DIAGNOSTIC VALUE OF COMPUTED TOMOGRAPHY IN DOGS WITH CHRONIC NASAL DISEASE

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Computed tomographic (CT) studies of 80 dogs with chronic nasal disease (nasal neoplasia (n = 19), nasal aspergillosis (n = 46), nonspecific rhinitis (n = 11), and foreign body rhinitis (n = 4)) were reviewed retrospectively by two independent observers. Each observer filled out a custom-designed list to record his or her interpretation of the CT signs and selected a diagnosis. Accuracy, sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were calculated for the diagnosis of each disease. The agreement between observers was evaluated. The CT signs corresponded to those previously described in the literature. CT had an accuracy greater than 90% for each observer in all disease processes. The sensitivity, specificity, PPV, and NPV were greater than 80% in all dogs with the exception of the PPV of foreign body rhinitis (80% for observer A and 44% for observer B). There was a substantial, to almost perfect, agreement between the two observers regarding the CT signs and diagnosis. This study indicates a high accuracy of CT for diagnosis of dogs with chronic nasal disease. The differentiation between nasal aspergillosis restricted to the nasal passages and foreign body rhinitis may be difficult when the foreign body is not visible. *Veterinary Radiology & Ultrasound, Vol. 44, No. 4, 2003, pp 409–413.*

Key words: canine, computed tomography, diagnostic value, chronic nasal disease.

Introduction

THE MOST COMMON causes of chronic nasal disease in the dog are neoplasia and aspergillosis.[1] Foreign body rhinitis and nonspecific rhinitis (including lymphoplasmocytic, allergic and hyperplastic rhinitis) occur occasionally; whereas, nasal polyps, rhinitis secondary to dental disease, traumatic rhinitis, parasitic rhinitis, congenital abnormalities, and idiopathic necrosis of the conchae are rarely encountered.[1–4]

Diagnostic imaging is an essential component to determine the cause of chronic nasal disease in the dog. The radiographic features of nasal neoplasia, nasal aspergillosis, and nonspecific rhinitis have been described in detail.[5–7] However, the value of radiography for diagnosis of chronic nasal disease is still controversial. It was not very reliable in a study of 40 dogs with chronic nasal disease because neoplasia was diagnosed in 15/18 dogs (83%), aspergillosis in 9/15 dogs (60%), and nonspecific rhinitis in only 2/7 dogs (28%).[1] Other investigators found radiography to be highly accurate for differentiation between nasal neoplasia and rhinitis.[8] The introduction of computed tomography (CT) added a new modality for evaluation of nasal and sinus disease. The CT features of nasal neoplasia, nasal aspergillosis, and nonspecific rhinitis have been described, and CT has been favorably compared to radiography to define tumor extension, revealing vital informations for prognosis and radiation therapy planning.[3,9–12]

The purpose of this study is to determine the diagnostic value (accuracy, sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV)) of CT in dogs with chronic nasal disease.

Materials and Methods

Medical records at the Faculties of Veterinary Medicine of the Ghent University and University of Liège were searched for dogs with chronic nasal disease, defined as having clinical signs of nasal disease for more than 2 months, that had a CT examination of the nasal cavities and frontal sinuses, and a diagnosis of neoplasia, aspergillosis, nonspecific rhinitis, or foreign body rhinitis. Eighty dogs were found. Dogs age ranged from 5 months to 13 years (median = 5.0 years; mean = 5.7 years). Body weight ranged from 5.0 kg to 65.2 kg (median = 33.5 kg; mean = 30.7 kg). The most common breeds were Rottweiler (n = 13), Golden retriever (n = 10), and Labrador Retriever (n = 10). There were 44 male dogs (12 neutered, 32 sexually intact) and 36 female dogs (13 neutered, 23 sexually intact). Seventy-two dogs were referred for diagnosis after unsuccessful antibiotic (n = 63), systemic antifungic (n = 8) or

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topical antifungic (n = 1) treatment, and eight dogs were first line patients. All dogs underwent physical, radiographic, CT, and rhinoscopic examinations. During rhinoscopy, swabs, cytobrush, and biopsy samples were taken for culture, and cytologic and histologic examination. Serology was only performed when nasal aspergillosis was suspected or when the other examinations were inconclusive. Definite diagnosis was based on histology for nasal neoplasia and nonspecific rhinitis, on visualization of a foreign body at rhinoscopy for foreign body rhinitis and on at least three positive diagnostic tests, including direct visualization of fungal colonies at rhinoscopy for nasal aspergillosis. On the 80 dogs, 19 had nasal neoplasia (10 adenocarcinoma, 5 undifferentiated carcinoma, 2 squamous cell carcinoma, 1 chondrosarcoma, and 1 osteosarcoma), 46 nasal aspergillosis, 11 nonspecific rhinitis, and 4 foreign body rhinitis. Among the dogs with aspergillosis, 26 dogs were used in a previous study of the same author.[10]

