



PREVALENCE OF PRIMARY GLAUCOMA AMONG DOGS FROM BULGARIA: A SINGLE-CENTER RETROSPECTIVE STUDY

V. S. NEDEV

Department of Veterinary Surgery, Faculty of Veterinary Medicine,
6000 Stara Zagora, Bulgaria

Summary

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The objective of current study was to investigate the incidence of primary glaucoma in patients from the University Veterinary Hospital of Trakia University, Stara Zagora for the period from January 2012 to December 2024 in terms of dogs' breed, age and sex. Information was collected from the clinical database and processed. All affected animals have undergone complete clinical and ophthalmic examination. During the period, 208 (0.33%) out of 62,792 dogs treated at the Veterinary University Hospital of Trakia University have been diagnosed with primary glaucoma. The illness was registered in 22 breeds and was more common in mixed breed dogs (15.38%) followed by Miniature Pinscher (13.46%), Siberian Husky (9.61%) and Chihuahua (9.61%). Four new affected breeds including Putbull (1.92%), Laika (1.92%), Bulgarian Hound dog (7.69%) and Bicolor hound (1.92%) were identified. The mean age of onset of glaucoma was 7.58 ± 2.25 years and the female to male ratio was 1.5:1. Primary glaucoma occurred in the right eye in 38 dogs, in left eye in 46 and bilaterally in 124 animals. The findings of the current study outlined the four most affected breeds suffering from primary glaucoma in Bulgaria and suggest careful observation of the dogs from these breeds after the 7th year of life.

Key words: Bulgaria, mixed breed, ophthalmology, primary glaucoma, Siberian Husky

INTRODUCTION

Glaucoma is a leading causes of blindness in dogs (Ofri & Narfstrom, 2007). Furthermore, it is a painful and progressive condition and the most common reason for enucleation in this species (Dees, 2014; Terhaar *et al.*, 2022; Sandmeyer & Leis, 2023; Sebbag & Pe'er, 2023). A major factor for necrosis of the retinal

ganglion cells and axons is the failure of adequate aqueous humour drainage, leading to an increase in intraocular pressure (IOP) (Strom *et al.*, 2011).

Canine glaucomas are classified on the basis of the possible cause (congenital, primary or secondary), the gonioscopic appearance of the drainage angle (open,

narrow or closed) and stage of the disease (acute, subacute, or chronic) (Gelatt, 2007).

Glaucoma in cats is less common than in the dog, and most of the cases appear to be secondary (Oikawa *et al.*, 2023) and affecting mostly the mixed breed, Angora and British shorthair (Gölgeli Bedir *et al.*, 2024). Equine glaucoma most commonly occurs secondary to uveitis; Appaloosas and older horses being more predisposed (Cassano *et al.*, 2023). Glaucoma and megaloglobos are rare in sheep and goats and are usually secondary to ocular puncture wounds or severe uveitis (Davidson & Pickett, 2008a). Congenital megaloglobos secondary to glaucoma is seen in Holsteins in association with malformation of the anterior chamber and lens. Acquired glaucoma in cattle is uncommon and usually secondary to corneal perforation following infectious bovine keratoconjunctivitis or traumatic or infectious uveitis (Davidson & Pickett, 2008b).

Congenital glaucoma in dogs, characterised by goniodysgenesis within the iridocorneal angle (ICA), occurs at a relatively early age (less than one year) and its occurrence in dogs is low (Yun *et al.*, 2022).

Primary glaucoma is inherited; more than 42 breeds appear to be predisposed (Gellat & Mackay, 2004). It can occur bilaterally (Park *et al.*, 2012). Primary glaucoma is divided into primary open-angle glaucoma (POAG) and primary angle-closure glaucoma (PACG). In POAG, the ICA is normal at the beginning of the disease, but gradually becomes closed (Ahonen *et al.*, 2014), whereas PACG is characterised by structural abnormalities, such as a narrowed ICA and ciliary cleft and is also closely associated with pectinate ligament dysplasia (Bjerkas *et al.*, 2002; Pumphrey *et al.*, 2024). POAG is more common in humans than in dogs

(Plummer *et al.*, 2021b), while clinical signs related to IOP elevation in PACG usually occur in middle to old age (Pearl *et al.* 2015). Primary glaucoma has been reported in American Cocker Spaniel, Basset Hound, Chow Chow, Shar-Pei, and Boston Terrier in North America (Gellat & Mackay, 2004); Siberian Husky, mixed breed, Entlebucher Mountain Dog, Vizsla, and Newfoundland in Switzerland (Strom *et al.*, 2011); Shiba Inu, Shih Tzu, Mixed breed, American Cocker Spaniels, and Beagle in Japan (Kato *et al.*, 2006); and American Cocker Spaniels and Shih Tzu (Gellat *et al.*, 1976; Gelatt, 1972). Secondary glaucoma develops after obstruction of the aqueous humour outflow pathways. The most frequent reasons are lens luxation, anterior uveitis, intraocular neoplasia, cataract surgery and trauma (Gelatt, 2007).

