Causes of death in dogs in the province of Rome (Italy)

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Summary
Dogs share with humans several zoonotic diseases as well as some important determinants of degenerative syndromes and tumours. For this reason, systematic surveillance on small animal disease carried out through the collection and analysis of necropsy records could be helpful to public health. To describe the causes of death in dogs from the province of Rome (Italy) submitted to the Istituto Zooprofilattico Sperimentale del Lazio e della Toscana for necropsy during 2003–2007, a retrospective study was conducted on diagnostic data of 870 dogs. The final diagnosis was established by anatomo-histopathological examinations and, when needed, by ancillary laboratory tests. The most common causes of death were 'infectious disease' (23%) and 'poisoning' (17%). In 5% of the cases, the cause remained undetermined. The frequency of 'poisoning' was higher (39%) in stray dogs, while 'infectious disease' was more frequent (49%) in dogs from breeding farms. Parvovirosis was the most frequent infectious disease (33%) while anticoagulants accounted for 30% of the cases involving toxicity. Death by neoplastic lesions was quite infrequent (7%). Findings from this study provide veterinarians with an overview of the causes of death in dogs and it could provide public health authorities with new data about both novel and re-emerging threats.

Cause di morte in cani provenienti dalla Provincia di Roma, Italia

Parole chiave
Autopsia,
Avvelenamento,
Cane,
Causa di morte,
Malattia infettiva,
Provincia di Roma,
Italia.

Riassunto
I cani condividono con l'uomo diverse zoonosi e alcuni importanti determinanti di malattie degenerative e tumori. Pertanto, una sorveglianza sanitaria sistematica sui cani, condotta anche tramite raccolta e analisi dei dati autoptici, può essere di grande utilità in sanità pubblica. A questo scopo è stato condotto, tra il 2003 e il 2007, uno studio retrospettivo sui dati diagnostici di 870 cani della provincia di Roma sottoposti ad autopsia all'Istituto Zooprofilattico Sperimentale del Lazio e della Toscana. La diagnosi conclusiva per ogni reperto autoptico è stata ottenuta tramite esame anatomo-istopatologico e test di laboratorio complementari. Le cause di morte più frequenti sono risultate: "malattia infettiva" (23%) e "avvelenamento" (17%), nel 5% dei casi la causa non è stata determinata. Le morti per malattie infettive sono risultate più frequenti in cani provenienti da allevamenti (49%), la parvovirosi è risultata la patologia infettiva più rilevata (33%). La frequenza di "avvelenamento" è risultata più alta nei cani randagi (39%), gli anticoagulanti sono stati usati nel 30% di questi casi. Le morti per neoplasia sono risultate poco frequenti (7%). I risultati di questo studio forniscono ai veterinari clinici un quadro generale sulle cause di morte della popolazione canina e possono costituire una fonte di dati per le autorità di sanità pubblica per eventuali allerte su malattie emergenti e ri-emergenti.

Introduction

The role of companion animals as a sentinel for human health disorders is widely recognised. As a matter of fact, pets share with their owners not only the domestic habitat, but also other environmental risk factors (Backer *et al.* 2001). Moreover, unlike humans, animals are not affected by common confounders related to individual behaviours (Schmidt 2009). In this context, data collection by veterinary clinics (Ward & Kelman 2012) and laboratory records could be useful for outlining potential risks to public health. In a recent paper, Doera *et al.* (Doera *et al.* 2011) reviewed several examples of syndromic surveillance in small animal practices, aimed to empower public health awareness towards new and emerging risks.

Cause-specific mortality rates are considered to be among the most powerful and informative epidemiological indicators, even though in veterinary medicine, and in particular in small animals, they are not widely used (Dohoo *et al.* 2009). One of the reasons for the lack of this kind of studies is the difficulty to clearly define, in most cases, the cause of death in the context of a complex pathogenetic process.

Studies on the causes of death in dogs have been carried out using autopsy files (Bronson 1982, Craig 2001, Eichelberg & Seine 1996, Moore *et al.* 2001, Olsen & Allen 2000, Schmidt 2009), especially through designed questionnaires (Adams *et al.* 2010, Michell 1999, Proschowsky *et al.* 2003), data from animal insurance databases (Bonnett *et al.* 1997, Egenvall *et al.* 2000), and animal cemetery records (Hayashidani *et al.* 1988). No similar surveys had been previously carried out in Italy, mostly because of the lack of information on the number and characteristics of the canine population.

