux.

***Key words**: Carotid artery, Doppler sonography, Jugular vein, Labrador dogs*

Doppler ultrasonographic examination provides quantitative and qualitative information regarding the blood flow in veins and arteries, enabling their morphological evaluation and the collection of haemodynamic data (Svicero *et al.*, 2013). Doppler pattern of each blood vessel is important for its identification because a Doppler signal is fairly specific to a particular vessel and its site (Spaulding, 1997). Carotid artery Doppler ultrasonography is frequently performed on those having neurological symptoms. As a result, regular checks of these arteries have become standard practice in human beings in the prevention of stroke, cerebral ischemia, and dementia (Wolff *et al.*, 2007).

In human beings, jugular venous outflow disturbance secondary to various factors that interfere with normal cerebral blood drainage has gained a particular interest (Zhou *et al.*, 2018). Svicero *et al.* (2013) conducted a study to register normal values for systolic peak velocity, minimum diastolic velocity, diameter and resistance index of both common carotid arteries of healthy Labrador retriever dogs. The objective of the present study was to evaluate Doppler sonographic findings of common carotid artery (CCA) and external jugular vein (EJV) blood flow in normal as well as neurological deficit Labrador dogs.

Materials and Methods

The current study was performed in two parts. In part I, the procedure for B-mode and Doppler ultrasonography of the CCA and EJV was standardized in 12 apparently healthy adult Labrador dogs of either sex in two groups (group I- animals aged 2-6 yr; group II- animals aged 6-10 yr); and in part II, a total of 5 dogs showing variable neurologic signs were examined using Doppler ultrasonography. A thorough neurological examination (evaluation of mental status, gait and posture, and evaluation of cranial nerves) was performed.

The animals were placed in a lateral decubitus position. The examination site (right and left jugular fossa) was cleaned with savlon followed by shaving the middle neck area, and application of acoustic gel. The examination was performed using MyLab40 VET ultrasounds system (Esaote Healthcare, Brazil) and using high frequency (7.5 MHz) linear transducer (Esaote LA523). The scanning was done with pulse repetition frequency of 6.7 kHz and B mode gain 55-65%. For Doppler study, the Doppler gain was kept at 64-76%. Pulse Doppler spectral evaluation was performed in the longitudinal plane (Fig. 1), with a 50-60° constant insonation angle (Fig. 2). The average 'sample volume' was 2 mm and 4 mm for CCA and EJV, respectively. For evaluation and measurements, the probe was held at a desired position for 4-5 seconds for proper sampling. The numerical data obtained were expressed as Mean±SE and the data were analyzed by t-test: paired two sample for means using MS Excel (Microsoft office home and student 2019).

Results and Discussion

The three layers of the carotid arteries (intima, media and adventitia) were discernible on B-mode

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Fig. 1: Longitudinal fixation of transducer with probe towards head.

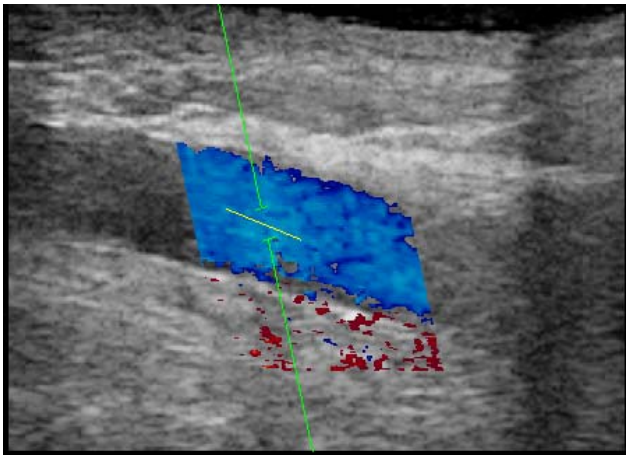

Fig. 2: Doppler angle along the axis of vessel.