The prevalence of primary glaucoma is affected by national, regional, and breed-related preferences. The aim of this study was to report the epidemiology of canine primary glaucoma in dogs presented to University Veterinary Hospital of the Trakia University in Stara Zagora, Bulgaria for the period from 1 January 2012 to 31 December 2024.

MATERIALS AND METHODS

Data collection

The current retrospective study included information from the medical records of dogs, presented at the University Veterinary Hospital of Trakia University in Stara Zagora, Bulgaria between 1 January 2012 and 31 December 2024. For the purpose of the study the information included the dog breed, age for determination of the time when glaucoma was detected, and the gender for determination

of male to female ratio of patients with primary glaucoma.

Case definition

As a definition, glaucoma in the dog is a group of ocular diseases that exhibit increased levels of IOP that are detrimental to the maintenance of vision and eye health (Gellat, 2007). In primary glaucomas, the IOP elevation develops without concurrent ocular diseases and is hereditary in many breeds. It has the likelihood of bilateral development. Primary glaucomas may result from abnormal biochemical metabolism of the trabecular meshwork cells of the outflow system (POAG) or the physical effects of pupillary blockage and changes in the ICA and ciliary cleft (PACG) (Plummer *et al.*, 2021a).

Diagnostic tests

All patients followed a strict order of ophthalmic examination. After obtaining a complete history, functional or neuro-ophthalmic tests were performed. Shirmer tear test-I (Schirmer tear test strap with blue band, FioniaVet, Denmark), fluorescein staining (Fluorescein Sodium Ophthalmic Strips U.S.P. Tarun Enterprises, India), tonometry (TonoVet, iCare, Finland), slit-lamp biomicroscopy (LED SLIT XL-1, Ohira CO., Japan), direct (rimini, Riester, Germany) and indirect ophthalmoscopy (Video omega 2c, Heine, Germany), gonioscopy (Ocular Koeppe Diagnostic Gonio – Small, Ocular Instruments, USA) with 20D condensing lens, B-wave ocular ultrasonography (Vetus 50, Mindray, P.R.China) and electroretinography (ERG-jet, Nicolet Biomedicals, USA) were performed in all dogs. Information for affected eye(s) was obtained in each case.

Inclusion and exclusion criteria

The criteria for inclusion in the study were dogs whose eyes had IOP of more than 30 mmHg measured with rebound tonometry and clinical signs of glaucoma, including pain, buphthalmos, episcleral injection, mydriasis and corneal oedema. Patients with lens luxation, uveitis and intraocular masses have been excluded.

Ethical considerations

Examination of patients was performed after signing a standard informed consent form by the owner which contains a clause authorising the use of signalment and/or clinical data gathered during the procedures by the academic staff of the hospital for research purposes. The access to patient data is allowed by the Manager of the University Veterinary Hospital of Trakia University respecting the full anonymity of the owner's name, address and phone number.

The handling of animals during the ophthalmological examination was gentle and secure in order to reduce stress to an absolute minimum and to protect the veterinarians. All rules set out in Regulation 20/2012 on the minimum requirements for the protection and humane treatment of experimental animals and the requirements for facilities for the use, care and/or supply of them were observed.

Statistical analysis

All data were recorded and analysed with MedCalc Statistical Software version 15.8 (MedCalc Software, Ostend, Belgium). Data for incidence rate and primary glaucoma rate were expressed as percentage and 95% confidence intervals and age as mean±standard deviation (SD). The sex- and breed-related comparisons were performed with the chi-square test.

RESULTS

For the studied 13-year period, 208 (0.33%) out of 62,792 dogs treated at the University Veterinary Hospital were diagnosed with primary glaucoma. The disease was registered in 22 breeds (Table 1). The most affected breed was the mixed breed (15.38%) followed by Miniature Pinscher (13.46%), Siberian Husky (9.61%) and Chihuahua (9.61%). There were significant differences between breeds affected with glaucoma ($P < 0.001$). Mixed breed dogs were statistically significantly more affected ($P < 0.05$) compared to the other breeds, excluding Siberian Huskeys and Chihuahuas. Miniature Pinschers were significantly more commonly affected ($P < 0.05$) compared with the other breeds, excluding Siberian Husky, Chihuahua and Bulgarian Hound dog.

