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Epidemiological Analysis of the Most Prevalent Sites and Types of Canine Neoplasia Observed in a Veterinary Hospital

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SUMMARY

A study of the epidemiology of canine neoplasia was conducted at the University of Pennsylvania School of Veterinary Medicine with data obtained from clinical and postmortem records for the period January 1, 1952, to December 31, 1963. Age-, sex-, and breed-specific ratios were obtained for the most popular breeds and the most prevalent types and sites. The overall prevalence of neoplasia in this population for the 12-year period was 4.2%. The highest relative risk was noted among boxers. This was true for a variety of types and sites of tumors. Age-adjusted data revealed a higher risk for boxers than nonboxers, particularly up to the age of 8 years. Again this was true for a variety of types and sites. Boxers were shown to have an unusually high prevalence of mastocytomas of the skin compared to nonboxers, but fewer mammary and circumanal tumors than expected. They also showed a particularly high relative risk of osteosarcomas and lymphosarcomas involving bone and lymph node as well as high relative risk for neoplasms of the testes and gingiva. An unusual distribution of age-specific ratios for lymphosarcomas and osteosarcomas was observed. Both presented similar age-specific ratios with a marked peak occurring between 7 and 10 years of age, followed by a marked decline. This was in contrast to other types or sites, which showed a continued increase in age-specific ratios with increased age.

INTRODUCTION

There has been considerable interest in canine neoplasia over the years. Many authors have pointed to the importance of comparative medical studies in this species which shares so intimately man's environment and which is subject to most of the same kinds of neoplasia seen in man (14, 22, 24). In more recent years in various parts of the developed world, the emergence of better diagnostic facilities at veterinary schools and the willingness of dog owners in affluent societies to pay the necessary costs of diagnosis have resulted in the accumulation of more complete data concerning canine neoplasia. This, in turn, has permitted the undertaking of better epidemiological investigations of spontaneously occurring neoplasms in pet animals.

A recent article by Priester and Mantel (25) reviewed the hospital-based tumor registries for 12 veterinary schools and indicated their reservations concerning the interpretation of such data. The concepts of risk presented were in their judgment to be viewed as "leads" rather than morbidity statistics and not as a substitute for more precise (but expensive) population-based studies, such as the survey of animal neoplasms in Alameda and Contra Costa Counties (8).

Similarly it is the objective of this paper to present an overall review of laboratory-confirmed canine neoplasia cases as they were diagnosed and confirmed at the University of Pennsylvania Veterinary Hospital over a period of 12 years from 1952 to 1964. This veterinary hospital was not included in the Priester-Mantel studies and the staff of the institution has long had an active interest in the field of cancer epidemiology. This review is essentially descriptive and utilizes age-, sex-, or breed-specific ratios to give concepts of greater or lesser risks for specific segments of the canine population. Again, these concepts of risk must be viewed as leads to further studies rather than morbidity statistics, *e.g.*, incidence rates. Like the Priester and Mantel studies, it differs from other epidemiological hospital-based studies of canine neoplasia (7, 15, 22) in that it relates the number of confirmed neoplasia cases to the total hospital population.

This paper initially presents the most salient features of neoplasia in the most frequently seen breeds in the hospital for the most prevalent types of cancers at the most prevalent sites. It then looks in more detail at 2 of the more promising leads, the apparent affinity of the boxer for neoplasia and peculiarities in age distribution of certain cancers.

MATERIALS AND METHODS

Age, breed, and sex estimates of the distribution of hospitalized dogs seen for all purposes were obtained from samples of case records for the total hospital population. The estimates of the total hospital population and its characteristics were obtained in the following manner. Three years were selected for analysis. The earliest data for which a complete set of hospital records was available were from 1955 and the latest data were from 1962. The year 1958 was selected at random from the interim period. The total number of hospital cases seen per year was obtained from annual hospital reports going

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back to 1952. This figure was slightly over 60,000 cases for the 12-year period with an average of about 5,000 cases per year with only slight variations. The total population was rounded off at 60,000 to facilitate analysis. For the 3 years sampled, 33.3% of the 15,100 records were examined by a systematic sampling method. A total of 5,035 records were analyzed for age, sex, and breed estimates. They represented 8.5% of the total hospital population seen during that 12-year period. These data were utilized to construct the standard or reference population used in the calculation of crude and adjusted ratios. For the purpose of this article, only the comparisons between boxer and nonboxer populations were age adjusted.

Biopsy and necropsy files were studied for the period 1952 to 1963. Only cases with histopathological confirmation were included in this study. Age-, breed-, and sex-specific prevalence ratios were calculated by utilizing only those dogs with neoplasms that were part of the hospital population during this period. A total of 2550 cases were analyzed. Summaries were prepared for the most frequently occurring neoplasms according to type and site in the most popular breeds.

On the basis of the initial impressions of the importance of the boxer, this breed was then examined in greater detail and compared with all other breeds seen at our hospital during this period. The statistical tests used were Student's t test and the χ^2 test. The Mantel-Haenszel procedure (17) was used to estimate relative risks and to determine their significance. The data were adjusted for age by the direct method utilizing the total hospital population as the reference population. The appropriate Mantel-Haenzel procedure for estimating overall risk when the data are adjusted in this manner was used.

