Inhaled grass awns, the sharp and sometimes barbed seeds of grasses, commonly cause respiratory disease during spring and summer, especially in hunting dogs.1–3 Acute inhalation often goes unnoticed by the owner, and awns can subsequently migrate through the airways into the lungs, pleural space, pericardium, retroperitoneal cavity, or sublumbar muscles, or through the thoracic wall.3–8 Migrating grass awns cause severe inflammatory tissue reactions and sepsis. The clinical signs can vary depending on the location of the foreign material. Grass awn migration into the lungs or pleural space commonly causes lobar pneumonia, abscessation, pneumothorax, pyothorax, or a combination of conditions. Treatment generally requires removal of the foreign material, debridement of abscesses or granulomas, and antimicrobial administration and can necessitate lung lobe resection or prolonged pleurocentesis.5,6,8–10

OBJECTIVE
To describe ultrasonographic findings and outcomes for dogs with suspected migrating intrathoracic grass awns.

DESIGN
Retrospective case series.

ANIMALS
43 client-owned dogs.

PROCEDURES
Records for dogs with suspected migrating intrathoracic grass awns examined between 2010 and 2013 were reviewed. Ultrasonographic images and additional information such as signalment and pleural fluid analysis, radiographic, bronchoscopic, and CT findings were collected. Surgical treatments and outcomes were also reviewed.

RESULTS
Transthoracic or transesophageal ultrasonography revealed grass awns in the pleural space (n = 13) or pulmonary parenchyma (10) of 23 dogs. Surgical removal of grass awns was successful on the first attempt in 21 of these 23 dogs (including 11/23 that had intraoperative ultrasonography performed to aid localization and removal of the awn). In the remaining 2 dogs, a second surgery was required. Twenty dogs with evidence of migrating intrathoracic grass awns had no foreign body identified on initial ultrasonographic evaluation and were treated medically; 16 developed draining fistulas, and awns identified ultrasonographically at follow-up visits were subsequently removed from the sublumbar region (n = 10) or thoracic wall (6). The remaining 4 dogs had no grass awn visualized. Clinical signs resolved in all dogs.

CONCLUSIONS AND CLINICAL RELEVANCE
Transthoracic, transesophageal, and intraoperative ultrasonography were useful for localization and removal of migrating intrathoracic grass awns. Ultrasonography may be considered a valuable and readily available diagnostic tool for monitoring dogs with suspected migrating intrathoracic grass awns. (J Am Vet Med Assoc 2016;248:413–421)

Foreign bodies such as grass awns in the bronchi can be successfully removed by bronchoscopic methods, preventing further migration.11 For grass awns that have migrated into other body tissues or cavities, evaluation by diagnostic imaging methods such as ultrasonography, CT, or MRI aids in the initial diagnosis and is useful for determining anatomical landmarks that can be used in surgical planning. Ultrasonography has been previously used to detect, localize, and guide removal of grass awn foreign bodies in dogs.2,5,6,12,15 Recently, transesophageal ultrasonography was used to visualize a migrating grass awn within the pulmonary parenchyma of a dog and to guide subsequent thoracoscopic removal of the plant material.14 Computed tomographic imaging has been used to identify and localize foreign bodies but does not always permit visualization.3 Magnetic resonance imaging has also been used to visualize an abnormal, low-signal linear
structure, consistent with a migrating grass awn, in the thoracic region of the spinal cord of a dog.¹⁵

Use of transthoracic, transesophageal, and intraoperative ultrasonography to detect migrating intrathoracic grass awns is limited to few clinical reports or case series.³,⁵,¹²,¹⁴ The purpose of the study reported here was to describe the ultrasonographic findings and outcomes for dogs with suspected migrating intrathoracic grass awns seen at a veterinary teaching hospital over a 3-year period.