The current study identified four new breeds including Putbull (1.92%), Laika (1.92%), Bulgarian Hound dog (7.69%) and Bicolor hound (1.92%) that were never reported with glaucoma in previous studies.

The mean age of presentation of primary glaucoma was 7.58 ± 2.25 years (Table 2). In the most affected mixed breed dogs, Miniature Pinschers and Siberian Huskies, the mean age was 6.83 ± 3 years, 6.16 ± 1.25 years and 7.75 ± 1.66 years, respectively. The distribution by gender demonstrated occurrence in 125 females and 83 males. Glaucoma was statistically significantly more prevalent in female dogs (60.1%; $P < 0.01$) compared to males (39.9%). The ratio of females to males in mixed breed, Miniature Pinscher, Siberian Husky and Chihuahua was 0.39:1, 4.6:1, 4:1, 0.53:1, respectively. Primary glaucoma occurred in the right eye in 38 dogs, in the left eye in 46 and bilaterally in 124 animals. Bilateral affection rate was statis-

tically significantly more frequently registered ($P = 0.0001$) than unilateral one.

DISCUSSION

This first retrospective study on the prevalence of canine primary glaucoma in Bulgaria demonstrated that the prevalence of primary glaucoma among dogs was 0.33%. In Switzerland, Strom *et al.* (2011) estimated 0.22% dogs affected with primary glaucoma. A study made in Korea (Park *et al.*, 2012), reported 0.55% prevalence among the dog population. Ten years later in the same country Yun *et al.* (2022) established a higher rate of the disease (0.73%). Similar observations in North America for a period of over 40 years showed increasing prevalence of the primary glaucoma through the years. For the period 1964–1973, the prevalence was close to that in the present study (0.29%) and reached 0.89% in the period of 1994–2002 (Gellat & Mackay, 2004). The increase of cases with this ocular affection is due to improvement and distribution of ophthalmic equipment such as tonometers, slit-lamp biomicroscopes, gonioscopes, and the increasing number of private specialty practices (Yun *et al.*, 2022).

The differences in primary canine glaucoma rate can be also connected to the occurrence of breeds that are more susceptible to the disease in other countries, compared to Bulgaria. American Cocker Spaniels demonstrated a high prevalence of primary glaucoma (5.52%) in North America (Gellat & Mackay, 2004) and in Japan (6.3%; Kato *et al.*, 2006). In our study, only four American Cocker Spaniels (1.92%) were affected. Another breed with greater primary glaucoma incidence in Japan is the Shih-Tzu (16.55%) (Kato *et al.*, 2006). The rate of affected dogs from that breed in South

Table 1. Distribution of dogs diagnosed with primary glaucoma by breed for the period 2012–2024.

Breed	Total number of dogs	Dogs with primary glaucoma	Incidence rate			Primary glaucoma rate		
			%	95% CI	%	95% CI		
Mixed breed	4524	32	0.71	0.48–0.99	15.38	10.52–21.72		
Miniature Pinscher	2415	28	1.16	0.78–1.68	13.46	8.95–19.46		
Siberian Husky	509	20	3.93	2.40–6.07	9.61	5.87–14.85		
Chihuahua	1243	20	1.61	0.98–2.49	9.61	5.87–14.85		
Bulgarian hound dog	84	16	19.05	10.89–30.93	7.69	4.40–12.49		
Jack Russell terrier	1201	12	1.00	0.52–17.45	7.76	2.98–10.08		
Alaskan Malamute	36	8	22.22	9.59–43.79	3.84	1.67–7.58		
Cavalier King Charles Spaniel	290	8	2.76	1.19–5.44	3.84	1.67–7.58		
Pomeranian	1879	8	0.43	0.18–0.84	3.84	1.67–7.58		
French Bulldog	1915	8	0.42	0.18–0.82	3.84	1.67–7.58		
Laika dog	64	4	6.25	1.70–16.00	1.92	0.52–4.92		
Shih-Tzu	149	4	2.68	0.73–6.87	1.92	0.52–4.92		
Breton Spaniel	166	4	2.41	0.66–6.17	1.92	0.52–4.92		
American Cocker Spaniels	179	4	2.23	0.61–5.73	1.92	0.52–4.92		
Bicolor hound	197	4	2.03	0.55–5.20	1.92	0.52–4.92		
Spitz	219	4	1.83	0.50–4.68	1.92	0.52–4.92		
Toy Poodle	445	4	0.90	0.24–2.30	1.92	0.52–4.92		
Beagle	487	4	0.82	0.22–2.10	1.92	0.52–4.92		
Pitbull	775	4	0.52	0.14–1.32	1.92	0.52–4.92		
Labrador Retriever	810	4	0.49	0.13–1.26	1.92	0.52–4.92		
German Shepard	1768	4	0.23	0.06–0.57	1.92	0.52–4.92		
Yorkshire Terrier	3094	4	0.13	0.03–0.33	1.92	0.52–4.92		

