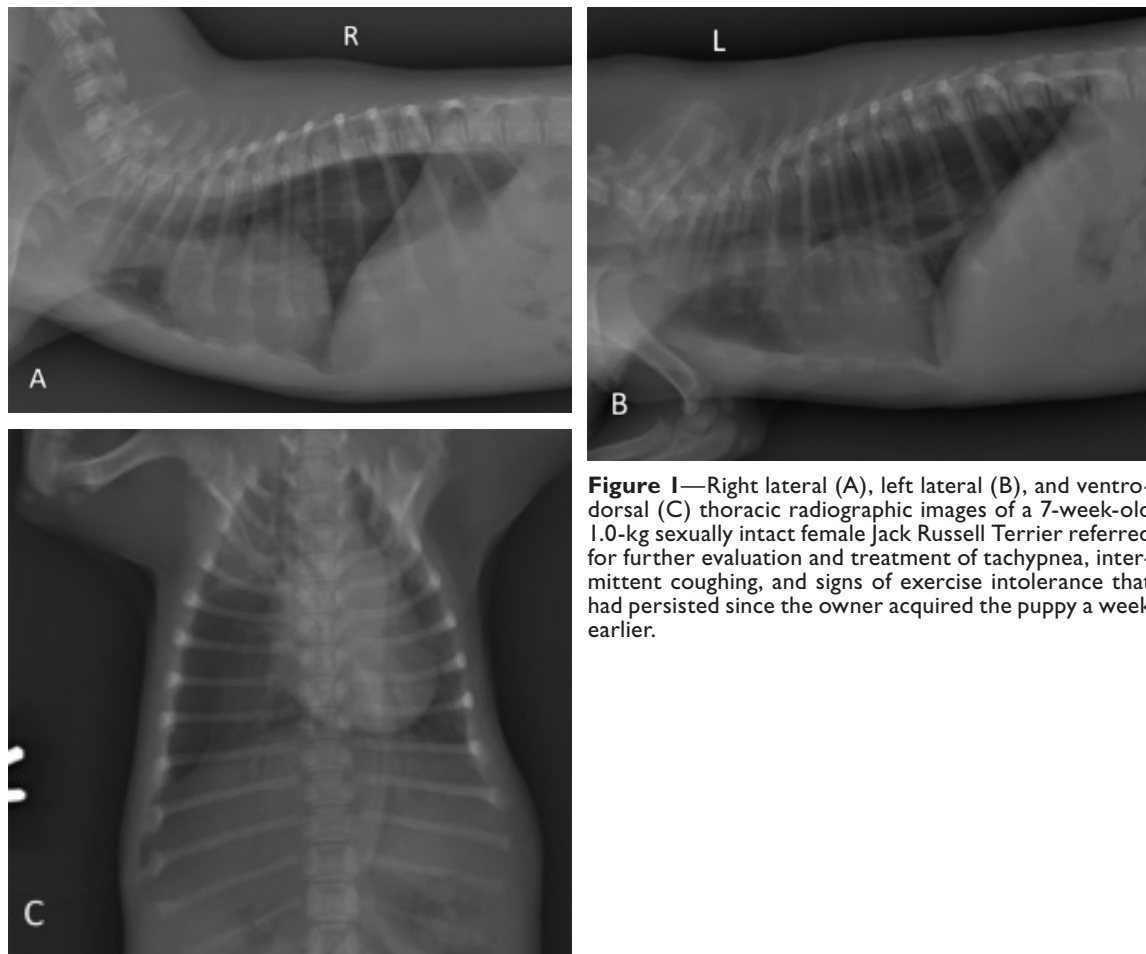




## What Is Your Diagnosis?



**Figure 1**—Right lateral (A), left lateral (B), and ventro-dorsal (C) thoracic radiographic images of a 7-week-old 1.0-kg sexually intact female Jack Russell Terrier referred for further evaluation and treatment of tachypnea, intermittent coughing, and signs of exercise intolerance that had persisted since the owner acquired the puppy a week earlier.

