



Pneumonia in weanlings

Bonnie S. Barr, VMD

Rood and Riddle Equine Hospital, PO Box 12070, Lexington, KY 40580, USA

Respiratory disease involving the lower respiratory tract is common in suckling and weanling foals. A study from Texas revealed that the most common cause of morbidity and mortality in foals 1 to 6 months of age was pneumonia [1]. In our practice, a large percentage of suckling foals and weanlings are presented to our department with the primary complaint of a respiratory problem. Susceptibility to pneumonia in these animals is the result of a decrease in the maternal antibodies and a potential delay in the production of their own antibodies. Also important are environmental factors, including crowding, handling, weaning, and, particularly in our area, preparation for sales and the actual sales process. This article reviews the causes of pneumonia seen in our hospital population, including bacterial and viral causes and an acute respiratory distress syndrome.

Bacterial causes

Streptococcus zooepidemicus

Streptococcus zooepidemicus is a common cause of lower respiratory tract disease in sucklings and weanlings. This organism has been implicated in bronchopneumonia, pleuritis, and pleuropneumonia in all age groups [2–4]. It has been reported that *S zooepidemicus* infection resulting in pulmonary abscess occurred in equal frequency as *Rhodococcus equi* in young foals and weanlings [3]. Last year in our hospital, *S zooepidemicus* was the most common organism isolated from transtracheal washes from young foals and weanlings. Clinical signs of *S zooepidemicus* infection of the lower airways include depression, nasal discharge, cough, fever, tachypnea, and increased respiratory effort [2,4]. Auscultation of the thorax reveals adventitial lung sounds ranging from diffuse crackles and wheezes to decreased or absent lung sounds ventrally [2,4]. *S zooepidemicus* is a β -hemolytic streptococcus

E-mail address: bbarr@roodandriddle.com

that is found in the upper respiratory tract of healthy horses [2,5]. Because *S zooepidemicus* is unable to invade intact mucous membranes, preexisting damage is necessary for infection [5]. Respiratory viral infections and environmental stressors, such as overcrowding, poor nutrition, concurrent disease, transportation, or weaning, can lead to impairment of the normal defense mechanism of the respiratory tract and allow the establishment of disease. Investigators have found that healthy horses harbor several strains of *S zooepidemicus* in their tonsillar region, although only a single strain has been found to cause pneumonia [5]. The virulence and pathogenicity of *S zooepidemicus* in horses have not been extensively studied [5].

Blood work generally reveals a neutrophilic leukocytosis and hyperfibrinogenemia. Thoracic radiographs are important in determining the degree of involvement and the presence or absence of abscesses. Ultrasound is useful to identify pleural effusion or abscessation of the peripheral lung parenchyma. Gram stains of material obtained from a transtracheal aspirate reveal gram-positive cocci and can help to establish a presumptive diagnosis of a streptococcal infection. Culture of the organism allows for a definitive diagnosis and an antimicrobial sensitivity pattern on which to base treatment. In most instances, *S zooepidemicus* is sensitive to β -lactams, chloramphenicol, trimethoprim-sulfa combinations, rifampin, and erythromycin [2,4]. Occasionally, cytology or culture reveals concurrent infection with other pathogenic organisms, and additional antimicrobials may need to be added. An appropriate response to treatment includes a decrease in the nasal discharge, normothermia, cessation of cough, and improvement of adventitial lung sounds [2]. The treatment course may be short (7–14 days) or long (4–6 weeks) depending on the severity of the disease and clinical response to therapy. Relapses have been reported along with complications, including polysynovitis, vegetative endocarditis, and vasculitis of the peripheral limbs [2]. These complications may be the result of a bacteremia or an immune-mediated response. No vaccination is available for *S zooepidemicus*, and the only means of prevention includes reduction of environmental stressors, appropriate vaccination for respiratory viruses, and reduction of exposure to respiratory viruses.