The Istituto Zooprofilattico Sperimentale del Lazio e della Toscana (IZSLT) conducts extensive investigations regarding animal diseases, which include not only anatomical and histopathological examinations, but also virological and bacteriological tests and chemical analyses for toxic substances. Dogs, cats, and other pets are submitted to the laboratory by veterinarians and owners whenever there is the need to know the cause of death. In fact, the post-mortem examination (PM) is not a routine procedure, but is usually carried out in the event of sudden death or when the cause leading to euthanasia is not known. Sometimes, as in the case of stray dogs and in all the cases for which a crime is suspected, the request for a PM is routinely carried out by official veterinarians. The aim of this study was to estimate the proportional mortality of the causes of death in dogs from the province of Rome, a mainly urbanized area, delivered to the Pathology Department of the IZSLT for PM over the period of 2003-2007.

Materials and methods

Data collection

An observational retrospective study of dogs from the province of Rome submitted by about 90 veterinary practitioners and official veterinarians was carried out over a 5-year period. For the necropsy of dogs submitted by practitioners, the owners were usually charged with a service fee, while the necropsy of dogs sent by official vets was free of charge. The original submission forms were collected in order to gather information about the identification, sex, age and, when available, the medical history of each dog. Eventually, the data were transferred to Microsoft Excel®. Regarding breed, age, and type of property, dogs were grouped into the following classes: purebred and crossbred; 0-1 month, 2-6 month, 7-12 month, 13-60 month, 61-119 month, > 120 month; and kennel (public or private), breeding farm, stray dog or free range, and owned dogs. Information on the specific breed was recorded and used when it was considered of interest. Military and police dogs were considered in the same category as those in breeding establishments, commercial puppy farms and pet shops because of the similarity in lifestyle and number of animals living in confined spaces.

Each dog was subjected to a complete PM, independently from the reason for the submission. After the PM, specific diagnostic investigation was carried out according to:

- specific request from the veterinary practitioner;
- medical history, when available;
- anatomo-pathological findings; and
- state of conservation of the carcass.

Diagnosis and classification of causes of death

Samples were submitted for one or more tests, such as virological, bacteriological, parasitological, histological, and toxicological tests in order to confirm or exclude specific causes of death. Test results and final diagnosis were all extracted from the information system of the IZSLT. The cause of death was unambiguously specified for each record and then all of the cases were grouped into 12 macro-categories accordingly. The macro-categories, intended as the main causes of death, were: 'infectious disease'; 'poisoning'; 'inflammation of unknown origin'; 'trauma'; 'organ displacement';

'neoplasia'; 'cardiovascular disease'; 'degenerative disease'; 'combined causes'; 'congenital anomalies'; 'other cause'; and 'not determined cause'. These categories include effective causes of death, i.e., diseases or injuries that are sufficient to lead to death as well as conditions characterized by severe structural or functional disorders that are considered incompatible with life by pathologists. When the PM was inconclusive and the results of laboratory tests were negative, the case fell into the latter category.

Statistical analysis

Frequencies were calculated for each categorical variable included in the study. The information about the medical history was used only to address the diagnosis and not for data analysis.

The proportion of each cause of death and its 95% binomial exact confidence interval (95% CI) were calculated. The χ^2 test was used to compare proportions of causes of death in dogs of different types of property, breeds, and classes of age. Two-sided tests were conducted and a p-value of less than 0.05 was considered statistically significant. The statistical analysis was performed using SPSS® (ver. 13) and STATA® 12.0.

Results

The study included 870 dogs whose characteristics are summarized in Table I. The sample was built as follows: 5% of dogs were euthanized before being submitted to the laboratory; 20% died after a disease course longer than a few days; and 75% were found dead or died immediately afterwards. Fifty-eight carcasses (7%) were in the initial or advanced putrefaction stage. The majority of the dogs were male (54%), adult, and elderly (60%). Fifty-one percent were owned dogs and about 50% were purebred, the most frequent breed being the German Shepherd. In 95% of the examined cases, it was possible to establish at least 1 possible cause of death. In 47 cases (5.4%, 95% CI 4.0–7.1), where no significant lesions were observed, it was not possible to define the diagnosis even when minimum standards tests, i.e. bacteriological and histological tests, were performed.