### History

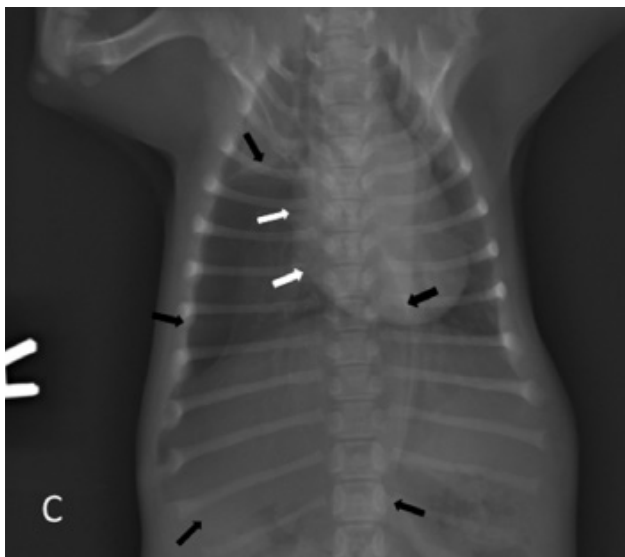
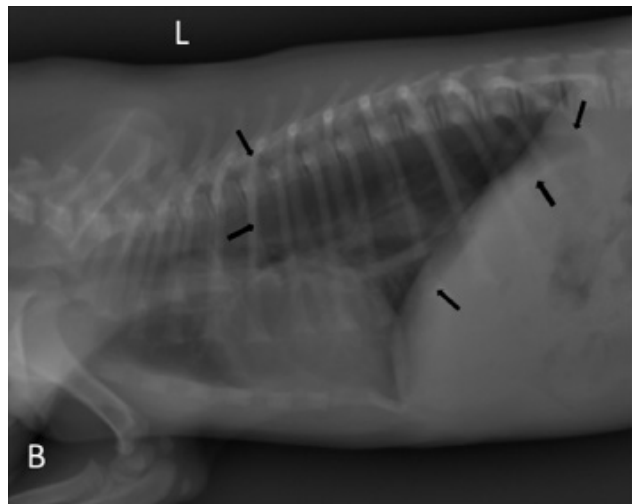
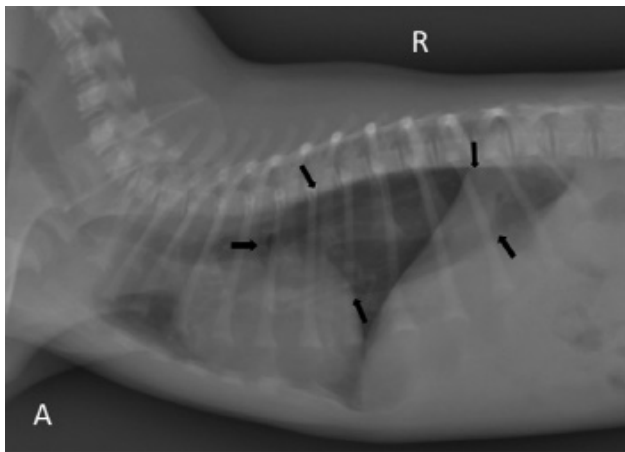
A 7-week-old 1.0-kg sexually intact female Jack Russell Terrier was referred for further evaluation and treatment of tachypnea, intermittent coughing, and signs of exercise intolerance that had persisted since the owner acquired the puppy a week earlier. The owner reported that the puppy was up-to-date on its vaccinations and had received pyrantel pamoate and sulfadimethoxine 2 weeks earlier.

On referral examination, the puppy was bright, alert, responsive, normothermic, tachycardic (172 beats/min; reference range, 80 to 160 beats/min), tachypneic (60 breaths/min; reference range, 15 to 35 breaths/min), and had a body condition score of 5 on a scale of 1 to 9. Thoracic auscultation revealed wheezes and increased lung sounds in the right hemithorax. A CBC and serum biochemical analyses revealed mild eosinopenia (85.2 eosinophils/ $\mu$ L; reference range, 120 to 1,300 eosinophils/ $\mu$ L), hyponatremia (140.4 mmol/L; reference range, 143 to 153 mmol/L), and hypoproteinemia (5.2 g/dL; reference range, 5.5 to 8 g/dL); moderate hyperphosphatemia (8.3 mg/dL; reference range, 2.5 mg/dL to 5 mg/dL); low serum concentrations of urea nitrogen (6 mg/dL; reference range, 8 to 24 mg/dL) and creatinine (0.34 mg/dL; reference range, 0.50 to 1.4 mg/dL); and high serum alkaline phosphatase activity (214 U/L; reference range, 11 to 140 U/L). Orthogonal thoracic radiographs were obtained (**Figure 1**).

**Formulate differential diagnoses and treatment strategies from the history, clinical findings, and Figure 1—then turn the page →**

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**Figure 2**—Same images as in Figure 1. The right caudal lung lobe (black arrows) is enlarged and extends more caudally than typical, and the mediastinum is shifted mildly leftward (white arrows).

## Diagnostic Image Findings and Interpretation

Thoracic radiography revealed that the mediastinum was shifted leftward and that the right caudal lung lobe was enlarged and hyperlucent, had small pulmonary lobar arteries and veins, and extended more caudally than expected (**Figure 2**). These findings were considered most consistent with congenital lobar emphysema (CLE), given the puppy's age. Extraluminal bronchial compression on expiration, intraluminal bronchial obstruction, partial lung lobe torsion, or other congenital causes for the hyperlucent and hyperinflated lung lobe could not be excluded without further diagnostic procedures.