Rhodococcus equi

Rhodococcus equi is an important cause of subacute to chronic bronchopneumonia in foals less than 6 months of age [4,6]. It usually manifests as a chronic, suppurative bronchopneumonia with extensive abscessation, although extrapulmonary lesions frequently are reported [3,4,6]. Early clinical signs of bronchopneumonia are vague and include mild fever or a slight increase in respiratory rate. As the pneumonia progresses, the clinical signs include inappetence, lethargy, fever, and tachypnea [4,6]. The tachypnea is characterized by an increased effort, a nostril flare, and an increased abdominal component [4,6]. Initial auscultation of the thorax reveals

a diffuse increase in bronchial sounds, which progresses to localized cranioventral wheezes and, eventually, to diffuse crackles with marked tracheal sounds. A small percentage of foals may be presented with a subacute form characterized by acute respiratory distress with a high fever and no history of previous respiratory disease, or the foal may be found dead [4,6].

Extrapulmonary lesions may be associated with pneumonia or independent of pneumonia. Gastrointestinal involvement may consist of ulcerative colitis, abdominal lymphadenitis, typhlitis, or a single large abdominal abscess [6]. Clinical signs of intestinal involvement include colic, diarrhea, weight loss, and poor growth [6]. In a retrospective study, approximately half of the foals that were presented for pneumonia also had evidence of gastrointestinal involvement [6,7]. Polysynovitis has been reported in foals that are presented with *R equi* pneumonia and is caused by an immune complex deposition within the synovial structures [6]. Lameness is rarely apparent, and cytologic evaluation of the synovial fluid reveals a nonseptic mononuclear pleocytosis. Bacteremia occasionally results in septic arthritis or osteomyelitis. Other manifestations, including uveitis, anemia, and thrombocytopenia, may arise from an immune-mediated response. Neurologic signs may be associated with *R equi* vertebral body osteomyelitis [8]. Other extrapulmonary disorders may involve the heart, kidney, or liver [6,7].

R equi is a pleomorphic gram-positive bacterium that has been frequently isolated from soil samples throughout the world, even in areas never inhabited by horses [9–13]. Despite this widespread environmental distribution, *R equi* infection is endemic to some farms, occurs occasionally on others, or may never be found on a farm [9,10,12,13]. Several factors may influence the incidence of the disease, including the environment, management of the farm, and virulence of the organism. Ideal environmental conditions for the organism include warm and dry temperatures, with optimal growth at around 37°C (98.6°F) [10]. Improper management also plays a role in the incidence of the disease, especially on endemic farms, and becomes important in prevention of the disease. There are several potential virulence factors, but it seems that an 85-kb plasmid is essential for the virulence of the organism and for intracellular replication within the macrophage [14–16]. Genes of this plasmid encode for several proteins called virulence-associated protein (Vap) A through H [14,16]. Isolates from foals with clinical disease express Vap A, although it seems that alone, this protein may not be enough to establish virulence [16]. Vap C, D, and E are expressed on Vap A-positive isolates only when the bacteria is grown at temperatures compatible with virulence; therefore, these proteins in combination may be crucial for virulence [14,16]. The major route of exposure for the pneumonic form is inhalation of dust particles laden with virulent *R equi* [13,17]. The pathogenesis of the organism is related to its ability to survive and replicate within alveolar macrophages by inhibiting

phagosome-lysosome fusion after phagocytosis [15,18]. Immunity to infection, although not fully understood, probably involves both humoral and cell-mediated immunity [6,15]. The organism can multiply in the intestine of foals up to 3 months of age and occasionally leads to hematogenously acquired pneumonia [17]. This exposure may result in antibody formation. The development of gastrointestinal lesions probably stems from the ingestion of large quantities of contaminated sputum. Most adults have been exposed to the organism and have an established immunity.

