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Research Article

Color Doppler Imaging of the Internal Ophthalmic and Long Posterior Ciliary Arteries in the Dog

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Abstract: The objective of this study was to demonstrate the specific blood velocity parameters called peak systolic velocity (PSV), end diastolic velocity (EDV) and the resistive index (RI) in the internal ophthalmic artery (IOA) and the long posterior ciliary artery (LPCA) with color Doppler imaging (CDI) in clinically normal dogs.

Eight healthy dogs were used in the study. Color Doppler ultrasonography was performed on both eyes. PSV, EDV and RI measurements were obtained for both eyes. The mean RI of the IOA was 0.57 ± 0.095 cm/s and that of the LPCA was 0.58 ± 0.083 cm/s. The RI values did not differ significantly between the right and left eyes.

As a result, since CDI is a reliable and easily applicable method for detecting eye vessel blood velocity parameters, such as the IOA and LPCA, it can be recommended for investigating ophthalmic vessel disorders in dogs.

Key Words: Doppler, ophthalmic, artery, dog

Köpeklerde Renkli Doppler Ultrasonografi ile İnternal Oftalmik ve Long Posterior Siliar Arterin Görüntülenmesi

Özet: Bu çalışma sağlıklı köpeklerde internal oftalmik ve long posterior siliar arterde pik sistolik, diastol sonu hız ve rezistif indeks gibi spesifik kan akım parametrelerinin renkli doppler görüntüleme ile belirlenmesi amacıyla yapıldı.

Çalışmada 8 sağlıklı köpek kullanıldı ve 16 göze bakıldı. Herbir gözde yapılan çalışma sonucunda ortalama rezistif indeks; internal oftalmik arterde 0,57 ± 0,095 cm/s, long posterior siliar arterde 0,58 ± 0,083 cm/s olarak belirlendi. Rezistif indeks açısından sağ ve sol gözde belirgin fark yoktu.

Sonuç olarak; Renkli doppler görüntüleme, internal oftalmik ve long posterior siliar gibi göz arterlerinin kan akım hız parametrelerinin belirlenmesinde güvenilir ve kolay uygulanabilir bir yöntem olduğundan, köpeklerde oftalmik damar bozukluklarının araştırılmasında önerilebilir.

Anahtar Sözcükler: Doppler, oftalmik, arter, köpek

Introduction

Ultrasonography is a useful diagnostic method that can determine various orbital and intraocular disorders in small animals. Recently, B-mode ultrasonography, a noninvasive method, has been used in veterinary ophtalmology for diagnostic procedures. Furthermore, if there is an orbital mass such as a tumor, needle biopsy can be performed via ultrasonography. In addition, ultrasonography can be used to examine the globe when direct imaging is prevented by corneal, lenticular or intravitreal opacity (1-3). Two features have made this procedure popular: firstly, there is no pain or discomfort for the animal during examination with ultrasonography and secondly this method is not expensive and gives reliable results (3-5).

Duplex ultrasonography is a new method in small animal diagnostic procedures. Color Doppler Imaging (CDI) provides both the real time anatomical situation and dynamic information about the vessels. Using CDI, the presence, direction and type of blood flow in a vessel can be evaluated (6).

CDI has been used to form an image of the deeper vessels in the eye, thus determining location, spectral characteristics, blood velocity parameters like peak systolic velocity (PSV), end diastolic velocity (EDV) and resistive index (RI) in healthy dogs and those with glaucoma (1,7,8).

CDI has been used as a combination of two-dimensional ultrasound and color-coded Doppler sonography. Real-time B-mode ultrasonography supplemented by Doppler ultrasonic imaging not only allows the evaluation of the vessel, but also permits the assessment of blood flow (1). After the detection of the vessels by CDI, blood flow patterns are determined. Since orbital vessels are small and difficult to locate, CDI is especially beneficial in determining the blood velocity parameters in these vessels (1,9).

RI is designed to evaluate the shape of the waveform of a vessel. RI values can vary between 0 and 1. When the value is 0 this means that there is no resistance, whereas an RI of 1 indicates high resistance in the vessel (1,10). A high RI demonstrates an increase in vascular resistance and a decrease in perfusion (8). The determination of such parameters as RI may help in evaluating functional variations of the vascular bed that may change during several ocular abnormalities in human beings (11).