RESULTS

Table 1 presents the most prevalent breeds seen in the hospital population over the 12-year period from 1952 to 1963 and the frequency of neoplasia cases observed in those breeds during this period. The boxer and the cocker spaniel together make up 40% of the total number of neoplasia cases. The breed-specific rates given in the same table show that 1 out of every 10 boxers presented at the hospital was seen for neoplasia. This represents the highest breed-specific rate amongst the 10 most frequently seen breed categories with a relative risk (R) of 2.8 when compared to $R = 1$ of tumors for all other breeds. The expected number of cases and χ^2 values are given in the last 2 columns. The breed distribution for neoplasia was significantly different from the total hospital population (χ^2, 526.4; d.f., 10). By far the most outstanding contributing factor to this difference was observed in boxers.

Table 2 presents a summary of the neoplasia cases according to the most prevalent sites and malignant types. The 7 sites selected account for 85.8% of all neoplasia sites. The 7 malignant types selected account for 52.5% of all neoplasia cases. The great frequency with which the boxer appeared as one of the most prevalent breeds for site and type (with the exception of the mammary gland and circumanal sites and of fibrosarcoma) is readily seen. Table 2 also demonstrates a male affinity for skin tumors of the circumanal region as well as a female affinity for adenocarcinomas. The latter are found primarily in mammary tumors. The last point, which the crude data draw to our attention, is the lower average age for neoplasms of the lymph node and bone, primarily lymphosarcomas and osteosarcomas, respectively.

This last observation was further examined and illustrated in Charts 1 and 2, which depict the age distribution of the hospital population and the age-specific ratios of all canine neoplasia cases and of the lymphosarcoma and osteosarcoma cases. Increasing risk with increasing age is a characteristic of all other crude rates of neoplasms according to site or type thus far examined (2, 5, 6). They include neoplasms of the respiratory and gastrointestinal tracts and oral and pharyngeal tumors. Osteosarcomas and lymphosarcomas, on the other

Table 1

Neoplasia cases diagnosed in the most frequently seen breeds at the University of Pennsylvania Veterinary Hospital, January 1, 1952, to December 31, 1963

	Total hospital population		Neoplasia cases observed				
Breed	No.	%	No.	%	Breed-specific rate %	Neoplasia cases expected	χ^2
Mixed	19,080	31.8	651	25.5	3.4	810	31.2
Cocker spaniel	5,700	9.5	338	13.3	5.9	242	38.1
Boxer	4,320	7.2	430	16.9	10.0	184	328.9
German shepherd	3,900	6.5	85	3.3	2.2	166	39.5
Poodle	2,520	4.2	70	2.7	2.8	107	12.8
Collie	2,160	3.6	61	2.4	2.8	92	10.4
Dachshund	2,040	3.4	54	2.1	2.6	87	12.5
Beagle	1,500	2.5	34	1.3	2.3	64	14.1
Boston terrier	1,380	2.3	82	3.2	5.9	59	9.0
Wire-haired and fox terriers	1,140	1.9	85	3.3	7.5	48	28.5
Others[a]	16,260	27.1	660	26.0	3.6	691	1.4
Total	60,000	100.0	2,550	100.0	4.2	2,550	526.4[b]

[a] Less frequent breeds grouped to facilitate analysis.
[b] Significantly different; $p < 0.001$ (10 d.f.).

Table 2

Summary of canine neoplasia cases according to most important primary sites and types at the University of Pennsylvania Veterinary Hospital, January 1, 1952, to December 31, 1963

	No.	Av. age	% males	The most popular breeds in order of their specific prevalence rates		
Primary sites						
Skin	864	9.0	55.1	Boxer	Boston terrier	Fox terrier
Skin, circumanal	175	10.8[a]	86.8[a]	Cocker spaniel	Fox terrier	
Mammary gland	546	10.1[a]	0	Fox terrier	Cocker spaniel	Boston terrier
Testis	178	10.0	100.0	Boxer	Fox terrier	Boston terrier
Lymph node	159	7.0[b]	48.1	Boxer	Fox terrier	Cocker spaniel
Gingiva	132	8.8	61.1	Boxer	Cocker spaniel	
Bone	134	7.3[b]	60.2	Boxer		
Types of cancers						
Adenocarcinoma	446	10.3[c]	27.8[b]	Cocker spaniel	Boxer	
Mastocytoma	226	8.5[d]	57.5	Boxer	Boston terrier	
Lymphosarcoma	193	7.3[d]	52.7	Boxer	Fox terrier	Cocker spaniel
Epidermoid carcinoma	130	10.0[c]	58.0	Boxer	Cocker spaniel	
Osteosarcoma	123	7.9[d]	56.6	Boxer		
Melanoma	109	9.8[c]	62.5	Cocker spaniel	Dachshund	Boxer
Fibrosarcoma	112	9.3	51.8	Fox terrier	Cocker spaniel	
All neoplasia cases	2,550	9.1	48.6			
Total population	60,000	4.0	55.4			

[a] Significantly higher than all neoplasia cases; $p < 0.001$.
[b] Significantly lower than all neoplasia cases; $p < 0.001$.
[c] Significantly higher than all neoplasia cases; $p < 0.05$.
[d] Significantly lower than all neoplasia cases; $p < 0.01$.