Diagnosis of *R equi* pneumonia includes a history, physical examination findings, blood work, thoracic radiographs, and results of the transtracheal wash. Cytologic evaluation and aerobic bacterial culture can be used to distinguish *R equi* pneumonia from other forms of pneumonia and can be used to establish a sensitivity pattern [6]. On cytologic evaluation, gram-positive pleomorphic rods are suggestive of *R equi*. If a transtracheal wash cannot be performed because of the severity of the disease, a presumptive diagnosis can be made from clinical signs, changes in blood work, age of the foal, and a history of an endemic problem on the farm. Common changes on blood work include hyperfibrinogenemia and neutrophilic leukocytosis with or without monocytosis. Radiographic changes can vary from a prominent interstitial pattern to dense patchy alveolar opacities, lung consolidation, and abscesses. Radiographs can help to establish the severity of the lesions and the response to therapy. Thoracic ultrasound can be helpful if the lesions extend to the periphery, but radiographs are generally more useful. Without clinical disease, serologic tests can be difficult to interpret as a result of antibody production because of the widespread exposure of foals to the organism and the presence of maternally derived antibodies [6,19,20]. Therefore, serologic tests may be more useful in detecting exposure at the farm level [6,19,20]. Polymerase chain reaction (PCR) testing is accurate, but bacterial culture offers the advantage of antimicrobial susceptibility testing [6,19,20]. Diagnosis of the extrapulmonary manifestations of *R equi* requires evaluation of the anatomic area in question. Additional procedures include a lameness examination, a neurologic examination, abdominal ultrasound, abdominocentesis, and arthrocentesis.

The most common antimicrobial combination used to treat *R equi* is erythromycin and rifampin [6,21]. These drugs are bacteriostatic and synergistic against *R equi*, and this combination is lipophilic in nature to penetrate abscesses and cells [6,21]. Azithromycin, an azalide antimicrobial, has been found to be effective against *R equi* and achieves appropriate intracellular levels [22]. An additional antimicrobial may need to be added if the transtracheal aspirate culture results reveal the presence of another pathogenic organism that is not susceptible to erythromycin or rifampin [6]. Results of in vitro testing of aminoglycosides in combination with erythromycin and rifampin reveal antagonistic activity against *R equi*; therefore, it is not recommended to use these drugs in combination [6].

Response to treatment is noted with resolution of clinical signs, normalization of blood work, and resolution of radiographic lesions. Usually, treatment ranges between 4 and 9 weeks, although resistant strains have been encountered. The treatment of extrapulmonary lesions includes the above-mentioned antimicrobials plus additional supportive measures such as fluids, blood transfusions, and nonsteroidal anti-inflammatories. Aggressive joint lavage and local therapy may be required if septic arthritis or osteomyelitis is diagnosed. Those clinical signs that result from an immune-mediated response resolve once the systemic disease is under control. Occasionally, erythromycin can cause changes in the foal's fecal consistency or thermoregulation [21,23]. *Clostridium difficile* enterocolitis has been reported in mares of foals being treated with erythromycin and is suspected to be caused by inadvertent ingestion of erythromycin from the feces of the foals or material contaminated with feces, which disrupts the mare's intestinal flora [24].

Prognosis for survival is reported to be around 70% to 80%, with death more likely in those foals that have severe respiratory signs, severe thoracic radiographic changes, lameness, and joint effusion [25]. Fifty-four percent of foals survived to race once, and their overall racing performance was average [26]. These findings suggest that appropriate therapy needs to be instituted, but more importantly, preventative and control measures must be taken to prevent the disease, especially on endemic farms. Appropriate management factors to decrease the size of infective challenges are important and include avoiding overcrowding, decreasing the amount of dirt or sandy areas, rotating pastures, housing in well-ventilated and dust-free areas, and isolation of foals with clinical signs because they have the more virulent form in their feces [6,9]. Foals should be closely monitored for earlier recognition of disease. Monitoring should include daily rectal temperature, serologic surveillance, plasma fibrinogen levels every 2 weeks, and physical examination [9]. Passive immunization with hyperimmune plasma has become the mainstay of protection on many endemically infected farms [9]. The ideal amount and time for plasma administration are still not known, but current recommendations include 1 L within the first week of life and then another liter 25 to 30 days later [9]. A single administration at 10 to 21 days may be adequate for those farms with lower morbidity [9].

