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Clinical features of brain tumors in dogs in the Moscow region: a retrospective study

Nikolay A. Glazov^{1,2}  , Yuri A. Vatnikov² , Marina N. Yakunina¹ 

¹Biocontrol Veterinary Oncology Research Center, Moscow, Russian Federation

²RUDN University, Moscow, Russian Federation

 nikolaygla-zovvet@gmail.com

Abstract. For the first time in the history of Russian veterinary medicine, a retrospective analysis of the clinical features of brain tumors (BT) in dogs was carried out. The study was conducted in the Moscow region in 2018–2024 on the basis of the Biocontrol veterinary clinic. The aim of the study is to determine the frequency, localization and clinical manifestations of BT. The data of 54,142 dogs were analyzed, of which 150 had BT (1.2% of oncological cases, 0.28% of the total number of patients). The average age was 9.4 years. Most often, BT was recorded in cross-breed, French bulldogs, Cane Corso and German shepherds. Brachycephalic breeds showed a predisposition to intra-axial lesions, mesocephalic to extra-axial. There was no gender predisposition. The main clinical manifestations included convulsions, ataxia, paresis and changes in consciousness depending on the location of the tumor. The median tumor volume was 6 cm³ for extra-axial and 9.4 cm³ for intra-axial lesions. Histological verification was performed in 23 patients. Diagnosis was carried out using MRI (1.5 Tesla), histology and immunohistochemistry. The study showed the need for histological analysis of BT for accurate typing of lesions and emphasized the importance of developing methods of imaging and invasive diagnosis in veterinary medicine. The data obtained partially differ from foreign ones, which is due to the difference in the breed sampling of the dog population. Unique results can serve as a basis for the development of standardized protocols for the diagnosis and treatment of canine BT.

Keywords: veterinary medicine, oncology, glioma, meningioma

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Introduction

Brain tumors (BT) in dogs pose a serious problem in veterinary medicine due to the complexity of diagnosis and the limited availability of verification methods. Moreover, dogs, along with humans, show the highest incidence of spontaneous BT among all mammals [1–3]. Researchers estimate the incidence of canine nervous system tumors to be 14.5 cases per 100,000 [4]. According to other authors, intracranial neoplasms are observed in 2...4.5% of dogs subjected to postmortem examination [1, 2]. Primary BT are represented by meningiomas (~50%), gliomas (~35%), and vascular plexus tumors (~7%). Secondary tumors account for about 50% of all BT cases [4–6]. Despite such a low incidence of BT, this pathology raises many questions among veterinarians. Firstly, the diagnosis of BT remains difficult, since it is possible to identify a tumor of the nervous system according to the results of magnetic resonance imaging, less often computed tomography [7–11]. However, these methods of instrumental diagnosis are not widely used in veterinary medicine. Secondly, the differentiation of the type of tumor during life is difficult due to the limited availability of biopsy. The material during life is mainly obtained during surgical intervention. Thirdly, accurate typing and determination of tumor malignancy often requires immunohistochemical analysis (IHC) in addition to histological, but it is rarely available in sufficient volume [12]. Finally, in the Russian-language scientific literature, systematic data on BT are practically absent, which may be due to the limited use of modern imaging methods and insufficient attention to this problem in Russian veterinary medicine.

It should be noted that BT occur in dogs of all ages and breeds. At the same time, there is no data on gender predisposition. However, these tumors are more often recorded in middle-aged and older animals (median — 8–10.5 years depending on the type of tumor), with a certain predisposition in brachycephalic breeds to gliomas and large breeds to meningiomas [1–4]. The clinical manifestations vary depending on the location and volume of the tumor, including convulsions, ataxia and impaired consciousness, which requires accurate and timely diagnosis to choose a therapeutic strategy.

For the first time in Russian practice, our study systematizes data on the frequency, localization and clinical manifestations of BT in dogs. It is based on the analysis of clinical cases of the Biocontrol veterinary clinic for the period 2018–2024.

The aim of the study is to establish the frequency, location and clinical manifestations of brain tumors in dogs in the Moscow region.

