Although the terms pleuritis and pleuropneumonia are often used interchangeably, pleuropneumonia is preferred because this disease in horses typically involves underlying viral or bacterial infection of the lung parenchyma with subsequent extension to the pleurae. The pleural response to inflammation is transudation or exudation of fluid into the pleural space, resulting in accumulation of a sometimes marked volume of effusion. Other causes of fluid in the pleural space include neoplastic effusion, transudation of fluid secondary to acute or severe hypoalbuminemia, and penetrating thoracic wounds. Although some forms of pleurisy in humans involve, and are restricted to, the pleural membranes, infectious pleuritis unassociated with a primary pulmonary infection is rare in horses. Pleural inflammation in horses usually develops secondary to bacterial infection, but mycotic, mycoplasmal, nocardial, and metacestodal infections have been identified. Penetrating thoracic wounds that lead to infection of the parietal pleura are an exception, but the assumption that a horse with pleuritis has concurrent underlying pneumonia is correct in most instances.

Diagnostic Criteria
- No sex predisposition.
- The disease most commonly affects adult horses but can also affect foals and yearlings.
- Medical history often includes recent land transport, air transport, or residence at a show or sales venue where large numbers of horses commingled.
- Other events commonly associated with pleuropneumonia in horses include recent general anesthesia, tracheal intubation, or surgery (especially procedures involving the upper airway).
- Continuing training or competition while being treated for low-grade signs of respiratory tract infection.
- Disruptions in routine, such as a recent increase in training intensity or competition stress.
- Influenza is a known precedent of pleuropneumonia.
- Diagnosed most commonly in racehorses, likely because horses in race training or competition are young and the most frequently exposed to various combinations of the above risk factors.
- Some horses develop pleuropneumonia despite having no identifiable risk factors.

Physical Examination Findings
- Fever, lethargy, and inappetence; owners may report that the horse has recently lost weight.
- High heart and respiratory rates (>40 bpm and >16 respirations/min, respectively); toxic vascular injection pattern in oral mucous membranes and sclerae.
- Anxious facial expression with overall depressed demeanor; nostrils may be flared at rest.
- Nasal discharge is variable and not always detected; when observed, discharge can be odorless or fetid.

*Updated by the author and reprinted with permission from Standards of Care: Equine Diagnosis and Treatment 2002;2:1-5, 10.
Signs of thoracic pain (pleurodynia) may be evident, including grunting during the chest wall's ventilatory excursions and standing with elbows abducted. Thoracic auscultation reveals dullness ventrally; lung sounds heard dorsally may vary from normal to abnormal according to the distribution of underlying pulmonary disease. Friction rubs may be auscultated initially; however, development of effusion separates visceral and parietal pleurae, eliminating some abnormal sounds.

Percussion of thorax reveals easily distinguished horizontal line below which dullness and absence of resonance are obvious. Affected horses often flinch or grunt at the examiner's efforts to percuss the chest and may try to evade contact.

Coughing, if present, is typically soft, moist, and deep.

Ventral edema often develops below the thorax; this finding is common when pleural effusion is voluminous.

Stiff, stilted gait in forelimbs. Reluctance to walk and signs of pain may be exacerbated when the horse is asked to turn, similar to signs of laminitis. This results from the horse’s attempt to minimize rib movement. Severe cases of pleuropneumonia may cause laminitis.

Signs of colic may result from referred pain from the thorax to visceral structures or impaction secondary to hypovolemia and reluctance to defecate.

Other Diagnostic Procedures

Ultrasonography is the initial imaging modality of choice.

Ultrasonography noninvasively and promptly confirms the presence of pleural effusion and distinguishes between unilateral and bilateral pleural effusion. Ultrasonography is very helpful for determining the optimum site of drain-tube placement.

Pleuropneumonia is recognized as anechoic to echogenic fluid accumulated in the pleural cavity. The fluid volume is often sufficient to buoy lung lobes while causing hydraulic compression and atelectasis along the ventral margin.

The pulmonary tissue usually has an abnormal appearance that may involve abscess formation, broad to coalescing comet-tail artifacts, early organization of fibrin and fluid into pockets that will become abscesses, adhesions to
parietal and diaphragmatic pleurae, or homogeneous infiltrative patterns (FIGURE 3).

