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JOURNAL TITLE: Journal of Small Animal Practice

PUBLISHER: Wiley

PUBLICATION DATE: November 2014

DOI: 10.1111/jsap.12278

Computed tomographic findings in 44 dogs and 10 cats with grass seed foreign bodies

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Key words: cat, computed tomography, dog, foreign body, grass seed

Running head: CT of grass seed foreign bodies

Summary

Objective. To supplement recent reports of computed tomographic (CT) findings in dogs and cats with grass seed foreign bodies.

Methods. Retrospective review of cases that had CT scan and subsequent retrieval of a grass seed during the same period of hospitalisation from a site included in the scan.

Results. Records of 44 dogs and 10 cats were reviewed. Most were presented in the months July-December. Median duration of clinical signs was 4 weeks (range 2 days- 2years). The most frequent clinical signs were soft tissue swelling (30% cases), coughing (28%), sneezing (28%) and discharge (26%). Grass seeds were retrieved from the thorax (35% cases), nasal cavity (31%), ear (7%), other sites in the head and neck (22%), sublumbar muscles (2%) and pelvic limb (2%). The grass seed was visible in CT images in 10 (19%) cases. Secondary lesions were visible in CT images of 52 (96%) cases, including collection of exudate (37%), abscess (24%), enlarged lymph nodes (22%) and pulmonary consolidation (20%). CT images appeared normal in 4% animals.

Conclusions. Grass seeds within the respiratory tract are frequently visible in CT images, but in general CT appears to be more useful for localisation of secondary lesions than as a method of definite diagnosis.

Introduction

Grass seed migration is a well-recognised problem in dogs and cats (Brennan and Ihrke 1983, Crha et al. 2003). Grass spikes, spikelets and individual florets (which contain the grass seed) may be retrieved from many sites, including the ears, eyes, nose, brain, vertebral canal, thorax, abdomen, retroperitoneum, subcutaneous tissues and feet (Johnston and Summers 1971, Brennan and Ihrke 1983, Lotti and Niebauer 1992, Aronson and Gregory 1995, Frendin 1997, Frendin et al. 1999, Demetroiu et al. 2002, Rooney and Monnet 2002, Crha et al. 2003, Hopper et al. 2004, Dennis et al. 2005, Granger et al. 2007, Dembovska et al. 2009, Baglietto et al. 2011, Weinmann et al. 2012, Cerquetella et al. 2013, Marvel and MacPhail 2013, Bouabdallah et al. 2014, Linon et al. 2014, Tinterrud et al. 2014). In many cases, septic inflammation occurs as a result of infection by various bacteria that are carried by the seed, particularly Actinomyces or Nocardia spp. (Johnston and Summers 1971, Brennan and Ihrke 1983, Frendin 1997). Inhaled grass seeds may pass down the trachea and bronchi, migrate into the pleural cavity and by following the diaphragm can reach the retroperitoneum and lumbar vertebrae (Johnston and Summers 1971, Frendin et al. 1999, Marvel and MacPhail 2013, Bouabdallah et al. 2014). Migrating grass seeds in the urinary tract may cause obstruction or act as a nidus for calculus formation (Savet et al. 2008, Cherbinksy et al. 2010, Del Angel-Caraza et al. 2011).

Retrieval of grass seeds can be difficult because their routes of migration are unpredictable, they can be deeply embedded in dense fibrous tissue, and embedded fragments may be small and hard to recognise (Frendin et al. 1999). Plant material that is flimsy and/or impregnated with water may be indistinguishable radiographically from adjacent soft tissues, hence radiographic signs in affected animals usually represent inflammatory lesions rather than the foreign body itself (Johnston and Summers 1971, Frendin et al. 1999, Demetroiu et al. 2002, Schultz and Zwingenberger 2008, Baglietto et al. 2011, Tinterud et al. 2014).

Ultrasonographic diagnosis of a grass seed foreign body is possible (Armbrust et al. 2003, Gnudi et al. 2005, Schultz and Zwingenberger 2008, Cherbinsky et al. 2010, Attanasi et al. 2011) and ultrasound guidance has been used to directly retrieve grass seeds from superficial abscesses (Staudte et al. 2004, Della Santa et al. 2008); however, applications of ultrasonography are limited by access. For example, a grass seed within the respiratory tract is unlikely to be detectable because of reflection of the ultrasound beam by surrounding air.

