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Original Article

Prevalence of hyoid injuries in dogs and cats undergoing computed tomography

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ABSTRACT

Fractures of the hyoid bones have been reported occasionally in dogs, but the prevalence and significance of hyoid injury in dogs and cats are unknown. In human beings, hyoid injury is rare and usually is caused by direct trauma to the greater cornu, which are analogous to the paired canine and feline thyrohyoid bones. The aim of this study was to describe the prevalence and morphology of hyoid bone injury detected in dogs and cats undergoing computed tomography (CT) for unrelated disease. CT studies of 293 dogs and 100 cats from 2012 to 2016 were identified and reviewed retrospectively. Hyoid fracture (total of eight bones) or luxation (total of four sites) was present in 9/293 (3.1%) dogs, but none of the cats. One dog had bilateral fractures and one dog had bilateral luxations. The most frequently fractured bone was the epihyoid bone (4/8 fractures). Fracture margins were tapered and sclerotic, consistent with chronic non-union. There was no history of trauma, dysphagia or dyspnea in 7/9 dogs with hyoid fractures. Hyoid bone injury, particularly epihyoid bone fracture, may be an incidental finding in dogs.

Introduction

The hyoid apparatus of dogs and cats is an arrangement of small bones connected by fibrocartilage (Evans, 2013). Fracture of the hyoid bones has been reported in large breed dogs trained using collars (Manus, 1965). Dog bite injury and abuse have also been implicated as causes of hyoid bone fractures (Pass and Seltzer, 1971; Munro and Thrusfield, 2001). A survey of canine and feline fractures failed to detect instances of hyoid bone injury (Phillips, 1979); however, in that report, animals were enrolled on the basis of presentation to a small animal practice for trauma and investigators did not use computed tomography (CT). It is possible that clinical signs did not prompt hyoid radiography and that physical examination may be insufficient to diagnose hyoid bone fractures due to the small size of the bones.

In human beings, the hyoid apparatus fuses into a single hyoid bone at maturity and fractures are rare, accounting for only 0.002% of all fractures (Dalati, 2005). This is an injury of forensic significance, because the cause is usually direct trauma (e.g. strangulation or hanging) and CT has been used to assess the hyoid bone in such cases (Naimo et al., 2015). The greater cornua of the hyoid bone are most commonly fractured in human beings (Dalati, 2005; Mukhopadhyay, 2010).

The aim of this study was to describe the prevalence of hyoid bone injury (fractures or luxation) identified in CT studies of dogs and cats. We hypothesized that hyoid apparatus injury would be more common in large breed dogs than in small breed dogs, or cats, and that the most commonly fractured bone would be the thyrohyoid bone, which is analogous to the greater cornu of human beings.

Materials and methods

Diagnostic imaging

The medical records data base at the Virginia Maryland College of Veterinary Medicine Teaching Hospital, Virginia, USA, was searched to identify all CT studies of dogs and cats over a 4 year period from May 2012 to May 2016. All studies were performed using the same 16 slice helical scanner (Toshiba Aquilion, Toshiba Medical Systems). Field of view and slice thickness (2–3 mm) varied according to size of animal. Thin slice reformatted images (1 mm thick) were used when available. CT images were collected at 120 kVP and 200–350 mA. In most studies, the animals were anesthetized (84% of dogs; 99% of cats); in the remaining animals, imaging was performed under sedation.

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All cases initially were screened by a single radiologist who included any study that contained images of the entire hyoid apparatus. Cases were excluded if a portion of the hyoid apparatus was not imaged or if the medical record did not list age, weight, sex, breed, species and a final diagnosis. The cases that met the inclusion criteria were then reviewed by two radiologists. When present, the location of any fracture or luxation was decided by consensus and recorded. Sagittal and dorsal planar reconstructions and maximum intensity projection reformatting was used to facilitate interpretation as needed (OsiriX version 5.5, OsiriX Imaging Software, OsiriX Foundation). When other supplemental imaging modalities were available for the affected dogs, those images were also evaluated.

Hyoid fracture was defined as discontinuity of the cortex of any hyoid bone. The normal hyoid bones are aligned end-to-end and the bones are separated by soft tissue merging into fibrocartilage. The resulting joint allows mobility of the apparatus and permits some variation in overall shape or position. Due to this variability, we did not seek to identify subluxation. Rather, luxation was recorded when there was gross alteration of the normal end-to-end alignment of the bones, resulting in complete overlap of two bones.

Statistical analysis

The primary outcome of interest was the presence or absence of hyoid injury (either hyoid bone fracture or luxation). Potential risk factors included age (years), weight (kg), sex (male, female, neutered male, spayed female), breed (as reported in medical record), species (dog or cat) and history of trauma or dysphagia at the time of CT.

Normal probability plots showed that age followed a normal distribution and was summarized as mean (standard deviation), while weight was skewed and summarized as median (range). Categorical variables, including hyoid injury, sex, breed, species (dog or cat), history of trauma and history of dysphagia, were summarized as contingency tables. Bivariable associations between presence of hyoid injury and each risk factor were tested using the 2-sample *t* test (age), Wilcoxon rank sum test (weight) and Fisher's exact test (breed, sex, species, history of trauma, history of dysphagia).