**Materials and Methods**

**Case selection**

Electronic medical records of dogs evaluated at the Veterinary Teaching Hospital of Perugia University between July 1, 2010, and November 30, 2013, were searched by use of the terms intrathoracic grass awn or intrathoracic foreign body to identify cases. All dogs with suspected intrathoracic grass awn migration or with grass awns identified by ultrasonography that had a follow-up recorded ≥ 6 months after diagnosis were included. Cases were selected on the basis of ultrasonographic findings consistent with a grass awn (identification of a spindle-shaped, hyperechoic structure of variable length, surrounded by a hypoechoic zone consistent with a focal inflammatory response as previously described⁵,¹³,¹⁴,¹⁶), or findings of pulmonary consolidation, pleural effusion, pleural thickening, and enlargement of sternal lymph nodes; a signalment consistent with exposure to grass awns; and cytologic and histologic findings of a hypoechoic zone consistent with a focal inflammatory response as previously described⁵,¹³,¹⁴,¹⁶, or findings of pulmonary consolidation, pleural effusion, pleural thickening, and enlargement of sternal lymph nodes; a signalment consistent with exposure to grass awns; and cytologic and histologic findings of a hypoechoic zone consistent with a focal inflammatory response as previously described⁵,¹³,¹⁴,¹⁶, or findings of pulmonary consolidation, pleural effusion, pleural thickening, and enlargement of sternal lymph nodes; a signalment consistent with exposure to grass awns; and cytologic and histologic findings of a hypoechoic zone consistent with a focal inflammatory response as previously described⁵,¹³,¹⁴,¹⁶.

**Ultrasonographic examinations**

Dogs underwent transthoracic ultrasonographic examination during the initial evaluation. This procedure was performed with dogs standing or in sternal recumbency, by use of an ultrasound system equipped with a 5- to 8-MHz microconvex transducer.¹ For transthoracic imaging, hair over the thoracic region was clipped and the transducer was positioned on the thoracic wall between adjacent ribs. All intercostal spaces were scanned from the dorsal to ventral aspect, with the transducer held parallel and perpendicular to the adjacent ribs. A costal approach, with the liver used as an acoustic window, was performed for assessment of the caudal mediastinum and caudal lung fields.

Transesophageal ultrasonography was performed preoperatively in dogs under general anesthesia (with anesthetic protocols determined on an individual basis by the attending anesthetist) after transthoracic ultrasonography; if bronchoscopic findings suggested grass awn migration (mucus and blood in distal portion of bronchus with no grass awn visible). Most of the dogs that underwent bronchoscopy were referred specifically for this diagnostic procedure. For some dogs in which grass awns were identified by transthoracic ultrasonography, transesophageal ultrasonography was performed immediately prior to surgery (during the same anesthetic procedure) to obtain additional images of the grass awns. For transesophageal ultrasonography, dogs were placed in lateral recumbency, and a 14-mm, 3- to 7.5-MHz, multiplane cardiac-phased array transducer was used. The transesophageal probe was advanced transorally into the esophagus with the beam oriented approximately 90° from the sagittal plane, and the probe was turned from right to left to visualize all lung lobes. Multiple scan planes of diseased areas were imaged.

Intraoperative ultrasonography was performed by use of a transesophageal probe or transthoracic microconvex probe encased in a sterile protective cover and positioned directly on the affected region of the lung or pleural space (identified by preoperative diagnostic imaging and intraoperative visual inspection) to precisely localize the grass awn and guide complete removal.

Intraoperative ultrasonography of the excised tissue and surgical margins was also performed in all cases where discrete pulmonary or pleural lesions were identified by the surgeon to confirm complete extraction of the grass awn or its presence within removed tissue (consolidated lung lobe, abscess or granuloma, or thickened pleura). Extracted awns, or photos of the awns, were submitted to an expert agronomist for species identification.

**Surgical procedures and other treatments**

A variety of surgical approaches and techniques were used, depending on the foreign body location, presence and severity of pyothorax, and the surgeon’s preferences. Anesthetic and analgesic protocols were determined on an individual basis by the attending anesthetist. When suitable, a thoracoscopic approach was used to decrease morbidity associated with surgery. The thoracoscope port was placed 2 or 3 intercostal spaces cranial or caudal to the location of the grass awn identified ultrasonographically; an instrumental port was placed 1 or 2 intercostal spaces caudal or cranial to the
awn location. When awns were visible protruding from the pleura, they were removed with 2.5-mm Hartmann forceps through the instrument port. When the foreign matter was not visible, a partial lobectomy of the damaged lung was performed by application of a surgical stapling device with 4.8-mm staples introduced through a second instrument port. When a lateral thoracotomy was performed, surgical access was achieved by an incision 1 intercostal space caudal to the putative site of the grass awn. A median sternotomy was performed in cases where it was necessary to explore the entire thoracic cavity and thoroughly debride chronically fibrosing mediastinal tissue and multiple pleural adhesions. Lateral thoracotomy and median sternotomy procedures were performed as described elsewhere. A thoracoabdominal stapling device with 4.8-mm staples was used when a total lung lobectomy was performed.