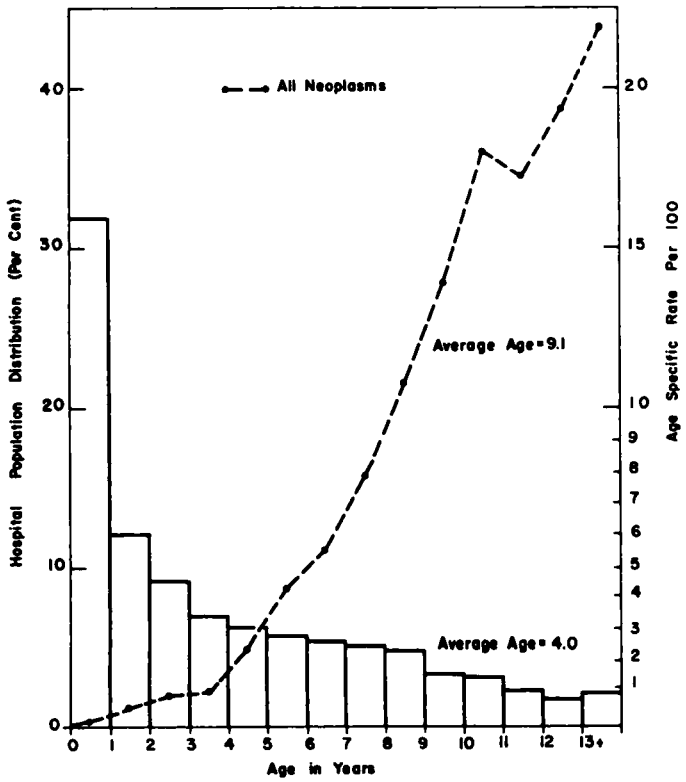

Chart 1. Age distribution of total hospital population and age-specific rates of all canine neoplasia cases, January 1, 1952, to December 31, 1963.

hand, seem to have a different age distribution. Age-specific ratios had a pronounced peak in the 6- to 10-year age group with the mode at 8 to 9 years of age, followed by a precipitous decline thereafter. If the individual figures for lymphosarcoma and osteosarcoma are superimposed as they appear in Chart 2, the patterns appear to be similar.

Table 3 presents the crude rates for the most prevalent sites and malignant types of tumors for the total of all breeds, for the high-prevalence breeds, for the beagle as an example of a low-prevalence breed, and for all breeds except the boxer. The table indicates a high relative risk for the boxer for neoplasms of the skin, testis, lymph nodes, and bone ($R = 4.1$) and for mastocytomas, lymphosarcomas, and osteosarcomas ($R = 7.0$).

Table 4 presents the age distribution of boxers and nonboxers for neoplasia cases and the total hospital population. Age data were available for 2,499 of the 2,550 neoplasia cases. The data were adjusted for age by applying the age-specific rates for boxers and nonboxers to a standard population consisting of the sum of the observed subpopulations (13). The age-adjusted neoplasia rate for boxers was 321.4/4,320 = 74.4/1,000 compared to 2,176.5/55,680 = 39.1/1,000 for non-boxers. These age-adjusted rates were found to be significantly different (χ^2, 124.3; $p < 0.001$) with a relative risk of 4.1. The χ^2 tests and relative risk for observed animals in each age interval are also given in Table 4. Significant differences between boxers and nonboxers appear in the age group 1 through 7 years of and in the group 13 years of age and over. Similar differences were noted in comparisons made with the age-adjusted rates.

The crude rates for neoplasia in boxers and nonboxers by

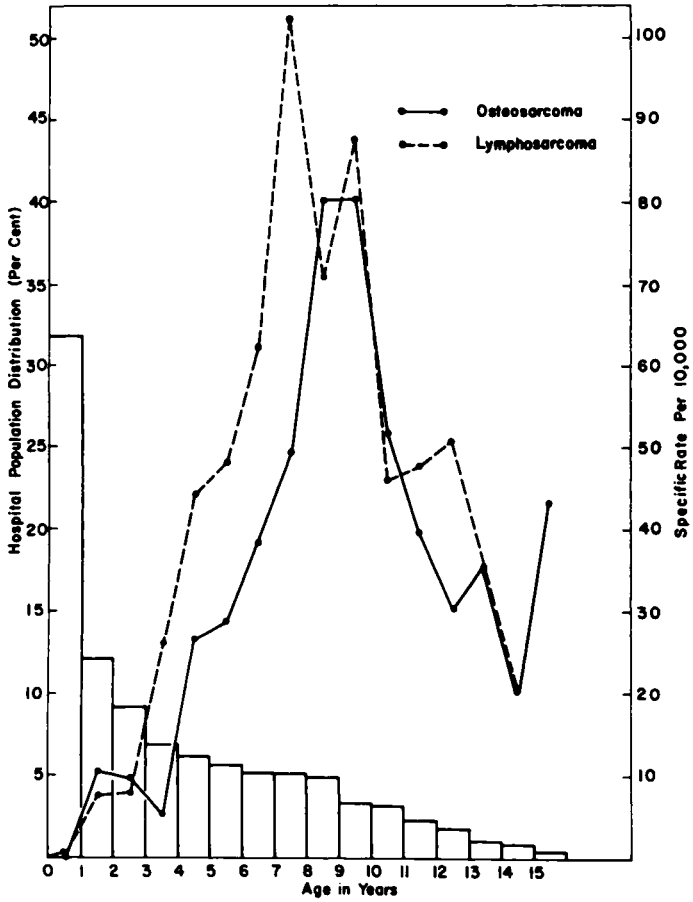

Chart 2. Age distribution of total hospital population and age-specific rates of lymphosarcoma and osteosarcoma cases, January 1, 1952, to December 31, 1961.

age are shown in Chart 3. Charts 4 to 6 utilize age-adjusted data in order to minimize differences attributable to discrepancies between the age distribution of boxers and other breeds in the hospital population. Calculations of adjusted numbers of cases were made by the direct method as described above (13).