Recent reports have described the computed tomographic (CT) findings associated with grass seed migration in dogs and cats (Schultz and Zwingenberger 2008, Hinken et al. 2010, Attanasi et al. 2011, Baglietto et al. 2011, Bouabdallah et al. 2014). CT enabled identification of the grass seed responsible for clinical signs in 2/24 (8%) dogs (Attanasi et al. 2011), 4/14 (29%) animals (Schultz and Zwingenberger 2008) and 4/11 (36%) animals (Bouabdallah et al. 2014). Grass seeds are reported to appear in CT images as foci of soft-tissue attenuation in air-containing structures, as elongated gas-containing foci in soft tissues or as slightly hyperattenuating foci within soft tissues (Schultz and Zwingenberger 2008, Attanasi et al. 2011, Bouabdallah et al. 2014). CT images may also reveal abnormalities that can be used to estimate the position of a foreign body in patients in which it is not directly visualised. These abnormalities include signs of soft tissue inflammation, cavitary lesions, tracts and pulmonary consolidation (Schultz and Zwingenberger 2008, Attanasi et al. 2011, Baglietto et al. 2011, Bouabdallah et al. 2014).

The aim of the present study was to supplement existing reports by describing in detail the CT findings associated with grass seed migration in a larger series of cases.

Materials and Methods

Electronic case records in the period between August 2004 and October 2013 were searched for patients that had CT imaging and subsequent retrieval of an intact grass seed or grass seed fragment identified by the attending clinician during the same period of hospitalisation from a site included in the CT. For all cases that satisfied these criteria, history, clinical findings, radiological reports and CT images were reviewed.

CT scans prior to August 2009 were performed using a single slice helical CT scanner (PQ5000, Universal Medical Systems, Solon, Ohio). CT scans after this date were performed using a 16-slice CT helical scanner (Mx8000 IDT, Philips, Best, The Netherlands). All CT scans were performed with patients under general anaesthesia. Thoracic CT scans were performed during temporary apnoea induced by hyperventilation. CT machine settings varied according to the anatomical region of interest. Nasal scans were performed using 120kVp, 150mAs, 1.0-1.5mm slice thickness and sharp reconstruction algorithm. CT scans of the lung in dogs were performed using 120kVp, 150-250mAs, 3.0-5.0mm slice thickness and a sharp reconstruction algorithm. CT scans to examine cervical soft tissues, thoracic soft tissues and the abdomen in dogs were performed using 120kVp, 150-250mAs, 2.0-5.0mm slice thickness and standard reconstruction algorithm. CT scans of cats were generally performed using similar settings as for dogs, but with 90kVp instead of 120kVp, reduced slice thickness and a smaller field of view. Matrix size was 512 x 512 and pixel size 0.3-0.6mm, depending on the size of the patient. Repeat CT imaging immediately after intravenous administration of a 600mgI/kg bolus of Iohexol (Omnipaque, Nycomed, Oslo) was performed routinely in all cases, except those having CT specifically to examine the nasal cavity.

For the purpose of the present study, CT images were reviewed by a Board-certified radiologist with knowledge of the diagnosis and site of retrieved grass seeds. Images were reviewed using various display settings: soft tissue (width 350, level 50); bone (width 2500, level 500); and lung (width 2000, level -500). Adjustments to image window width and level, multiplanar reconstructions, and maximum and minimum intensity slab projections were made as considered necessary for review of each case. Based on localisation of a suspected abscess cavity in post-contrast CT images, circular regions of interest were placed for measurement of attenuation (Hounsfield units, HU) of abscess contents in pre-contrast images.

The difference in median age of canine and feline patients was tested using the Mann-Whitney test. The variation in seasonal occurrence of referrals was tested using Poisson distribution. Associations between species and gender ratio and sites from which grass seeds were retrieved were tested using cross-tabulation. Statistical tests were done using SPSS version 19 (IBM Corporation, Chicago, Illinois). Results with $p<0.05$ were considered significant.

Results

Patients

Records of 44 dogs and 10 cats were found that satisfied the inclusion criteria (Table 1). Affected dogs were significantly younger than cats ($p=0.002$). There were 28 male dogs (17 neutered) and 16 female dogs (9 neutered), 6 neutered male cats and 4 neutered female cats. The difference in gender ratio between dogs and cats was not significant. Canine breeds included mixed breed (n = 7), springer spaniels (n = 6), Labrador retriever (n = 5), cocker spaniel (n = 4), pointer (n = 3), Staffordshire bull terrier (n = 3), lhasa apso (n = 2) and one each of Dalmatian, bull mastiff, flat-coated retriever, boxer, American bulldog, English bulldog, French bulldog, Cairn terrier, Cavalier King Charles spaniel, bichon frisé, beagle, Bernese mountain dog, lurcher and miniature poodle. Feline breeds included domestic shorthair (n = 6), and one each of domestic longhair, British shorthair, Persian and Bengal.