A thoracic drainage tube was placed under direct visual observation in all dogs undergoing thoracic surgery. At the end of surgery, lung lobes were gradually reinflated by means of positive-pressure ventilation and gentle aspiration through the thoracic drainage tube. When necessary, continuous aspiration by the use of 3-chamber system was used for treatment of surgical patients that had a critical respiratory compromise in the immediate postoperative period.

The drain was removed 2 to 7 days after surgery, depending on subjective evaluation of drainage, and the dogs were discharged from the hospital on the day after drain removal. Pleural fluid samples were collected during the surgery and submitted for microbiologic culture. All surgical patients were reevaluated monthly by ultrasonography after surgery (usually for the first 3 to 4 months after the initial evaluation).

A thoracic drain was also placed in dogs with suspected, but initially unconfirmed, intrathoracic grass awn migration and pyothorax unresponsive to initial antimicrobial treatment if deemed necessary by the clinician responsible for the case. In these dogs, a thoracic drain with a trocar was blindly inserted as previously described.

Antimicrobials (drugs and dosages at the discretion of the attending clinician) were prescribed for all surgical patients for a 15-day period. Prolonged antimicrobial treatment (3 to 8 weeks’ duration), when used, was administered on the basis of results of microbiologic culture and susceptibility testing of samples from the pleural fluid.

Conservative management of dogs with suspected but unconfirmed migrating intrathoracic grass awns consisted of the described prolonged antimicrobial treatment. These dogs were monitored at home and had frequent (7- to 10-day interval) reevaluations by ultrasonography until grass awns were visualized and treatment was determined or until clinical signs resolved.

Outcome assessment
Outcome was considered successful if all clinical signs were resolved ≤ 6 months after surgery. The short-term outcome was assessed by reviewing recheck examination records (usually for the first 3 to 4 months after initial evaluation), and long-term outcome was reviewed by telephone consultation with the owners or the referring veterinarians.

Descriptive data were reported. Statistical analysis was not performed.

Results
Forty-three dogs with a diagnosis of suspected intrathoracic grass awn migration met the study inclusion criteria. Breeds included English Setter (n = 15), German Shorthaired Pointer (9), Italian Bloodhound (6), Labrador Retriever (1), Springer Spaniel (5), English Pointer (4), and mixed (3). Of the 43 dogs, 27 were female and 16 were male, with a median age of 5 years (range, 2 to 15 years) and median weight of 20 kg (44 lb; range, 12 to 38 kg [26.4 to 83.6 lb]). One dog had been described in a previous clinical report. All dogs had been treated with antimicrobials prior to initial evaluation at the veterinary teaching hospital.

Diagnostic imaging
All 43 dogs underwent transthoracic ultrasonography as part of the initial evaluation at the veterinary teaching hospital. Fourteen of these dogs subsequently had transeosophageal ultrasonography immediately prior to surgery, in an attempt to locate grass awns not found with the transthoracic approach or to obtain more information for awns that had been identified.

Grass awns typically appeared ultrasonographically as spindle-shaped, hyperechoic structures of variable length (range, 0.8 to 2.5 cm; Figure 1). In 1 dog, the awn appeared as a 0.3-cm, oval-shaped structure with a small linear hyperechoic projection compatible with a barb (Figure 2). The grass awns were often surrounded by a hypoechoic zone, consistent with a focal inflammatory response. In dogs with migrating pleural grass awns (n = 29), pleural effusion, pleural thickening, and enlargement of sternal lymph nodes were present and, when visualized, the grass awn was observed in the ventral region of the thorax, entrapped in a pleural abscess or granuloma or in the thickened pleura. In dogs with grass awns visualized within the pulmonary parenchyma (n = 10), areas of pulmonary consolidation, focal presence of lung adherences (absence of the so-called glide sign), and focal pleural effusion were visualized. In the remaining 4 dogs, transthoracic and transeosophageal ultrasonography were performed following bronchoscopy, and results suggested grass awn migration from the airways into the pulmonary parenchyma (mucus and blood in distal portion of bronchus). Ultrasonographic findings in these dogs were characterized by pulmonary consolidation in lung lobes with the described endoscopic findings, but a foreign body was not identified.

