Canine tumor development and crude incidence of tumors by breed based on domestic dogs in Gifu prefecture

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ABSTRACT. We analyzed the status of tumor development in dogs by breed based on tumor cases that presented to the Department of Veterinary Pathology of the Gifu University for diagnostic examinations over eight years (2005–2012). We also calculated the crude incidence of tumors in dogs by breed based on the results of a survey conducted in 2011 in Gifu Prefecture. The most common sites of tumor development included the skin, digestive organs and mammary glands. Smaller dogs showed a tendency to have a higher incidence of breast tumors. We thus identified dog breeds with a higher crude incidence of tumors (Bernese mountain dog, golden retriever, corgi, etc.) and those with a lower crude incidence of tumors (Pomeranian, poodle, Chihuahua, etc.). Unlike the current trends for domestic dogs in the US and Europe, Japan has a higher number of small dogs as pets; it is therefore necessary to develop a policy for canine cancer specific to Japan.

KEYWORDS: benign-malignant tumor ratio, breed difference, canine tumor, crude incidence of tumors, number of domestic dogs

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In recent years, the incidence of various diseases in companion animals has increased along with their extended life expectancy has been extended. Among such diseases, the incidence of cancer in dogs—an intractable disease—seems to be increasing in particular. However, there are no detailed reports regarding the current status of cancer in dogs in Japan, and the incidence of tumors in dogs is not clear. This is primarily because the accurate number of domestic dogs in Japan is unknown. Although the results of research conducted by the Japan Pet Food Association and/or pet insurance companies [21], and data published by governmental agencies and/or domestic dog registration organizations are available, they are not adequate. Under these circumstances, considering that no epidemiological studies have been conducted, effective management of cancer in domestic dogs is not possible.

There are reports concerning the incidences of tumors in dogs in Denmark and some other regions of the world [2–5, 16, 18, 19, 22], including a report based on a survey conducted by a Swedish insurance company [8] as well as a survey conducted in Italy, which revealed the results by age distribution [15]. With respect to human data, cancer registration started in the mid-twentieth century, serving as a basis for effective cancer management in subsequent years.

Therefore, we conducted the following analysis to understand the current status of tumor development in dogs by breed: (1) Analysis of the status of tumor development in dogs by breed based on the tumor cases in Gifu Prefecture for which the Department of Veterinary Pathology of the Gifu University received a request for diagnostic examinations from veterinary hospitals and clinics in Gifu Prefecture over eight years, and (2) Calculation of the crude incidence of tumors in dogs by breed based on the number of dogs obtained from the survey conducted in all municipalities in Gifu Prefecture in 2011.

MATERIALS AND METHODS

1. Analysis of tumor cases over eight years

Among the samples for which the Department of Veterinary Pathology, Gifu University, received requests for histological examination from other institutions during the eight-year period from 2005 to 2012, we used data only from the institutions located in Gifu Prefecture to understand the status of tumor development in dogs by breed in the prefecture.

1–1. Distribution of age at the time of diagnosis of tumor cases classified by sex

Of the requested samples, only tumor cases were extracted for the analysis of age distribution of tumor cases classified by sex. Statistical analysis was conducted using JMP11 analysis software (SAS Institute Inc., Tokyo, Japan), and the mean age by sex and standard deviation were calculated; the Wilcoxon rank sum test was conducted at a significance level of less than 5%.

1–2. Ratios between benign and malignant tumors by dog breed

We calculated the ratios between benign and malignant tumors in dogs by breed for the tumor cases included in this study.
The comparison of the ratios of benign and malignant tumors by breed was statistically calculated using the chi-square test with a significance level of less than 5% using R (version 3.2.2). Additionally, we performed residual analysis to clarify and confirm this further.