Streptococcus equi

Equine strangles, the causative agent of which is *Streptococcus equi*, is typically a disease of the upper respiratory tract and lymph nodes, although disease of the lower respiratory tract can occur [27–30]. Typically a disease of older horses (1–3-year-olds), strangles can also infect young animals especially in cases of herd outbreaks. The onset of disease is marked by depression, fever, mucoid nasal discharge, slight cough, loss of appetite, difficulty in swallowing, and slight swelling and tenderness in the

intermandibular area [27–30]. Eventually, the nasal discharge becomes purulent, and the abscesses in the submandibular, submaxillary, or retropharyngeal lymph nodes enlarge and become hard and painful. The abscesses usually rupture and drain within 7 to 14 days [27,29,31]. Most animals recover quickly after rupture and drainage of the lymph nodes, but complications can arise. These complications result from metastasis of the organism to adjoining tissue or to other organs [27,29–31]. Purulent lymphangitis or cellulitis can occur if the organism spreads further in the head or neck region. Bastard strangles occurs when the organism metastasizes and abscesses occur in other organs, with clinical signs noted months after the initial infection [27,29–31]. These abscesses can occur anywhere, but the more common locations include the lungs, brain, liver, spleen, kidney, and mesentery [27–31]. Bronchopneumonia can result from aspiration of pus or metastatic spread of the organism to the lungs [28,31]. Laryngeal hemiplegia may result from pressure atrophy of the recurrent laryngeal nerve caused by abscessation of the anterior cervical lymph node [27–31]. Abscessation of the retropharyngeal lymph nodes can result in compression of the trachea or larynx and acute respiratory tract obstruction. This is a more common sequela seen in weanlings and younger foals. Guttural pouch empyema may result if the abscessed retropharyngeal lymph nodes rupture into the pouch [27–31]. One potential complication after strangles is myocarditis. Purpura hemorrhagica results from leukocytoclastic vasculitis and occurs 2 to 4 weeks after an acute infection [27–30]. Clinical signs include edema of the head and limbs, urticarial plaques, petechia, and skin necrosis.

S equi is an obligate parasite that requires an equid for its survival and interepidemic maintenance [28,29]. The organism is transmitted directly by nose or mouth contact with a diseased individual or aerosol, although close contact is needed [28,29,32]. Indirectly, the organism can be obtained from various fomites, including flies, contaminated buckets, feed, pasture, and surfaces [28,29,32]. The organism does not survive long in the environment and is inactivated by sunlight and drying but can survive in organic debris-like pus and nasal discharge for weeks or months. Carrier animals can harbor the organism in the guttural pouches and may shed the organism intermittently for many months [33]. Outbreaks occur when an animal is still shedding the organism during the recovery phase or by a carrier animal shedding [28,29,33]. The incubation period varies from 3 to 14 days after exposure, and nasal shedding of the organism is preceded by fever of 2 to 3 days. The organism enters via the nose or mouth and attaches to the lingual and palatine tonsils, forming microabscesses [29,32]. Within hours, the organism travels to the lymph nodes, which drain into the pharyngeal or tonsillar region, and multiplies [29,30,32]. Spread to other lymph nodes or organs may be hematogenous or via lymphatic channels [29,30,32]. The organism evades phagocytosis through a combination of the SeM protein and the hyaluronic acid capsule. The SeM protein may also be responsible for adherence to

(or penetration of) the nasopharyngeal mucosa [29,30]. Pyrogenic mitogens SePE-H and SePE-I are involved in the acute-phase reaction and local edema by triggering release of proinflammatory cytokines from mononuclear cells [34]. Variations in the virulence of the organism are a result of the level of expression of the SeM protein and hyaluronic acid capsule [34].