Thoracic radiography was performed by referring veterinarians for 18 dogs. Radiographic findings, obtained only from imaging reports, included focal pulmonary opacities (4 dogs) and pleural effusion (14 dogs). In all 4 dogs, focal pulmonary opacities were distributed to the left caudal lung lobe, and the location was in agreement with findings of ultrasonographic examination. Bronchiectasis was detected in 1 dog. Pleural effusion

JAVMA • Vol 248 • No. 4 • February 15, 2016 415

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was present bilaterally in 12 dogs and unilaterally in 2 and was assessed subjectively by the radiologist as severe (n = 6), moderate (6), or mild (2).

Preoperative CT was performed to further characterize the lesions in 10 dogs. The images allowed localization of the affected region, but no foreign bodies were identified with this method. The lesions were characterized by focal soft tissue density in 7 dogs and by pleural fluid with pleural thickening in 3 dogs. The localization of the single focus detected by CT in dogs with pulmonary parenchymal abnormalities corresponded to findings on transthoracic (4 dogs) and transesophageal ultrasonography (3 dogs). In the remaining 3 dogs, moderate pleural fluid was present bilaterally on CT; the CT findings were in accordance with ultrasonographic features. In all 3 of these dogs, the transthoracic or transesophageal ultrasonographic examination revealed an intrathoracic foreign body.

**Transthoracic ultrasonography**

Grass awns were identified by this method in 20 of 43 (47%) dogs. Awns were localized to the pleural space and pulmonary parenchyma of 13 and 7 dogs, respectively. Twenty three of 43 (53%) dogs were suspected to have intrathoracic grass awn migration on the basis of radiographic, clinical, or ultrasonographic findings; pleural fluid analysis; or a combination of these, but no grass awn could be clearly identified with transthoracic ultrasonography for these dogs at the time of initial evaluation.

**Transesophageal ultrasonography**

Seven dogs underwent preoperative transesophageal ultrasonography after transthoracic ultrasonography failed to identify the suspected grass awn. In all 7 of these dogs, an area of lobar consolidation was visualized with the transesophageal method. A grass awn was identified with this approach in the pulmonary parenchyma in 3 dogs; in each case, the awn was located near the esophagus, so that portions of normal air-filled lung near the thoracic wall prevented detection by transthoracic ultrasonography. In the remaining 4 dogs, no grass awn was visualized with this method.
Seven of the 20 dogs in which a grass awn had been identified via transthoracic ultrasonography also underwent preoperative transesophageal ultrasonography in an attempt to obtain additional images of the grass awns. However, the awn was not visualized by transesophageal ultrasonography in any of these dogs.

**Surgical results for dogs with grass awns visualized by ultrasonography**

Grass awns were successfully removed via thoracotomy with a lateral approach (n = 16 dogs), median sternotomy (2), thoracoscopy (2) or laparotomy (1). In 2 dogs, the grass awn was removed with Hartmann forceps introduced through fistulae. The first attempt to remove the awn was successful in 21 of 23 dogs; 2 dogs required a second procedure.

A partial lung lobectomy was performed in 8 dogs in which grass awns were within consolidated lung lobe regions. A total lung lobectomy was performed in 1 dog in which the entire affected lobe was consolidated. Grass awns were identified in the left caudal lung lobe (n = 6 dogs), the left cranial lung lobe (1), the right caudal lung lobe (1), and the accessory lung lobe (1). In 11 dogs, the awn was found in the pleural cavity. In 2 dogs, the grass awn was within an abscess in the pleural space next to thoracic wall. In 1 dog, the awn was removed from the sublumbar region 9 weeks after removal from the thorax was attempted.

Two surgical patients that had undergone a median sternotomy had critical respiratory compromise in the immediate postoperative period, requiring continuous aspiration by the use of a 3-chamber system for 24 hours. The cause of respiratory impairment was thought to be attributable to a restrictive lung disease and reduced lung volume caused by severe and chronic pyothorax. The continuous aspiration provided a safe and smooth recovery from respiratory distress. After 24 hours, these dogs had intermittent drainage performed for 7 days. The remaining patients with thoracic drains (n = 19) had intermittent drainage for variable lengths of time (usually 2 to 7 days). The drainage tube was removed after this period, and prolonged antimicrobial treatment (duration, 3 to 8 weeks) was administered on the basis of results of culture and antimicrobial susceptibility analysis for isolates from the pleural fluid.