The most frequent main causes of death were 'infectious disease' (n=204, 23.4%, 95% CI 20.7-26.4) and 'poisoning' (n=149, 17.1%, 95% CI 14.7-19.8; Figure 1). In 122 cases (14.0%, 95% CI 11.8-16.5), the observed inflammatory changes could not be attributed to any infectious agent or specific cause. In 23 cases (2.6%, 95% CI 1.7-3.9), the degenerative changes were so severe that they were considered to be the cause of death, although the primary cause of death remained unknown.

Table I. *Characteristics of dogs in the study population (N=870) examined in Rome province between 2003-2007.*

Variable	N° of dogs (%)
Sex	
Female	323 (37.1)
Male	470 (54.0)
Not reported	77 (8.9)
Age classes (months)	
0-1	50 (5.7)
2-6	139 (16.0)
7-12	67 (7.7)
13-60	199 (22.9)
61-119	169 (19.4)
> 120	152 (17.5)
Not reported	94 (10.8)
Property/Breeding	
Kennel	297 (34.1)
Breeding farm	35 (4.0)
Stray dog	84 (9.7)
Owned dog	440 (50.6)
Not reported	14 (1.6)
Breed	
Crossbred	396 (45.5)
Purebred	435 (50.0)
Not reported	39 (4.5)
Total	870 (100.0)

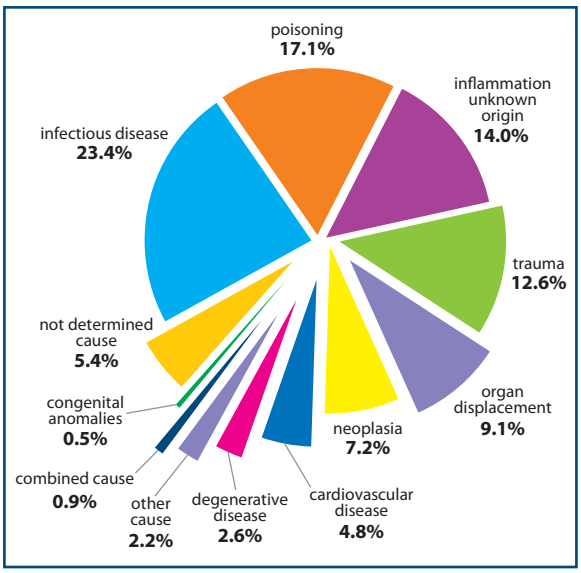

Figure 1. *Main causes of death in dogs (N=870) from Rome province examined between 2003-2007.*

No differences were detected in the frequency of causes between sexes. Categorising by type of property, the proportion of poisoning in stray dogs (n=33, 39.3%) was significantly higher than in owned (n=100, 22.7%), kennelled (n=15, 5.1%) and

Table II. *Specific causes of death according to the macro-categories of dogs (N=870) from Rome province examined between 2003-2007.*

Macro-categories/ specific causes	N (%)	95% CI	Macro-categories/ specific causes	N (%)	95% CI
Infectious disease			**Neoplasia**		
parvovirosis	68 (33.3)	26.9–40.3	haemangiosarcoma	17 (27.0)	16.6–34.0
Gram + septicaemia	57 (27.9)	21.9–34.8	lymphoma	9 (14.3)	6.7–25.4
Gram - septicaemia	37 (18.2)	13.1–24.1	others	37 (58.7)	45.6–71.0
others	42 (20.6)	15.2–26.8	Total	63 (100.0)	----
Total	204 (100.0)	----	**Cardiovascular disease**		
Poisoning			cardiomyopathy	16 (38.1)	23.6–54.4
anticoagulants	45 (30.2)	23.0–38.3	heat stroke	8 (19.0)	8.6–34.1
strychnine	33 (22.1)	15.8–29.7	vascular diseases	7 (16.7)	7.0–31.4
zinc phosphide	28 (18.8)	12.9–26.0	others	11 (26.2)	13.9–42.0
metaldehyde	22 (14.8)	9.5–21.5	Total	42 (100.0)	----
others	21 (14.1)	8.9–20.7	**Degenerative disease**		
Total	149 (100.0)	----	hepathosis	13 (56.5)	34.5–76.8
Inflammation of unknown origin			myocardosis	6 (26.1)	10.2–48.4
haemorrhagic enteritis	31 (25.4)	18.0–34.1	others	4 (17.4)	4.9–38.8
nephritis	30 (24.6)	17.2–33.2	Total	23 (100.0)	----
pneumonia	20 (16.4)	10.3–24.2	**Combined causes**		
others	41 (33.6)	25.3–42.7	Total	8 (100.0)	----
Total	122 (100.0)	----	**Congenital anomalies**		
Trauma			Total	4 (100.0)	----
generic trauma	44 (40.0)	30.8–49.8	**Organ displacement**		
dog bite	23 (20.9)	13.7–29.7	gastric dilatation and volvolus	62 (78.5)	67.8–86.9
car accident	12 (10.9)	5.8–18.3	others	17 (21.5)	13.1–32.2
post-surgery haemorrhages	9 (8.2)	3.8–15.0	Total	79 (100.0)	
others	22 (20.0)	13.0–28.7	**Other cause**		
Total	110 (100.0)	----	organ laceration	11 (57.9)	33.5–79.7
Not determined cause			others	8 (42.1)	20.2–66.5
Total	47 (100.0)	----	Total	19 (100.0)	----