Only 11 (20%) animals were admitted in the months January-June compared to 43 (80%) animals admitted in July-December ($p<0.00002$). Median duration of clinical signs referable to grass seed foreign bodies was 4 weeks (range 2 days- 2 years).

In dogs grass seeds were found in a range of locations, whereas in cats grass seeds were found predominantly in the nose (Table 1). Thoracic grass seeds were retrieved from a bronchus in 14 instances (right caudal in 7, left caudal in 6, right middle in 1) from the thoracic wall in 4 and from the pleural cavity in one. The method of grass seed removal was surgery in 26 cases (48%), endoscopy in 22 (41%), flushing the external ear canal in four (7%), ultrasound-guided aspiration in one (2%) and conjunctival flush in one (2%).

Overall, the most frequent clinical signs were soft tissue swelling in 16 (30%) cases, coughing in 15 (28%), sneezing in 15 (28%) and discharge from an orifice or sinus in 14 (26%). Pyrexia was reported in 11 (20%) cases and neutrophilia ($>11.5x10^9/L$) in 12 (22%) cases. Only two dogs had both pyrexia and neutrophilia; both had pulmonary consolidation associated with bronchial grass seeds.

Clinical signs associated with grass seeds were related to their anatomical location. Grass seeds affecting the thorax were associated with cough in 13 (68%) cases, pyrexia in 8 (42%) cases, lethargy in 5 (26%) cases, thoracic wall swelling in 4 (21%) cases, draining sinus in 3 (16%) cases, tachypnoea in 3 (16%) cases, enlarged regional lymph nodes in 2 (11%) cases and inappetence in 2 (11%) cases. One dog that had a bronchial grass seed for approximately 2 years had limb pain and diffuse periosteal reactions on limb bones compatible with hypertrophic osteopathy. Grass seeds in the nasal cavity were associated with sneezing in 15 (88%) cases, nasal discharge in 9 (53%) cases, epistaxis in 2 (12%) cases, head-shaking in 2 (12%), pawing or rubbing the muzzle in 2 (12%) cases and cough in 1 (6%) case. In two dogs from which nasal grass seeds were retrieved, owners reported seeing their dog inhale the grass seeds. Grass seeds in the ear were associated with aural pruritus in 3 (75%) cases, otitis externa in 1 (25%) case, head tilt in 1 (25%) case and head shaking in 1 (25%) case. Grass seeds in other sites in the head and neck were associated with a soft tissue swelling in 11 (92%) cases and discharge in 2 (17%) cases. The cat with a grass seed lodged in the sublumbar muscles had cough, signs of lumbar pain and pyrexia. The dog with a grass seed lodged in the pelvic limb had swelling and pyrexia.

CT findings

The grass seed was visible in CT images in 10 (19%) cases. In each instance the grass seed was located in an airway (bronchus in 6 instances, nasal cavity or nasopharynx in 3 and external ear canal in 1), and was visible only when using a wide CT display window suitable for lung. Appearances of grass seeds varied from delicate linear structures, representing grass seed fragments, elongated fusiform structures representing individual intact florets, or an oblong cluster of soft tissue and gas foci representing part of the spike or spikelet (figure 1).

Secondary lesions associated with grass seeds were visible in 52 (96%) cases and CT images appeared normal in 2 (4%) cases. CT findings varied with anatomical site of grass seeds. CT images of the nasal cavity had signs of exudate in 15 (88%) cases, localised loss of turbinate structure in 4 (24%) cases (figure 2), a linear intraluminal inclusion compatible with the retrieved grass seed in 3 (18%) cases and appeared normal in one (6%) case. CT images of the ears had thickened lining of the external ear canal in 2 (50%) cases, a linear intraluminal inclusion compatible with retrieved grass seed in 1 (25%) case, signs of exudate in the tympanic cavity in 1 (25%) case, para-aural soft tissue swelling in 1 (25%) case, and enlarged ipsilateral medial retropharyngeal lymph node in one (25%) case. CT images of other sites in the head and neck had signs of cavitary lesions compatible with abscesses in 9 (75%) cases, soft tissue swelling in 7 (58%) cases, enlarged regional lymph nodes in 7 (58%) cases and appeared normal in one (8%) case. Gas pockets were evident in 3 (33%) suspected abscesses.