Study objectives:

- 1) determine the frequency of BT in dogs among all oncological diseases;
- 2) identify breed predisposition and age characteristics;
- 3) to analyze the clinical symptoms depending on the location and volume of the tumors.

Materials and Methods

In the veterinary clinic Biocontrol (Russia, Moscow) for the period from January 2018 to June 2024, 54,142 dogs were admitted. The tumor process was revealed in 12,427 animals on the basis of anamnesis, clinical examination, ultrasound data and radiographs in various projections. In 2709 patients, a neurological deficit was established during a neurological examination. In 175 animals with symptoms of brain damage, MRI results showed massive intracranial lesions.

Criteria for full or partial exclusion:

- cases with pituitary tumors ($n = 25$) were not taken into account;
- patients without MRI conclusion, but with a known localization ($n = 7$, were taken into account only in the total count of patients with BT and localization);
- patients without MRI conclusion and with an unknown localization ($n = 2$, were taken into account only in the total count of patients with BT)
- tumors of irregular shape ($n = 6$, did not calculate the volume);
- multiple brain lesions ($n = 7$, no analysis of symptoms, localization and volume).

The final sample for analysis was 150 dogs. Of these, we calculated the volume of the tumor in 137 patients, 23 cases had histological verification of the diagnosis. In two of them, the diagnosis was confirmed on the basis of IHC.

Data collection. Patients were recorded and data were collected using electronic medical records in the “ENOT” program (developed by VetSoft LLC, Russia). The patient record included: breed, gender, age, weight, clinical symptoms, MRI results (location, size, nature of the lesion) and, if available, histological and immunohistochemical data.

Magnetic resonance imaging Diagnosis was carried out using MRI scanners with a magnetic field strength of 1.5 Tesla (Siemens Magnetom Impact Expert, GE Signa Explorer, Siemens Magnetom Symphony, Siemens Aera and Philips Ingenia devices) in three mutually perpendicular planes.

Slice thickness 3 mm. Interpretation of MRI was carried out by the method of radiation diagnostics by veterinary specialists with more than 5 years of experience, in some cases with the involvement of a neurologist. Tumor localization was classified as:

- extra-axial (outside the brain parenchyma);
- intra-axial (in the brain parenchyma);
- by divisions: frontal, temporal, parietal, occipital lobe, cerebellum, brainstem, ventricles, cranial nerves (CN) or cranial structures.

Tumor volume calculation. Tumor volume V was determined for 137 cases with well-defined boundaries using the ellipsoid formula:

$$V = \frac{4}{3} \pi \left(\frac{d_1}{2} \right) \left(\frac{d_2}{2} \right) \left(\frac{d_3}{2} \right),$$

where d_1, d_2, d_3 is the maximum tumor diameter in three mutually perpendicular planes obtained from manual measurement using Vidar Dicom Viewer, RadiAnt DICOM Viewer, or eFilm Lite software based on MRI data. The method is confirmed by studies [13].

Histological examination. Histological verification was performed in 23 patients based on the material obtained during surgery ($n = 21$) or postmortem ($n = 2$). Tissues were fixed in 10% formalin solution, dehydrated and waxed. Specimen 2 μm thick were stained with hematoxylin-eosin and examined under a light microscope at 400 $\times$ (Olympus C $\times$ 43 microscope). The analysis was carried out by veterinary pathologists (candidates of veterinary and biological sciences). In 2 cases, an IHC study was additionally performed using PanCK, Vimentin, GFAP, MCK, S100, CD31, Ki67, vWF markers to clarify the diagnosis.

Classification and Diagnostics. In 127 cases, the diagnosis remained presumptive and was based on MRI data and animal breed (signal characteristics, localization, presence of contrast enhancement, characteristic breed) in accordance with the criteria described by Roberto José-Lopez et al. [14] and James L.M. et al. [7]. Presumptive types of tumors (meningioma, glioma, etc.) were determined based on the literature and the experience of clinicians. The final diagnosis was established only in the presence of histological confirmation ($n = 23$), less often — IHC ($n = 2$). The frequency of BT was calculated as the proportion of cases among cancer patients ($150/12427 \times 100$) and the total number of dogs ($150/54142 \times 100$).