- In aggravated or severe cases, exuberant fronds of fibrin may be seen emanating from pleural surfaces and undulating in the fluid or forming thick tethering adhesions between the lung and the chest wall. Also commonly imaged is collapsed or hepatized lung tissue containing pockets of gas that can represent islands of aerated alveoli be gas elaborated by anaerobes (FIGURE 4).

- Radiography is useful in detecting pulmonary lesions in deeper, more axial tissue planes that do not communicate with the pleural surface (e.g., lesions associated with deep parenchymal abscesses, interstitial infiltration, pulmonary edema, or peribronchial infiltration).

- Thoracocentesis: yields pleural fluid for bacterial culture and cytologic analysis (BOX 2). Fluid can be collected via cannula or from the placed chest tube.

- Transtracheal aspiration should be performed at admission, ideally before administration of antimicrobials, and samples submitted for culture and cytology. It is helpful to culture both pleural fluid and tracheal fluid because pleural fluid does not always yield bacterial growth and because isolates cultured from airways differ from those cultured from pleural fluid in many instances.

- Blood culture is a useful ancillary diagnostic aid for increasing the odds of isolating causative pathogens and for determining whether an equine patient is septic.

### Laboratory Findings

#### Complete Blood Count and Serum Biochemistry

- Blood work frequently reveals inflammatory changes such as neutrophilia, with or without a left shift, and hyperproteinemia secondary to hyperfibrinogenemia and hyperglobulinaemia; some horses are also hypovolemic at evaluation, which exacerbates high serum protein values.

- Blood values in horses in the peracute or subacute stages of infection with bacterial sepsis may reveal leukopenia, neutropenia, hypoprothrombinemia, hypoconcentration, and azotemia.

### Critical Point

It is helpful to culture both pleural fluid and tracheal fluid because pleural fluid does not always yield bacterial growth and because isolates cultured from airways differ from those cultured from pleural fluid in many instances.

### Chest-Tube Placement

1. **Sedate** the patient and aseptically prepare the area of tube placement as determined by ultrasonography.
2. **Block** the skin and chest wall with anesthetic solution at the site of tube placement.
3. **With sterile technique**, make a full-thickness stab incision using a scalpel.
4. **Insert** the chest drain or cannula into the incision and carefully advance it into the pleural cavity. The depth markers on the ultrasonographic image can be used to determine how far the trocar must penetrate before reaching the pleural cavity.
5. **Have sterile forceps available** to clamp onto the tube if positive flow of pleural fluid stops. Aspiration of air into the tube can lead to pneumothorax.
6. **Secure chest tube** in place using a Chinese finger-trap suture and affix a Heimlich valve (or a condom) over the end of the drain and secure with electrical tape.
7. **The drain** should be left indwelling only if the patient can be visually monitored frequently. This is especially important in foals. When the fluid exiting the drain becomes minimal, the tube may be ready to remove; serial ultrasonography can help determine removal.

**Ultrasonogram of the right hemithorax in a yearling Thoroughbred colt.** Note the thick bilayered accumulation of fibrin adherent to the parietal pleura (circle) and the large volume of anechoic fluid (brackets) separating the chest wall from the surface of the abnormal lung.
With chronicity, the leukocyte count and fibrinogen concentration may be within reference range or may be high.

**Analysis of Pleural Fluid and Tracheal Aspirate**
- Assessment of fluid samples (BOX 2; FIGURE 5).
- Wright's staining should be performed and fluid cytologically assessed to determine whether the effusion is neoplastic.
- Tracheal aspirate should undergo Gram staining, aerobic and anaerobic culture and sensitivity testing, and cytologic analysis.

**Summary of Diagnostic Criteria**
- History of recent transport, upper respiratory tract viral infection, surgery, anesthesia, or intubation.
- Painful cough, fever, and possible nasal discharge.
- Auscultation of dullness in the ventral portion of the thorax, with normal or abnormal lung sounds dorsally; fluid line can often be established via auscultation or percussion.
- Inflammatory changes in routine blood work results (e.g., complete blood count).
- Ultrasonographic demonstration of hypoechoic to anechoic fluid in one or both pleural cavities.

