Bacterial meningitis and brain abscesses secondary to infectious disease processes involving the head in horses: seven cases (1980–2001)

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Objective—To determine clinical features of horses with bacterial meningitis or brain abscesses secondary to infectious disease processes involving the head.

Design—Retrospective study.

Animals—7 adult horses.

Procedure—Medical records of Tufts University, the University of Pennsylvania, and the Livestock Disease Diagnostic Center (Lexington, Ky) were reviewed to identify adult (> 12 months old) horses in which a postmortem diagnosis of bacterial meningitis or brain abscess had been made. Horses were included in the study if an intracranial infection was confirmed, the horse had a primary infectious disease process involving the head, and there were no signs of systemic infection.

Results—23 adult horses with bacterial meningitis or a brain abscess were examined during the study period, but only 7 met the criteria for inclusion in the study. Primary sites of infection included the paranasal sinuses, nasal cavity, periocular tissues, and submandibular lymph nodes. Three horses died suddenly prior to hospitalization, and 1 horse was hospitalized but died 7 days after the onset of neurologic abnormalities. The remaining 3 horses were euthanatized because of a rapid deterioration in clinical status.

Conclusions and Clinical Relevance—Although rare, fatal intracranial complications can develop in horses with infectious diseases involving the head. (*J Am Vet Med Assoc* 2004;224:739–742)

Bacterial infections of the CNS, including bacterial meningitis and brain abscesses, can develop as a result of invasion via the cranial nerves, direct inoculation (eg, as a result of penetrating injuries or during surgery), extension of an adjacent infectious process, or hematogenous spread.[1-3] Between 0.5% and 24% of human patients admitted to a hospital because of rhinosinusitis develop intracranial complications.[4-10] In contrast, most reported cases of bacterial meningitis and brain abscesses in horses and ruminants developed secondary to systemic disease processes,[11-19] and to our knowledge, only 1 report[16] involving 3 horses that developed intracranial infections as a result of infectious processes involving the head has been published. Nonetheless, upper respiratory tract infections,[20,21] dental disease,[22] periocular lesions, and traumatic head injuries[23] are common in horses, and we suspect that primary septic processes involving the head in horses might result in intracranial complications similar to those observed in humans. The purpose of the study reported here was to determine clinical features of horses with bacterial meningitis or brain abscesses secondary to infectious disease processes involving the head.

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Criteria for Selection of Cases

Medical records of the Tufts University, School of Veterinary Medicine, North Grafton, Mass (1995 through 2001); the University of Pennsylvania, George D. Widener Hospital for Large Animals, Kennett Square, Pa (1980 through 2001); and the Livestock Disease Diagnostic Center, Lexington, Ky (1993 through 2001) were reviewed to identify adult (> 12 months old) horses in which a postmortem diagnosis of bacterial meningitis or brain abscess had been made. Horses were included in the study if an intracranial infection was confirmed, the horse had a primary infectious disease process involving the head, and there were no signs of systemic infection.

Procedures

Information obtained from the medical records included signalment, history, clinical observations, laboratory test results, postmortem findings, and results of bacterial culture.

Results

A search of medical records of horses examined at Tufts University during the study period revealed 2 horses with bacterial meningitis. In both, a primary infectious disease process involving the head was found, and both horses were included in the study. Seven horses examined at the University of Pennsylvania during the study period had bacterial meningitis, but 4 of these had evidence of systemic disease and were excluded from the study. The remaining 3 had an infectious disease process involving the head and were included in the study; information for 1 of these horses has been published previously.[16] Finally, a review of necropsy reports from the Livestock Disease Diagnostic Center yielded information on 14 adult horses with bacterial meningitis during the study period. However, 12 of the 14 had signs of systemic disease and were excluded from the study. The remaining 2 horses had lesions involving the head and were included in the study.

Signalment—Mean age of the 7 horses included in the study was 7.4 years (median, 6 years; range, 13 months to 14 years). Five were Thoroughbreds, 1 was a Standardbred, and 1 was a Dutch warmblood. Six were females and 1 was a gelding.

History—All horses had a history of an infectious disease process involving the head that was identified prior to the development of neurologic abnormalities. Primary sites of infection included the paranasal sinuses, nasal cavity, periocular tissues, and submandibular lymph nodes. Two horses had maxillary sinusitis secondary to dental disease, and 1 horse had primary maxillary sinusitis. One horse had rhinitis that had developed secondary to surgical excision of an ethmoid hematoma, 1 horse had exophthalmos without any other clinical signs, and 2 horses had presumptive eye trauma and submandibular lymphadenopathy. Duration of the primary infection was unknown for 3 horses and 11 months in 1 horse. In the remaining 3 horses, duration of the primary infection was < 15 days. Two horses had not been treated for the infectious disease process involving the head. The remaining 5 had undergone a variety of treatments, including repeated surgical debridement and treatment with antimicrobials selected on the basis of results of bacterial culture and susceptibility testing (1 horse), treatment with nonsteroidal anti-inflammatory drugs (1 horse), and broad-spectrum antimicrobial treatment (3 horses). Bacterial culture of samples from the primary site of infection was performed in only 1 horse prior to the onset of neurologic abnormalities; *Escherichia coli* and nonhemolytic *Streptococcus* spp were identified.