Results and Discussion

The results of our studies demonstrated the frequency of BT in the Moscow region, which was 1.2% (150 of 12427) among dogs with cancer and 0.28% (150 of 54142) of the total number of dog patients of the Biocontrol clinic for the period 2018–2024. The percentage of all patients with symptoms of nervous system damage is 5.5 (150 out of 2709). The average age of the animals was 9.4 ± 3 years. The median age for extra-axial tumors is 10.4 years, for intra-axial tumors it is 9 years.

Breed and gender predisposition. Most often, BT was recorded in cross-breed (16.7%, $n = 25$), French bulldogs (16%, $n = 24$), Cane Corso (6.7%, $n = 10$) and German shepherds (6%, $n = 9$) (Table 1), 26 other breeds with BT met once, therefore they are not presented.

Table 1

Incidence of brain tumor by breed in the Moscow region

Breed	Number n	Percentage of the final sample, %*
Cross Breed	25	16.7
French Bulldog	24	16
Cane Corso	10	6.7
German Shepherd	9	6
Yorkshire Terrier	7	4.7
Chihuahua	6	4
Boxer	6	4
West Highland White Terrier	5	3.3
American Staffordshire Terrier	4	2.7
English Bulldog	4	2.7

Ending tabl. 1

Breed	Number <i>n</i>	Percentage of the final sample, %*
Labrador Retriever	3	2
Pembroke Welsh Corgi	3	2
Jack Russell	3	2
German Spitz	3	2
Siberian Husky	3	2
Dachshund	3	2
East European Shepherd	2	1.3
Rhodesian Ridgeback	2	1.3
Russian Toy	2	1.3
One case of BT was detected in 26 breeds **		

*Final sample of 150 dogs; ** 26 breeds with a single detection of BT: Akita Inu, English Cocker Spaniel, Belgian Shepherd, Beagle, Border Terrier, Boston Terrier, Bullmastiff, Doberman, Golden Retriever, Cà de Bo, Collie, Maltese, Maremma, Mittelschnauzer, Papillon, Pincher, Pomeranian Spitz, Petit Brabanson, Russian Spaniel, Sibü Inu, Sicilian Hound, Zwergschnauzer, Sharpei, Chtzu, Japanese Chin, Italian greyhound

Source: compiled by N.A. Glazov.

Brachycephalic breeds prevailed among cases with intra-axial lesions ($n = 50$, or 61% of 82 cases). Mesocephals ($n = 39$, or 92.9% of 42 cases) prevailed at extra-cranial locations. There was no significant gender predisposition for all tumors (males — 54%, $n = 82$; females — 46%, $n = 68$). At extra-axial localization, the ratio was 1:1 (males $n = 21$; females $n = 24$), at intra-axial — 1.4:1 (males $n = 50$; females $n = 32$).

The location and volume of the tumors. Extra-axial cases were 30.4% ($n = 45$), intra-axial cases were 55.4% ($n = 82$) of the 148 cases. The remaining cases included tumors of the cranial nerves (4%, $n = 6$), ventricles (2%, $n = 3$), secondary formations (3.4%, $n = 5$) and multiple lesions (4.7%, $n = 7$) (Table 2). The most common localization is the temporal lobe (intra-axial, 29.7%, $n = 44$) and the frontal lobe (extra- and intra-axial — 14.7% each, $n = 21$). Median tumor volume: 6 cm³ (0.45...34.9) for extra-axial ($n = 41$) and 9.4 cm³ (0.9...54.6) for intra-axial ($n = 81$). The maximum volumes are marked in the temporal lobe (10.3 cm³ intra-axially, 9.85 cm³ extra-axially), the minimum — in the occipital lobe (4.6 and 3.7 cm³, respectively) (Table 3).