farming dogs (n=1, 2.9%, p<0.001). Dogs housed in kennels seemed to die of 'inflammation of unknown origin' (n=58, 20%), 'neoplasia' (n=33, 11%), and 'degenerative disease' (n=15, 5%) more often than owned dogs (n=51, 12%, p=0.014; n=26, 6%, p=0.005; n=7, 2%, p=0.012, respectively).

Proportional mortality due to 'infectious disease' was comparable between owned and kennelled dogs (n=110, 25% and n=68, 23%, respectively), but was significantly higher in dogs from breeding farms (n=17, 49%, p<0.001). With regard to the cause of death by age, the proportion of deaths by 'infectious disease' was higher in the first 2 age classes (n=36, 72% and n=83, 60%, respectively) than in all the others (p<0.001). The highest proportion of death by 'neoplasia' was detected in the class '> 120 month' (n=36, 24%).

After stratifying the sample by breeds, purebred dogs seem to die more frequently of 'infectious disease' (n=121, 28%) and 'organ displacement' (n=50, 12%) than crossbreds (n=66, 17%, p<0.001 and n=26, 7%, p=0.014, respectively), while the frequency of 'inflammation of unknown origin' was higher in crossbreds (n=45, 10%, p=0.001). Amongst German Shepherd dogs, gastric dilatation volvolus syndrome accounted for 25% (n=24) of the observed causes of death.

Within each macro-category, the most frequent and specific cause of death was recorded (Table II). For instance, within 'infectious disease', parvovirosis was the most frequent diagnosis (n=68, 33.3%, 95% CI 26.9-40.3), while salmonellosis, the only important zoonosis detected, was diagnosed in 5 dogs out of 870 and was considered the primary cause of death in only 2 of them. Between the 2 classes of bacteria generating septicaemia, Gram + were more frequent (n=57, 27.9%). In particular,

the proportion of Gram + septicaemia in puppies up to 30 days old was 50% (25/50). Among toxic substances, anticoagulants (especially difenacoum) were detected in 45 cases (30.2%, 95% CI 23.0-38.3).

Among the inflammatory syndromes, where no specific causes were detected, the proportions of haemorrhagic enteritis (n=31, 24.6%, 95% CI 17.2-33.2) and nephritis (n=30, 25.4%, 95% CI 18.0-34.1) were similar. Within the "trauma" main category, generic trauma was the most frequent cause of death (n=44), followed by dog bite (n=23). Haemangiosarcoma was the most frequent neoplasia observed (n=17, 27.0%, 95% CI 16.6-34.0), most often in the spleen (8 out of 17 cases).

Among the combinations of causes, various infectious diseases were observed, such as canine distemper or salmonellosis, which were often associated with degenerative syndromes like hepathosis or nephrosis.

Discussion

The present study is the first attempt in Italy to investigate the causes of death in pets with the main purpose of obtaining information useful for epidemiological research and surveillance. Unlike similar studies (Fleming *et al.* 2011, Lord *et al.* 2007), it did not only include a set of specific breeds or certain age classes, but the general dog population living in the province of Rome. Some results, i.e. the proportion and typology of poisoning or the identification of the prevalent infective agents in kennels, could be used by regional official veterinarians to better address control and prevention measures.