1–3. Classification of tumors in dogs by breed

Tumors were classified as shown in Table 1 in reference to the report by Brønden et al. [5]. To analyze the common sites for the development of tumors in dogs by breed, we determined the total number of tumor cases by calculating multiple tumors individually, i.e., when multiple, different types of tumors developed in the same dog, each tumor was separately included in the calculation. However, with regard to breast tumors, since the formation of numerous tumors is common and each tumor is given a different definitive diagnosis, it was difficult to classify each of the tumors separately. Therefore, in such cases, only the most malignant tumor among the tissues submitted for pathological examination was selected for calculation.

The incidence of tumor sites by dog breed was statistically calculated using the chi-square test with a significance level of less than 5% using R (version 3.2.2.). Additionally, we performed residual analysis to clarify and confirm this further.

2. Analysis of the number of domestic dogs by breed and crude incidence of tumors in dogs in Gifu Prefecture

2–1. The number of domestic dogs based on the dogs receiving antirabic vaccination in 2011 in Gifu Prefecture

A request for a questionnaire survey regarding the number of domestic dogs by breed was sent to 42 municipalities through postal mail or email. For the types of dog breed, 20 breeds, including crossbreeds, were selected (Table 2) in reference to Shimamura’s report [21]. For the number of domestic dogs by breed, the number of dogs that received antirabic vaccination (RV) was selected, since these data were considered to reflect the current status most appropriately, and the number of domestic dogs for the 20 breeds was investigated for the period from April 2011 to March 2012. Although the official data for the number of dogs receiving RV are published by each of the prefectural and municipal veterinarian associations as well as the Ministry of Health, Labour and Welfare (MHLW), the figure represents the total number of dogs receiving RV, and the breakdown by dog breed is unknown. Therefore, we collected the information through questionnaire surveys (Fig. 1).

2–2. The crude yearly incidence of tumors in dogs and the crude yearly incidence of malignant tumors in dogs based on the number of dogs receiving antirabic vaccination in 2011 in Gifu Prefecture

To identify the number of tumor cases in dogs, the tumor cases from veterinary hospitals and clinics located only in Gifu Prefecture were extracted to calculate the samples for which the Department of Veterinary Pathology of the Gifu University received a request for histological examination in 2011, as stated in the previous section. With regard to the dog breeds, 20 breeds were selected, including crossbreeds.

The crude incidences of tumors and malignant tumors were calculated in the following manner, using the number of dogs receiving RV in 2011 in Gifu Prefecture and the data mentioned above.

Crude incidence of tumors (%)=the number of tumor cases (the above-mentioned data) ÷ the number of domestic dogs (number of dogs receiving RV in 2011) × 100

Crude incidence of malignant tumors (%)=the number of cases of malignant tumor (the above-mentioned data) ÷ the number of domestic dogs (number of dogs receiving RV in 2011) × 100

The crude incidence of tumors and malignant tumors by dog breed was statistically calculated by the chi-square test with a significance level of less than 5% using R (version 3.2.2.). Additionally, we performed residual analysis to clarify and confirm this further.

RESULTS

1. Analysis of tumor cases over eight years

As of April 2012 (mid-term), there were 131 veterinary hospitals and clinics in practice in Gifu Prefecture. Among them, approximately 23% or 31 hospitals and clinics requested the Department of Veterinary Pathology of the Gifu University to conduct tests for tumors in 3,597 cases (1,598 male dogs; 2,160 female dogs; and 161 dogs of unknown
Research of domestic dogs receiving RV in 2011 in Gifu prefecture (*1)  

