“Apollo, So Astonishing It Will Take Your Breath Away”

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Introduction:

Pneumothorax occurs when there is loss of parietal or visceral pleural membrane integrity ensuing in the presence of gas or air accumulation within the pleural cavity and loss of negative pressure.[1,4] Classifying a pneumothorax is primarily done by etiology as an acquired pneumothorax or spontaneous pneumothorax occurring secondary to rupture of cavitary, emphysematous lesions within the lung parenchyma.[4,6] Acquired pneumothorax is usually associated with trauma and is the most common in young, male intact dogs.[2,6] In one study, spontaneous pneumothorax was the most common in deep-chested, large breed dogs and was usually secondary to underlying lung disease.[4,5] Siberian Huskies were an overrepresented breed within the study.[5] Cavitary emphysematous lesions, such as bullae rupture or lung abscesses secondary to aspiration pneumonia, are less common than traumatic causes.[4,6] The following case report will review the history and presentation, pathophysiology, diagnostic consideration, treatment and management, and case outcome of a spontaneous tension pneumothorax in a canine.

History and Presentation:

Apollo is a 6-month-old male Great Dane who presented to MSU-CVM Emergency Service on April 5th, 2021 for a pneumothorax. Apollo had initially presented to Dr. Mitchell on March 29th, 2021 for vomiting and diarrhea the week prior to presentation. He was taken to surgery on March 30th, 2021 for an exploratory laparotomy and a foreign body was identified in the distal jejunum. The foreign body was removed by a single enterotomy and a prophylactic gastropexy was performed during surgery. He was hospitalized for 2 days following surgery and given the following medications orally: Simplicef, carprofen, omeprazole and sucralfate. He returned to his primary veterinarian on April 5th, 2021 for coughing and labored breathing.

Radiographs were taken of the thorax and he was diagnosed with a pneumothorax. Apollo was referred to AERC in Flowood, MS, where a thoracocentesis was performed, removing 5 liters of air from the right side of the thoracic cavity, and recheck thoracic radiographs taken immediately afterwards revealed the thorax had already refilled with air. AERC placed a thoracostomy tube on the right side of his thorax and sent him to MSU-CVM for further treatment and management. On arrival, Apollo was stable but had a continuous amount of air being pulled off his chest tube as well as a small amount of pleural fluid.

On physical exam, Apollo was quiet, alert, and responsive. He weighed 34.1 kg and had a body condition score of 4/9, with 4-5/9 being ideal. His mucous membranes were pink and with a capillary refill time of less than 2 seconds. He was tachypneic, coughing, and had increased abdominal effort were noted on presentation. On auscultation, diminished to absence of normal bronchopulmonary sounds were appreciated in the dorsal aspect of his thorax. Cardiac auscultation was normal with no murmurs, or arrhythmias heard. A Thoracic FAST (Focused Assessment with Sonography for Trauma) scan revealed B-lines throughout the ventral lung lobes and mild pleural effusion. He had an approximately 20 cm incision on his ventral abdomen for his foreign body surgery on March 30th. Femoral pulses were strong and synchronous with the heart. Lymph nodes were uniform and symmetrical. All other physical exam findings were within normal limits.

Immediately following presentation, fluid obtained from the right thoracostomy tube by the owner while in transport was submitted for fluid analysis, revealing severe suppurative inflammation. The differential consisted of 78% non-degenerate neutrophils, 2% small lymphocytes and 20% macrophages. No infectious agents or evidence of neoplasia were observed. Performing both aerobic and anaerobic cultures on the pleural fluid revealed growth of

hemolytic E. coli and an Alpha Streptococcus sp. A Complete Blood Count (CBC) revealed a moderate leukocytosis (27.04 10^3/ul, normal range 5.00-14.20), a moderate neutrophilia (22443.2 /ul, normal range 3100.0-11800.0), and mild thrombocytosis (536 10^3/ul, normal range 159-455). A chemistry panel revealed mild hypoalbuminemia (2.2 g/dl, normal range 2.5-3.9), mild hyperphosphatemia (6.9 mg/dl, normal range 2.5-5.0), mild hypercholesterolemia (446 mg/dl, normal range 140-360), and mild hypomagnesemia (1.5 mg/dl, normal range 1.7-2.4).