Diagnosis is based on history (especially of a herd outbreak) clinical signs, and isolation of the organism. Blood work reveals a neutrophilia and hyperfibrinogenemia. In cases with complications, anemia or changes in liver or kidney values may be noted [30]. Endoscopy of the upper respiratory tract, including the guttural pouches, can help in identifying enlarged lymph nodes and allows for lavage of the guttural pouches as both a therapeutic and diagnostic procedure. Culture of a nasal swab, nasal wash, guttural pouch lavage, or transtracheal aspirate is a reliable method of detection [30]. PCR of nasal swabs, nasal washes, or guttural pouch lavage is a more sensitive and rapid way to detect *S equi* [30,33]. Results of PCR from a long-term guttural pouch carrier may remain positive after viable organisms are cultured, suggesting that DNA persists for some time after the death of the organism [30,33]. Conversely, nasal swabs and nasal washes become PCR-negative shortly after a viable organism is no longer detectable, most likely because of the mucociliary clearance from the nasopharynx [30]. Serology seems to be useful in the detection of a possible bastard strangles infection and may help in the diagnosis of this condition with the appropriate history and clinical signs [30].

S equi is sensitive to many antimicrobials, including penicillin, chloramphenicol, erythromycin, and tetracycline, and an appropriate sensitivity pattern can be obtained at the time of culture [28–31]. Treatment with antimicrobials in those cases with mild signs and no evidence of respiratory compromise or systemic involvement is controversial [28–31]. Individuals treated with antimicrobials early in the infection are unlikely to develop a protective immune response and are susceptible to reinfection after cessation of the antimicrobials [28–31]. Therapy may also delay the maturation and drainage of the abscess. Antimicrobial therapy should be reserved for individuals that are in respiratory distress from obstruction of the airway by enlarged retropharyngeal lymph nodes, or have had high fevers for a prolonged period of time, prolonged depression, or involvement of other organ systems [28–31]. The administration of antimicrobials to individuals exposed to *S equi* is an effective prophylactic measure, but the antimicrobials need to be administered for a long period and the individual is susceptible to infection after discontinuation of the antimicrobials [28–31]. Treatment of those animals with sequelae such as purpura hemorrhagica includes administration of steroids in combination with antimicrobials.

Immunity against *S equi* infection seems to be mediated by a combination of mucosal IgG and IgA antibodies produced locally in the nasopharynx, together with opsonic IgG antibodies in the serum [30,32]. These antibodies are SeM specific, with approximately 75% of horses developing a solid

immunity to strangles after recovery from the disease [29,30]. Those animals that do not initially develop immunity, do develop immunity after a second attack of the disease. Mucosal antibodies are produced in response to local stimulation and appear earlier than serum antibodies [29,30]. In the convalescent period, the animal is unable to contract the disease [29,30]. Mares that have recovered from strangles have IgG and IgA antibodies in their colostrum [35]. These antibodies can be detected in the nasal mucosa and sera of foals after ingestion of colostrum [35]. Parturition vaccination of mares increases colostrum levels of these antibodies [35].

Prevention includes isolation and culture of new animals for 14 to 21 days. Rectal temperatures should be taken twice daily, and individuals should be monitored for any nasal discharge or indication of infection [27–31]. Clinically affected horses, those known or suspected to be infected, and those exposed to clinically affected horses should be isolated immediately. Buckets, containers, and stable areas should be disinfected with chlorhexidine gluconate or glutaraldehyde. Paddocks grazed by infected animals should be regarded as contaminated for 1 month. Individuals with a change in temperature greater than 1° to 5° above normal should be considered suspect, and samples should be cultured or submitted for PCR [27–31].