CDI has been used to describe the course of ocular vessels and to assess their blood flow patterns in human beings (12,13). There has been limited research in dogs in using CDI to evaluate the orbital vessels in veterinary medicine (1,14).

The objective of this study was to determine blood velocity parameters such as PSV, EDV and the RI of the IOA and the LPCA with color Doppler sonography in clinically healthy dogs.

Materials and Methods

In this study, 5 male and 3 female healthy dogs were used. The dogs ranged from 1 to 4 years, and their body weight ranged from 2 to 25 kg. Three breeds were represented: terriers (1 female and 2 male), and Kangals (2 female and 2 male) and crossbreed (1 male). The dogs were determined to be clinically normal on the basis of physical examination. There was no evidence of symptoms of ophthalmic disease in any of the dogs.

CDI was performed, using ultrasonography (Toshiba, SSA/240 A) with a 7.5 MHz linear transducer. Doppler settings (pulse repetition frequency, 6000 Hz; gain setting, medium; wall filtering, 100 Hz; color doppler flow setting, low to medium) were kept constant to minimize technical errors. Both eyes and orbits were imaged with the dog lightly restrained in a sitting position. During the examination all the dogs remained in a sitting position.

CDI was performed by two people, one of whom restrained the dogs while the other performed the technique. Gel was applied to the dorsal region and to the zygomatic arch, and the transducer was positioned in a horizontal plane. The lateral wall of each eye and the retrobulbar fat were imaged. Doppler sonography was performed to identify the vessels of the IOA and the LPCA for spectral Doppler analysis. The flow towards the transducer was depicted in red for the artery and the flow away from the transducer in blue for the vein. The PSV and EDV parameters were determined. The RI was calculated by tracing, using the internal software of the ultrasound unit. This value was determined using the following formula:

RI = PSV-EDV/PSV

In this technique, all the measurements were performed three times to minimize technical errors. Statistical analysis 95% confidence intervals were calculated for PSV, EDV and the RI in the IOA and LPCA to obtain values for clinically normal dogs. The t-test was used to compare the left and right eyes. Calculations were carried out by commercially available software. For all tests, P values of 0.05 were considered significant.

Results

The observation range, mean, standard deviation and standard error measurements for both the IOA and LPCA are summarized in Table 1. There were no significant differences in blood velocity parameters such as PSV, EDV and the RI of the IOA and the LPCA between the right and left eyes (Table).

The IOA could be detected in the deep ventral orbit, and its spectral waveform morphology is shown in Figure 1.

The LPCA was imaged in the sclera, and its spectral waveform morphology is given in Figure 2.

Table. Doppler ultrasonographic values of eight clinically normal dogs.

IOA Values					LPCA Values				
Measurements	Range	Mean	Std. Dev	Std. Error	Measurements	Range	Mean	Std. Dev	Std. Error
Left eye (n = 8)					Left eye (n = 8)				
PSV (cm/s)	11.00-35.00	19.75	0.091	0.032	PSV (cm/s)	11.00-27.00	18.0	0.062	0.022
EDV (cm/s)	4-19	9	0.490	0.017	EDV (cm/s)	5-14	7.6	0.033	0.012
RI (cm/s)	0.45-0.64	0.55	0.071	0.025	RI (cm/s)	0.43-0.70	0.575	0.092	0.033
Right eye (n = 8)					Right eye (n = 8)				
PSV (cm/s)	12.00-27.00	19.12	0.051	0.018	PSV (cm/s)	13.00-.32.00	0.186	0.059	0.021
EDV (cm/s)	5-12	7.5	0.026	0.091	EDV (cm/s)	6-10	7.3	0.014	0.0049
RI (cm/s)	0.40-0.77	0.59	0.115	0.041	RI (cm/s)	0.54-0.75	0.593	0.076	0.027
Both eye (n = 16)					Both eye (n = 16)				
PSV (cm/s)	11.00-35.00	0.194	0.071	0.018	PSV (cm/s)	11.00-32.00	0.183	0.059	0.0147
EDV (cm/s)	4-19	8.2	0.039	0.0096	EDV (cm/s)	5-14	7.4	0.024	0.0061
RI (cm/s)	0.40-0.77	0.57	0.095	0.0239	RI (cm/s)	0.43-0.75	0.58	0.083	0.0206