Chart 4 presents the cumulative normalized age-specific frequencies in percentage of neoplasia in boxers and nonboxers. Neoplasia appears earlier in boxers than in all other breeds. There is also a more uniform distribution of the relative frequency of cases in boxers than in other breeds, where there is a more pronounced increase in relative frequency in later life.

The data were examined to see whether there was any significant difference between the boxers and nonboxers, after an adjustment for age, in the primary sites and types of neoplasia. Table 5 persents the ratios/1000 and the relative risks and χ^2 values for the 7 most frequently involved sites and the 7 most frequent malignant types. Except for neoplasms of the mammary gland and circumanal neoplasms which were significantly lower, neoplasms of the 5 other sites were all significantly higher in boxers. In the frequency of malignant types examined, the boxer was significantly higher for mastocytoma, lymphosarcoma, and osteosarcoma.

Chart 5 presents the cumulative frequency in percent for the adjusted data by site. All neoplasms, with the exception of circumanal tumors, showed more marked affinity for younger boxers than those of all other breeds. Circumanal tumors were relatively infrequent in boxers and the data may be less reliable. Chart 6 shows the same method of analysis applied to the most frequent types of cancer. Again, all types of neoplasms showed a more pronounced affinity for younger boxers than all other breeds combined. This is consistently

Table 3

Breed-specific crude rates per thousand according to most frequent sites and types at the University of Pennsylvania Veterinary Hospital, January 1, 1952, to December 31, 1963

		High-prevalence breeds					
	All breeds	Boxer	Cocker spaniel	Boston terrier	Fox terrier	Beagle	Total nonboxer
Most important primary sites							
Skin	14.4	44.2	19.3	25.4	21.1	8.7	12.1
Skin, circumanal	2.9	1.2	7.7	1.4	7.9	2.0	3.1
Mammary gland	9.1	7.2	17.0	12.3	24.6	7.3	9.2
Testis	3.0	9.0	1.1	5.1	5.3	1.3	2.5
Lymph node	2.7	11.1	3.7	2.2	4.4	2.7	2.0
Gingiva	2.2	5.6	4.4	1.4	1.8		1.9
Bone	2.2	7.6	0.4	1.4			1.8
Most important types of cancer							
Adenocarcinoma	7.4	11.8	12.8	5.8	8.8	4.7	7.1
Mastocytoma	3.8	23.4	1.6	17.4	2.6	0.7	2.2
Lymphosarcoma	3.2	13.0	4.2	2.2	6.1	2.7	2.5
Epidermoid carcinoma	2.2	3.5	3.0	1.4	2.6	0.7	2.1
Osteosarcoma	2.1	6.9	1.2	1.4	0.9		1.7
Melanoma	1.8	3.0	4.2	0.7	1.8	0.7	1.7
Fibrosarcoma	1.9	2.3	3.0	2.2	3.5		1.8
All sites and types	42.5	99.7	59.3	59.4	74.6	22.7	37.2

Table 4

Age distribution of boxers and nonboxers in the neoplasia cases and total hospital population at the University of Pennsylvania Veterinary Hospital, January 1, 1952, to December 31, 1963

Age (yr)	Neoplasia cases			Hospital population			Age-specific neoplasia ratio/1000			Boxers *vs.* nonboxers		
	Boxers	Non-boxers	Total	Boxers	Non-boxers	Total	Boxers	Non-boxers	Total	x^2	*p*	*R*
<1	7	17	24	704	18,418	19,122	9.9	0.9	1.3	43.00	<0.001	10.9
1	11	29	40	324	6,924	7,248	34.0	4.2	5.5	49.51	<0.001	8.4
2	11	42	53	260	5,266	5,526	42.3	8.0	9.6	30.62	<0.001	5.5
3	15	33	48	260	3,892	4,152	57.7	8.5	11.6	51.80	<0.001	7.2
4	19	73	92	207	3,489	3,696	91.8	20.9	24.9	39.81	<0.001	4.7
5	39	108	147	324	3,066	3,390	120.4	35.2	43.4	51.57	<0.001	3.7
6	37	136	173	324	2,808	3,132	114.2	48.4	55.2	24.06	<0.001	2.5
7	55	188	243	441	2,649	3,090	124.7	71.0	78.6	15.04	<0.001	1.9
8	68	246	314	648	2,274	2,922	104.9	108.2	107.5	0.06	>0.05	1.0
9	53	223	276	324	1,668	1,992	163.6	133.7	138.6	2.03	>0.05	1.3
10	44	297	341	207	1,689	1,896	212.6	175.8	179.9	1.69	>0.05	1.3
11	41	195	236	207	1,161	1,368	198.1	168.0	172.5	1.12	>0.05	1.2
12	14	194	208	60	1,014	1,074	233.3	191.3	193.7	0.66	>0.05	1.3
13+	11	293	304	30	1,362	1,392	366.7	215.1	218.4	3.85	<0.05	2.1
All ages	425	2,074	2,499	4,320	55,680	60,000	98.4	37.2	41.7			