| Registration dog species          | Number of dogs | Notes                        |
|----------------------------------|----------------|------------------------------|
| Dachshund                        | 407            | DAX |
| Golden retriever                 | 388            | GR |
| Labrador retriever               | 304            | LR |
| Shih Tzu                         | 281            | SZ |
| Siba                             | 204            | SIB |
| Welsh Corgi                      | 185            | CG |
| Shetland sheepdog                | 171            | SSD |
| Beagle                           | 139            | BG |
| Yorkshire terrier                | 112            | YT |
| Maltese dog                      | 92             | MAR |
| Pug                              | 84             | PG |
| Papillon                         | 79             | PAP |
| Chihuahua                        | 70             | CW |
| Schnauzer                        | 65             | SCH |
| Poodle                           | 63             | PD |
| Cavalier King Charles Spaniel    | 34             | CK |
| Pomeranian                       | 33             | POM |
| Bernese mountain dog             | 30             | BMD |
| French bulldog                   | 23             | FB |
| Mixed breed                      | 713            | MIX |
| Other breed                      | 508            | Other |

Table 2. Abbreviated terms for the dog breeds included in this study and the number of tumor cases

| Dog breed                  | Abbreviated word | No. of tumor cases |
|----------------------------|-------------------|--------------------|
| Dachshund                  | DAX               | 407                |
| Golden retriever           | GR                | 388                |
| Labrador retriever         | LR                | 304                |
| Shih Tzu                   | SZ                | 281                |
| Siba                       | SIB               | 204                |
| Welsh Corgi                | CG                | 185                |
| Shetland sheepdog          | SSD               | 171                |
| Beagle                     | BG                | 139                |
| Yorkshire terrier          | YT                | 112                |
| Maltese dog                | MAR               | 92                 |
| Pug                        | PG                | 84                 |
| Papillon                   | PAP               | 79                 |
| Chihuahua                  | CW                | 70                 |
| Schnauzer                  | SCH               | 65                 |
| Poodle                     | PD                | 63                 |
| Cavalier King Charles Spaniel | CK           | 34                 |
| Pomeranian                 | POM               | 33                 |
| Bernese mountain dog       | BMD               | 30                 |
| French bulldog             | FB                | 23                 |
| Mixed breed                | MIX               | 713                |
| Other breed                | Other             | 508                |

Table 2. Abbreviated terms for the dog breeds included in this study and the number of tumor cases

*1: Not registration number of dogs. Check of RV receiving dogs.

*2: Not registration number of dogs. Check of RV receiving dogs in 2011.

Fig. 1. Questionnaire regarding domestic dogs receiving RV in 2011 in Gifu Prefecture.

Birthday of domestic dogs (*2)

| Birth of | Male | Female |
|----------|------|--------|
| 1992     |      |        |
| 1993     |      |        |
| 1994     |      |        |
| 1995     |      |        |
| 1996     |      |        |
| 1997     |      |        |
| 1998     |      |        |
| 1999     |      |        |
| 2000     |      |        |
| 2001     |      |        |
| 2002     |      |        |
| 2003     |      |        |
| 2004     |      |        |
| 2005     |      |        |
| 2006     |      |        |
| 2007     |      |        |
| 2008     |      |        |
| 2009     |      |        |
| 2010     |      |        |
| 2011     |      |        |
| 2012     |      |        |

Number of dogs receiving RV (*3)

| Year | Male | Female |
|------|------|--------|
| 2011 |      |        |

sex) over the eight-year period from 2005 to 2012. Among the total of 3,597 tumor cases that presented for pathological examination requests, 388 cases were found to have more than one tumor, excluding breast tumors, including 277 cases (6.95%) with 2 different types of tumors and 41 cases (1.03%) with 3–5 different types of tumors. Including these multiple tumors, a total of 3,985 tumors were diagnosed (Table 2).

1–1. Distribution of the age at the time of diagnosis of tumor cases classified by sex

In the analysis of age in all the samples, the mean age at which a tumor developed was 10.4 ± 3.0 years (mean ± S.D.) in male dogs and 10.4 ± 2.8 years (mean ± S.D.) in female dogs, showing no significant difference between males and females (Fig. 2).