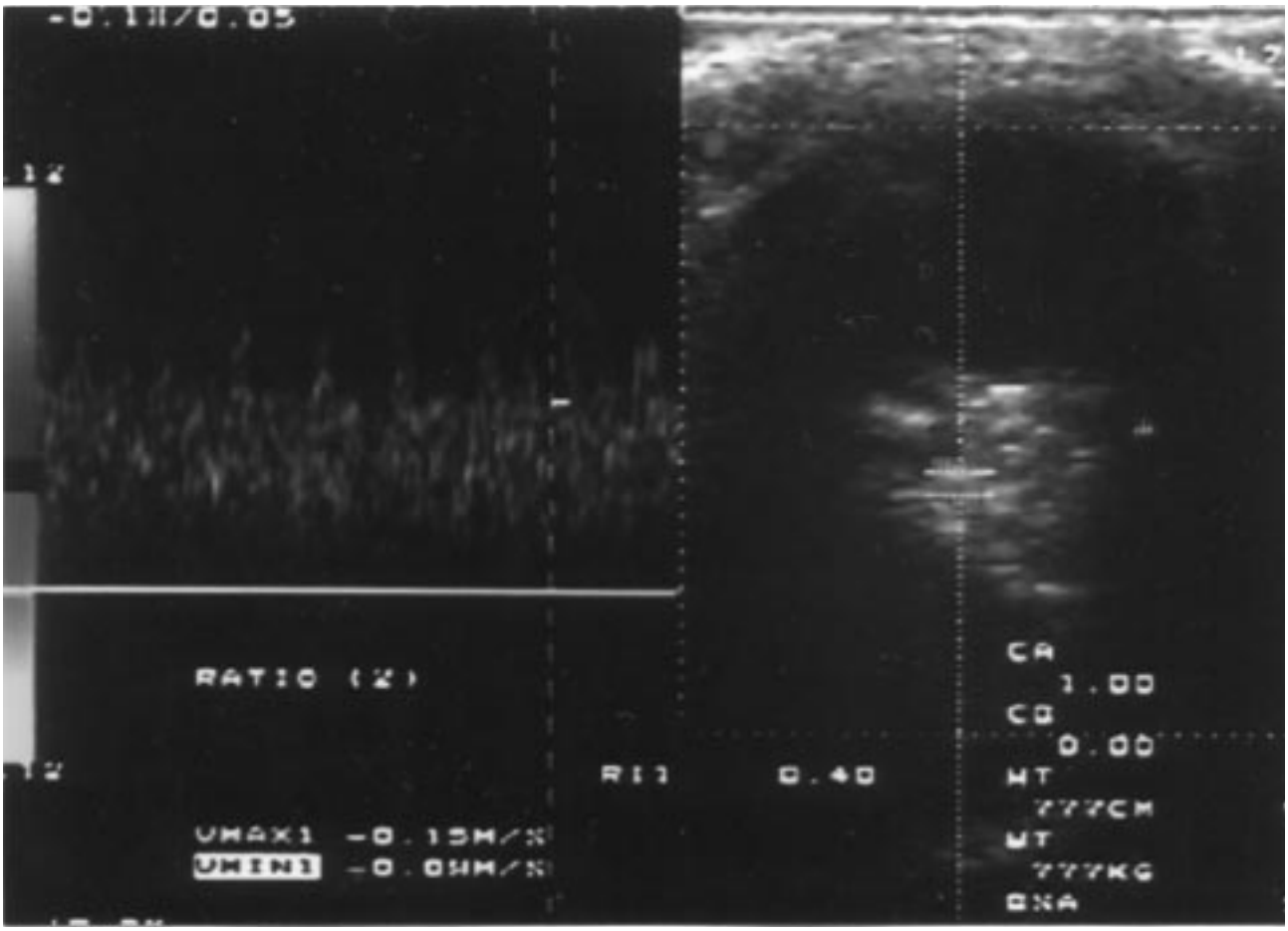

Figure 1. Blood flow pattern of the IOA.