Multivariable analysis was performed using stepwise logistic regression; the initial model specified hyoid injury as the outcome, and age, weight, history of trauma, breed and sex as the predictors (i.e. all risk factors regardless of bivariable associations). *P* value to enter and *P* value to stay were set to 0.05. An history of dysphagia was not included in the multivariable model because of a cell with zero count in the 2 by 2 contingency Table Statistical significance was set to $P < 0.05$. Cats were only considered when testing the bivariable association between hyoid fracture and species (cats versus dogs). All the other association analyses (bivariable and multivariable) are applicable to only dogs (there were zero hyoid fractures among cats). Statistical analyses were performed using SAS version 9.4 (IBM).

Results

Demographics

Of 1270 CT studies, 393 (293 dogs and 100 cats) met all inclusion criteria. The remaining 877 studies were excluded because the entire hyoid apparatus was not imaged (870) or the medical record lacked age, weight, or final diagnosis data (7).

Dogs weighed 24.6 (1.1–65.0) kg and were 7.9 ± 3.6 years old. Among dogs, there were 123 neutered males, 122 spayed females, 29 intact males, and 19 intact females. Dogs were comprised of a wide variety of breeds: gun dogs (Brittany, Chesapeake Bay retriever, Cocker spaniel, English setter, Llewelyn setter, German shorthair pointer, Labrador retriever, Golden retriever, Standard poodle, Weimaraner, Nova Scotia duck tolling retriever; 64 dogs; 22%), terriers (Jack Russell terrier, Fox terrier, Irish terrier, West Highland white terrier, Norwich terrier, Miniature schnauzer, Staffordshire terrier and bull terrier; 39 dogs; 13%), companion dogs (Chihuahua, Boston terrier, English bulldog, French bulldog, Havanese, Lhasa apso, Miniature pinscher, Papillon, Miniature poodle, Shih Tzu, Tibetan terrier, Yorkshire terrier; 34 dogs, 12%), herding dogs (Australian cattle dogs, Australian shepherd, Border collie, Welsh corgi, Belgian shepherd, German shepherd dog, Louisiana Catahoula leopard dog, Briard; 26 dogs; 9%), guard dogs (Boxer, Doberman pinscher, Great Dane, Great Pyrenees, Rottweiler, Newfoundland; 21 dogs, 7%), scenthounds (Dachshund, Basset hound, beagle, coonhound; 15 dogs; 5%), and Northern breeds (Akita, American Eskimo, Chow Chow, Shiba Inu, Siberian husky, Shar-Pei, 12 dogs, 4%). The remaining 82 dogs (28%) were classified as mixed breeds. Shepherd-type dogs (German shepherd dog, Belgian shepherd, and dogs specified as German shepherd dog-cross) were grouped for statistical comparison with other breeds.

Cats weighed 4.6 (2.3–8.0) kg and were 9.3 ± 4.4 years old. Among cats, there were 51 neutered males, 47 spayed females, 1 intact male and 1 intact female. Cat breeds included domestic short-hair (86 cats; 86%), domestic long-hair (9 cats; 9%), Siamese (2 cats; 2%), and others (one each of Burmese, Himalayan, and Persian).

The reasons for these animals undergoing CT evaluation varied. Final diagnoses in dogs included neoplasia (66%), infectious/inflammatory disease (26%), trauma (6%), neurologic disease (2%), and developmental disease (<1%). Final diagnoses in cats included neoplasia (47%), infectious/inflammatory disease (46%), trauma (5%), and developmental disease (2%).

Hyoid fractures

Hyoid bone fractures (total of eight bones) or luxation (total of four sites) were identified in 9/293 (3.1%) dogs, but 0/100 cats. One dog had bilateral fractures and one dog had bilateral luxations. The nine affected dogs consisted of four neutered males, three spayed females, one intact male and one intact female. We found no association between hyoid injury and age ($P = 0.95$), weight ($P = 0.69$), sex ($P = 0.67$), species ($P = 0.12$), history of trauma ($P = 0.10$) or history of dysphagia ($P = 0.99$).

The affected dogs included an 8-year-old neutered male Belgian shepherd with nasal chondrosarcoma (unilateral epihyoid fracture), a 9-year-old neutered male beagle with nasal carcinoma (bilateral epihyoid-ceratohyoid luxation), a 13-year-old male cocker spaniel with otitis media/interna (unilateral epihyoid fracture), a 10-year-old spayed female dachshund with lymphoplasmacytic rhinitis (unilateral stylohyoid-epihyoid luxation), a 7-year-old female German shepherd dog with nasal chondrosarcoma (unilateral stylohyoid fracture), a 13-year-old spayed female miniature poodle with nasal carcinoma (unilateral epihyoid fracture) and a 3-year-old spayed female German shepherd dog cross with orbital cellulitis (unilateral thyrohyoid fracture). Two affected dogs had a history of trauma, including an 8-year-old spayed female Staffordshire terrier (bilateral ceratohyoid fractures and unilateral basihyoid-thyrohyoid luxation) and a 9-month-old neutered male Yorkshire terrier with a unilateral epihyoid fracture.

Of the two affected dogs that had a history of trauma, one presented with cervical dog bite injuries and dyspnea that improved after resolution of soft tissue swelling (edema and hemorrhage), while the other presented with blunt trauma of unknown cause and no signs referable to the larynx. Hyoid injury