Table 2

Distribution of tumors in the brain

Department	Extra-axial		Intra-axial		Cranial nerves		Ventricles		Multiple		Secondary	
	<i>n</i> *	% **	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%
Frontal	21	14.7	21	14.7	6	4.2	3	2.1	7	4.7	5	3.5
Temporal	5	3.5	44	29.7								
Parietal	3	2.1	2	1.4								
Occipital	1	0.7	4	2.8								

Ending tabl. 2

Department	Extra-axial		Intra-axial		Cranial nerves		Ventricles		Multiple		Secondary	
	<i>n</i> *	% **	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%
Trunk	8	5.6	9	6.1	6	4.2	3	2.1	7	4.7	5	3.5
Cerebellum	7	4.9	2	1.4								
Total	45		82									

Note. **n* is the number of cases; **% is the percentage of dogs that had data on the localization of the tumor in the medical history.

Source: compiled by N.A. Glazov, Yu.A. Vatrikov.

Table 3

The median volume of tumors depending on the location

Localization	Frontal lobe. intra-axial	Frontal lobe. extra-axial	Temporal lobe. intra-axial	Temporal lobe. extra-axial	Parietal lobe. intra-axial	Parietal lobe. extra-axial	Occipital lobe. intra-axial	Occipital lobe. extra-axial	Trunk. intra-axial	Trunk. extra-axial
Median. cm ³	8.7	7	10.3	9.85	8.7	5.8	4.6	3.7	9.4	9
Quantity	21	19	42	6	2	3	5	1	9	7

Source: compiled by N.A. Glazov.

The tumors of the largest volume were located in the temporal lobe, the smallest — in the occipital lobe.

Clinical manifestations. Seizures were observed in 66% of cases (*n* = 99), more often with temporal (100% extra-, 63.6% intra-), parietal (100% extra- and intra-) and frontal (85% extra-, 85.7% intra-) localization. Ataxia (21.3%, *n* = 32) prevailed in lesions of the cerebellum (85.7% extra-, 100% intra-) and trunk (44.4% intra-). Paresis (8%, *n* = 12) — with lesions of the brain stem (44.4% intra-), change in consciousness (6.7%, *n* = 10) — with lesions of the frontal and parietal lobes extra-axially (14.3 and 33.3%). Damage to the cranial nerves (8.7%, *n* = 13) was manifested by their dysfunction in 100% of cases (Table 4). Tumor volume did not correlate with symptom severity. But the symptoms occurred only after the tumor reached 1 cm in one of the diameters.

Table 4

The dependence of symptomatic manifestations on the location of the tumor

Localization (<i>n</i>)	Symptom incidence, %				
	Seizures	Ataxia	Paresis	Change in the level of consciousness	CN damage
Frontal extra (21)	85	4.7		14.3	
Temporal extra (5)	100				
Parietal extra (3)	100	33.3		33.3	
Occipital extra (1)	100				

Ending tabl. 4

Localization (n)	Symptom incidence, %				
	Seizures	Ataxia	Paresis	Change in the level of consciousness	CN damage
Trunk extra (8)	50	20			
Cerebellum extra (7)	14.3	85.7	14.3		
Frontal intra (21)	85.7	9.5	4.8		
Temporal intra (44)	63.6	6.8	4.8	6.8	
Parietal intra (2)	100				
Occipital intra (4)	75	25			
Trunk intra (9)	11.1	44.4	44.4	11.1	
Cerebellum intra (2)		100			
CN (6)	16.7	33.3	16.7		100
Ventricles (3)	66.6	33.3			

Source: compiled by N.A. Glazov, M.N. Yakunina.

Diagnostic accuracy. Histological verification ($n = 23$) revealed meningiomas (54.5%, $n = 12$), gliomas (31.7%, $n = 7$) and rare cases (bone sarcoma, peripheral nerve sarcoma, metastasis of breast carcinoma and hematoma — 1 case each). Presumptive MRI diagnoses coincided with histological ones in 92.3% of cases for meningiomas (12 of 13) and in 77.8% for gliomas (7 of 9). Based on MRI data, gliomas in 52.8% of cases were presumably diagnosed in 127 cases, meningiomas in 36.2% of them.