Fig. 3: B-Mode sonography of CCA showing 3 layers

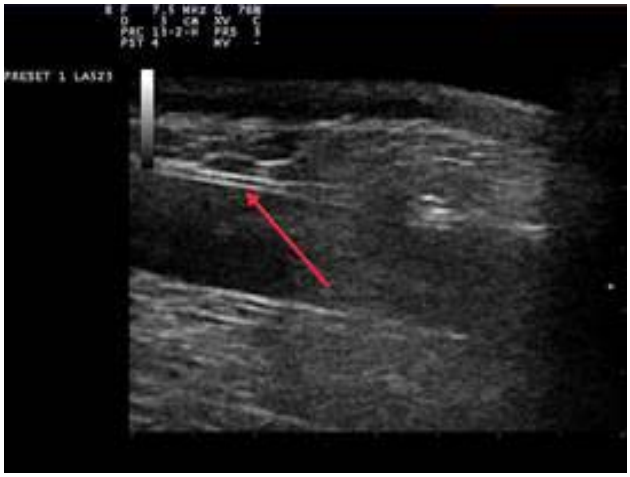

Fig. 4: B Mode sonography of EJV had thin hyperechoic walls

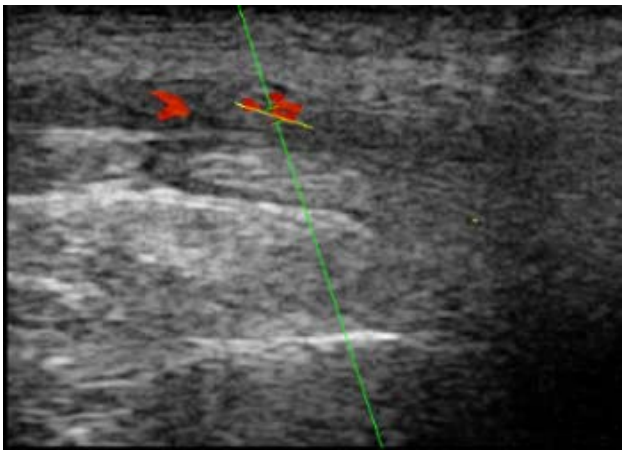

Fig. 5: Doppler sonography of CCA

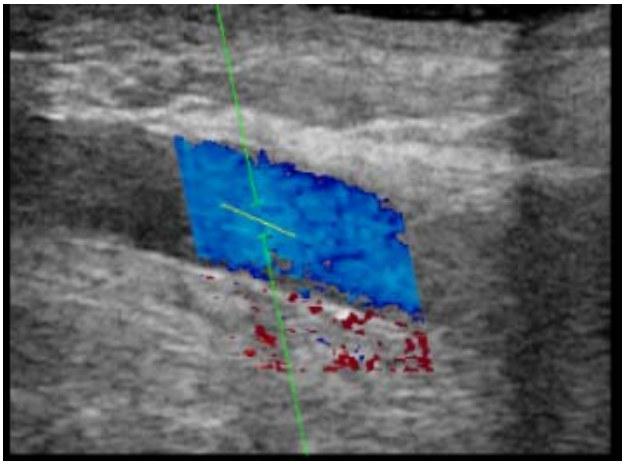

Fig. 6: Doppler sonography of EJV

(Gray-scale) ultrasound images (Fig. 3). The wall of the external jugular vein and perivascular connective tissue appeared as thin hyperechoic lines that were clearly demarcated from the surrounding tissues (Fig. 4). The CCA was scanned at a depth of 1.43±0.04 cm from the transducer, while the EJV was scanned at a depth of 0.91±0.01 cm. No statistical differences were found between genders or CCA and EJV sides of same age groups. In this study, the mean D, PSV, EDV, PI, RI of left and right CCA was significantly greater ($P<0.01$) in animals of group II as compared to those of group I (Table 1). The mean D, V and PI of left and right EJV was significantly greater ($P<0.01$) in the Labradors of group II as compared to those of group I (Table 3). All the CCA scanned in part I study had an antegrade flow direction, having a pulsatile blood flow and multiphasic waveform (Fig. 5) and EJV scanned had an antegrade/ central/forward flow direction (Fig. 6).