Additionally, the cardiac silhouette was radiographically normal, other than the described mediastinal shift. On lateral projection, the trachea undulated mildly in its course, likely attributable to head positioning. The serosal margin detail in the cranial abdomen was poor, consistent with the patient's young age and expected accumulation of brown fat.

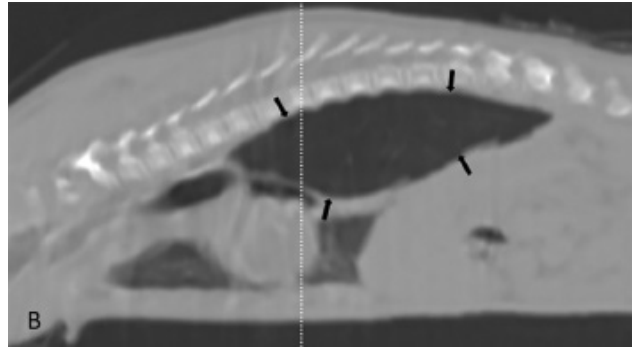
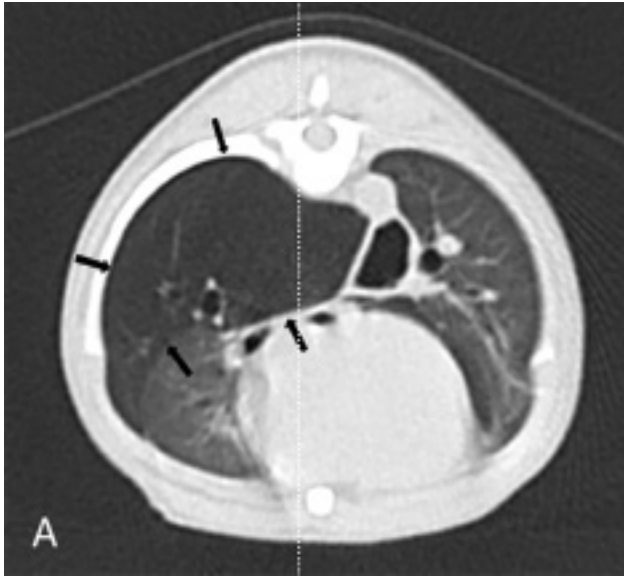
The puppy underwent general anesthesia for thoracic CT for surgical planning (**Figure 3**). Similar to

radiography, CT revealed mild to moderate leftward mediastinal shift. The right caudal lung lobe was severely enlarged and hypoattenuating ( $-889$  HU; reference range,<sup>1</sup>  $-500$  to  $-900$  HU), compared with the left lung ( $-725$  HU). The pulmonary lobar arteries and veins in the right caudal lung lobe were smaller than those in the other lung lobes. The esophagus had mild gas distention caudally. Small, sharply margined gas attenuating structures were in the soft tissues dorsal to the right 13th rib, consistent with supplemental fluids administered SC by the referring veterinarian. No extraluminal bronchial compression, intraluminal bronchial obstruction, or lung lobe torsion were observed. These findings further supported the diagnosis of CLE.

## Treatment and Outcome

The puppy underwent a right lateral thoracotomy and right caudal lung lobectomy. The right caudal lung lobe was hyperinflated and light pink, did not fully deflate on expiration, and was removed and submitted for histologic examination. Thoracotomy was completed, and a thoracostomy tube was placed. The puppy recovered without complication and received lactated Ringer solution supplemented with 2.5% dextrose (2 mL/kg/h, IV) and a constant rate infusion of fentanyl (18  $\mu$ g/kg/h, IV). The thoracostomy tube was removed 2 hours postoperatively because it was nonproductive on aspiration. The puppy continued to progress well and was discharged the following day with a prescription of acetaminophen-codeine (75 mg/kg acetaminophen and 15 mg/kg codeine, PO, q 12 h for 5 days) for pain control.

Histologic examination of sections of lung tissue revealed that the smaller airways had epithelial cells with staining pallor of the cytoplasm, whereas larger airways had no abnormalities, other than the finding of a few neutrophils in 1 bronchus but no overt evidence



**Figure 3**—Transverse (A) and sagittal (B) plane thoracic CT images of the dog described in Figure 1. The right caudal lung lobe (black arrows) is enlarged and is hypoattenuating (−889 HU), compared with the left lung (−725 HU). A—The dog’s right is toward the left of the image. B—The dog’s head is toward the left of the image. The images are displayed in a lung window (window width, 1,600 HU; window level, −550 HU) and a slice thickness of either 1 mm (A) or 2 mm (B), and the dotted line across each image represents the plane of the orthogonal image.

of bronchopneumonia. At the periphery of the lung in alveoli beneath the pleura, there were scattered small clusters of hypertrophied and hyperplastic alveolar macrophages, and phagocytosis of surfactant by the macrophages was considered the cause of these abnormal appearing cells. Because findings on histologic examination did not indicate any bronchial cartilage abnormalities, and surgery did not reveal any intraluminal bronchial obstruction or extraluminal bronchial compression that could have caused the lobar emphysema in this puppy, we diagnosed idiopathic CLE.