1–2. Ratios between benign and malignant tumors by dog breed

The proportion of malignant tumors in all dogs was revealed to be 57.5%. The ratio of malignant tumors was significantly lower (P<0.05) in the following five dog breeds: Yorkshire terrier (YT) (32.1%), Maltese dog (MAR) (42.4%), Poodle (PD) (44.4%), Shih Tzu (SZ) (48.0%) and Dachshund (DAX) (48.2%), while the proportion of malignant tumors was significantly higher in the following seven dog breeds: Labrador retriever (LR) (63.2%), Welsh corgi (CG) (65.9%), Shiba (SIB) (68.1%), Shetland sheepdog (SSD) (69.0%), Chihuahua (CW) (70.0%), Beagle (BG) (73.4%) and Bernese mountain dog (BMD) (80.0%) (P<0.05) (Fig. 3).

Analysis of the ratios between the benign and malignant tumors by dog breed showed that smaller dogs tended to have a higher proportion of benign tumors.
1–3. Classification of tumors by dog breed

In the analysis of the 3,985 tumors in terms of the location of tumor development, tumors were found most often in the skin and surrounding tissues, with 1,233 cases accounting for 30.9%. In particular, the pug (PG) and Golden retriever (GR) breeds had the highest incidence of tumors in the skin and surrounding tissues with an incidence of 58.3% and 41.2%, respectively, while YT and Pomeranian (POM) had a lower incidence of 15.2% and 12.1%, respectively. Gastrointestinal tumors were the second most common tumors and were found in 733 cases accounting for 18.4%. Gastrointestinal tumors included the areas from the oral cavity to the anus, and intraoral melanoma was particularly common, accounting for 55% of all gastrointestinal tumors as an intraoral tumor, followed by perianal tumors that accounted for 21%. Gastrointestinal tumors included the areas from the oral cavity to the anus, and intraoral melanoma was particularly common, accounting for 55% of all gastrointestinal tumors as an intraoral tumor, followed by perianal tumors that accounted for 21%. Breast tumors were the third most common tumors and were found in 716 cases that accounted for 18.0%. Smaller dog breeds had greater proportion of breast tumors, which accounted for 0% in BMD, 7.1% in PG, 6.4% in GR, 7.0% in SSD, 10.8% in SIB and 12.8% in LR. With regard to mast cell tumors, they were found more often in the two breeds, PG and BMD, accounting for 46.4% and 23.3%, respectively.

2. Analysis of the number of domestic dogs by breed and crude incidence of tumors in dogs in Gifu Prefecture

The number of domestic dogs in Gifu Prefecture in terms of the location of tumor development, tumors were found most often in the skin and surrounding tissues, with 1,233 cases accounting for 30.9%. In particular, the pug (PG) and Golden retriever (GR) breeds had the highest incidence of tumors in the skin and surrounding tissues with an incidence of 58.3% and 41.2%, respectively, while YT and Pomeranian (POM) had a lower incidence of 15.2% and 12.1%, respectively. Gastrointestinal tumors were the second most common tumors and were found in 733 cases accounting for 18.4%. Gastrointestinal tumors included the areas from the oral cavity to the anus, and intraoral melanoma was particularly common, accounting for 55% of all gastrointestinal tumors as an intraoral tumor, followed by perianal tumors that accounted for 21%. Breast tumors were the third most common tumors and were found in 716 cases that accounted for 18.0%. Smaller dog breeds had greater proportion of breast tumors, which accounted for 0% in BMD, 7.1% in PG, 6.4% in GR, 7.0% in SSD, 10.8% in SIB and 12.8% in LR. With regard to mast cell tumors, they were found more often in the two breeds, PG and BMD, accounting for 46.4% and 23.3%, respectively.