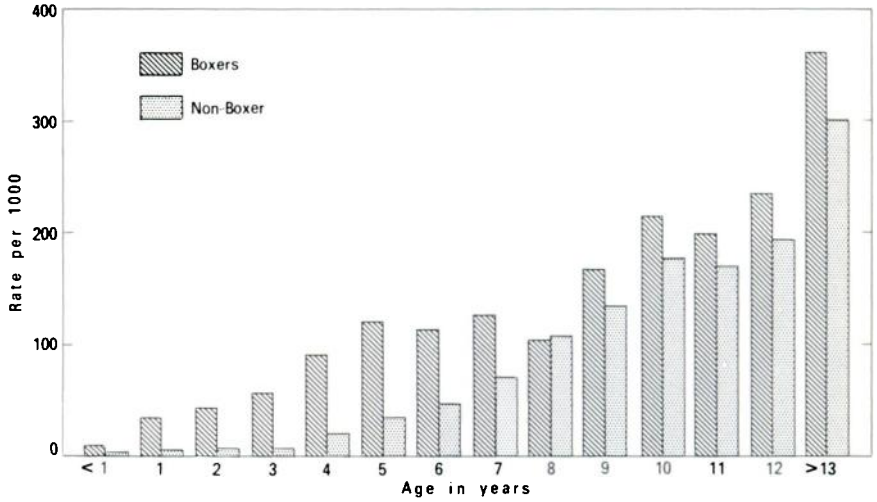

Chart 3. Age-specific crude neoplasia rate per thousand in boxers and nonboxers, January 1, 1952, to December 31, 1963.

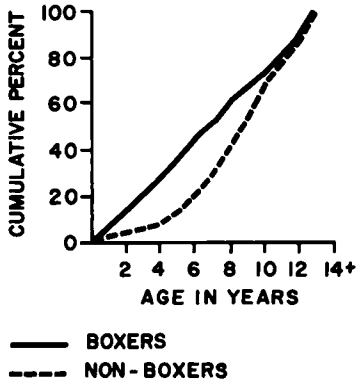

Chart 4. Cumulative normalized age-specific frequencies in boxers and nonboxers, January 1, 1952 to December 31, 1963.

observed until the age of 6 or 7 after which, as in the case of adenocarcinoma, epidermoid carcinoma, and melanoma, there may be no significant differences or, in fact, the reverse situation may be noted.

Chart 7 shows simultaneously the crude relative frequency of the most frequently seen malignant types of neoplasms and their respective sites in boxers and nonboxers. The major differences to be noted in the 2 populations are the greater percentages of mastocytomas involving the skin in the boxer and of adenocarcinomas of the mammary gland in the nonboxers. The site distribution of melanomas seems to be different in boxers when compared with nonboxers. They appear to occur with greater frequency in the gingiva of the latter, whereas in the boxer the most frequent site is the skin.

SEX DIFFERENCES

The sex ratio (males to females) of boxers with neoplasia was found to be different from the total canine population with neoplasia (see Table 6). However, this difference was caused by what might be called the most obvious sex-determined neoplasias: mammary gland tumors and testicular tumors. Upon the removal of these sex-determined cases from

Table 5

Specific age-adjusted rate of neoplasia cases in boxers and non-boxers according to most frequent site and type at the University of Pennsylvania Veterinary Hospital, January 1, 1952, to December 31, 1963

	Age-adjusted rate/1000			
	Boxers	Nonboxers	χ^{2a}	R^b
Most frequent neoplastic sites				
Skin	34.9	12.2	151.4[c]	2.93
Skin, circumanal	0.7	3.1	7.9[d]	0.22
Mammary gland	5.1	9.7	9.19[d]	0.52
Testis	6.1	2.6	17.46[c]	2.36
Lymph node	8.5	2.0	68.27[c]	4.26
Gingiva	4.2	2.0	9.09[d]	2.10
Bone	5.3	1.9	21.48[c]	2.80
Most frequent malignant types				
Adenocarcinoma	9.1	7.3	1.75 (NS)[e]	1.25
Mastocytoma	16.3	2.3	237.97[c]	7.18
Lymphosarcoma	9.9	2.5	72.78[c]	3.99
Epidermoid carcinoma	3.5	2.1	3.57 (NS)	1.67
Osteosarcoma	4.8	1.7	20.01[c]	2.83
Melanoma	2.2	1.7	0.57 (NS)	1.29
Fibrosarcoma	1.5	1.9	0.35 (NS)	0.79

[a] Based on 4,320 boxers and 55,680 nonboxers.
[b] The departure of the breed ratio (boxer/nonboxer) from unity.
[c] $p < 0.001$.
[d] $p < 0.01$.
[e] NS, no significant difference.

the neoplasia frequencies, it was seen that the sex ratios (which favor female boxers) were not significently different in terms of boxer or nonboxer frequencies.