The CT examinations were performed on a 3rd generation axial CT* at the Ghent University in 43 dogs (120 kV, 100 mA) and on a fourth generation helical CT† (110 kV, 125 mA, pitch 1.5) at the University of Liège in 37 dogs. General anesthesia was performed in 66 dogs and was induced with droperidol + fentanyl‡ at a dosage of 0.08 mg/kg body weight IV, penthotal§ at a dosage of 5–15 mg/kg body weight IV and maintained with halothane‖ (1.5–2%). Fourteen CT examinations, all helical, were performed under sedation by IM administration of medetomedine hydrochloride# at a dosage of 50 μg/kg body weight. All dogs were in ventral recumbency. Contiguous transverse slices (5-mm thickness) were obtained from the caudal level of the frontal sinuses to the nares. Reformatted dorsal plane images were also obtained.

The CT images were examined independently by two board-certified radiologists who were unaware of patient information except patient number, name, and date of examination. Hard copies as well as digital workstation images were available for interpretation in all dogs. A custom-like design list was established and filled out separately to ensure that the same criteria were evaluated. The CT criteria that were evaluated were: *location of the lesions* (rostral half—caudal half–one entire nasal cavity—nasal cavity + frontal sinus or only frontal sinus, uni- or bilateral); *presence or absence of abnormal soft-tissue and/or mucosal thickening* (nasal cavities classified as absent = no abnormal soft tissue—mild = abnormal soft tissue in 1/3 of the nasal cavities—moderate = 2/3 or severe = all, caudal recesses, retrobulbar space, nasofrontal ostium, frontal sinuses, presence of a focal rounded soft tissue accumulation, presence of calcifications, presence of a foreign body); *presence of lysis* (turbinates classified as absent = no turbinate lysis—mild = turbinate lysis in 1/3 of the nasal cavities—moderate = 2/3 or severe = all, bones surrounding the nasal cavities, frontal bone, cribriform plate, vomer bone and nasal septum), *presence of hyperostosis or reactive new bone* and *classification of the process* as cavitated-like, mass-like, or nondestructive. In dogs with bilateral involvement, the lesions of the most affected nasal cavity and frontal sinus were recorded. Using previously described CT predictors as a base for diagnosis of these diseases, each observer selected a diagnosis from the four following options: nasal neoplasia, nasal aspergillosis, nonspecific rhinitis, or foreign body rhinitis.[4,9,10,13] The term "nasal aspergillosis" was preferred to "fungal rhinitis" because of the low prevalence of fungal rhinitis attributable to non-*Aspergillus* species.

The CT signs were recorded and compared with those described in previous studies. The accuracy, sensitivity, specificity, PPV, and NPV of CT, as defined in a previous study, were calculated for each type of nasal disease.[14] The agreement between the observers about diagnosis and CT signs was evaluated with a kappa test.[15]

Results

Nasal neoplasia was associated with a moderate to severe turbinate destruction in all dogs (100%) involving one entire nasal cavity in 18/19 dogs (94%) and the contralateral nasal cavity in 11 and 14/19 dogs for observers A and B, respectively (57–73%). Retrobulbar involvement was present in 3/19 dogs (15%). The bones surrounding the nasal cavities were affected in 10/19 dogs (52%), nearly always with a lytic pattern, and the cribriform plate was destroyed in 8 and 9/19 dogs, respectively (42–47%). The frontal sinuses contained fluid/soft tissue in 13 and 15/19 dogs, respectively (68–78%), and the frontal bone was affected, mostly lytic changes, in 6 and 8/19 dogs, respectively (31–42%). The process was classified as mass-like in 17/19 dogs for both observers (89%) (Fig. 1A).