Table 2. Age, sex and eye affection distribution of dogs diagnosed with primary glaucoma by breed for the period 2012–2024

Breed	Age of onset (mean±SD)	Sex (F:M)	Affected eye (OD:OS:BI)
Mix breed	6.83±3.00	0.39:1	4:8:20
Miniature Pinscher	6.16±1.25	4.6:1	4:8:16
Siberian Husky	7.75±1.66	4:1	4:0:16
Chihuahua	7.08±1.08	0.53:1	4:0:16
Bulgarian hound dog	10.08±1.00	4.3:1	0:16:0
Jack Russell terrier	7.83±0.83	5:1	0:0:12
Alaskan Malamute	10.25±1.08	1.66:1	8:0:0
Cavalier King Charles Spaniel	10.16±1.33	3:1	6:2:0
Pomeranian	8.00±0.91	0.6:1	0:4:4
French Bulldog	5.75±0.83	1.66:1	0:0:8
Laika dog	9.91±0.25	1:3	0:0:4
Shih-Tzu	7.41±0.91	4:0	0:0:4
Breton Spaniel	10.91±0.33	3:1	0:4:0
American Cocker Spaniels	7.00±1.33	3:1	0:4:0
Bicolor hound	4.75±0.50	0.33:1	0:0:4
Spitz	7.25±0.75	0.33:1	0:0:4
Toy Poodle	11.25±0.75	3:1	4:0:0
Beagle	6.08±0.41	0:4	0:0:4
Pitbull	5.58±1.08	3:1	4:0:0
Labrador Retriever	9.33±0.58	3:1	0:0:4
German Shepard	3.90±0.33	4:0	0:0:4
Yorkshire Terrier	8.50±0.58	1:1	0:0:4
Total	7.58±2.25	1.5:1	38:46:124

OD – right eye, OS – left eye, BI – both eyes.

Korea (2.3%; Yun *et al.*, 2022) and in this study (1.92%) is low. Beagles are prone to primary open-angle glaucoma (Gelatt, 1972; Gellat *et al.*, 1976), but in Japan Kato *et al.* (2006) detected only five affected dogs. The diseased Beagles in this study were four.

Kato *et al.* (2006) reported primary glaucoma prevalence in Yorkshire Terriers of 2.4%. In our research the percentage of affected animals from that breed was 1.92%. While the rate of affected Chihuahua in our country was 9.61%, this breed included only 0.51% of dogs suffering from primary glaucoma in North America (Gellat & Mackay, 2004).

In all previous studies, only Yun *et al.* (2022) has reported affection of Pomeranians reporting four dogs suffering from primary glaucoma. The prevalence among the other breeds was 0.43%. Our research found a significantly higher percentage of affection in Pomeranians, 3.84%.

In Switzerland (Strom *et al.*, 2011), Siberian Husky (16.3%), Entlebucher Mountain Dog (9.8%), Magyar Vizsla (6.5%) and Newfoundland (4.9%) were the most affected breeds. Out of all dogs in our study, 9.61% of Siberian Huskies were affected ranking third among all breeds. In the study of Gelatt & Mackay (2004), the prevalence of glaucoma for

this breed was 1.88%. Our database did not include dogs from the other three affected breeds in Switzerland. The main reason for the primary glaucoma in the Siberian Husky is PLD and progressive narrowing of the ICA, which lead to ocular hypertension (Plummer *et al.*, 2021a). The second most affected breed in our study was the Miniature Pinscher. In all previous reports, only that in South Korea (Yun *et al.*, 2022), has identified one female dog from that breed suffering from primary glaucoma. While we observed that the mixed breed was the most susceptible to primary glaucoma, mixed breed dogs from North America, South Korea and Switzerland showed very low prevalence rates of 0.71% (Gellat & Mackay, 2004), 0.25% (Strom *et al.*, 2011) and 0.18% (Yun *et al.*, 2022) respectively. In Japan, mixed breed dogs ranked third among the affected breeds with 7.9% (Kato *et al.*, 2006).

