

IMAGING DIAGNOSIS: ACUTE LUNG INJURY FOLLOWING MASSIVE BEE ENVENOMATION IN A DOG

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A 5-year-old neutered male mixed breed dog presented for increased respiratory effort after being stung by over 100 bees and developing anaphylactic shock. Given the history, clinical signs and thoracic radiographic findings of a mild bilateral interstitial pattern, acute lung injury/acute respiratory distress syndrome (ALI/ARDS) was suspected. Further testing was performed to support this diagnosis. On computed tomographic images, there was a diffuse bilateral opacification of the lungs, with preservation of bronchial and vascular margins. Pulmonary function testing indicated decreased pulmonary compliance, decreased diffusion capacity and decreased functional residual capacity. These results supported the diagnosis of ALI/ARDS secondary to bee sting envenomation and development of anaphylactic shock. After 8 days of treatment with oxygen, steroids, antibiotics, and bronchodilators the dog improved. This case demonstrates the usefulness of computed tomography and pulmonary function testing in the diagnosis of ALI/ARDS. *Veterinary Radiology & Ultrasound*, Vol. 46, No. 4, 2005, pp 300–303.

Key words: computed tomography, anaphylactic shock, veterinary, ARDS.

Signalment

FIVE-YEAR-OLD, neutered male, mixed breed (beagle).

History

The dog was examined by his primary-care veterinarian after being found collapsed in an outdoor pen covered with bees. The dog was treated for anaphylactic shock secondary to massive bee sting envenomation with dexamethasone sodium phosphate (2 mg/kg intravenously (i.v.)), LRS (80 ml/kg/h), and oxygen via a face mask. The dog's cardiovascular status rapidly improved and over 100 bee stingers were removed after stabilization. The dog was discharged home later the same day.

Over a 48 h period after the initial incident, the dog developed progressive tachypnea, vomiting, and restlessness. The dog was then referred to The Foster Hospital for Small Animals at Tufts University School of Veterinary Medicine (TUSVM) for diagnostic evaluation.

Physical Examination

There was tachycardia (190 bpm), dehydration and increased respiratory rate and effort. No heart abnormalities,

such as a heart murmur or arrhythmia were detected on auscultation. The oxygen saturation (SpO_2) as measured by pulse oximetry was consistently in the 88–90% range on 28% fraction inspired oxygen (FiO_2) as delivered in an oxygen cage. Laboratory testing supported liver (increased ALT, AST, and ALP) and muscle injury (increased AST and CK) that was attributed to shock, bee envenomation and hypoxia. Differential diagnosis for the respiratory distress included acute lung injury/acute respiratory distress syndrome (ALI/ARDS), aspiration pneumonia, interstitial pneumonia, congestive heart failure, and pulmonary thromboembolism.

Imaging Findings

Thoracic radiographs were obtained. There was a mild, diffuse linear interstitial pattern with a normal size heart and no vascular abnormalities (Fig. 1). These findings were most compatible with ALI/ARDS, interstitial pneumonia or pulmonary thromboembolic disease. The dog was treated supportively for 4 days with fluids (60 ml/kg/day), cefazolin (22 mg/kg), heparin (150 U/kg t.i.d.), and oxygen (oxygen cage) but failed to improve. Severe dyspnea with marked respiratory distress ensued whenever the dog was removed from supplemental oxygen. Thus, computed tomography (CT) and pulmonary function testing were performed to attempt to clarify the underlying lung injury.

The dog was preoxygenated with 100% oxygen and general anesthesia was induced with propofol (6 mg/kg/i.v.) and maintained with isoflurane in oxygen. Ventilation was manually assisted so that SpO_2 was maintained above 95%.

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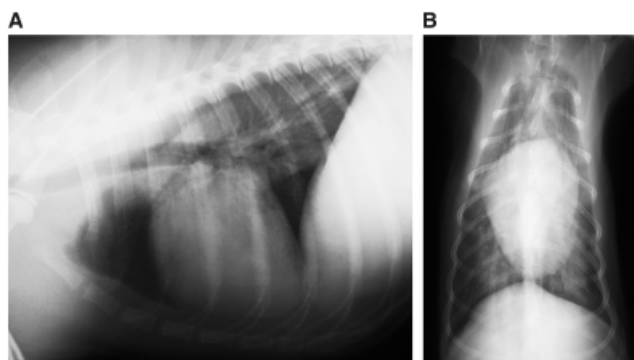


FIG. 1. (A) Lateral and (B) dorsoventral thoracic radiographs obtained 48 h after bee-sting envenomation. There is a mild, diffuse, bilateral, linear interstitial pattern.