The population samples for the years 1955, 1958, and 1962 were examined for sex differences. Comparison of the male to female, boxer to nonboxer samples (drawn from the total populations of each) via 4-fold significance tests, yielded χ^2 values of 01.01, 01.22, 01.28 for each of the 3 years, respectively. None of these values was significant; therefore it can safely be stated that the total boxer population was not different from the total canine population in terms of sex. Since neither the total population nor the neoplasia populations showed sex differences between boxers and nonboxers, it was not considered necessary to adjust the crude neoplasia frequencies in terms of sex.

DISCUSSION

The overall neoplasia prevalence ratio seen at the Veterinary Hospital from 1952 to 1964 was 4.2%. This ratio is in part due to the interest of the faculty in cancer research and the fact that the hospital served as a diagnostic referral center for suspected cancer cases in our area. A reflection of the possible bias can be seen in the fact that only 20% of our noncancer cases are referred from outside practitioners, whereas 30% of the neoplasia cases are so referred.

A general description of canine neoplasia from a clinical-pathological point of view, has been presented by Brodey (1) in a review article which is based, to a large degree, on the tumor registry at the University of Pennsylvania, utilized for the above studies. The studies undertaken above, have focused on 2 leads: (*a*) the apparent unusual age distribution of osteosarcomas and lymphosarcomas; (*b*) the affinity of boxers for most neoplasms with the exception of cutaneous adnexal, mammary, and circumanal tumors.

The 1st lead was the unusual distribution seen for the osteosarcomas and lymphosarcomas which varies dramatically from that seen for all other forms of neoplasia. The data suggest a marked similarity which may have some relationship to a common etiology. This is of some interest because of the association of lymphomas and leukemias with an oncogenic virus in rodents, poultry, and cats. A virus producing an osteogenic sarcoma in mice has been reported (9). Immunological evidence (by immunofluorescent techniques) of the presence of antibodies to osteosarcomas in the sera of human patients with the disease and their close associates suggests the possibility of an infectious agent (18). Cell-free extracts from a human osteosarcoma cell line have induced transformation of normal human embryo fibroblasts in tissue culture and leukemias in newborn mice (19). This supports the possibility of a common etiological agent capable of producing either osteogenic sarcomas or leukemia-lymphomas. The association of large breeds with osteosarcoma reported by Tjalma *et al.* (26) may indicate that associative physical and genetic factors are needed for activation of latent viruses.

The peculiarities of age distribution observed for the canine osteosarcomas and lymphosarcomas may therefore indicate a defined latency period which could be of importance for further laboratory investigations.

The high relative risk of boxers for a wide variety of neoplasms has substantiated the observations first made by Krook (15) for carcinomas and later substantiated by Howard and Neilsen (12) for neoplasms of various other tissues. A review of our data substantiates their observations of a lower frequency of mammary tumors for boxers as well as the more

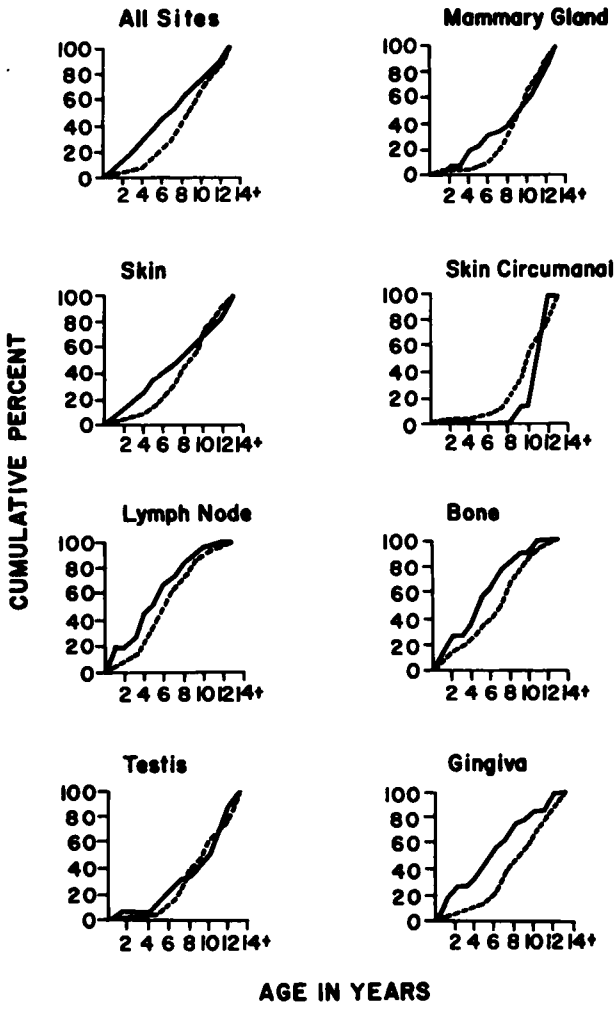

Chart 5. Cumulative normalized age-specific relative frequency of neoplasia in boxers and nonboxers according to site of cancer, January 1, 1952, to December 31, 1963.