Thoracic radiographs showed a large volume pneumothorax and a small volume of fluid bilaterally within pleural spaces with retraction and rounding of the lung margins. There was dorsal displacement of the cardiac silhouette from the sternum on the lateral projections with a flattened and caudally displaced diaphragm with scalloping at the costal attachments. A moderate unstructured interstitial multifocally coalescing into an alveolar pulmonary pattern within all lung lobes most severe the ventral aspects of the right cranial and right middle lung lobes. The pulmonary lobar arteries and veins and caudal vena cava are moderately small. Overnight, Apollo experienced elevated respiratory rate and effort, and the decision was made to place a left thoracostomy tube to allow aspiration of air from the left side of his thoracic cavity. Treatments overnight included continuous suction of the right thoracostomy tube using a Pleuravac, hourly aspiration of the left thoracostomy tube, Lactated Ringer's Solution (55 ml/kg/day), methadone (0.2 mg/kg IV q6h), and cefoxitin (30 mg/kg IV q6h).

On April 6th, 2021, a thoracic CT with contrast revealed a marked right-sided pneumothorax and a mild left-sided pneumothorax with bilateral pleural effusion, most likely secondary to the necrosis of the right cranial lung lobe with gas tracts extending to the periphery of this lung lobe. The pulmonary changes were suspected to be secondary to necrotizing pneumonia as with previous aspiration. Due to high suspicion of necrosis of the right cranial lung

lobe leading to a continuous pneumothorax, an emergency exploratory right lateral thoracotomy was scheduled for the evening of April 6th, 2021.

Pathophysiology:

When air is within the pleural space without an obvious precipitating cause it is classified as a spontaneous pneumothorax.[4] The source of the air can be from the pulmonary parenchyma, trachea, bronchi, esophagus, and rarely, gas-producing bacteria within the pleural space.[4] When the loss of parietal or visceral pleural membrane integrity occurs due to underlying lung pathology, the pulmonary parenchyma is at risk of airway rupture.[2,4] This develops a fistula between the pleura and the lung, which acts like a one-way valve.[2,4] Each inspiration allows for air to enter the pleural space, but air is unable to exit on expiration leading to air accumulation within the pleural cavity resulting in loss of negative pressure.[2,4] The increase of intrathoracic pressure leads to significant respiratory and cardiovascular compromise.[2,4] Atelectasis occurs as a result of physical compression of the lungs leading to decreased ventilation through the affected lobes.[2,4] As a consequence the patient becomes rapidly hypoxemic, hypercapnic, and hypotensive.[2,4] Compensatory mechanisms to maintain adequate ventilation triggers chemoreceptors to increase ventilatory drive and simultaneously, mechanoreceptors stimulated by the deflated lung will increase respiratory rate and inspiratory force.[4] Literature suggests that spontaneous pneumothorax in dogs is often a secondary complication of aspiration pneumonia.[2,4,6] Additional secondary sequelae to aspiration pneumonia are often identified as abscessation and/or pleural effusion.[2,6,7]

Diagnostic Consideration:

The diagnosis of pneumothorax is suspected based on clinical signs but confirmed with thoracic radiographs and/or emergency TFAST ultrasound. Patients present for coughing,

increased respiratory rate and effort, exercise intolerance, history of vomiting, anorexia, pale or cyanotic mucous membranes, and lethary.[2,4,5] Some patients may present with rapid shallow inspirations and increased abdominal effort.[4] Thoracic FAST scan is commonly the first-line screening diagnostic for patients when there is clinical suspension of a pneumothorax.[4] The loss of "glide sign" on thoracic ultrasound is often utilized for diagnostic evidence for a pneumothorax.[4] In one prospective study in dogs, the overall sensitivity and specificity of TFAST was 78.1% and 93.4% respectively.[4] TFAST was reliable in detecting pleural fluid in a prospective study looking at diagnosis of pneumothorax using TFAST compared to computed tomography (CT), however, detection of pneumothorax was less reliable.[4] Utilization of serial TFAST examination to identify progressive pneumothorax can be critical in monitoring for when intervention is necessary prior to developing compromise of the respiratory or cardiovascular system.[4]