With nasal aspergillosis, there was a variable amount of soft tissue in the nasal cavities and frontal sinuses. Mucosal thickening along the nasal cavities was present in 32 and 36/46 dogs, respectively (69–78%), and along the frontal sinuses in 25 and 27/46 dogs, respectively (54–58%). Retrobulbar involvement was present in 4/46 dogs (8%). A rounded soft tissue accumulation was observed in the nasal cavities in 15 and 17/46 dogs, respectively (32–36%), and in the frontal sinuses in 9 and 10/46 dogs, respectively (19–21%). Changes in the bones surrounding the nasal cavities, mostly mixed, were present in 26 and 27/46 dogs, respectively (56–58%), in the frontal bone (mostly hyperostotic) in 30 and 31/46 dogs, respectively (65–67%), and the cribriform plate was destroyed in 7/46 dogs (15%). The process

*Pace CT, GE Medical Systems, Milwaukee.
†Picker 6000, Picker, Ohio.
‡Thalamonal®, Janssen-Cilag, Beerse, Belgium.
§Phenobarbital®, Abbott, Illinois.
‖Fluothane®, Zeneca, Delaware.
#Domitor®, Smith-Kline, Louvain-la-Neuve, Belgium.

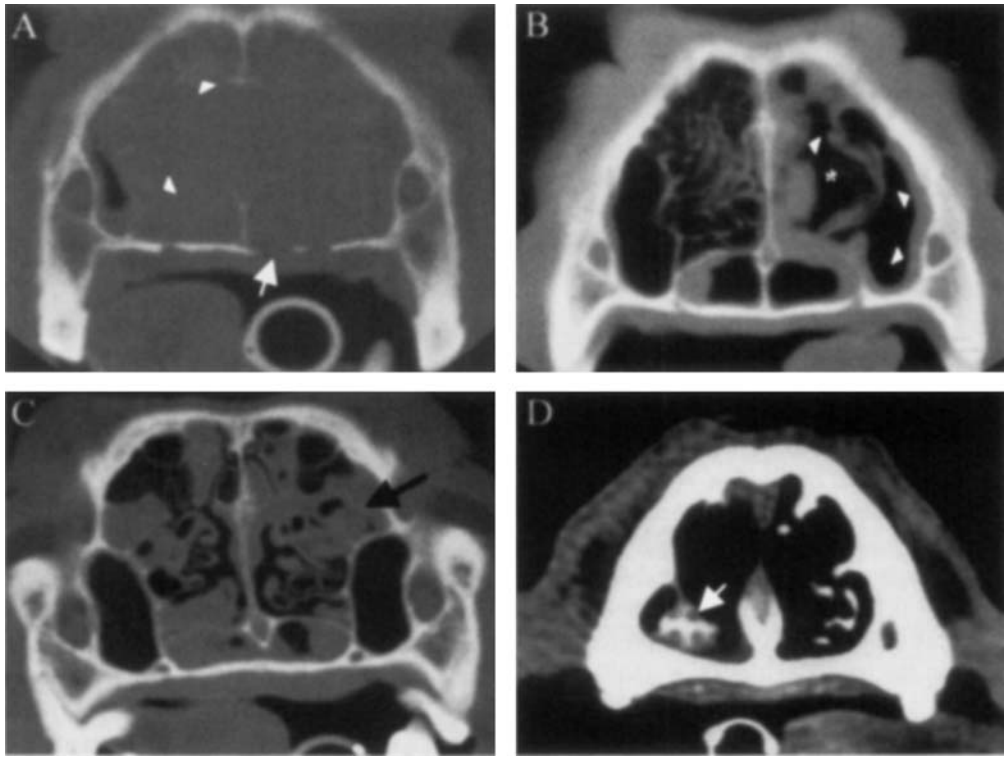

FIG. 1. Transverse CT images of the nasal cavities from four dogs. Classification of the process as mass-like for nasal neoplasia (A), cavitated-like for nasal aspergillosis (B), nondestructive for nonspecific rhinitis (C) and, when a foreign body could be visualized as foreign body rhinitis (D) permitted a correct diagnosis to be made in 93–95% of the dogs. (A) Eleven-year-old Bobtail with a nasal adenocarcinoma (window width (WW) = 3500, window level (WL) = 500). Both nasal cavities are completely filled with a soft tissue density. Some deformed turbinates are visible (arrowheads). There is also lysis of the palatine bone (arrow). (B) Five-year-old Golden Retriever with nasal aspergillosis (WW = 3500, WL = 500). Severe turbinate destruction creates an increased air space in the left nasal cavity (asterisk). There is also mucosal thickening (arrowheads). (C) Four-year-old German Shepherd Dog with a diagnosis of nonspecific rhinitis (WW = 3500, WL = 500). There is a severe bilateral fluid/epithelial edema (arrow). The integrity of the turbinates is conserved. (D) Eight-year-old Poodle with a foreign body rhinitis (WW = 150, WL = 50). The foreign body (arrow) was a grass awn.

was classified as cavitated-like in 44 and 45/46 dogs for observers A and B, respectively (95–97%) (Fig. 1B).