**Dogs with grass awns visualized by transthoracic ultrasonography**

In 10 of 20 dogs with grass awns detected by this method, the awn was successfully removed via thoracotomy without ultrasonographic guidance. Intraoperative transesophageal ultrasonography was performed in 9 of the remaining 10 dogs (Figures 1–3). In 7 of the 9 dogs, the awn was removed via thoracotomy; in the remaining 2 dogs, the awn had been visualized within an abscess in the pleural space next to thoracic wall and was removed under ultrasonographic guidance with Hartmann forceps introduced through the fistulae. Thoracotomy with a lateral approach was initially unsuccessful in the remaining dog that had a grass awn identified by transthoracic ultrasonography. In this dog, pyothorax recurred after an interval of antimicrobial treatment (4 weeks after the first surgery), and the awn was successfully located by gross examination and removed during a second surgery (with the same approach). All 20 dogs had complete resolution of the clinical signs and resumed normal activity within 4 to 6 weeks after successful surgical removal of the awn. Time from awn removal to most recent follow-up ranged from 6 to 36 months.

**Dogs with grass awns visualized by transesophageal ultrasonography**

In 1 of the 3 dogs in which a grass awn was visualized with this method prior to surgery, initial surgery (thoracoscopy) was unsuccessful. The affected lesion could not be visually identified, and the dog underwent medical management with antimicrobial treatment for 4 weeks. The awn was subsequently identified by means of ultrasonography approximately 9 weeks later, after migration to the lumbar retroperitoneal region, and was removed via laparotomy in which intraoperative (intra-abdominal) ultrasonography was used as guidance to direct the Hartmann forceps tips to the awn (Figure 4). For the remaining 2 dogs, surgical removal via thoracoscopy was successful on the first attempt. Because of the surgeon’s experience with the first of
these 3 cases, both of these dogs underwent intraoperative transesophageal ultrasonography, which was used as guidance in localizing the awn. All 3 of these dogs had complete resolution of the clinical signs and full return to normal activity within 4 to 6 weeks after awn removal. Time from surgery to most recent follow-up for these dogs ranged from 12 to 30 months.

**Dogs with suspected intrathoracic grass awn migration but no foreign body visualized on initial evaluation**

In 20 of 43 (47%) dogs, including 16 that had transthoracic ultrasonography only and 4 that had transthoracic and transesophageal ultrasonography, the clinical, radiographic, and ultrasonographic findings and results of pleural fluid analysis were consistent with a suspected migrating intrathoracic grass awn that was not visualized by ultrasonography.

Sixteen of these dogs had been referred for evaluation of pleural effusion, and none underwent surgery after the initial evaluation. Two dogs with suspected, but initially unconfirmed, intrathoracic grass awn migration and pyothorax unresponsive to initial antimicrobial treatment had thoracic drains placed for 5 days. Management of these 16 dogs consisted of monitoring with transthoracic ultrasonography every 7 to 10 days and prolonged antimicrobial treatment (3 to 8 weeks’ duration). Fourteen had pleurocentesis performed as needed. All of these dogs developed draining fistulas within 4 to 10 weeks after the initial evaluation failed to identify the grass awn. In all 16 dogs, the grass awns were found by ultrasonographic evaluation of the fistula and removed under general anesthesia. Grass awns in 10 dogs were extracted from the sublumbar region via laparotomy with intraabdominal ultrasonography used for guidance in directing the Hartmann forceps to the awn site. In the other 6 dogs, awns were removed from the thoracic wall with transthoracic ultrasonography used to guide Hartmann forceps placement. Clinical signs resolved in all 16 dogs after grass awn removal, with a return to normal activity within 3 to 6 weeks. Time from surgery to most recent follow-up for these dogs ranged from 8 to 18 months.

The remaining 4 of 20 dogs did not have a grass awn or other foreign body identified, although all 4 had undergone transthoracic ultrasonography, bronchoscopy, and transesophageal ultrasonography. Because these dogs responded to conservative management, with resolution of clinical signs and return to normal activity after 3 to 4 weeks of antimicrobial treatment, no further treatment was deemed necessary. These dogs underwent additional ultrasonographic examinations once monthly for 2 months, with no evidence of grass awn migration within or outside of the thorax. Time from first evaluation to most recent follow-up for these dogs ranged from 8 to 12 months.