Several vaccinations are available for *S equi*, including a killed suspension of *S equi* in aluminum hydroxide gel (Equibac II; Fort Dodge Labs, Fort Dodge, IA), a concentrated M-protein extract of *S equi* (Strepvax; Cooper Animal Health, Kansas City, KS), and a purified M-protein extract of *S equi* (Strepguard; Haver Mobay Corporation, Shawnee, KS) [29,30,36]. These vaccines are administered by the intramuscular route, and adverse reactions have been reported, including inflammation and abscess formation at the injection site, muscle soreness, and, occasionally, the onset of purpura hemorrhagica. The level of immunity stimulated by these vaccines is low because of failure to induce local protection. Pinnacle-IN (Fort Dodge Labs) is a modified-live strain of *S equi* that produces an adequate serum antibody response along with a mucosal response [30,36,54]. Administration of the intramuscular vaccines is an initial series of two or three injections followed by annual boosters. The intranasal vaccine is an initial dose at 3 months of age, followed by a second dose in 2 weeks, and then annual boosters. It takes 2 to 3 weeks to acquire an adequate immune response after the administration of the intranasal vaccine [30,36]. Vaccinating in the face of an outbreak may cause the production of more antibodies, which may result in a purpura hemorrhagica reaction [30,36].

Viral causes

Equine influenza

Equine influenza virus is an orthomyxovirus that has been isolated from respiratory outbreaks worldwide. The organism has many variants and is

classified into subtypes based hemagglutinin (H) and neuraminidase (N) surface antigens [37]. The two most commonly recognized subtypes are H7N7 (A/equine 1) and H3N8 (A/equine 2). Horses of all ages are susceptible, although it is particularly prevalent in 2- and 3-year-olds. Weanlings and sucklings are susceptible when stressed or in situations of overcrowding and areas with poor ventilation [37,38]. Clinical signs depend on the dose and virulence of the organism, environmental conditions, and host defenses. Fever, lethargy, anorexia, serous nasal discharge, and occasionally a dry deep cough are typical signs of an infection [37]. Other clinical signs include pharyngitis, tracheitis, and viremia, which may result in some animals displaying signs of myalgia, myositis, limb edema, or myocarditis [37]. Secondary bacterial infections of the lower airway can occur as a result of the virus disrupting the host's normal defenses [37,38]. Occasionally, a rapid fatal pneumonia is encountered in younger foals, which present with nostril flare, labored breathing, anxious appearance, and respiratory distress.

Most outbreaks of influenza arise from a subclinically infected animal shedding the virus, and such outbreaks can occur at any time of the year. They are most commonly seen in the late fall, winter, and spring, however, because of the mixing, confining, and concentration of young susceptible horses for weaning, training, transportation, showing, and sales [37–39]. The stress induced by these activities may increase susceptibility to infection as well as frequently providing the crowded and poorly ventilated environment conducive to transmission of the virus [37–39]. According to investigators, many vaccinated horses are only partially immune and may experience infection with virus shedding in the absence of clinical signs of infection [39]. These animals are difficult to identify and may be a significant focus for the spread of infection. Transmission is primarily through direct nose-to-nose contact [37]. The aerosolized virus is inhaled and attaches to the N-acetylneuraminic acid receptors on respiratory cells by hemagglutinin (HA) spikes on the organism [37]. The neuraminidase alters the efficiency of the mucociliary apparatus. Replication of the virus occurs after endocytosis of the organism into the cell and release into the cytoplasm of the cell [37]. The virus spreads throughout the respiratory tract within 1 to 3 days, damaging the epithelial cell and cilia in the trachea and bronchial tree [37].