## Comments

Congenital lobar emphysema is a rarely diagnosed disease in veterinary medicine that has been reported in various breeds, including Jack Russell Terriers, and that primarily affects young dogs, generally between 1.5 and 6 months of age, with some adult dogs also affected.<sup>2-6</sup> Common clinical signs of CLE in dogs include progressive dyspnea, exercise intolerance, coughing, and tachypnea.<sup>3-5</sup> A pathological characteristic of CLE is the combination of clinically normal patency of the bronchi of the affected lung lobe during inspiration but dynamic bronchial collapse in the affected lung lobe during expiration. This bronchial collapse results in air entrapment that leads to hyperinflation of the affected lung lobe.<sup>1-5</sup> This in turn causes atelectasis of the surrounding lung lobes. Furthermore, the affected lung lobe can rupture, releasing air into the pleural space and creating pneumothorax, pneumomediastinum, or subcutaneous emphysema.<sup>1-5</sup> The right middle and the left cranial lung lobes are most commonly affected; however, other and multiple lung lobes can be affected.<sup>3-5</sup> The condition is diagnosed when a lung lobe is hyperinflated and does not deflate on expiration; emphysematous blebs on the surface of the lobe are also usually seen.<sup>3,4,6</sup> Congenital lobar emphysema is

most often idiopathic with no specific histopathologic findings but may be secondary to bronchial cartilage abnormalities (aplasia, dysplasia, hypoplasia) or less commonly to either intraluminal bronchial obstruction or extraluminal bronchial compression.<sup>2,4-6</sup> Thus, histologic examination could aid in the diagnosis of CLE.<sup>2,3,6</sup>

Radiographic findings of CLE in the dog of the present report included a hyperlucent and hyperinflated right caudal lung lobe that had small pulmonary lobar arteries and veins combined with a mediastinal shift toward the contralateral hemithorax. Additional radiographic findings for affected patients could include smaller and fewer pulmonary vessels at the periphery of the affected lung lobe, caudal displacement, flattening, or both of the ipsilateral or entire diaphragm, and atelectasis of the surrounding lung lobes.<sup>3,5</sup> Concurrent pneumothorax or pneumomediastinum can also be seen.<sup>4</sup> Caution must be exercised when interpreting radiographic images of patients with these findings because hyperlucent and overinflated lung lobes can look similar to pneumothorax, and thoracocentesis of a hyperinflated lung lobe can cause it to rupture, creating an iatrogenic tension pneumothorax. If advanced imaging (eg, CT as performed with the dog of the present report) is unavailable, a comparison of radiographic images acquired at peak inspiration versus peak expiration can be beneficial diagnostically because an emphysematous lung lobe will not deflate on expiration.<sup>5</sup>

Common CT findings of CLE identified for the dog of the present report were a large, hypoattenuating lung lobe and small pulmonary lobar vessels in the affected lobe.<sup>3</sup> Positive-pressure ventilation of patients with CLE is not recommended, including during CT, because the affected lung lobe is already hyperinflated and likely has pulmonary pressures higher than the recommended 10 to 12 cm H<sub>2</sub>O.<sup>1</sup> Iatrogenic

rupture of the affected lung lobe parenchyma can result if it is further inflated with positive-pressure ventilation.<sup>1</sup> Also, lung lobe hypoattenuation can be artifactually created on CT and falsely suggest CLE when lungs are hyperinflated with positive-pressure ventilation > 15 cm H<sub>2</sub>O.<sup>1</sup>

Thoracotomy with lung lobectomy is the treatment of choice for CLE.<sup>3-6</sup> Removing the affected lung lobe tends to be curative because CLE most often affects 1 lung lobe.<sup>3-6</sup> In contrast, conservative management with intrathoracic tube drainage has been ineffective in resolving the clinical signs associated with CLE.<sup>4</sup> Prognosis is generally good as long as the disease is caught prior to the development of tension pneumothorax, which has been reported as a fatal development in 1 puppy.<sup>2</sup>

Findings for the patient of the present report highlighted a somewhat uncommon disease process that should not be mistaken for pneumothorax in young animals. To our knowledge, although medical management of CLE is unrewarding, surgical excision of the affected lung lobe is typically curative. Thoracotomy with lung lobectomy resolved the clinical signs associated with CLE in the puppy of the present report while hospitalized. However, it was unknown

whether recurrence of CLE-related clinical signs occurred after discharge because the puppy was lost to follow up.

## Acknowledgments

The authors declare there were no conflicts of interest.

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