CT images of the thorax had signs of focal or multifocal pulmonary consolidation in 11 (58%) cases (figure 3), a linear intraluminal inclusion compatible with retrieved grass seed in 6 (32%) cases, pleural fluid in 4 (21%) cases, pleural gas in 3 (16%) cases, thickening of soft tissues in the thoracic wall in 3 (16%) cases, pulmonary cavitary mass in 2 (11%) cases, enlarged thoracic lymph nodes in 2 (11%) cases and overinflation of the affected lung lobe in 1 (5%) case. In 4 animals with pleural fluid, attenuation of fluid ranged from 19–28 HU. Irregular masses within the pleural cavity were evident in post-contrast CT images in 2 animals with pleural fluid (figure 4). At surgery, these masses were adherent to pleural surfaces and appeared to be composed of granulation tissue and fibrin. All animals with pleural fluid or gas had peripheral pulmonary consolidation. In one dog a focal defect was observed affecting the visceral pleura of the right caudal lobe at the exact site from which a grass seed was subsequently retrieved surgically (figure 5).

In the cat with a grass seed lodged in the sublumbar muscles, CT images had signs of focal consolidation affecting the tip of the left caudal lung lobe and a focal cavitary lesion compatible with an abscess on the left aspect of the cranial abdominal aorta. In the dog with a grass seed lodged in the pelvic limb CT images had signs of two subcutaneous cavitary swellings compatible with abscesses containing gas, stranding of sub-cutaneous fat and enlarged ipsilateral medial iliac and superficial inguinal lymph nodes.

A total of 14 surgically-confirmed abscesses were identified in CT images of animals in this series, each containing a grass seed or fragment; however, grass seeds were not identified in CT images in any abscess. Abscess cavities were clearly defined only in post-contrast CT images in which the wall of the abscess accumulated contrast medium (figure 6). Wall thickness in eight abscesses in which it was relatively regular was 2-5mm; in the remaining abscesses the wall was uneven in thickness or had ill-defined margins with surrounding tissues, which prevented accurate measurement. Ten abscesses were considered unicameral and four multicameral. Median attenuation of abscess cavities was 30 HU (range 5-60 HU). Stranding of adjacent fat was evident in CT images in 10/12 (83%) abscesses in locations with adjacent fat. Enlarged regional lymph nodes were evident in 8/13 (62%) animals with abscesses.

Discussion

Grass seed foreign bodies may affect animals of any age and breed. It is unclear why affected cats should be significantly older than affected dogs in the present series. The inclusion of six retrievers and six springer spaniels in the present series is consistent with previous reports in which hunting dogs have been well represented (Lotti and Niebauer 1992, Schultz and Zwingenberger 2008, Cerquetella et al. 2013).

Schultz and Zwingenberger (2008) noted a seasonal variation in the occurrence of intrathoracic grass seed foreign bodies with the majority of patients presenting in the spring or summer. In the present series, a significant majority of patients were referred during the second half of the year, which likely reflects animals encountering grass seeds predominantly during the summer and developing signs within the next few weeks or months. In the present series, the median duration of clinical signs prior to referral was 4 weeks. A prolonged period without signs or occurrence of low grade, non-specific signs will tend to delay referral and obscure any seasonal variation.

Clinical signs associated with grass seeds were related to their anatomical location. Systemic signs, including pyrexia and neutrophilia, were infrequent in the present series. Pyrexia and neutrophilia occurred concurrently only in two dogs with bronchial grass seeds and pulmonary consolidation. Neutrophilia was observed in 17/26 (65%) dogs with intrathoracic grass seeds in a previous report (Schultz and Zwingenberger 2008). Site of grass seed lodgement, degree of inflammation, nature of any secondary infection, chronicity and treatments administered by veterinarians prior to referral are all likely to affect the possibility of pyrexia and neutrophilia in these cases.

Bronchial grass seed foreign bodies were found in approximately equal numbers in the right and left caudal bronchi in the present series. This distribution is more even than observed in previous reports in which the majority of bronchial grass seeds were found on the right, mainly in the right caudal and accessory lobar bronchi (Brownlie 1990, Weinmann et al. 2012, Cerquetella et al. 2013). In an individual patient, it may not be possible to predict the site of a bronchial foreign body from the imaging findings. Even when using CT, many grass seed foreign bodies will not be visualised. Conversely, CT lesions are liable to occur at sites without a grass seed, for example because the grass seed has already migrated to another site or because of redistribution of exudate within the bronchial tree. These considerations necessitate endoscopy of the entire bronchial tree in patients with suspected grass seed (Cerquetella et al. 2013).