**Grass awn species**

Species identification was performed for all 39 grass awns removed from dogs in this study. *Avena* spp (n = 20), *Bromus* spp (10), *Hordeum* spp (8), and an *Echinochloa* sp (1) seeds were found in these patients.

**Discussion**

Our study provides evidence of the utility of ultrasonography for diagnosis, localization, and intraoperative guidance for surgical removal of suspected migrating intrathoracic grass awns in dogs. Previous reports have described the ultrasonographic visualization of grass awns within the thoracic wall, pleural space, or pulmonary parenchyma in a small number of cases without examining the individual and additive uses of different ultrasonographic approaches (transthoracic, transesophageal, and intraoperative imaging) in such patients. In the present study, grass awns were visualized in the thoracic cavity by transthoracic or transesophageal ultrasonography in 23 of 43 (53%) dogs during initial evaluations. In another 16 of 43 (37%) dogs for which the initial evaluation was nondiagnostic, grass awns were subsequently found in the sublumbar region or thoracic wall by
Ultrasonographic examination of draining fistulas after presumptive intrathoracic migration; thus, the method was ultimately useful for identification and localization of the awn in 39 of 43 (91%) dogs. Furthermore, in 11 of 23 dogs that had awns visualized by ultrasonography on initial evaluation, intraoperative ultrasonography facilitated the surgeon’s localization of the lesion and the decision to perform less or more radical resections of affected tissues. In 4 (9%) dogs of this study, no grass awn was visualized or recovered, despite having ultrasonographic findings compatible with foreign body migration. However, these 4 dogs responded to conservative (nonsurgical) treatment consisting of several weeks of antimicrobial administration and had full recoveries.

Transthoracic ultrasonography is a safe, readily available, and noninvasive diagnostic technique that can be used to identify anatomic landmarks for planning and guiding a surgical approach for removal of intrathoracic grass awns. In contrast to CT, MRI, or transesophageal ultrasonography, transthoracic ultrasonography can be performed without anesthesia. Moreover, CT, MRI, and transesophageal ultrasonography are less frequently available to clinicians and require more advanced training for their use.

Ultrasonographic evaluation of intrathoracic structures is commonly hampered by interference from air-filled lungs. Pleural effusion or lung consolidation, which frequently accompanies migrating intrathoracic grass awns, can provide an acoustic window that substantially increases the ability to examine intrathoracic lesions and identify foreign bodies. The ultrasonographic appearance of grass awns, typically as spindle-shaped, hyperechoic structures, has been reported for various sites, but their appearance within body cavities such as the thorax is not as well documented.

Similar to previous reports, identification of the grass awns in dogs of the present study was enhanced by a surrounding hypoechoic region of fluid associated with an inflammatory response. It is important to realize that the visualization of the grass awns might be difficult, especially when located in the pleural space, because of the large field that needs to be examined and presence of scattered hyperechoic elements (fibrin, tissue remnants, cellular debris, or air). A spindle-shaped hyperechoic structure casting an acoustic shadow and surrounded by a hypoechoic area is suggestive of a migrating grass awn. We found it useful to scan lesions in multiple planes to distinguish foreign bodies from air or debris present in the diseased region. In dogs with pleural effusion and intrapleural grass awns, the awn was located in the ventral portion of the thorax. We subjectively found it useful to alter the position of a given patient to help visualize the foreign body. In our experience, dogs with intrapulmonary grass awns had pulmonary consolidation that helped the ultrasonographer to visualize the awn. Additionally, some of these dogs also had focal pleural effusions and absence of a glide sign between the parietal and visceral pleura overlying the affected lung lobe.

In 3 dogs, because the pulmonary lesion was located in close proximity to the esophagus, the portions of air-filled lung near the thoracic wall hampered transthoracic ultrasonographic examination. However, transesophageal ultrasonography permitted visualization of the area of pulmonary consolidation and the grass awn. Transesophageal ultrasonography was performed unsuccessfully in 11 other dogs; in these dogs, the grass awn was localized within the pleural space (caudal mediastinum) or in a more peripheral lung region. In 7 of these 11 dogs, the awn had been previously identified with transthoracic ultrasonography, and in the other 4, no grass awn was identified by either approach. This suggests that transesophageal ultrasonography is most useful for identifying grass awns that are not localized to the pleural space or peripheral lung lobe regions, but to the medial portion of the lung parenchyma close to the esophagus. However, we suggest that clinicians initially attempt transthoracic ultrasonography and reserve the use of transesophageal ultrasonography for cases in which the suspected grass awn cannot be identified by transthoracic imaging.