2–1. The number of domestic dogs in Gifu Prefecture by breed based on the number of dogs receiving RV in 2011

We conducted a questionnaire survey in 42 municipalities in Gifu Prefecture, and 29 of the 42 (approximately 69%) responded. With regard to the number of domestic dogs, the number of dogs receiving RV during the period from April 2011 to March 2012 was 93,234 according to the Gifu Veterinary Medical Association, and information about 76,316 dogs or approximately 82% of the total number of RV dogs was collected through the questionnaire survey. The numbers of domestic dogs in Gifu Prefecture revealed by this questionnaire survey included 18,357 mixed breeds (MIX) (24.1%), 9,609 DAX (12.6%), 8,609 SIB (11.3%), 5,017 PD (6.6%) and 4,873 CW (6.4%); this demonstrated the high popularity of small dog breeds except for MIX and SIB, while large dog breeds were fewer, namely, 2,312 LR (3.0%) and 1,213 GR (1.6%). The top 5 dog breeds including MIX accounted for 60% of all the dogs (Table 3).

2–2. The crude incidence of tumors in dogs and the crude incidence of malignant tumors in dogs in 2011

With regard to the number of samples for which examination was requested from the University during the one-year period (2011), most requests were for MIX, with 116 samples, followed by DAX with 71, LR with 61, CG with 57, GR with 52 and SIB with 41 samples (Table 3).
Using the samples collected for pathological examination, the crude incidences of tumors by dog breed were calculated for reference. Our results showed that the crude incidence of tumors was significantly low in POM at 0.1%, PD at 0.2%, CW at 0.3%, SIB at 0.5%, DAX at 0.7%, and MIX at 0.6% \((P < 0.05)\), while it was significantly high in PAP at 1.3%, SZ at 1.5%, YT at 1.5%, SCH at 1.5%, MAR at 2.0%, PG at 2.1%, BG at 2.3%, SSD at 2.5%, LR at 2.6%, CG at 3.0%, GR at 4.3%, and BMD at 7.9% \((P < 0.05)\). The crude incidence of malignant tumors was also calculated in the same manner; it was found to be low in SIB, PD, CW, POM, MIX and other breeds \((P < 0.05)\), but high in LR, CG, BG, GR, SSD and BMD \((P < 0.05)\).

**DISCUSSION**

The analysis of tumor development in dogs by breed in Gifu Prefecture revealed the following characteristics: Common breeds of dogs, such as MIX and DAX, showed a high number of tumor cases, and uncommon breeds of dogs, such as GR and LR, also showed a high number of tumor cases; in contrast, common breeds of dogs, such as SIB, showed a low number of tumor cases, suggesting the possibility that the crude tumor incidence in dogs varied depending on the dog breed. The analysis of the ratio between benign and malignant tumors by dog breed showed that small dog breeds tended to have a greater proportion of benign tumors. Although the ratio of malignant tumors in this study was 57.5%, there was a Swiss report in which malignant tumors accounted for 47.07% of all investigated tumors in the survey [10]. This difference was considered to be caused by the differences in the types of dog breeds and breeding environment; however, further investigation is necessary to clarify this point. With regard to the samples submitted for pathological examination, there is a possibility of potential bias with regard to the collection of the samples, since the primary veterinary hospital or clinic may have sent fewer samples of benign tumors or more samples of malignant tumors, keeping in mind that the “University” would be performing the pathological examination.

With regard to analysis of the most commonly developed organ systems, tumors were found most frequently in the skin and surrounding tissues, similar to reports from other countries [7, 10, 14], but the organ systems showing a high
frequency of tumors after the skin and surrounding tissues, differed slightly from reports from other countries. This is considered to be due to the differences in the types and incidence of dog breeds, e.g., reports from other countries included higher number of large dog breeds.