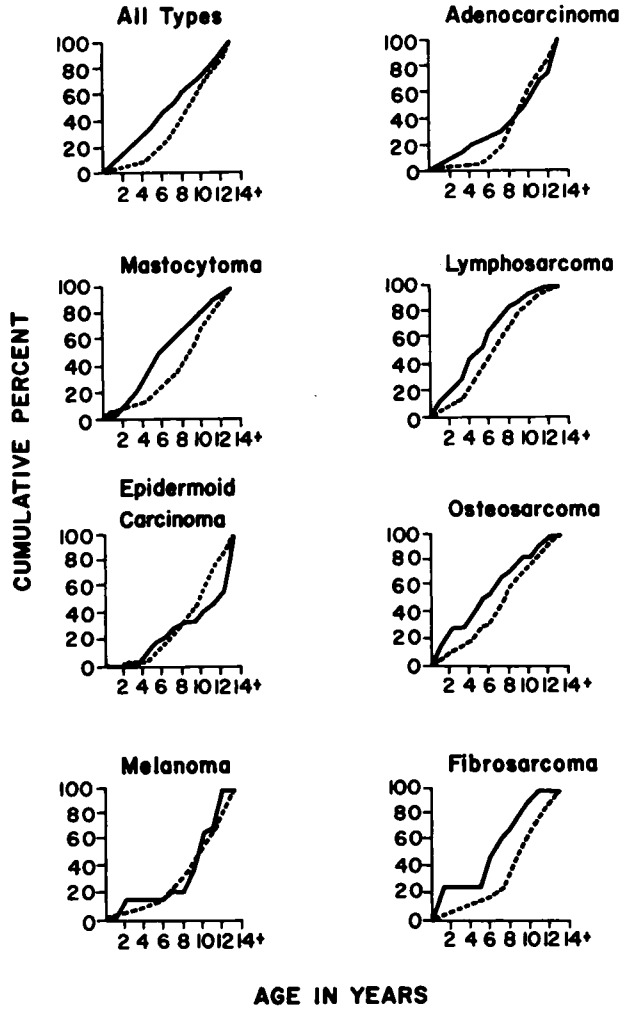

Chart 6. Cumulative normalized age-specific relative frequency of neoplasia in boxers and nonboxers according to type of cancer, January 1, 1952, to December 31, 1963.

frequent occurrence of mesenchymal neoplasms of the skin. In both papers cited above, the studies were based on necropsy and biopsy accessions as a denominator rather than on a total hospital population.

The boxer was not only significantly higher in relative risk in our studies but also showed its greatest difference from nonboxers in the 1st 7 years of life. This was true for a wide variety of neoplasia types and sites. Thus, the boxer may prove to be a more useful and economical animal in long-term studies involving a carcinogenic insult. In our data the beagle was consistently a dog of low neoplasia risk. This is of some interest, since the beagle is frequently the breed of choice for experiments involving carcinogenesis. Zaldiver (28) found, in studying beagles in 3 colonies, that the occurrence of cancers in beagles necropsied was 4.3% and the percentage of dogs over 1 year old with malignant neoplasms was 14.4%. However, as Morris (21) pointed out, the use of the term "incidence" was misleading, since it gave no information on the population from which it was drawn and therefore has no predictive value and since the dogs (at least at Argonne) were subjected to environmental and breeding conditions that could significantly influence their frequency of dying from cancer. At any rate, the information is not directly comparable with our estimates of relative risk. It is appropriate to consider whether utilization of a breed of high tumor prevalence such as the boxer along with a breed of low tumor prevalence such as the beagle might not yield meaningful results in a shorter period of time (3).

This is of current interest because of the decline in popularity of the boxer in recent years. In our study of the hospital population in 3 sample years, it was clear that certain of the leading breeds declined in popularity and were replaced by others. Thus, cocker spaniels declined from 14.4% of the hospital population in 1955 to 5.8% in 1962 and were replaced as the most popular purebred by German shepherd dogs, which went from 4.8% in 1955 to 10.1% in 1962. During this same period, the boxer declined from its 2nd place among purebreds seen at our hospital, going from 8.8% in 1955 to