All grass seeds visualised directly in CT images in the present study were in the respiratory tract or were surrounded by air. Contrary to previous reports, grass seeds in CT images appearing as elongated gas-containing foci or hyperattenuating foci within soft tissues were not recognised (Schultz and Zwingenberger 2008, Attanasi et al. 2011, Bouabdallah et al. 2014). Similarly, tracts in CT images representing migration paths of the grass seeds were not recognised (Schultz and Zwingenberger 2008), although the route of a migrating grass seed could be deduced in some cases from the spatial relationship of lesions, for example in the cat with sublumbar abscess in which there was a focus of pulmonary consolidation immediately cranial to the abdominal lesion. As reported previously, CT appears to be useful mainly as a method for localising sites of lesions responsible for clinical signs and as a guide for ultrasonography (Attanasi et al. 2011) or exploratory surgery (Bouabdallah et al. 2014).

Compared to CT using scanners with a single detector row, multi-detector CT provides increased spatial resolution by use of thinner slices and faster scan times (Flohr et al. 2005).

Abscesses associated with grass seed foreign bodies had a range of CT features that reflected varying degrees of encapsulation. The abscess wall was depicted most clearly in post-contrast CT images (Hinken et al. 2010). The appearance of the abscess wall varied from regular, thin (2mm) and well-defined, to irregular with ill-defined margins that merged with surrounding tissues, frequently with stranding of adjacent fat. Fat stranding refers to an abnormal increased attenuation in fat, which occurs as a result of oedema and engorgement of lymphatic vessels (Thornton et al. 2011). In dogs with abscesses, fat stranding probably represents varying combinations of secondary oedema and cellulitis.

This series, in which grass seeds were retrieved following CT and predominantly from the respiratory tract, likely under-represents anatomical sites from which retrieval does not usually require CT, such as the external ears, or where retrieval is more difficult, such as from the sublumbar muscles. During the review of medical records, numerous examples of dogs with abscesses in the cervical region or abdomen (including the sublumbar muscles) were found in which a migrating foreign body was suspected clinically to be the underlying cause, but was not proven. Grass seeds can be difficult to identify even at open surgery and diagnosis of grass seed may depend on histopathological examination of resected pyogranulomatous tissues (Frendin 1997, Rouabdallah et al. 2013, Trinterud et al. 2014). Nidus removal is considered the optimal surgical technique for cases with suspected foreign body (Amalsadvala and Swaim 2006), but it requires an accurate pre-operative method of identifying grass seeds. On the basis of this and other recent reports, CT does not satisfy that requirement, although CT and ultrasonography in combination might (Attanasi et al. 2011).

Table 1. Summary of patients with grass seed foreign bodies

	Dogs	Cats	p
n	44	10	
Median (range) age	3y (3m-11y)	8y (2-15y)	0.002
Males:Females	28:16	6:4	0.1
Sites of grass seeds			
Nasal cavity	9 (21%)	8 (80%)	0.006
Ear	4 (9%)	0	
Other head and neck sites	12 (27%)	0	
Thorax	18 (41%)	1 (10%)	
Abdomen	0	1 (10%)	
Pelvic limb	1 (2%)	0	

