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Determining Carotid Pulse Wave Velocity in Dogs with Canine Cognitive Dysfunction by Doppler Ultrasonography

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Abstract

A neurodegenerative condition affecting geriatric dogs is called "canine cognitive dysfunction", (CCD) a disease that is similar to Alzheimer's disease in many aspects. Vascular risk factors have been implicated in the development of all-cause dementia and Alzheimer's disease in humans. The purpose of this study was to determine the carotid pulse wave velocity in CCD dogs by Doppler ultrasonography and compare with normal dogs. Carotid ultrasonography was done on 17 CCD dogs that were positive base on CCD rating scale. One way ANOVA (post-hoc Scheffe) was used to compare the velocities among the vessels.
Mean values of RI and PI in CDS(cognitive dysfunction syndrome) positive dogs were more than those of CDS negative dogs and the mean values of PSV, EnDV and MV in CDS positive dogs were less than those of CDS negative dogs. But there was no significant association between the values of carotid pulse wave velocity among CDS positive and negative doges. However, the results of this study may be useful as a baseline data for future investigations.

Keywords: Ultrasonography, Resistive index, Cognitive dysfunction syndrome, Canine Dementia, Aged dogs

Introduction

Canine cognitive dysfunction (CCD) or "Canine Dementia" is a neurobehavioral syndrome in aged dogs characterized by deficits in learning, memory and spatial awareness, alternation in interaction with people and other pets and changing sleep-wake cycles (1,2).
A distinctive feature of the CCD is the extensive β-amyloid peptide deposition within the neurons and in the synaptic regions of the brain (3), which is similar to the primitive or early stage β-amyloid plaques in the brain of human patients with Alzheimer's disease (AD) (4,5), so it is likely that CCD can be known as dog's Alzheimer's disease and has been proposed as a suitable model for studying AD (4,5).
Although vascular risk factors have been implicated in the development of all-cause dementia and Alzheimer's disease (AD), multiple measure of carotid atherosclerosis are associated with prospective risk of dementia (6).

The aim of this study is to determine blood flow velocity parameters such as Pulsatility index (PI), Resistive index (RI), Systolic peak velocity (SPV), End diastolic velocity (EnDV) and Mean velocity (MV) of carotid artery in 2 groups of CDS positive and CDS negative dogs and examine the association between changes in carotid pulse wave velocity as a risk factor of cognitive dysfunction and the difference in the results of two groups.

Material and methods:

In the base of previous study that was done on total 234 owned pet dogs in Tehran (capital of Iran), cognitive assessment was performed by CCD rating scale (CCRD), Twenty-one dogs with CCDR scores> 50 were consider CDS positive. (7) In CCDR, 13 behaviors were used which focuses on problems related to orientation, memory, apathy, impaired olfaction and locomotion (7,8).

Among the 21 dogs, 17 dogs' carotid pulse wave velocity was examined by Doppler ultrasonography (Ultrasound equipment, Myndray, US Sonosite Titan) as shown below(fig1).

The ultrasound examination of the neck is performed in lateral recumbence (9). The dog was placed in a flat position and the neck was stretched out. Jugular region on both right and left of the neck was cleaned by alcohol. Ultrasound examination was done by 13 MHz linear array transducer.

The common carotid artery can be imaged by placing the transducer in the jugular furrow with the scanning plane directed along the long axis of the neck with a 45^{o} Doppler angle between the parasagittal and dorsal plane. Pulsatile blood flow was detected on two-dimensional gray-scale images and by Doppler analysis of the vessel lumen. Doppler angle was maintained between 52^{o} and 60^{o} long axes. It was characterized by anechoic lumen and a surrounding thick hyper echoic arterial wall. The size of the sample volume was set at 2 mm. Doppler wave forms were recorded at a gain in which noise first became apparent and at a pulse reception frequency that was sufficient to prevent aliasing (9). It is important to note Doppler angle correction was performed wherever possible.

SPV systolic peak, EnDV end diastolic velocities, MV mean velocities, PI pulsatility index and RI restrictive index were calculated in 17 dogs with CDS positive and 17 dogs that have not CDS in this study the value of hemodynamic indexes in the same species in our geriatric dogs were compared.
Also, the following details of dogs (age, sex, breed, breed, BCS, reproductive status) were obtained by questionnaire through face-to-face interview with owners of dogs.

Data analysis

Statistical analysis was performed using the SPSS statistical computer program (version 12.0; SPSS, USA).
One way ANOVA (post-hoc Scheffe) was used to compare the velocities among the vessels. Results were considered statistically significant when the *p* value was less than 0.05.

Results

Mean values of PSV, EndV and waveform analysis Doppler are listed in the table.
Mean values of RI and PI in CDS positive dogs were more than CDS negative dogs and the mean values of PSV, EnDV and MV in CDS positive dogs were less than those of the CDS negative dogs (Table 1).