**Differential Diagnosis**
- Neoplastic effusion.
- Transudation of fluid into intracavitary location secondary to low oncotic pressure (from protein-losing enteropathy or nephropathy).
- Penetrating chest wound.
- Hemothorax.
- Pulmonary hydatidosis.

**Treatment Recommendations**

**Initial Treatment**
Acute, mild pleuropneumonia may be managed successfully with antimicrobials and antiinflammatories, and affected horses may recover with no need for invasive procedures, protracted treatment, or monitoring. Even horses with mild disease should be prescribed at least 30 days of rest from training or any form of induced exercise. Principles guiding treatment of complicated pleuropneumonia include:

- Removal of effusion and inflammatory material from pleural space as needed.
- Arrest of underlying bacterial infection by administering broad-spectrum antimicrobials.
- Serial monitoring and control of secondary complications that can result from the disease process or develop as iatrogenic problems associated with interventional measures.

**Removal of Pleural Fluid**
In horses with substantial volumes of effusion (e.g., 10 to 20 L), establishing drainage and removing the fluid is necessary, in addition to administering antimicrobials and other medications. Administration of antimicrobials alone will not result in a successful outcome in horses with pleural effusion. Insertion of a teat cannula into the pleural space is effective for sampling and removing fluid if the volume is modest and there is little or no fibrin in the fluid to obstruct the cannula. If pleural effusion is removed by cannulization, it must often be repeated daily or multiple times before antimicrobial treatment effectively controls the underlying infection, thereby curtailing the inflammatory mechanisms that drive production of effusion.

An indwelling chest tube is a more efficient conduit for removing a large volume of pleural fluid. However, rapid removal of effusion may lead to circulatory collapse and shock because of third-space effects; intravenous replacement fluids should be administered before and during drainage of pleural fluid.

**Critical Point**
Acute, mild pleuropneumonia may be managed successfully with antimicrobials and antiinflammatories, and affected horses may recover with no need for invasive procedures, protracted treatment, or monitoring. Even horses with mild disease should be prescribed at least 30 days of rest from training or any form of induced exercise.
A Heimlich valve (or a condom with the end snipped off) must be affixed to the end of the tube to avoid pneumothorax.

An indwelling large-bore tube (e.g., a 20- to 32-French trocar catheter) enables constant egress of effusion and exudate, which is facilitated by lung excursions during inspiration and expiration.

In some instances, a drain placed in one hemithorax will drain both sides of the chest because of the perforated conformation of the caudal part of the mediastinum in horses. With chronicity, the pores become plugged or filled with inflammatory debris, and the two hemithoraces may not communicate. In this instance, a tube must be placed in each hemithorax to remove all fluid.

Whether a cannula or larger-bore tube is placed, the instrument should be situated in the middle of the selected intercostal space to avoid the vein–artery–nerve bundles that course along the caudal aspect of each rib.

The lateral thoracic vein must be avoided in its course along the ventral aspect of the thorax.

Once placed and secured, chest tubes may be left indwelling until substantial drainage ceases. Tubes are typically left in situ for 2 to 3 days but, because of the risk of acute pneumothorax, should not be left indwelling if the horse cannot be monitored around the clock. It is not unusual for ultrasonography to reveal reaccumulation of pleural fluid several days after removal of a drainage tube; in this instance, a new tube should be placed, optimally by ultrasound guidance. Because this scenario is common, it should be included in the estimate to the owner at the outset of treatment.

Controlling Underlying Bacterial Infection

Frequently isolated aerobes:
- β-hemolytic Streptococcus spp.
- Actinobacillus spp.
- Pasteurella spp.
- Escherichia coli.
- Klebsiella pneumoniae.

Assessment of Pleural Fluid Samples

Assessment of pleural fluid samples collected during thoracocentesis should include aerobic and anaerobic bacterial culture and sensitivity testing as well as determination of protein concentration (<2.5 mg/dL is normal) and nucleated cell numbers (<5000 [some references cite <10,000] cells/µL is normal). The latter two indices indicate whether effusion is exudative or transudative in nature and, combined with values of L-lactate dehydrogenase (>1000 U/L is high), glucose (<40 mg/dL is low), and pH (<7.1 is low), offer prompt empiric determination of septic effusion until culture results are available.
Anaerobes:
- *Bacteroides* spp (common).
- *Peptostreptococcus* spp (common).
- *Clostridium* spp (uncommon).