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Legends

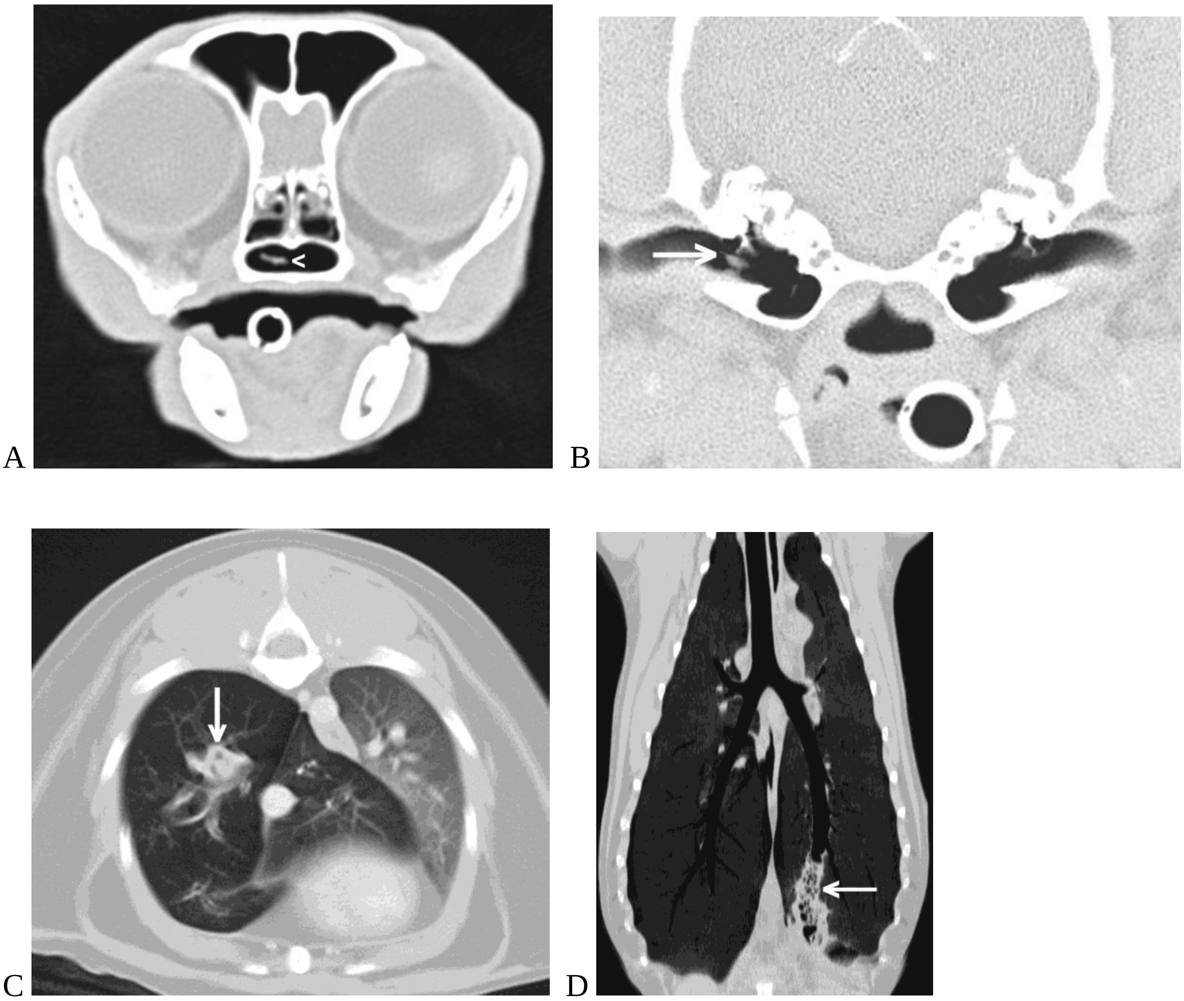


Figure 1. Examples of CT images showing grass seed foreign bodies. All images are displayed using a lung window (width 2000, level -500). A) Grass seed fragment in the nasopharynx of a cat (arrowhead), B) individual grass floret (4.5 x 1.5mm) in the external ear canal of a dog (arrow), C) portion of grass spikelet (diameter 7mm) in the dilated right caudal lobar bronchus of a cat (arrow). Note that the right caudal and accessory lobes are overinflated as a result of the partial bronchial obstruction caused by the foreign material. D) Portion of grass spike (36 x 12mm) in the left caudal bronchus of a dog (arrow).