With regard to breast tumors, dogs were divided into the high incidence group, including CK, DAX, MAR, PAP, PD, POM and YT, and the low incidence group, including BMD, GR, LR, MIX, PG and SSD. Itoh et al. have also reported that small dog breeds have a lower risk of malignant breast tumors compared to another types of dogs [12]. In some of the reports from other countries concerning breast tumors in dogs, dogs, such as boxer, cocker spaniel, English springer spaniel, DAX, pointer, PD and Boston terrier, had a higher incidence of breast tumors [14, 16]; further, contrary to the results of our study, there was a report that breast tumors developed more frequently in large dog breeds, such as Leonberger, Irish wolfhound and BMD [13]. It has been known for some time now that mast cell tumors develop more frequently in the mastiff-type boxer dog breeds [1]. Mast cell tumors have been found with a high frequency in PG, BMD and FB, which are related to mastiff-type breeds in the same manner as boxer breeds [21, 23], and breeds with a lower frequency for such tumors were also revealed to be CK, POM, SSD and YT.

Frequently, data registered at municipalities do not reflect the deaths of domestic dogs accurately. Therefore, there is a possibility that many dogs as old as 25 years and even older exist in the database, and the research of Hayashidani, et al. [11] also showed that there is a possibility that the data of elderly dogs that are not alive have not been removed from the records. In this study, there were not many domestic dogs older than 20 years; therefore, the reliability of the municipal data collected in this study was considered to be high. With regard to the fewer domestic dogs younger than 3 years noted in the age distribution, it was probably caused by unregistered younger dogs (RV not received) and decreasing number of breeding dogs. The performance rate of RV in Gifu Prefecture has been 79.5–80.9% every year (2008 to 2011), which was higher than the national mean of 72.8% (2011). This shows the regional characteristics of Gifu Prefecture, and it was considered that the basic data were thus reliable. The decreasing number of domestic dogs leads to a bias in the age distribution. When more elderly dogs are present than younger dogs, the tumor incidence should be calculated after adjustment for age to be accurate, because higher figures would be noted otherwise. However, at present, it is difficult to obtain information regarding age for each breed from the municipal data, and we therefore decided to investigate the crude tumor incidence.

The crude incidence of 0.9% seems to be slightly lower than the tumor incidence reported overseas, ranging from 0.96% to 4.82% [14, 17, 20], which may be the influence of basic data. It was considered that the tumor incidence calculated in this study may be lower than the actual incidence, because the performance rate of RV was not 100% of the population, and there is a possibility that the primary institutions may only have sent approximately 24% of the tumor samples for examination. In addition, since the number of dogs with tumors that visit a veterinary hospital (some dogs may not visit a hospital), the percentage of dogs diagnosed with a tumor at veterinary hospitals or clinics (some dog owners do not want to have examinations) and the percentage of cases for which a sample is sent to the University for pathological examination (some samples may be sent to another pathology laboratory) influenced the tumor incidence, it was considered that there is a possibility that the calculation of the crude tumor incidence and crude malignant tumor incidence in this study may have underestimated the reality. To control such bias, measures should be adopted to select target animals randomly in future studies.

Although the crude tumor incidence calculated by breed may be lower than it should be due to the problems with the size of the population and the number of samples collected, it is considered that the incidence by breed and by organ would not be easily affected by the changes in the number of samples or age distribution.

Most domestic dogs in Japan are of small breeds, such as those kept mainly inside the house; in our study, only three large dog breeds (LR, GR and BMD) were present among all the 20 selected breeds, which differed largely from the reports from other countries [6, 9, 20]. Since the crude tumor incidence was affected by the type of breed and the body size, it is considered that the data obtained in this study are unique to Japan, where most domestic dogs are small- and medium-sized, differing from data from other countries. It is necessary to investigate the relationship between the breeding environment and the crude tumor incidence in future studies.

We consider that, in addition to improving the accuracy of the survey data, it is necessary to promote antirabic vaccination, to utilize the municipal database, and to obtain an accurate number of bred animals by adding an item in the surveys, such as a census, to investigate the status of bred animals. In addition, it is important to use domestic Japanese data to manage cancers in dogs in Japan, instead of using data obtained from other countries, where the size of the dogs is mostly large, considering the differences in dog size in Japan and other countries.

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