According to Olsen and Allen (Olsen & Allen 2000), the cause-specific proportional mortality may be influenced by the category of dead dogs received at the laboratory for post-mortem diagnosis. Indeed, for most of these dogs, death was characterised by sudden and unexpected events, such as hyperacute infectious disease and poisoning, and the owner was not aware of any previous diseases. Since the service is not free, only owners who are motivated and with adeguate means, as well as veterinarians, sometimes for legal reasons, apply for the diagnostic service. Due to this selection bias, it is not possible to extend the results to the general dog population.

The low percentage of undetermined cause of death compared with reports by other authors (Graig 2000, Olsen & Allen 2000) is likely to be a consequence of the access to multiple tests at the IZSLT. Nevertheless, a small proportion of examined cases remained undetermined because of the poor condition of the carcass, which did not allow the identification of specific lesions and compromised the accuracy of microbiological tests. Furthermore, the available tests may be not sufficiently sensitive or are, as in the case of toxicological testing, too expensive to be performed for every possible substance.

In the present study, 'infectious disease' was the most frequent cause of death. Among these, zoonoses were not common, since *Salmonella* spp. were found only in the 0.6% of cases. Due to the high prevalence of leishmaniasis in the area of study (Scarpulla *et al.* 2010), it is possible that some cases of observed nephritis were attributable to this disease, but unfortunately no specific tests were performed.

As expected, the proportional mortality for poisoning in stray dogs was higher than in dogs of other categories. Nevertheless, the frequency of poisoning in owned dogs might be due to a low level of social tolerance to neighbours' dogs in overcrowded urban environments, in the city of Rome and its surrounding areas where it is not uncommon to find intentionally located poisoned baits. To confront this illegal and dangerous phenomenon (well known to the authorities), the Italian Ministry of Health issued legislation that made the toxicological analysis compulsory and free of charge on any suspected bait found within the whole national territory[1]. The easy access to the purchase of anticoagulants, used primarily as a means for pest control, results in their frequent use for intentional poisoning, although accidental ingestion by dogs is also likely. However, it is notable that strychnine, forbidden by law since 1977 for commercial sale and use, was detected, even if its occurrence is progressively decreasing.

Infectious diseases, especially parvovirosis, are obviously more common in young animals, as already reported by Walter and Kirchhoff (Walter & Kirchhoff 1995), either in dogs housed in domestic environments or in those from shops or puppy farms. In this respect, one possible risk factor that must be mentioned is the incorrect implementation of vaccination programmes. Strains of parvovirus not completely matching the commercial vaccines were indeed found in Italy (Decaro *et al.* 2011). In the case of pet shop puppies, a legal certificate of the cause of death is often required by the owners. This could justify the frequent recourse to PM investigation in cases of clinically evident gastroenteritis. In rehoming kennels, dogs seem to die quite often because of inflammation of unknown origin. This may be due to 2 primary factors: first, the high frequency of old animals in kennels with a consequent high prevalence of chronic syndromes; and the negative results in bacteriological analysis because of the prompt use of antibiotics in those premises when an infection occurs.

[1] Ministerial Order of 18 December 2008.

The high susceptibility of some breeds to infectious diseases has already been reported by other authors (Houston *et al.* 1996, Walter & Kirchhoff 1995). Also, the susceptibility of the German Shepherd dog and other large and giant breed dogs to gastric volvolus is well known to be due to the large thoracic depth-to-width ratio (Monnet 2003). Old age (64.7% were more than 60 months old) was also the most probable reason for the relatively high frequency of neoplasia in kennels, although the present estimate is lower than that of other reports (Adams *et al.* 2010, Bronson 1982, Craig 2001, Eichelberg & Seine 1996, Proschowsky *et al.* 1993) because of the selection bias mentioned above. In the neoplasia macro-category, haemangiosarcoma might have been diagnosed more frequently because it can easily cause sudden death following internal haemorrhage. A high proportional mortality for this neoplasia was also reported by Olsen and Allen (Olsen & Allen 2000) and Craig (Craig 2001). Conversely, very common tumours like skin and mammary carcinoma were only sporadically found in this study, probably because they are easily diagnosed by clinical examination and do not predispose to sudden death.

In conclusion, findings from this study provide veterinarians and health professionals with an overview of the causes of death in dogs, especially for young ones and for sudden death events. This study could be considered a first step to building a more comprehensive and representative surveillance system for small animal diseases aimed at supplying data to public health authorities about known diseases and emerging threats.

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