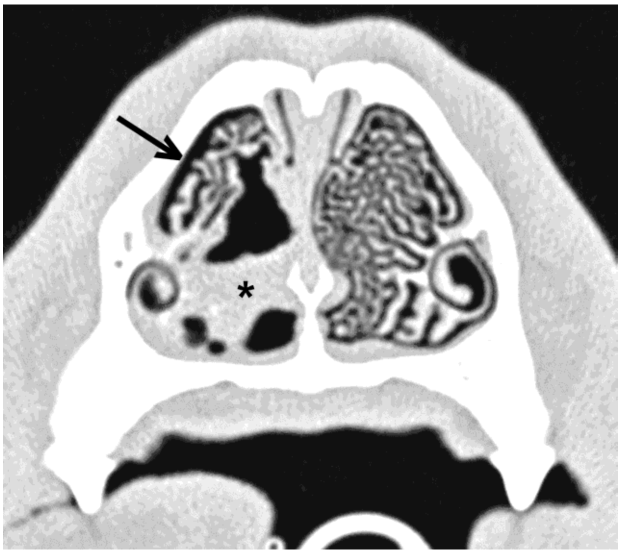
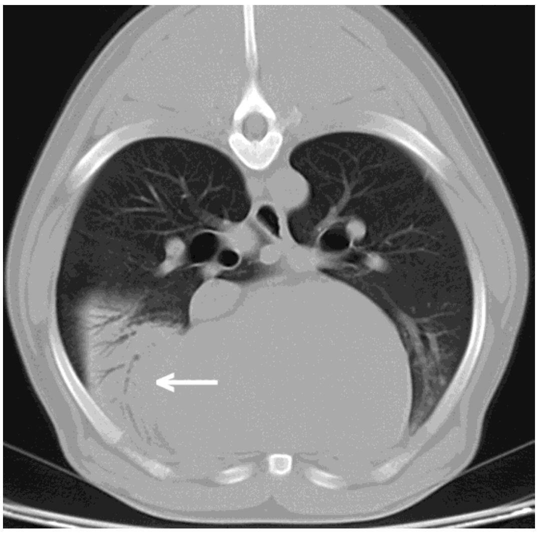
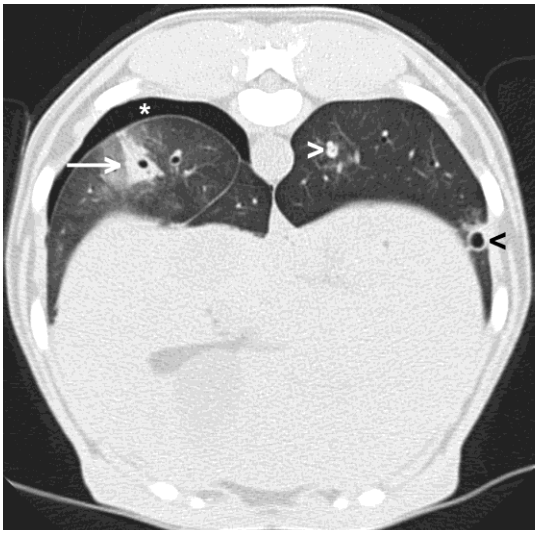


Figure 2. CT image (lung window, width 2000, level -500) showing localised turbinate loss (arrow) and accumulation of exudate (*) in the right nasal cavity of a dog from which a grass seed was retrieved.

A  B 

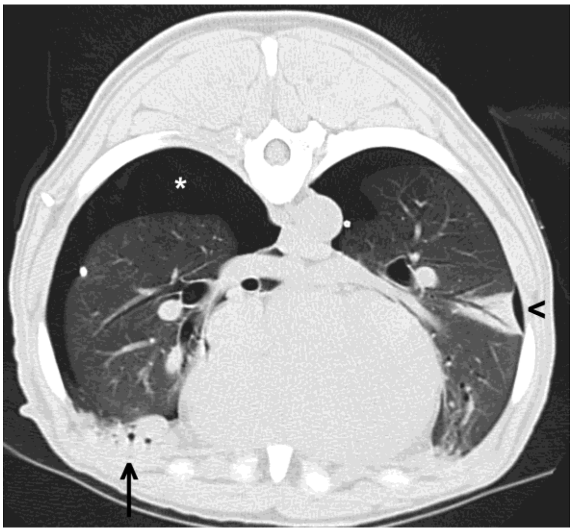
C 

Figure 3. Examples of CT images (lung window, width 2000, level -500) showing pulmonary lesions associated with migrating grass seeds. A) lobar consolidation affecting only the right middle lobe (arrow) in a dog from which a grass seed was found following lobectomy. B) Multifocal lesions including a cavitary pulmonary lesion (black arrowhead), bronchial obstruction (white arrowhead) and localised consolidation in a dog in which a grass seed was retrieved endoscopically from the left caudal lobe. There is also a small volume pneumothorax on the right (*). C) Localised segmental consolidation of a portion of the left caudal lobe (arrowhead) in a dog from which two grass seeds were retrieved from the pleural cavity. There is also collapse of the tip of the right middle lobe (arrow) and pneumothorax (*). Bilateral pleural drainage tubes are present.