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Table 1: Mean±SE values of Doppler haemodynamic parameters of left and right CCA of dogs in different age groups.

Sides	Left CCA		Right CCA	
Parameters	**Group 1**	**Group 2**	**Group 1**	**Group 2**
Peak systolic velocity (PSV in cm/s)	54.12^{a}±2.56	80.88^{b}±0.69	57.93^{a}±0.91	72.37^{b}±1.41
End diastolic velocity (EDV in cm/s)	13.50^{a}±0.58	15.53^{b}±0.85	14.08^{a}±0.92	15.63^{b}±0.79
Pulsatility index (PI)	1.85^{a}±0.22	1.83^{b}±0.33	2.12^{a}±0.22	2.24^{b}±0.19
Resistivity index (RI)	0.78^{a}±0.03	0.82^{b}±0.02	0.80^{a}±0.01	0.84^{b}±0.01
Diameter (D)	0.39^{a}±0.01	0.49^{b}±0.01	0.37^{a}±0.01	0.48^{b}±0.01

Table 2: Mean±SE values of Doppler haemodynamic parameters of left and right EJV of dogs in different age groups.

Sides	Left EJV		Right EJV	
Parameters	**Group 1**	**Group 2**	**Group 1**	**Group 2**
Velocity (V in cm/s)	12.47^{a}± 0.58	17.92^{b}± 0.96	11.75^{a}± 0.46	18.00^{b}± 0.69
Pulsatility(PI)	0.32^{a}± 0.01	0.56^{b}± 0.01	0.34^{a}± 0.01	0.52^{b}± 0.02
Diameter (D)	0.42^{a}± 0.03	0.72^{b}± 0.02	0.40^{a}± 0.01	0.73^{b}± 0.01

In part II of the study, a total of 5 dogs showing variable neurologic signs were included. On the basis of Doppler sonographic examination, the neurological conditions were broadly categorized as inflammatory conditions (PSV, EDV, PI values were > mean PSV, EDV, PI values of group 1, and V and PI values were > mean of respective sides V and PI of group 1), upstream stenosis of CCA (PSV, EDV, PI values were < mean PSV, EDV, PI values of group 2, and RI value was > mean RI in group 2), downstream stenosis of CCA (PSV, PI, RI values were < mean PSV, PI, RI values of group 2 and EDV value was > mean EDV in group 2) and jugular venous reflux (V and PI values were > mean V and PI values of group II and V_{rev} was observed here).

The measurement of PSV and EDV is an important tool in the detection of stenosis (Tortoli *et al.*, 2015). Pulsality index (PI) and resistive index (RI) are typically used to assess the resistance in a pulsatile vascular system (Carroll and Bell, 2020). As per McNaughton and Abu-Yousef (2011), it is obvious that if pumping is done into a relative blockage, then a higher resistance waveform (decrease early diastolic reverse flow) is formed. It is clear that direct result of downstream stenosis is spectral broadening due to turbulent flow.

In the majority of the body's organs, blood flow and tissue metabolic activity are tightly correlated (Klabunde, 2021). Blood flow increases due to an increase in tissue metabolism, which happens when neuronal activity in the brain changes. Necas (2010), Coghlan (2004), and Bemmelen *et al.* (1990) all state that it is not well understood why venous valves can malfunction occasionally, leading to varicose veins without any secondary injury. Endothelial dysfunction, genetic predisposition, and hormonal factors in humans are probably involved.

In conclusion, results of this study may assist veterinarians in figuring out the etiology of some of the neurologic symptoms in dogs as mentioned above.

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