A presumptive diagnosis can be made based on the history, clinical signs, and the rapidity of spread of the infection through a group of individuals. Blood work initially displays a leukopenia characterized by a moderate to marked lymphopenia and, later, a monocytosis. Occasionally, a mild anemia is documented. These changes are transient and only seen early in the course of infection. Later, a neutrophilia and hyperfibrinogenemia may be documented, especially if a secondary bacterial infection is established. Virus isolation can be performed using nasopharyngeal swabs or tracheal aspiration within the first 24 to 48 hours of the infection [37,39]. After this time, the success of isolation of the virus diminishes. Serum antibody titer is

another means to document an infection [39]. An acute sample should be obtained early in the infection, followed by a convalescent sample 10 to 14 days later [37,39]. A single sample is usually not diagnostic. A fourfold or greater increase in antibody titer is considered significant, although a declining titer may also be informative [37,39]. When interpreting the results, it is important to take into consideration when the initial sample was obtained in relation to the onset of clinical signs, the vaccination status of the individual, and the age of the individual because of the presence of maternal antibodies. PCR has been used to identify this virus.

Treatment includes close monitoring for any signs of secondary bacterial involvement. The animal should be given complete rest in a clean and well-ventilated environment with minimal dust for 3 to 4 weeks [37]. Those individuals with high fevers, depression, anorexia, or stiffness may benefit from the administration of nonsteroidal anti-inflammatory drugs. The individual should be closely monitored for any signs of secondary bacterial infections or complications, and these should be treated accordingly. In the case of an outbreak, those clinically infected and those exposed should be isolated for 3 to 4 weeks [37]. An animal is considered infectious for 3 to 6 days after the last signs of illness. Infection usually induces long-term immunity by stimulating circulating antibodies and secretory IgA antibodies locally in the nasal mucosa, and by the production of cell-mediated immunity [39].

The initial intramuscular vaccines included either an inactivated purified whole virus or subunit viral antigens, although these vaccines have failed to provide adequate protection [36,39,54]. A new modified-live intranasal vaccine (Flu Avert IN; Heska Corporation, Fort Collins, CO) has been introduced and provides better protection [54]. Broodmares should be vaccinated before foaling to ensure colostrum protection of the foal, although the intranasal vaccine should not be administered to these individuals [36,39]. Our clinic recommends vaccinating foals with the intranasal vaccine at 180 and 330 days of age. In addition to vaccination, prevention of the disease in weanlings and sucklings can include reducing stress and isolating new arrivals to the farm for 3 to 4 weeks.

Equine herpesvirus 1 and 4

Equine herpesvirus 1 (EHV1) and equine herpesvirus 4 (EHV4) are important alpha herpes viruses affecting the equine respiratory tract [40]. Exposure to the organism and clinical disease are commonly manifested in foals, weanlings, and yearlings, although clinical signs can be seen in all age groups of horses [40,41]. In most cases, the infection is limited to the upper respiratory tract, although as in the case of influenza, equine herpes may disrupt the normal defense mechanism of the airway, allowing the establishment of a secondary bacterial infection [38,40]. Infections are characterized by a biphasic fever, depression, and initially, a serous nasal

discharge which may progress to a mucopurulent discharge. The primary mode of transmission is inhalation of the organism, with the incubation period being 3 to 7 days [40]. Attachment and replication of the virus occur in the mucosal epithelial cells of the nasal passages, pharynx, and tonsillar tissue [40]. The virus is then transported to other organs by mononuclear cells, primarily the T lymphocytes. Both EHV1 and EHV4 can establish latent infections in circulating mononuclear cells, principally in CD8+ T lymphocytes and neurons in the trigeminal ganglion [42,43].

Initial blood work reveals a leukopenia, which may be followed by an inflammatory leukogram, especially if a secondary bacterial infection is established. Virus isolation and serologic titer can aid in diagnosis of the disease [39]. Samples to submit for virus isolation include nasopharyngeal swabs or a citrated or heparinized whole-blood sample. Serum samples should reveal a fourfold rise in antibody titer from the acute to the convalescent samples. The presence of maternal antibodies, vaccination status, and the stage in the course of the disease when the samples were obtained must be taken into consideration when interpreting the results. Maternal antibodies against EHV are present in colostrum, and the half-life of these antibodies is approximately 1 month [39,41].