With nonspecific rhinitis, there was a nondestructive process affecting both entire nasal cavities in all dogs (100%), with a minimal to moderate amount of fluid in the frontal sinuses in 4/11 dogs (36%) (Fig. 1C). The presence of fluid/epithelial edema was minimal to severe. A mild or moderate turbinate destruction was present in 2/11 dogs (18%).

For foreign body rhinitis, the foreign body was visible in three of the four dogs (2 grass awns, one bullet) (Fig. 1D). There was a localized turbinate destruction with a minimal to moderate amount of soft tissue around the foreign body.

Accuracy, sensitivity, specificity, PPV and NPV for the CT diagnosis are summarized in Table 1. The accuracy was greater than 90% for both observers in each nasal disease. The PPV of foreign body rhinitis was 80% for observer A and 44% for observer B. Observer B erroneously classified four dogs with nasal aspergillosis restricted to the nasal cavities as foreign body rhinitis (Fig. 2).

The agreement between observers was almost perfect about the diagnosis (κ = 0.89). In terms of CT signs, the measurement of agreement between observers was perfect for the retrobulbar involvement (κ = 1.00). It was almost perfect for the evaluation of the caudal recesses (κ = 0.91), soft tissue around the nasofrontal ostium (κ = 0.90), mucosal thickening in the frontal sinuses (κ = 0.90), frontal bone changes (κ = 0.90), presence of a rounded soft tissue opacity in the frontal sinuses (κ = 0.89), presence of a rounded soft tissue opacity in the nasal cavities (κ = 0.87),

TABLE 1. Accuracy, Sensitivity, Specificity, Positive Predictive Value (PPV) and Negative Predictive Value (NPV) of Computed Tomography in Dogs with Chronic Nasal Disease as Agreed by Two Independent Observers

	Accuracy	Sensitivity	Specificity	PPV	NPV
Nasal neoplasia					
Observer A	98	89	100	100	97
Observer B	96	89	98	94	96
Nasal aspergillosis					
Observer A	98	98	97	98	97
Observer B	93	89	100	100	87
Nonspecific rhinitis					
Observer A	99	100	98	91	100
Observer B	96	91	97	83	98
Foreign body rhinitis					
Observer A	99	100	99	80	100
Observer B	93	100	93	44	100

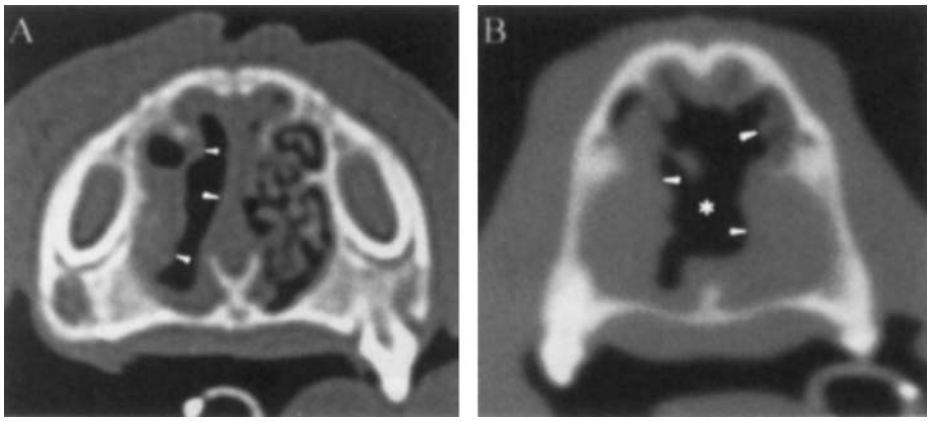

FIG. 2. Transverse CT images (window width = 3500; window level = 500) showing the similarity of CT features in nasal aspergillosis and foreign body rhinitis. (A) Six-month-old Cairn Terrier with foreign body rhinitis. There is unilateral turbinate destruction and mucosal thickening (arrowheads) in the right nasal cavity. The foreign body (small plant part) could not be visualized. (B) Six-year-old Teckel with nasal aspergillosis. There is bilateral turbinate destruction (asterisk) and mucosal thickening (arrowheads).

mucosal thickening in the nasal cavities (κ = 0.82), bones surrounding the nasal cavities (κ = 0.82), location of the lesions (κ = 0.82), and frontal sinuses fluid/soft tissue (κ = 0.81). A substantial agreement was calculated for turbinate destruction (κ = 0.72), vomer bone lesions (κ = 0.70), nasal septum destruction (κ = 0.69), and presence of abnormal soft-tissue in the nasal cavities (κ = 0.69).