The incidence of BT in our study was 1.2% of the total number of oncological patients and 0.28% of the total number of dogs. These indicators are within the literary range (0.0145...4.5%) [1–4], but at the lower limit, which may indicate a lack of detection of this pathology in Russian veterinary medicine. Among all dogs with symptoms of nervous system damage, 5.5% showed intracranial tumor lesions during the survey. The average age of dogs with BT of 9.4 years coincides with international data (8–11 years) [2, 5]. Extra-axial tumors were more common in older dogs (10.4 years), intra-axial in younger dogs (9 years). These data are consistent with studies by Miller D.A. et al. [8] (10.5 and 8 years, respectively). The absence of gender predisposition to BT is generally confirmed by various studies [2, 5]. In our sample, the percentage of males is 54, females — 46. At the same time, males showed a tendency to gliomas, the ratio was 1.4:1. In the work of José-López et al. [14], the ratio is 1.3:1, respectively.

The breed predisposition coincides with the literature data. Brachycephalus (French bulldogs prevailed ($n = 23$)) — 58% of intra-axial cases and mesocephalus (cross-breed, German shepherds) — 92.9% of extra-axial cases. These indicators confirm the tendency of brachycephalic to gliomas, and large breeds to meningiomas [14, 15]. The study was significantly dominated by French bulldogs (16%, $n = 25$ of all cases and 46%, $n = 23$ of intra-axial), which significantly differs our sample, possibly due to the

popularity of the breed in the region. The distribution of tumors by localization (30.4% of extra-axial and 55.4% of intra-axial) differs from generally accepted statistics, where meningiomas (~50%) prevail over gliomas (~35%) [5] (Table 5 and 6). This discrepancy is explained by a small proportion of histologically confirmed cases: out of 23 verified diagnoses, meningiomas accounted for 54.5 and gliomas — 31.7%, which is closer to the literature. Presumptive MRI diagnoses in our study (gliomas — 52.8, meningiomas — 36.2% among 127 cases) could distort the picture, which indicates the complexity of tumor differentiation without histological examination [13].

Table 5

Comparative analysis of the data obtained with the results
of Forward A.K. et al. by localization of extra-axial BT

Localization	Extra-axial (own research)		Forward A.K. et al. [16]	
	<i>n</i>	%	<i>n</i>	%
Frontal lobe	21	46.6	69	68.3
Temporal lobe	5	11.1	9	8.9
Parietal lobe	3	6.7	10	9.9
Occipital lobe	1	2.2	6	5.9
Brainstem	8	17.8	Not specified	
Cerebellum	7	15.6	7	6.9
Total	45	100	101	100

Source: compiled by N.A. Glazov, M.N. Yakunina.

Table 6

Comparative analysis of the data obtained with the results
of José-Lopez R. Et al. on the localizations of intracranial BT

Localization	Intra-axial (own research)		José-Lopez R. Et al. [14]	
	<i>n</i>	%	<i>n</i>	%
Frontal lobe	21	25.6	29	34.5
Temporal lobe	44	52.4	25	29.8
Parietal lobe	2	2.4	11	13.1
Occipital lobe	4	4.8	Not detected	
Brainstem	9	11	4	4.8
Cerebellum	2	2.4	1	1.2
Diencephalon	Not detected		14	16.7
Total	82	100	84	100

Source: compiled by N.A. Glazov, M.N. Yakunina.

Clinical manifestations correlate with localization: convulsions (66%) dominated in lesions of the large brain (84.5% intra-axial, 66.6% extra-axial), ataxia (21.3%) — in tumors of the cerebellum and trunk, which is consistent with the studies [14, 17]. The absence of a dependence of symptoms on the tumor volume indicates the possible role of other factors, such as edema or mass effect, which were not evaluated in this study.

For the first time, our study systematizes data on BT in dogs in Russian practice, revealing both similarities (age, symptoms) and differences (localization, breed composition) from international studies. The limitations are a small proportion of histological data and the lack of analysis of edema, which could affect the interpretation. Nevertheless, the results emphasize the importance of MRI and the need to develop invasive diagnostic methods in veterinary medicine.