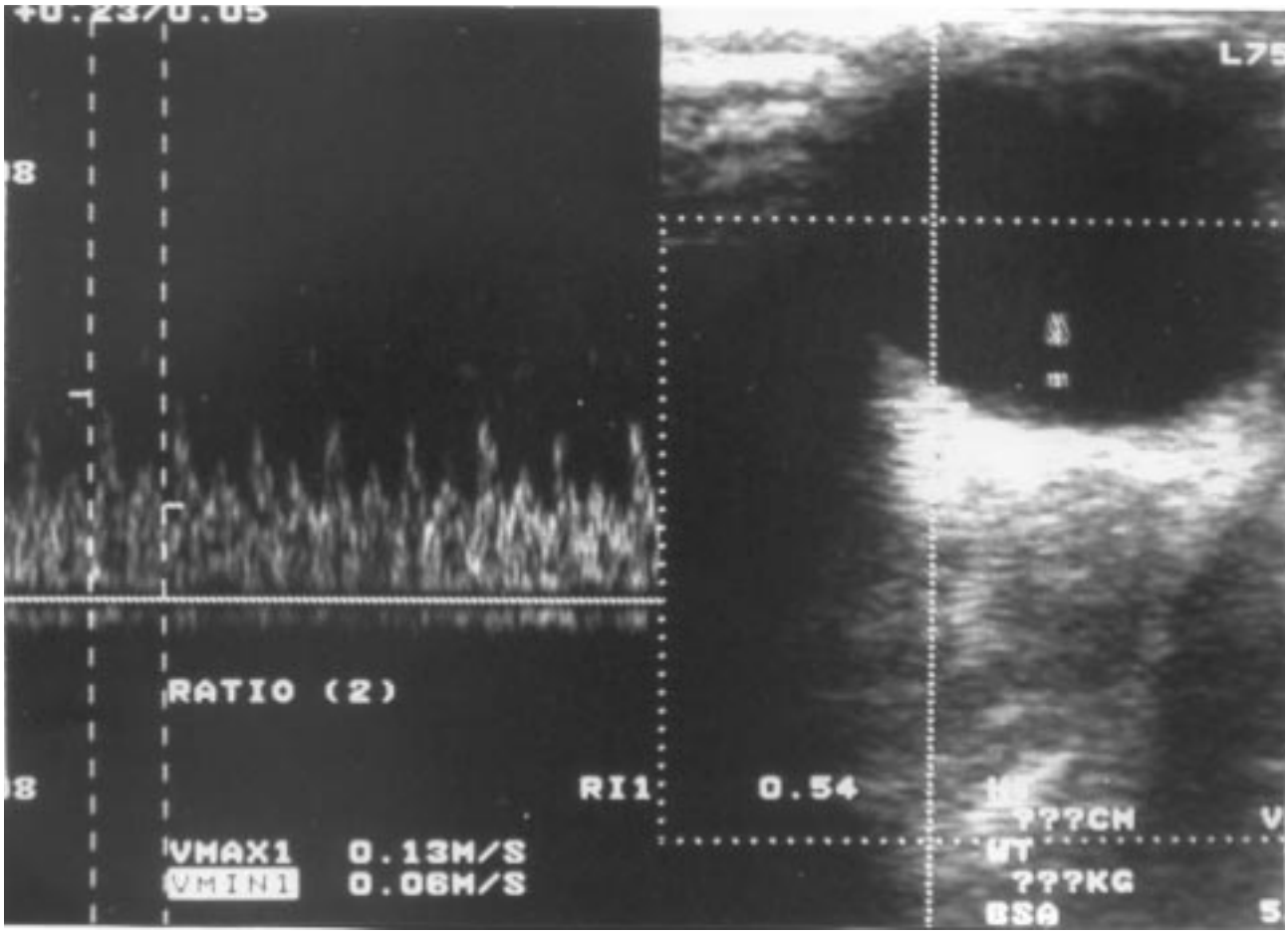

Figure 2. Blood flow pattern of the LPCA.