CT was performed with a Picker PQ 5000 spiral scanner using the following scan and display parameters: 120 kV, 200 mA, 5-mm collimator width, 3-mm reconstruction index, 1.5 pitch factor, sharp reconstruction algorithm, window center of minus 600, window width of 1600.* The dog was in ventral recumbency and breathed unassisted during image acquisition.

There was diffuse, bilateral relatively homogenous opacification of the lung that appeared to spare some regions, notably the accessory lobe (Fig. 2). Bronchial and vascular markings were preserved. Hounsfield unit measurements ranged from -550 to -850 . These values corresponded to the visibly hyperattenuating regions of lung and the relatively lower attenuating regions, respectively. Although the increased opacity was slightly more apparent in the ventral aspect of lung, there was no evidence of consolidation to suggest aspiration pneumonia. Pulmonary embolism was considered unlikely based on the distribution of lung changes, and an arteriogram was not performed.

Pulmonary Function Testing

Pulmonary function testing was performed to support altered mechanical properties of the acutely injured lungs. Results included decreased compliance at 33 ml/cm H₂O (reference range 45–50 ml/cm H₂O), decreased diffusion capacity (DLCO) at 2.54 ml/min/mmHg (reference range 10–12 ml/min/mmHg), and decreased functional residual capacity (FRC) at 49 ml/kg (reference range 55–65 ml/kg).

Diagnosis/Outcome

Based upon the combination of the acute insult (bee stings), clinical signs of respiratory distress, decreased SpO₂, the presence of bilateral pulmonary infiltrates, the absence of cardiac abnormalities and the CT findings, the clinical diagnosis was ALI/ARDS.

*Picker PQ 5000 spiral scanner, Picker International, Cleveland, OH.

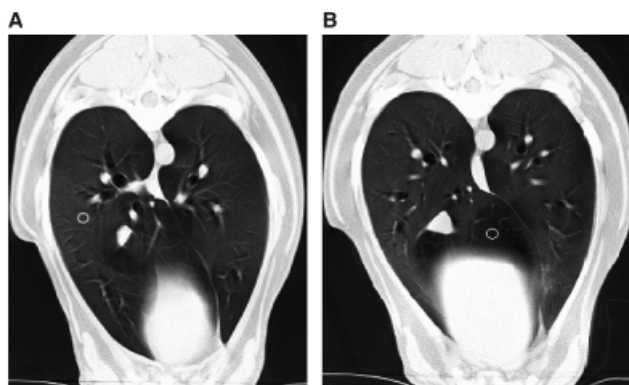


FIG. 2. (A, B). Transverse spiral computed tomography images of the caudal thorax obtained 4 days after thoracic radiography (collimator width = 5 mm, reconstruction index = 3 mm, pitch factor = 1.5, sharp algorithm, window center = -600 , window width = 1600). Dorsal is at the top and right is to the left of the figures. There is diffuse, bilateral mild opacification of the lungs that appears to spare most of the accessory lobe and other small patches of lung. Hounsfield unit measurements ranged from -550 in the relatively higher attenuating areas (regions of interest (ROI) cursor in A) and -850 in the relatively lower attenuating areas (such as the accessory lobe, ROI cursor in B). Findings are consistent with acute lung injury/acute respiratory distress syndrome.

Supportive care consisting of fluids (60 ml/kg/day), prednisone (0.5 mg/kg/day) after 7 days, heparin (150 U/kg t.i.d.), cefazolin (22 mg/kg), theophylline (10 mg/kg b.i.d.) and oxygen (oxygen cage) were continued. Improvement in respiratory effort and rate was noted after the eighth day of hospitalization at TUSVM and the dog was discharged 12 days after the initial bee sting. Fourteen days later there were no major abnormalities and the owner reported normal activity and appetite.

Discussion

The development of ALI/ARDS involves an initiating event that leads to neutrophil migration and subsequent severe inflammation of the pulmonary parenchyma. Criteria in people for identification of ALI/ARDS include an acute onset of respiratory distress with hypoxemia, bilateral pulmonary infiltrates on thoracic radiographs, and a pulmonary capillary wedge pressure less than 18 mmHg or absence of clinical evidence of left sided congestive heart failure.¹ Distinction between ALI and ARDS relies on the calculation of the PaO₂:FiO₂ ratio. The normal ratio is greater than 500, while a value of <300 is compatible with ALI and a value of <200 is compatible with ARDS.¹ In this dog, collection of an arterial blood gas sample was not successful, because of the patient's size and severity of cyanosis during attempts. However, pulse oximetry documented consistently decreased oxygen saturation of 88–90% in 28% oxygen. Extrapolation of this value would suggest the PaO₂:FiO₂ ratio would approximate 200–225, clearly in the range of acute lung injury.