Treatment is similar to that for influenza, including rest in a well-ventilated stall and monitoring for any secondary complications [39,40]. Our clinic recommends vaccinating foals for EHV1 and EHV4 at 180, 210, and 330 days of age. Although the exact mechanism of protective immunity has not been identified, it is likely to consist of the generation of appropriate local antibodies, serum antibodies, and maintenance of B and T memory cells [39,40]. The immune response after vaccination is short lived.

Equine herpesvirus 2

Equine herpesvirus 2 (EHV2), also called equine cytomegalovirus, is classified as a γ -herpesvirus [44]. The exact role of EHV2 in respiratory disease is unknown, but many speculate that there may be an association between EHV2 and lower respiratory tract disease [33,44,45,53,55]. In 1996, Murray et al [31] documented a greater prevalence of EHV2 in tracheal aspirates from foals with clinical signs of lower respiratory disease. These foals, along with foals that had no clinical signs of lower respiratory disease, had serum antibodies to EHV2 [45]. The virus was also isolated from peripheral blood mononuclear cells in many of these foals [45]. EHV2 is trophic for lymphocytes and can remain latent in these cells [44,53].

Acute respiratory distress syndrome

An acute respiratory distress syndrome has been reported in foals between the ages of 1 and 8 months of age. It is manifested as an interstitial

or bronchointerstitial pneumonia [33,46,47]. Foals were either found dead or presented with acute onset of respiratory distress [46–48]. Characteristic features include a sudden onset of respiratory distress, tachypnea, fever, cyanosis, hypoxemia, and hypercapnia, resulting in respiratory acidosis. Initially, thoracic auscultation reveals loud bronchial sounds over the large airways with quieter sounds over the periphery [46,48,49]. The most common radiographic abnormality is a bronchointerstitial pulmonary pattern of increased opacity, which varies in severity from an interstitial opacity with variable bronchial thickening to a more severe coalescing nodular pattern of increased interstitial opacity [46,47,49]. Several etiologies have been suspected, including viruses, bacteria, *Pneumocystis carinii*, toxins, allergic response, and heat stroke [4,46–48,52]. A percutaneous trans-tracheal wash of affected foals can result in bacterial growth, but a specific bacterial species may not be isolated. Organisms that have been identified include *Escherichia coli*, *R equi*, *Enterobacter spp*, and *Streptococcus sp* [4,46–48]. Virus isolation and serology have not identified a specific virus, although some have speculated that EHV2 may be a cause [4,45]. *P carinii* is a fungal organism that causes acute respiratory failure in immunocompromised human patients [50,52]. It has been identified in foals 2 to 3 months of age, most commonly in association with *R equi* [48,51,52]. At presentation, some foals may have already been treated for a preexisting pulmonary disease and have exhibited an episode of acute respiratory distress [47]. Many foals die despite aggressive medical therapy. On necropsy, common histopathologic lesions of the lungs include bronchiolitis, bronchiolar and alveolar epithelial hyperplasia, and necrosis [46]. Therapy should include broad-spectrum antimicrobials, oxygen insufflation, bronchodilators, and anti-inflammatory medications [4,47]. One study reported a better recovery rate when corticosteroids were administered, although care should be taken when administering corticosteroids because of their immunosuppressive effects [46,47]. Environmental control, such as air-conditioned stalls and alcohol baths, may be useful in attempting to decrease the core temperature.

Summary

Lower respiratory tract infection is common in weanling- and suckling-aged animals. Increased susceptibility to disease in this age group can result from a delay in the establishment of a competent immune system and environmental factors, such as overcrowding, shipping, and sales. *S zooepidemicus* and *R equi* are the two most common bacterial isolates. *S equi* is primarily a disease of the lymph nodes and upper respiratory tract. Viral agents can compromise the natural defense mechanisms of the respiratory tract, resulting in secondary bacterial infections. The acute respiratory distress syndrome is one of unknown etiology and high mortality.

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