Discussion

B-mode ultrasonography has become increasingly important in the diagnosis of ophthalmic disease in veterinary medicine. Using this imaging procedure, the morphology and shape of orbital blood vessels, such as enlargement, narrowing and changes in position, can be determined (4,5,7). On the other hand, deeper vessels can be imaged with Doppler sonography (5).

Recently, the use of Doppler imaging has been reported in dogs, both clinically normal and with intraocular disease. On the other hand, to our knowledge, the number of studies on blood velocity measurement in healthy dogs is limited.

Blood velocity parameters obtained by CDI have been called normovascular, hypervascular, hypovascular and neovascular for the orbital and ocular states (15). In this study, the blood velocity parameters of the IOA and the LPCA were investigated using CDI.

It is suggested that Doppler imaging of blood velocity parameters be used for the most frequently measured orbital and ocular blood vessels in healthy dogs (7). These measurements, using the same experimental protocol, are highly reproducible, and may permit valid comparisons with the blood flow parameters in certain orbital and ocular diseases that exhibit vascular changes.

Gelatt-Nicholson et al. (7) identified a majority of the vessels, including the external ophthalmic artery, the anterior ciliar artery and vein, the short and long posterior ciliary arteries, the primary retinal arteries and the vortex vein. The IOA was able to be assessed 100% of the time in the deep ventral orbit. LPCA was imaged 100% of the time at either the 3 or 9 o'clock position within the sclera (7). In this study, the IOA and LPCA were imaged easily. The IOA was detected in the deep ventral orbit and the LPCA was imaged in the sclera at the 9 or 3 o'clock positions.

The velocity waveform derived from the Doppler frequency shift of an artery has a high PSV followed by a rapid drop in velocity to the low EDV. The RI varies from 0 to 1, with 0 representing no resistance and 1 representing high resistance (16). High RI correlates to an increase in distal vascular resistance and decrease perfusion (17,18). Blood velocity parameters obtained from veins exhibited uniform velocities (16).

In Doppler imaging, the blood flow toward the ultrasonic transducer is directional and is depicted as red, while the flow away from the transducer is directional and is depicted as blue (15).

Findl et al. (19) reported that sedatives and general anesthetic drugs also have the potential to reduce intraocular pressure as well as systemic blood pressure. The effects of preanesthetic agents on the blood velocity parameters for orbital and ocular vessels need to be assessed.

Gelatt-Nicholson et al. (7) established the RI value for IOA of healthy dogs as 0.58 ± 0.077 cm/s. In this study the RI of the IOA of clinically normal dogs was 0.57 ± 0.095 cm/s. The results of this study are similar to Gelatt-Nicholson et al.'s findings.

The RI values of the LPCA in healthy dogs were established as 0.68 ± 0.07 by Lee et al. (1), whereas this value was put at 0.51 ± 0.08 cm/s by Gelatt-Nicholson et al. (7). However, Gelatt-Nicholson et al. (7) used sedative agents such as acepromazin. Lee et al. (1) suggested that the differences between their study and that of Gelatt-Nicholson et al. (7) may be due to the sedative agents used. Sedative drugs may have influenced the orbital tension and ophthalmic blood flow patterns in the eyes of the dogs used in Gelatt-Nicholson et al.'s research. The decrease in the RI values may arise from the sedatives. In this study, the LPCA value was 0.58 ± 0.083 cm/s in healthy dogs without using any preanesthetics.

Lee et al. (1), Greenfield et al. (12) and Lieb et al. (20) reported that there were no significant differences in the RI values between the left and right eyes or male and female subjects or breeds. Furthermore, they reported that there were no significant differences in body weight in dogs. In this study there were no significant differences in RI between the left and right eyes of male and female subjects. The results of this study support the findings of these other authors.

Baxter and Williamson (9) and Greenfield et al. (12) suggested that age may affect normal blood flow and vascular resistance in human beings. In the current study, age ranges were between 1 and 4 years in the dog. The RI values obtained in this study exhibited no significant differences due to age.

In conclusion, the IOA and LPCA have been easily and reliably imaged in healthy dogs by CDI. It is suggested that CDI is a useful technique for investigating ophthalmic vessel disorders in dogs.

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