In 2 dogs that had grass awns visualized by preoperative ultrasonography but did not undergo intraoperative ultrasonography, the awn was not removed during the initial surgery. To avoid this complication with subsequent cases (n = 11), we used intraoperative ultrasonography to precisely localize intrathoracic grass awns and guide their complete surgical removal. Intraoperative ultrasonography permitted high-resolution visualization of grass awns because the probe could be placed directly on the diseased region through the surgical opening without interference from the thoracic wall (ribs) or air-filled lungs. Additionally, the resected tissues were imaged intraoperatively to confirm the presence of the awn prior to closing the incisions. When intraoperative translesional ultrasonography was used, the grass awn was successfully removed on the first surgical attempt for 9 of 9 dogs in our study. This suggests that intraoperative ultrasonography after preoperative visualization of the foreign body might increase the likelihood of complete surgical removal. Although only used in 2 dogs, transesophageal ultrasonography during thoracoscopy also appeared useful in aiding grass awn removal, with grass awns recovered from the 2 dogs that underwent the intraoperative ultrasound procedure but not from the 1 dog that had thoracoscopy without it.

In 1 dog, the grass awn was visualized within a consolidated lung lobe by preoperative transesophageal ultrasonography but was not removed during an initial surgery. The surgeon could not grossly identify any clearly abscessed tissue and elected to preserve the lung and institute long-term antimicrobial treatment. At the 2-week follow-up, the same lung region had regained a normal ultrasonographic appearance. The grass awn was located in the sublumbar region by means of ultrasonography 9 weeks after the first removal attempt and was successfully extracted with Hartmann forceps. In the 16 dogs that did not have grass awns visualized during the initial evaluation, but ultimately had awns recovered from the sublumbar region or thoracic wall after prolonged antimicrobial treatment, we believe that awns likely migrated through the lung to the retroperitoneal cavity or tho-
racic wall. The unidirectional migratory characteristics of grass awns, attributable to their backward-pointing barbs and fusiform shape, have been previously described.3–8

The variations in grass awn length identified by ultrasonography and confirmed by surgical removal likely reflects the different species of grass awns present in Italy.3,5,5 Arenaria spp, Bromus spp, Hordeum spp, and Echinochloa spp grass awns and an Echinochloa sp grass awn were recovered from the dogs in this study. However, similar species of grasses exist elsewhere, suggesting that our ultrasonographic descriptions are likely to apply to grass awns in various regions of the world. In this regard, it should be noted that one of the grass awns found in this study was visualized as an oval-shaped foreign body with a small linear projection and did not have the spindle shape characteristic of most grass awns.

Consistent with findings in other studies,3,19 CT examinations performed to further characterize the pulmonary lesions in 10 dogs of the present study failed to identify the intrathoracic grass awns. Computed tomography has a spatial resolution inferior to that of ultrasonography, and local inflammation may inhibit or prevent visualization of the foreign body.20 Moreover, CT might fail to detect a foreign body if image quality is suboptimal owing to motion artifact (patient respiration). However, CT might be a useful diagnostic tool for guiding case management when ultrasonography fails to identify intrathoracic foreign bodies.19

When surgery was elected, thoracoscopy (when available) was preferred over open thoracotomy for dogs with intrathoracic grass awns because decreased tissue trauma, reduced postoperative pain, and shorter recovery time were anticipated with the former method. However, thoracoscopy also carries a risk of less complete visualization of the pleural space or lungs.21 This was supported by the failure to visually identify the affected lung lobe in 1 dog after the awn had been visualized by preoperative ultrasonography. In our case series, thoracoscopy was not performed in 7 dogs because it was not available at the time of the diagnosis, and 11 dogs required extensive debridement of the pleural cavity that would not be possible via thoracoscopy. Multiple pleural adhesions associated with chronic pyothorax or lobar consolidation are considered to be contraindications for thoracoscopy.21,22

In the present study, 20 dogs with suspected but unconfirmed intrathoracic grass awn migration were treated with pleurocentesis (n = 14), placement of a thoracic drain (2), and long-term antimicrobial administration prescribed on the basis of results of microbial culture and susceptibility testing (20). Ultrasonography in these cases was useful in monitoring the clinical condition of the patient and ultimately allowed visualization and removal of the awn in subsequent evaluations of 16 dogs. The remaining 4 dogs that had no grass awns detected at any time had complete resolution of clinical signs with antimicrobial treatment. This observation raises the question of whether acute surgical intervention involving lung resection has a better outcome than conservative management followed by retrieval from fistulae, if these develop. However, our study was not designed to address this question.