Radiographs of the thorax are the primary imaging modality for diagnosing pneumothorax due to the relatively high sensitivity, easy of performing, widely available, and inexpensive.[4] Radiographic findings of a pneumothorax are diffuse interstitial to alveolar pulmonary pattern, retracted lung lobes from the thoracic wall, radiolucent area of free air in which no pulmonary vascular structures are visible, tenting of the diaphragm, and dorsal deviation of the cardiac silhouette from the sternum on lateral projections.[4,6] Elevation of the cardiac silhouette from the sternum is not pathognomonic for a pneumothorax.[4] Tension pneumothorax is radiographically and clinically distinct due to the fatality risk necessitating critical early recognition and intervention.[4] Radiographic findings with tension pneumothorax are more severe pulmonary atelectasis, flattening, with or without "tenting" of the diaphragm, and thoracic barrel shape on VD/DV views.[4]

While CT is the gold standard for identifying bulla(e) and small volume pneumothorax, the practicality of radiographs makes them ideal for initial diagnosing imaging modality for pneumothorax.[4] In one study, the use of CT to detect bulla(e) in sternal and dorsal recumbency reported a sensitivity and positive predictive value of 57.7%-69.2% and 62.1%-78.9% respectively.[1,4] Performing a CT prior to an exploratory thoracotomy is useful for surgical planning, and the surgeon may elect a lateral thoracotomy for ipsilateral lesions.[4] A thoracocentesis may need to be performed prior to the CT to decrease atelectasis, as this can contribute to decreased identification of bullous lesions on CT.[1] Thoracocentesis does not only confirm diagnosis of a pneumothorax, but is also therapeutic in decreasing volume of air within the thorax.[1,3,4]

Treatment and Management:

If the patient presents tachypneic and with shallow inspiration, initial stabilization of the patient is the mainstay of treatment.[4] By performing a thoracocentesis to relieve the pneumothorax, the patient has immediate improvement in ventilation.[6] If more than two thoracocentesis are performed within twenty-four hours, it is recommended to place a thoracostomy tube.[2,3,6] Thoracostomy tubes are often indicated when large volume and/or rapid accumulation of air is causing respiratory compromise and allow for continuous suction to be step up when intermittent drainage is inadequate.[3,6] These can be placed under sedation or anesthesia, which is dependent on the stability of the patient.[3] Thoracostomy tubes may remain in place for 10-14 days, but they cause pleural reaction and will promote a mild pleural effusion.[6]

Surgical management is recommended early in treatment of spontaneous pneumothorax as strict medical management is often unsuccessful.[3,6] In one study, the mortality and recurrence rates of strict medical management of spontaneous pneumothorax were high, with 53% and 50%

respectively.[3] Clients should be informed of the high recurrence and mortality rates of treating conservatively when surgery is not feasible.[3] In dogs that underwent surgery, recurrence and mortality rates are low (0-25%, 12% respectively), and high long-term survival times with 83.5% alive at 5 years.[3] A median sternotomy is often preferred over a lateral thoracotomy, as it allows access to both sides of the thoracic cavity.[2,3,5] A recent study compared the short-term outcomes between the approaches revealed either approach is well tolerated in dogs.[3] The utilization of filling the thoracic cavity with saline aids in identification of the lesions by localizing the bubbling to where the air leakage is occurring.[1,3] Upon localization of the lesion, the surgeon can decide whether to perform a partial or complete lung lobectomy.[2,3] In cases of lung abscesses, a lung lobectomy is preferred to antimicrobial therapy and thoracocentesis alone, as these appear to be in adequate therapy and have higher risk of pyothorax and pneumothorax.[2] During surgery, any tissue samples collected should be submitted for histopathology and culture. Prognosis is variable, but with successful identification of the lesion and surgical removal, prognosis is typically excellent.[3]