Conclusion

The study made it possible for the first time to obtain data on the frequency of BT in dogs in the Moscow region, to systematize information about their localization and clinical manifestations and to determine the average age of occurrence of this pathology. The predisposition of brachycephalic breeds to intra-axial lesions (especially French bulldogs) was revealed, and mesocephalic to extra-axial. The predisposition of males to intra-axial localization was established, the correspondence of symptoms to the level of brain damage was confirmed, and convulsions were the most frequent of them. It is noted that the tumor volume does not correlate with the severity of symptoms, but additional assessment of the severity of cerebral parenchymal edema against the background of the neoplasm is required to identify a possible relationship. The obtained data have a number of discrepancies with the literature, which may be due to the number of samples and the number of histologically confirmed diagnoses. Conclusions: histological verification of the disease is mandatory; further research should be directed to the development of standardized diagnostic protocols for tumor lesions of the brain in animals.

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About the authors:

Glazov Nikolay Aleksandrovich — Veterinarian, Veterinary Oncology Research Center “Biocontrol”, 24 Kashirskoe shosse, bldg. 10, Moscow, 115522, Russian Federation; postgraduate student, Department of Veterinary Medicine, RUDN University, 6 Miklukho-Maklaya St., Moscow, 117198, Russian Federation; e-mail: nikolaygla-zovvet@gmail.com

ORCID: 0009-0005-5637-2828

Vatinikov Yuri Anatolyevich — Doctor of Veterinary Sciences, Professor, Director of the Department of Veterinary Medicine, Agrarian and Technological Institute, RUDN University, 6 Miklukho-Maklaya St., Moscow, 117198, Russian Federation; e-mail: vatinikov@yandex.ru

ORCID: 0000-0003-0036-3402 SPIN-code: 2726–8270

Yakunina Marina Nikolaevna — Doctor of Veterinary Sciences, Head of the Oncology Department, Veterinary Oncology Research Center “Biocontrol”, 24 Kashirskoe shosse, bldg. 10, Moscow, 115522, Russian Federation; e-mail: irsovet@yandex.ru

ORCID: 0000-0002-5278-1641

Клинические особенности опухолей головного мозга у собак в Московском регионе: ретроспективное исследование

Н.А. Глазов^{1, 2}  , Ю.А. Ватников² , М.Н. Якунина¹ 

¹Ветеринарный онкологический научный центр «Биоконтроль», г. Москва, Российская Федерация

²Российский университет дружбы народов, г. Москва, Российская Федерация
 nikolaygla-zovvet@gmail.com

Аннотация. Впервые в истории российской ветеринарии осуществлен ретроспективный анализ клинических особенностей опухолей головного мозга (ОГМ) у собак. Исследование проведено в Московском регионе в 2018–2024 гг. на базе ветеринарной клиники «Биоконтроль». Цель исследования — определение частоты, локализации и клинических проявлений ОГМ. Проанализированы данные 54142 собак, из которых у 150 выявлены ОГМ (1,2 % от онкологических случаев, 0,28 % от общего числа пациентов). Средний возраст составил 9,4 года. Наиболее часто ОГМ регистрировали у метисов, французских бульдогов, кане-корсо и немецких овчарок. Брахицефалические породы показали предрасположенность к интрааксиальным поражениям, мезоцефалы — к экстрааксиальным. Половая предрасположенность отсутствовала. Основные клинические проявления включали судороги, атаксию, парезы и изменения сознания в зависимости от локализации опухоли. Медиана объема опухолей составила 6 см³ для экстрааксиальных и 9,4 см³ для интрааксиальных поражений. Гистологическая верификация выполнена у 23 пациентов. Диагностику проводили с использованием МРТ (1,5 Тесла), гистологии и иммуногистохимии. Исследование показало необходимость гистологического анализа ОГМ для точного типирования поражений и подчеркнуло важность развития методов визуализации и инвазивной диагностики в ветеринарии. Полученные данные частично отличаются от зарубежных, что обусловлено различием породного состава поголовья собак. Уникальные результаты могут служить базой для разработки стандартизированных протоколов диагностики и лечения ОГМ у собак.

Ключевые слова: ветеринария, онкология, глиома, менингиома

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