One possible limitation for the use of intraoperative ultrasonography is the inability to place the transducer directly on the lesion during thoracoscopy. We overcame this limitation by performing transesophageal ultrasonography during thoracoscopy, and in both cases where this technique was used, ultrasonography successfully guided the surgeon to the diseased region. Thus, transesophageal ultrasonography may be particularly useful in detecting grass awns that are sagittally located or when the lung lobectomy is performed via thoracoscopy.

Our study had several limitations. The study was retrospective, with the limitations inherent in such study designs, although retrospective studies often provide the most suitable means of collecting sufficient data for evaluation of infrequently diagnosed disorders in a timely manner. Also, ultrasonography is a highly operator-dependent technique, and our results might not be readily extrapolated to similar situations where the methods involve other clinicians or alternative ultrasonography imaging systems. The study population was also somewhat small, and ultrasonographic modalities such as transesophageal and intraoperative imaging were performed only in a limited number of the cases.

Our results suggested that preoperative ultrasonography can be useful for evaluation of dogs with clinical signs suggestive of intrathoracic grass awn migration and for planning of surgical approaches in such patients. Although the number of dogs that underwent intraoperative ultrasonography was small, the results suggested that this may be a useful adjunct, and further research is needed. Transthoracic, transesophageal, and intraoperative ultrasonography are useful and complementary imaging techniques that can improve localization and removal of migrating intrathoracic grass awns. Moreover, ultrasonography may be considered a valuable and readily available diagnostic tool to monitor canine patients with suspected migrating intrathoracic grass awns that cannot be readily identified.

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Footnotes

a. MyLab 30 Vet Gold, Esaote, Genoa, Italy.
b. Delta Med Medical Devices, Viadana, Italy.
c. Karl Storz, Verona, Italy.
e. Auto Suture TA90, Tyco Healthcare, Norwalk, Conn.
f. Smiths Medical PM, Waukesha, Wis.
g. Ocean Water Seal Chest Drain, Atrium Medical Corp, Hudson, NH.
h. Argyle, Covidien, Mansfield, Mass.

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From this month’s AJVR

Correlation of the ratio of caudal vena cava diameter and aorta diameter with systolic pressure variation in anesthetized dogs
Caterina Meneghini et al

OBJECTIVE
To evaluate in dogs the correlation coefficient of the ratio between diameter of the caudal vena cava (CVC) and diameter of the aorta (Ao) as determined ultrasonographically with systolic pressure variation (SPV).

ANIMALS
14 client-owned dogs (9 females and 5 males; mean ± SD age, 73 ± 40 months; mean body weight, 22 ± 7 kg) that underwent anesthesia for repair of skin wounds.

PROCEDURES
Anesthesia was induced. Controlled mechanical ventilation with a peak inspiratory pressure of 8 cm H2O ± 7 kg was immediately started, and SPV was measured. During a brief period of suspension of ventilation, CVC-to-Ao ratio was measured on a transverse right-lateral intercostal ultrasonographic image obtained at the level of the porta hepatis. When the SPV was ≥ 4 mm Hg, at least 1 bolus (3 to 4 mL/kg) of Hartmann solution was administered IV during a 1-minute period. Bolus administration was stopped and the CVC-to-Ao ratio was measured when SPV was < 4 mm Hg. Correlation coefficient analysis was performed.

RESULTS
28 measurements were obtained. The correlation coefficient was 0.86 (95% confidence interval, 0.72 to 0.93). Mean ± SD SPV and CVC-to-Ao ratio before bolus administration were 7 ± 2 mm Hg and 0.52 ± 0.16, respectively. Mean ± SD SPV and CVC-to-Ao ratio after bolus administration were 2 ± 0.6 mm Hg and 0.91 ± 0.13, respectively.

CONCLUSIONS AND CLINICAL RELEVANCE
In this study, the CVC-to-Ao ratio was a feasible, noninvasive ultrasonographically determined value that correlated well with SPV (Am J Vet Res 2016;77:137–143).

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