The current study identified four new breeds including Putbull, Laika, Bulgarian Hound dog and Bicolor hound. Bulgarian Hound dog and Bicolor hound are not reported to suffer from primary glaucoma in other countries and regions, because they are local Bulgarian breeds, just as the West Highland White Terrier in North America, the Entlebucher Mountain Dog in Switzerland, the Dachshund in Japan and Jindo dog in Korea (Yun *et al.*, 2022).

Age appears to be an important risk factor for development of glaucoma in purebred dogs. The time for onset and the time for clinical presentation may vary from months to years (Plummer *et al.*, 2021b). The age of onset of primary glaucoma in this study varied according to the breed. The mean age of onset of primary glaucoma in dogs was 7.58 ± 2.25 years. In previous reports, the age when primary glaucoma appeared was slightly different

but close to our findings: 6.39 ± 1.30 years in North America (Gellat & Mackay, 2004), 7.54 ± 1.54 years in Japan (Kato *et al.*, 2006), 7.25 ± 0.70 years in Switzerland (Strom *et al.*, 2011) and 7.8 ± 2.3 years in South Korea (Yun *et al.*, 2022) years. Siberian Huskies were presented with primary glaucoma at a mean age of 5.5 ± 3.3 years in a previous report (Strom *et al.*, 2011), but in the present study the age was 7.75 ± 1.66 years. Miniature Pinschers in our study were presented at a mean age of 6.16 ± 1.25 years which is close to age found in South Korea (Yun *et al.*, 2022), 6 years. The mixed breed had an age of onset of primary glaucoma of 6.83 ± 3 years. In South Korea and Japan, the mean age was little higher, 7.5 ± 3.5 years and 8.1 ± 3.1 years respectively. The youngest affected breed was the German Shepard, 3.9 ± 0.33 years. The local Bulgarian hound dog breed was presented with primary glaucoma at a mean age of 10.08 ± 2 years, which is a higher age than that in most breeds with primary glaucoma (Gellat & Mackay, 2004).

It is believed that in middle age or older dogs, increases in the axial length and thickness of the lens and its anterior movement close to the pupil, reduce the drainage of aqueous humour (Yun *et al.*, 2022). Other reasons may be appearance and development of PLD with aging of the dog (Oliver *et al.*, 2016; Stanbury *et al.*, 2023). This is a possible reason why primary closed-angle glaucoma is eight times more common than primary open-angle glaucoma in dogs (Miller *et al.*, 2000).

The impact of gender appears important in humans with PACG, where women are affected much more frequently than men (Foster, 2002; Plummer *et al.*, 2021b; Esporcatte *et al.*, 2022; Yoo *et al.*, 2022). Almost all previous studies in dogs have

shown a gender effect in certain breeds with females being more prone to develop glaucoma. In North America, the F:M ratio in the Siberian Husky was 1.88:1 (Gellat & Mackay, 2004), while the study from Switzerland reported 1.5:1 F:M ratio (Strom *et al.*, 2011). The present study found a F:M ratio of 4:1 in that breed. The most susceptible mixed breed had F:M ratio of 0.39:1. In Japan, mixed breed dogs had 1.5:1 ratio in favour of females (Kato *et al.*, 2006). The higher prevalence of glaucoma in both human and canine female species indicates common predisposing abnormalities (Gellat & Mackay, 2004). Recent studies with high resolution ultrasound suggested that the predisposition of the female dog to PACG may be related to a reduced iridocorneal angle opening and smaller outflow pathway for aqueous humour (Tsai *et al.*, 2012, Kim *et al.*, 2023; 2024).

In conclusion, the glaucoma in Bulgaria was encountered in both purebred and mixed breed dogs, with the mixed breed being most affected. The prevalence of the glaucoma was lower compared to that in other countries as North America and Korea. The onset of the disease occurred at 7.5 years of age on the average, and females were significantly more commonly affected. The local Bulgarian Hound dog breed was often affected from primary glaucoma.

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Correspondence:

Vladi S. Nedev
Department of Veterinary Surgery,
Faculty of Veterinary Medicine,
6000 Stara Zagora, Bulgaria
email: nedevladi@gmail.com