Case Outcome:

The patient underwent an emergency right lateral exploratory thoracotomy surgery on the evening of April 6th, 2021. While the patient was being prepped for surgery, his right thoracostomy tube was continuously aspirated to ensure adequate inflation of his lungs. It was removed prior to the final sterile prep in the operating room. A right cranial thoracotomy of the 5th intercostal space was performed, the right cranial and middle lung lobe were evaluated, and on the dorsal aspect of the right cranial lung lobe was a ruptured lung abscess. A complete lobectomy was performed on the isolated right cranial lung lobe using a Thoraco-abdominal (TA)-30 stapler to seal the pedicle, and the lobe was removed. All other lung lobes were

examined and were all within normal limits. The right cranial lung lobe was cut through the lesion, swabbed with a culturette on the cut edge, and was submitted for histopathology. The thoracic cavity was filled with sterile saline and the patient was ventilated in order to observe any air escaping in the form of bubbles. A 20 French thoracostomy tube was placed transcostally through the right thoracic wall and a diffusion catheter was placed lying under the superficial muscle layers prior to closing the thoracic cavity. After closing, his post-surgical care included aspiration from the right thoracostomy tube with a goal of 1-2 ml/kg/day of air and fluid, enrofloxacin (10 mg/kg IV q24h), bupivacaine (1 mg/kg diffusion catheter q6h), cefoxitin (30 mg/kg IV q6h), hydromorphone (0.05 mg/kg IV q4h), monitoring the incision site for infection and monitoring for respiratory distress. The day after surgery, Apollo was switched to oral enrofloxacin and cefpodoxime, and started on Tylenol 4 (1.8 mg/kg PO q8h), carprofen (2.2 mg/kg PO q12h). Following surgery, Apollo's pneumothorax and pleural effusion continued to decrease and his right thoracostomy tube and diffusion catheter were removed on April 9th, 2021. Histopathology of the right cranial lung lobe revealed necrotizing and fibrinosuppurative bronchopneumonia with focal abscess formation and intralesional bacterial colonization. The aerobic and anaerobic culture from the cut edge of the lung lesion revealed growth of hemolytic E. coli, *Enterococcus faecalis*, and *Staphylococcus intermedius*. On April 10th, 2021, Apollo was discharged after six days in the hospital and at this time his physical exam parameters were within normal limits. His incision was healing appropriately, and he was breathing normally. Client discharges included activity restriction, incision care, what to monitor Apollo for, and medication instructions. Apollo was prescribed Tylenol 4 at 1.8 mg/kg every eight hours for seven days, carprofen at 2.2 mg/kg every twelve hours for two days, Clavamox at 15 mg/kg every twelve hours for seven days, enrofloxacin 10 mg/kg once daily for seven days, and

trazodone at 5.8 mg/kg every eight hours for fourteen days. At the time of discharge, a recheck was recommended to evaluate Apollo's incision in ten to fourteen days following his surgery. His owner elected to schedule rechecks with his primary veterinarian. Based on Apollo's history leading up to his pneumothorax, the results of his diagnostic tests, and the findings during surgery, Apollo was diagnosed with a spontaneous pneumothorax secondary to a ruptured right cranial lung lobe abscess consequential to aspiration pneumonia from vomiting the previous week. Apollo was successfully treated with a right cranial lung lobectomy, aspiration of right thoracostomy tube following surgery to establish negative pressure, and broad-spectrum antimicrobial medications based on culture and sensitivity to treat his aspiration pneumonia. In a recent phone call with Apollo's owners, he has been doing great at home and has not experienced any long-term respiratory complications.

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