Discussion

The most frequently encountered CT features of neoplasia, aspergillosis and nonspecific rhinitis corresponded to those described in previous studies.[4,10,12] The results of this study demonstrate that CT is an excellent tool for diagnosis of chronic nasal disease, particularly considering that imaging studies are only a part of the diagnostic procedure. The accuracy (number of correct diagnosis/total number of dogs) was greater than 90% in all disease processes, and low (<12%) false-negative (1-sensitivity) and false-positive (1-specificity) rates were noted. The high accuracy of CT for diagnosis of chronic nasal disease obtained in this study may be explained by the fundamental characteristics of CT and the severity of the lesions at presentation. CT eliminates superimposition of surrounding bony structures decreasing the complexity of the image and allows display of the images in different gray-scale formats allowing enhanced visualization of specific structures.[16] The lesions at presentation were extensive because at least one entire nasal cavity was involved in 69/80 dogs (86%). The severity of the lesions enabled evaluation of the global aspect of the disease (classification as mass-like, cavitated-like, nondestructive, or visualization of a FB) to provide a correct diagnosis in 75 and 76/80 dogs for observers A and B, respectively (93–95%).

In this study, destructive rhinitis was classified in two separate categories, nasal aspergillosis and foreign body rhinitis, because it was postulated that CT would allow differentiation between these conditions. This could not be completely confirmed because the PPV of foreign body rhinitis was low for one observer because of confusion with nasal aspergillosis restricted to the nasal passages ("localized"). Beyond the presence of a foreign body, which occurred in three of the four dogs with foreign body rhinitis, foreign body rhinitis was characterized in our study with features similar to a "localized" nasal aspergillosis: a localized turbinate destruction with presence of a minimal to moderate amount of soft tissue and thickening of the mucosa. Classification in foreign body rhinitis only when a foreign body was visible would have strongly improved the results of observer B. CT enables detection of highly attenuating foreign objects, such as metal or glass, very clearly; whereas, the detection of an organic foreign body is more complicated.[17–19] Therefore, a negative CT examination does not rule out the presence of an organic foreign body.

On the basis of our results, CT seems to be more accurate than radiography for diagnosis of chronic nasal disease. This was also suggested in two studies comparing radiography and CT for chronic nasal disease in dogs.[3,20] However, these studies only involved a small number of dogs and did not examine test performance in a rigorous fashion.[3,20] CT and radiography were compared in dogs with nasal neoplasia in two studies.[11,12] In both studies, CT provided more precise evaluation of the extent of the lesions. This was important regarding radiation therapy planning.[11,12]

There was an almost perfect interobserver agreement about most CT signs and the final diagnosis. Substantial agreement was obtained for the amount of abnormal soft tissue, degree of turbinate destruction, nasal septum destruction, and vomer bone lysis. The authors did not use precise criteria for evaluation of the amount of abnormal soft tissue and degree of turbinate destruction, so these CT signs were subjectively evaluated as absent, mild, moderate or severe and, the nasal septum and the vomer bone are two structures submitted to a wide range of anatomic variation. These factors may explain the poorer, but still valuable, results observed for these signs. The interobserver agreement about CT signs and diagnosis was better than observed in a previous study using radiography.[8] Exact comparison between

the two studies is not possible because it is not the same group of dogs, and the criteria evaluated are not the same. Nevertheless, it suggests that CT signs are less subjective than radiographic signs for evaluation of chronic nasal disease.

Nondynamic contrast studies were not used for interpretation in this study. Use of attenuation measurements may permit differentiation between the mucosa and other soft tissue or fluid, or between necrotic and vascularized soft tissue. However, it has been demonstrated that attenuation measurements are susceptible to a variety of errors in a diseased nasal cavity mainly caused by the presence, and sometimes mixing, of many complex structures of different physical densities.[10,21,22]

One limitation of this study is that a final diagnosis of nasal neoplasia, nasal aspergillosis, nonspecific rhinitis, *or* foreign body rhinitis was required for the dog to be included. Consequently, three dogs with more than one disease (two dogs with a nasal aspergillosis associated with a foreign body rhinitis and one dog with a nasal aspergillosis associated with a nasal neoplasia), and two dogs without definite diagnosis, all having undergone a CT examination during the study period, were not included.

To conclude, CT is accurate for diagnosis of chronic nasal disease in the dog. The differentiation between nasal aspergillosis restricted to the nasal passages and foreign body rhinitis may be difficult if the foreign body cannot be seen.

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