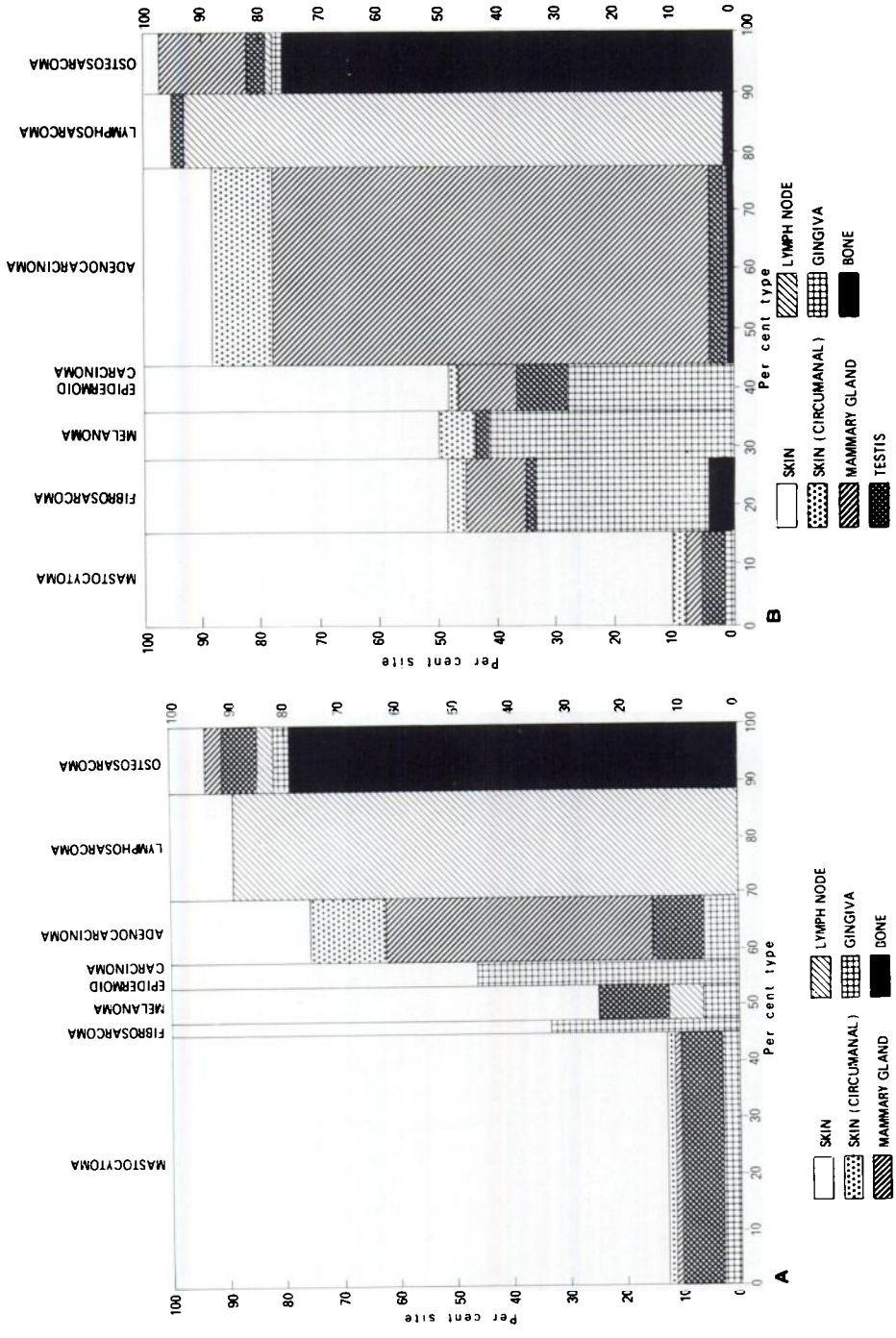

Chart 7.A, specific relative frequency of neoplasia in boxers of most important types of cancer, stratified according to the relative frequency at the most important sites, January 1, 1952, to December 31, 1963. *B*, relative frequency of neoplasia in nonboxers of most important types of cancer at the most important sites, January 1, 1952, to December 31, 1963.

Table 6

Sex distribution of all neoplasia cases and non-sex-determined neoplasia cases[a] in boxers and all canines seen at the University of Pennsylvania Veterinary Hospital, January 1, 1952, to December 31, 1963

	Male	Female	M/F ratio	χ^2	*p*	*R*
All neoplasia cases						
Boxers	237	193	1.23	8.84	<0.01	1.37
All canines	1236	1308	0.94			
Non-Sex-determined Cases[a]						
Boxers	198	162	1.22	1.81	NS[b]	0.85
All canines	1058	762	1.39			

[a] All neoplasia cases, excepting those that occurred at the mammary and testicular sites.
[b] NS, no significant difference.

5.7% in 1962, and was replaced by the poodle, which increased from 2.4 to 7.1% during that same period.

The boxer has continued its steady descent into popular obscurity at our hospital, and by the end of December 1970 only 1.3% of the hospital population were boxers. Today, we rarely see boxer puppies in our clinics for routine vaccinations. The data system used gave a new accession number to each animal presented for a new and unrelated event. Repeat visits for the same event were recorded under the original accession number. The varying popularity of the breeds could produce a bias in favor of those breeds more likely to be seen for multiple events. Under the circumstances, the pronounced age specific affinity of the boxer for neoplasia and the occurrence of highest relative risk in the younger age groups are considered highly significant.

The relative importance of mastocytomas of the skin in the boxer has been observed by others commenting on the overrepresentation of boxers in mastocytoma cases (11, 23). Peters, in his study of mastocytomas (11), not only found the boxer to be of high relative risk (16.7) but also noted that the beagle was 1 of 6 notably deficient exceptions to a relatively equal ratio of observed-*versus*-expected cases. The evidence of transmissibility with cell-free material (producing mast cell leukemias) (16) and the suggested usefulness of mastocytomas as an end-result model in studying chemical carcinogenesis (11) makes the boxer a potentially invaluable laboratory animal for the study of this type of neoplasm. The growing concern with environmental pollution and safety has led to a reconsideration and expansion of the role of animals as indicators of harmful environmental conditions for man. In this regard, the search for animals that could serve as highly sensitive indicators of environmental hazards as well as laboratory models is receiving international attention (27). The development and utilization of the boxer as a sentinel animal and laboratory model should be undertaken.

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