There were no significant differences between the mean values of PSV, EndV, MV, PI and RI in CDS positive and negative dogs.

Results of 17 CCD positive dogs are summarized in table 2. All CDS dogs weighed 6-11 kg that considered small breed.

Discussion:

This study is the first investigation determining carotid pulse wave velocity in CDS dogs. Doppler ultrasound has become an accepted and routine method for estimating blood velocity and stenosis of carotid in both

humans and animals since it can provide information rapidly and noninvasively (9). One of the most common uses of Doppler ultrasound in humans is for estimating blood velocity through the analysis of blood wave form. (10)

Two-dimensional and color Doppler ultrasound examinations are commonly used in people to detect carotid artery stenosis and atherosclerotic plaque. Although atherosclerotic disease is not a major concern in dogs and cats, carotid artery stenosis may accrue from other causes such as trauma, neoplastic or previous surgery and ultrasound may be useful in diagnosing the presence and severity of stenosis (9).

In dogs, a few studies have focused on measuring blood flow velocity parameters in major vessels (11), Therefore in this study, the value of hemodynamic indexes in the same species and age was compared.
Kichang Lee et al. (2004) determined the normal values of arterial blood flow velocity and waveforms in major arteries of 10 healthy Beagle dogs using Doppler ultrasonography. These findings may be used as references in future studies on vascular diseases and hemodynamics in dogs (11).

Debaki et al. (2013) had a record on carotid stenosis by ultrasound on 2 German shepherd and one Labrador dogs (10-12 years old). These dogs had complained regarding the in-coordination of movement, hyperesthesia, shivering of head and exercise intolerance. Increased RI and PS peak systolic were diagnosed as the stenosis of carotid artery (12).

In this study, there was no significant association between the values of carotid pulse wave velocity among CDS positive and negative doges.

Mean values of RI and PI in CDS positive dogs were more than CDS negative dogs and the mean values of PSV, EnDV and MV in CDS positive dogs were less than CDS negative dogs.
PSV, EnDV and PI values are the most frequently reported Doppler ultrasonography parameters for detecting arterial disease in human and dogs (9). It has been reported that progressive common carotid arterial disease, which may lead to brain damage, results in decreased PI in the basilar artery of humans (15). Findings of Silvestrini et al. (2011) suggested that severe internal carotid artery stenosis can be considered as a marker of faster rate of progression of the cognitive decline in AD. (12) In addition Li J et al. (2010) found that vascular risk factors accelerated the progression of AD (14).

Early detection among potential individuals for getting AD is very essential in order to have high chance to be cured from this disease. It could be done through assessing the carotid artery condition since the impairment of this artery leads to the central process of Alzheimer's. It has been proven that AD could be accurately detected by analyzing carotid artery structure, which is due to vascular dysfunction that could stimulate synaptoxic B-amyloid (AB) accumulation in the brain considered as the central process for AD formation. (16)

Prior research about CDS in dogs has not studied carotid artery changes as a risk factor. This work is the first study that focused on the correlation between CDS dogs and changing carotid pulse wave velocity in these patients' dogs and the severity of carotid velocity changes contemplated as a potential risk factor for cognitive impairment, like persons with AD.

In normal elderly humans, the systolic peak velocity and minimum diastolic velocity are reportedly up to 50% lower than those of younger individuals, which may be explained by vascular complacency (17). But, no study in veterinary has attempted to quantify this difference in CDS dogs. Persons with AD demonstrate a significant decrease in diastolic flow velocities along the common carotid arteries (15).

The early detection of functional main artery alternation that compromise brain perfusion may provide an early warning signal and impetus to provide therapeutic interventions which prevents or delays CDS in dogs, like AD in humans (15).

Despite these new insights (carotid pulse wave velocity), there is limited research investigation in dogs.

Based on these results we can say in future longitudinal research designs with large sample similar to human studies in AD are needed for the association of vascular factors and cognitive impairment in dogs.

The present study is considered a pilot study and has limitations such as relatively small number of CDS dog's participants, these parameters can be further studied in larger samples.

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Table.1: Mean values of PSV, EndV and waveform analysis Doppler in CDS positive and negative dogs

Parameters	Positive CDS dogs	Negative CDS dogs
PSV (cm/s)	56.33±0.02	58.72±0.71
EnDV (Cm/s)	10.18±0.091	10/18±0.091
MV (cm/s)	26.47±0.035	26.47±0.035
PI	1.85±0.007	1.85±0.007

RI	0.81±0.02	0.76±0.02

Table.2: Summary of characteristics of studied dogs

Parameters		Number of dogs
Age	7-10 years	7
	10-13 years	7
	13-16 years	3
Sex	Male	10
	Female	7
Breed	small	17
BCS	4-5	12
	>5	5
Reproductive Status	neuter	14
	Non-nature	3

Fig.1: Colour Doppler of common carotid artery