Common causes of ALI/ARDS in humans include direct causes such as smoke inhalation, pneumonia, and aspira-

tion of gastric contents, and indirect causes such as shock caused by sepsis, anaphylaxis, or trauma, and multiple transfusions.¹ In dogs, microbial pneumonia, sepsis, aspiration pneumonia and shock are the most common predisposing factors.² To the authors' knowledge, survival from ALI/ARDS has not been previously reported in a dog.

ALI/ARDS in this dog was thought to be caused by bee stinging envenomation and development of anaphylactic shock. ALI/ARDS has been described previously in five men attacked by multiple killer bees. Three died after the attack and were histopathologically identified with ARDS, hepatocellular necrosis, acute tubular necrosis, subendocardial necrosis, and disseminated intravascular coagulation.³

Massive envenomation has been previously reported in dogs.⁴ These dogs experienced respiratory distress and post-mortem examination of one dog supported disseminated intravascular coagulation and lung injury.⁴

In this dog, advanced imaging was used to substantiate a clinical diagnosis of ALI/ARDS. In people, CT is widely used to characterize diffuse pulmonary parenchymal diseases.⁵ The CT features of diffuse alveolar injury include patchy or diffuse ground glass opacification, consolidation, and a diffuse reticular pattern.^{6,7} Ground glass opacification is a hazy increase in lung attenuation, with preservation of bronchial and vascular margins, as was seen in the dog of this report.⁸ Consolidation is a homogeneous increase in lung attenuation, but bronchovascular margins are obscured. Air bronchograms may be present with consolidation.⁸ A reticular pattern involves innumerable, interlacing lines that may be fine, intermediate or coarse.⁸ The presence, degree, and distribution of these findings depend on the temporal stage of the disease and its etiology, i.e., ARDS because of pulmonary vs. extrapulmonary causes.^{6,9}

Although not specific, ground glass opacification in ALI/ARDS is thought to reflect an active inflammatory process involving both the lung interstitium or alveolar wall and incomplete filling of the air space with inflammatory cells, cellular debris and edema.^{6,10} Consolidation occurs when the lung is completely or near completely airless, because of filling of air spaces or atelectasis or a combination of both.⁶ A reticular pattern may be acute because of edema or interstitial inflammation or chronic because of fibrosis.⁶

CT may also be used to quantitatively assess the lung parenchyma in patients with diffuse alveolar injury. This

type of assessment is based on correlation of the X-ray attenuation of a given volume of lung with its physical density.⁶ In the early stage of ALI/ARDS, there is an increase in density because alveolar gas is decreased and tissue mass is increased because of interstitial or alveolar infiltrate.⁶ X-ray attenuation, expressed as Hounsfield units (HU), is therefore increased on a CT image. Lung attenuation is generally homogenous in people at full inspiration, and normally ranges from -700 to -900 HU.¹¹ In a study of six dogs where ventilation pressure was maintained at 15 cm of H₂O during the CT scan, the mean HU was -846.¹²

In the dog of this report, the lung opacification was bilateral and diffuse but appeared to spare some regions of the lung, notably the accessory lobe. HU measurements ranged from -550 in opacified areas to -850 in the accessory lobe and other small patches of lung. Although positive pressure ventilation was not maintained during CT image acquisition, we believed that a lung attenuation value of -550 HU was nevertheless abnormal and indicative of increased lung density, especially when compared with other regions having normal attenuation values of -850 HU. In light of the clinical presentation, and the similarity of the CT findings in this dog to those in people with diffuse alveolar injury, CT supported the diagnosis of ALI/ARDS.

Pulmonary function tests were also performed to evaluate the pulmonary mechanics of the lungs and specifically to evaluate for any of the classical findings that accompany ALI/ARDS. This dog's pulmonary function testing results demonstrated these changes and supported the diagnosis of ALI/ARDS.

Treatment of this dog's acute lung injury was primarily supportive and included oxygen, antibiotics, bronchodilators, anticoagulants, and glucocorticoids. Glucocorticoids were added after 7 days in an attempt to prevent pulmonary fibrosis. In people, no specific therapy has been found to be beneficial for patients with ARDS/ALI except lower tidal volumes, which minimize barotraumas, in ventilated patients.^{1,13}

Conclusion

Prevalence and mortality rates of ALI in veterinary medicine is unknown. This case is an example of ALI that demonstrates many of the human ALI criteria. It also demonstrates the usefulness of CT and pulmonary function test in the diagnosis of ALI.

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