Broad-spectrum antimicrobials (TABLE 1) should be administered as soon as fluid samples have been obtained from the transtracheal aspirate and pleural space. If a horse has been treated with antimicrobials at the time of admission and is physiologically stable, I may recommend withdrawing the treatments and delaying these procedures for 24 hours to maximize the likelihood of microbial growth from fluid samples. In more compromised horses, the procedures are performed at admission regardless of previous treatment.

TABLE 1 Therapeutic Agents and Dosages

<table>
<thead>
<tr>
<th>Drug</th>
<th>Dose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium ampicillin</td>
<td>15–30 mg/kg IV q8h</td>
</tr>
<tr>
<td>Potassium penicillin G</td>
<td>20,000–50,000 IU/kg IV q6h</td>
</tr>
<tr>
<td>Procaine penicillin G</td>
<td>20,000–50,000 IU/kg IM q12h</td>
</tr>
<tr>
<td>Ceftriaxone</td>
<td>2.2–5 mg/kg IV or IM q12h</td>
</tr>
<tr>
<td>Ceftazidime</td>
<td>20–50 mg/kg IV q12h</td>
</tr>
<tr>
<td>Gentamicin sulfate</td>
<td>6.6 mg/kg IV or IM q24h</td>
</tr>
<tr>
<td>Amikacin sulfate</td>
<td>21–23 mg/kg IV or IM q24h</td>
</tr>
<tr>
<td>Enrofloxacin</td>
<td>5.5 mg/kg IV q24h; 7.5 mg/kg PO q24h or 4 mg/kg PO q12h</td>
</tr>
<tr>
<td>Metronidazole</td>
<td>10–25 mg/kg PO q6–12h</td>
</tr>
<tr>
<td>Trimethoprim–sulfamethoxazole</td>
<td>30 mg/kg PO q12h</td>
</tr>
<tr>
<td>Doxycycline HCl</td>
<td>5–10 mg/kg PO q12–24h</td>
</tr>
<tr>
<td>Chloromphenicol palmitate</td>
<td>40 mg/kg PO q6–8h</td>
</tr>
<tr>
<td>Rifampin</td>
<td>5–10 mg/kg PO q12h</td>
</tr>
<tr>
<td>Phenybutazone</td>
<td>2.2–4.4 mg/kg IV or PO q12h</td>
</tr>
<tr>
<td>Flunixin meglumine</td>
<td>0.5–1.1 mg/kg IV or IM q12h</td>
</tr>
<tr>
<td>Butorphanol tartrate</td>
<td>0.01–0.02 mg/kg IV or IM q6–12h</td>
</tr>
</tbody>
</table>

- Adjust as needed based on therapeutic drug monitoring and determination of peak and trough concentrations.
- Metronidazole can be given rectally, with some loss in availability and absorption, in equine patients with ileus or other forms of gastrointestinal tract failure. At higher dosages, horses can develop depression, ataxia, and anorexia.

Treatment with NSAIDs is also indicated to relieve pyrexia and pain; flunixin meglumine, phenylbutazone, and ketoprofen are commonly used for the first week of treatment or longer. Narcotics such as butorphanol tartrate can effectively augment the analgesic effect of NSAIDs, but long-term administration of these drugs can cause constipation, especially in horses that are not drinking adequately and are reluctant to defecate because of chest-wall pain. Administration of corticosteroids is not indicated in horses with pleuropneumonia, despite the antiinflammatory effects of these drugs.

The decision to change to orally administered antimicrobials should be made on the basis of a positive response to treatment, manifested by resolution of drainage from chest tubes or by serial sonographic imaging to confirm absence of effusion.

Selection of oral antimicrobials should be based on culture and sensitivity results; repeated culturing of pleural or tracheal fluid is recommended when effusion continues despite treatment or when fever persists. Trimethoprim–sulfamethoxazole, chloramphenicol, rifampin, doxycycline, and enrofloxacin may be useful in horses with pleuropneumonia. As with any horse receiving antimicrobials, colonic disturbance is a potential complication of treatment; therefore, the horse’s appetite and fecal consistency should be closely monitored during treatment.
Monitoring and Controlling Complications
Serial blood monitoring and sonographic imaging should be conducted frequently during the initial treatment period to ensure response to therapy. Complications associated with pleuropneumonia include those that develop as a result of the disease process (e.g., laminitis) or therapeutic measures (such as development of pneumothorax or cellulitis of the thoracic wall).