A B

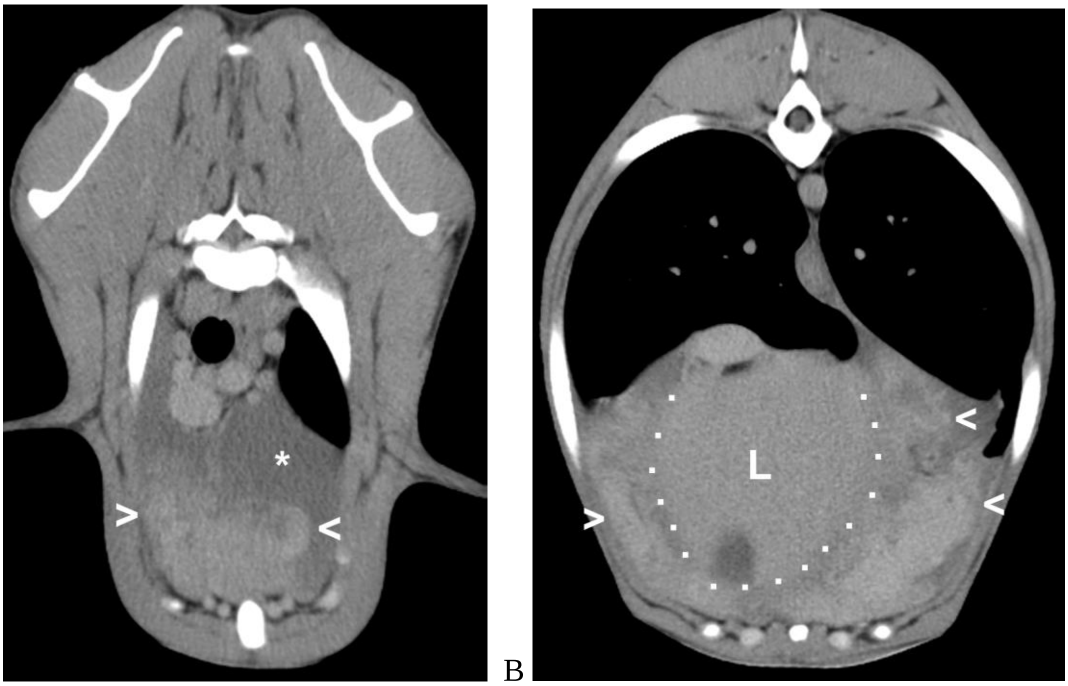


Figure 4. Examples of post-contrast CT images (soft tissue window, width 350, level 50) showing pleural masses in a dog with chronic pleuritis associated with grass seed foreign bodies. Transverse images through the cranial thorax (A) and costophrenic angle (B) showing pleural fluid (*) containing irregular soft tissue masses (arrowheads). Dots in B indicate the border of the liver (L).

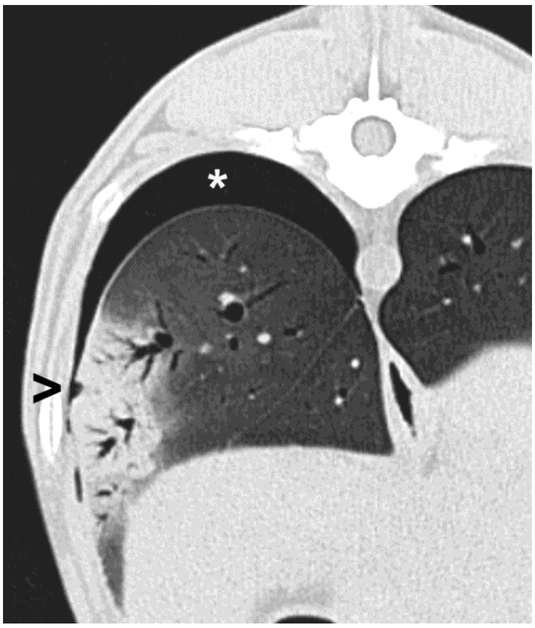


Figure 5. CT image (lung window, width 2000, level -500) of a dog with a focal defect in the visceral pleural surface of the right caudal lobe (arrowhead). The lung adjacent to defect is consolidated and there is a small volume pneumothorax (*). At thoracotomy, a grass seed was found protruding from this defect.

A B C D

Figure 6. Examples of post-contrast CT images showing features of abscesses associated with grass seed foreign bodies in dogs. All images are displayed using a soft tissue window (width 350, level 50). A) Abscess comprising multiple small cavities (*) on the ventrolateral aspect of the parotid (P) and mandibular (M) salivary glands. Borders of abscess are ill-defined and

the lesion spreads across the ventral midline, causing stranding of sub-cutaneous fat (white arrowheads), which may reflect oedema and/or inflammation. B) Abscess with a single irregular cavity (*) containing a small gas bubble on the ventral aspect of the tongue. The wall of the abscess appears thick and irregular. Stranding of fat (white arrowheads) is evident. C) Abscess with single large cavity and well-defined, relatively regular thin wall ventral to the left ramus of the mandible (M). Layer of adjacent sub-cutaneous fat appears normal (white arrowheads). D) pulmonary abscess with thin regular wall (black arrowhead). This dog also has pleural fluid (*).