Ideally, horses with pleuropneumonia are hospitalized during the initial treatment phase, when instrumentation with indwelling pleural drains and intravenous catheters is necessary. Access to a facility where diagnostic ultrasonography is available and personnel are on duty to recognize and respond to problems is a critical factor in patient outcome.

Complications Associated with the Disease Process
- Bronchopleural fistula formation (and secondary pneumothorax) due to lung tissue necrosis leading to communication between the airways and pleural space.
- Development of fibrinous interpleural adhesions.
- Development of pulmonary abscesses and loculation of fluid into multiple noncommunicating cells.
- Forward dissection and organization of empyema into cranial mediastinal abscess.
- Pericarditis.
- Laminitis.

Iatrogenic Complications
- Cellulitis at chest-tube insertion sites.
- Development of pneumothorax from leakage of air around or into indwelling tubes.
- Antimicrobial-induced colitis.
- Immune-mediated anemia secondary to administration of β-lactam drugs or enrofloxacin.
- Jugular phlebitis or thrombosis at catheter site.

Additional Treatment Measures
- Trocarization of pulmonary or extrapulmonary abscesses.
- Lavage of pleural cavity may be necessary to remove inspissated material, eliminate fluid dead space and large microbial populations, and help prevent adhesion formation between the visceral and parietal pleurae.
- Thoracostomy or use of the “finger-hole” technique may aid in draining exudate or accumulated fibrinous material. Before such a defect is created in the thoracic wall, it must be determined whether the mediastinum has become imperforate (by plugging and filling of the communicating pores) so that the resultant pneumothorax will not affect both hemithoraces. This can be facilitated by placing a trocar catheter and leaving it open to aspirate air for brief periods in order to determine whether the horse remains stable with the other lung inflated. Otherwise, the horse is not a candidate for thoracostomy.
- Surgical thoracotomy or rib resection can be performed in aggravated cases in which response to treatment is poor or lavage of the pleural cavity through an indwelling tube or thoracostomy opening is insufficient. The same considerations mentioned for pneumothorax apply.
- Trocarization and drainage of cranial mediastinal masses may be necessary to manage abscesses that compromise cardiovascular function by compressing the cardiac chambers (especially the right ventricular outflow tract) or great vessels.

Prognosis
Once pleuropneumonia has been diagnosed, recommendations regarding treatment should be made with candid discussion of the protracted course of treatment; expenses associated with hospitalization, medications, and monitoring; and likelihood for development of sequelae and necessary treatment. Many horses with pleuropneumonia can have a favorable prognosis for survival if appropriate treatment and intervention are provided. The prognosis for survival in horses with pleuropneumonia is largely related to the persistence of a treating veterinarian who is experienced in diagnostic ultrasonography, pleurocentesis, and placing pleural drainage tubes. Complications and sequelae of the infection or of treatment must be addressed promptly and sometimes repeatedly.

Although clients must decide whether the horse’s value justifies the expense and long-term commitment to provide care, it is possible to have a positive outcome. Referral of the horse to a referral care center for initial confirmation, instrumentation, and treatment is often the most tenable course of action, with the horse discharged as soon as feasible.

Critical Point
Many horses with pleuropneumonia can have a favorable prognosis for survival if appropriate treatment and intervention are provided.
to the owner’s care and referring veterinarian’s supervision for long-term follow-up monitoring and treatment.

Favorable Criteria
- Positive response to treatment: resolution of fever and substantial decrease in or cessation of pleural fluid production.
- Horse tolerates chest-tube manipulation, medication, and ancillary care procedures and does not develop secondary laminitis.

Unfavorable Criteria
- Pleural effusion continues despite administration of broad-spectrum antimicrobials.
- Development of anaerobic infection.
- Development of necrotizing or gangrenous pneumonia.
- Development of laminitis.
- Horse is intractable or intolerant of handling, confinement, or frequent medical intervention.

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SEE RECOMMENDED READING ON NEXT PAGE.
Pleuropneumonia

**Recommended Reading**