Clinical signs—All horses developed signs of acute, rapidly progressive neurologic disease. Three horses died suddenly prior to hospitalization, and 1 horse was hospitalized but died 7 days after the onset of neurologic abnormalities. The remaining 3 horses were euthanized because of a rapid deterioration in clinical status 24 hours (2 horses) or 3 days (1 horse) after the onset of neurologic signs and hospitalization. The most common clinical signs in addition to the neurologic abnormalities were hyperthermia and signs of depression (4 horses).

Results of diagnostic testing—A neurologic evaluation was performed in 2 horses; abnormalities detected included lethargy, generalized weakness, signs of cervical pain and stiffness, hind limb ataxia, urinary incontinence, dysphagia, absent menace reflexes, and, eventually, recumbency. Results of CBCs performed on 3 horses were consistent with a stress response (ie, mature neutrophilia and lymphopenia). Fibrinogen concentration was high in the 3 horses in which it was measured. Blood samples from 1 horse were submitted for bacterial culture but did not yield any growth.

Diagnostic imaging, including skull radiography, nuclear scintigraphy of the skull and cervical vertebrae, and ultrasonography of the temporomandibular joints and mandibular regions, was performed in 1 horse. Results of ultrasonography were normal, but scintigraphic and radiographic findings were suggestive of maxillary sinusitis and maxillary osteitis. Skull radiographs obtained from a second horse did not reveal any abnormalities.

Cerebrospinal fluid was obtained from the lumbosacral space in 1 horse and from the atlanto-occipital space in another horse. In the first horse, CSF was xanthochromic with a high total protein concentration but normal nucleated cell count; activated macrophages and neutrophils were seen and considered suggestive of an inflammatory process. Samples of CSF were submitted for determination of antibody titer against equine herpes virus 1 and bacterial culture; equine herpes virus antibodies were not detected, and bacterial culture did not yield any growth. In the second horse, the CSF had a high total protein concentration and high nucleated cell count. Gram-positive cocci were seen, but bacterial culture of the CSF did not yield any growth.

Treatment—Four horses were treated following the onset of neurologic abnormalities. Two were treated with antimicrobials. In 1, cefotaxime sodium (20 mg/kg [9 mg/lb], diluted in 5 L of balanced electrolyte solution, IV, q 8 h) was administered on the basis of results of bacterial culture of a draining tract from the maxillary sinus that developed following sinusotomy and tooth repulsion. In the other, treatment with procaine penicillin G (22,000 U/kg [10,000 U/lb], IM, q 12 h) and trimethoprim-sulphonamide (30 mg/kg [13.6 mg/lb], PO, q 12 h) had been initiated 6 days prior to hospitalization because of suspected sinusitis, and this treatment was continued throughout the hospitalization period.

Treatment to reduce cerebral edema and inflammation included administration of dimethyl sulfoxide (1 g/kg [450 mg/lb] in a 20% solution mixed with a balanced electrolyte solution, IV, q 24 h) in 2 horses, methylprednisolone sodium succinate (20 mg/kg [9 mg/lb], IV, q 24 h) in 1 horse, and flunixin meglumine (1.1 mg/kg [0.5 mg/lb], IV, q 12 h) in 4 horses.

Postmortem findings—A postmortem examination was performed on 6 of the 7 horses. In the remaining horse, a complete postmortem examination was declined by the owner, and computed tomography and a limited necropsy involving the head only were performed. Primary sites of infection included the paranasal sinuses (3 horses), paranasal sinuses and periorbital tissues (1 horse), submandibular and retropharyngeal lymph nodes (1 horse), periorbital tissues (1 horse), and periorbital tissues and submandibular and retropharyngeal lymph nodes (1 horse).

In 1 horse, the right maxillary sinus contained a well encapsulated, 3 × 2.5-cm abscess covered with necrosuppurative inflammatory debris at the site of a previous tooth repulsion. Most of the vessels in the region of the maxillary sinus abscess were severely congested, and extensive suppuration was present in tissues surrounding the pituitary gland. In a second horse, inflammatory cells and purulent material were found overlying several dental roots in the maxillary sinus and the cribiform region; bacteria were also identified in the periorbital tissues and attributed to previous trauma. Rhinitis and abscess formation at the cribiform plate secondary to infection with *Aspergillus*

fumigatus following excision of an ethmoid hematoma was found in 1 horse. In another horse, the right frontal, maxillary, and sphenopalatine sinuses and the right nasal cavity contained mucoid, yellow exudates; a pituitary abscess and chronic necrosuppurative osteomyelitis of the sphenoid bone were also seen. In 1 horse, microscopic abscesses were seen in the periorbital tissues, optic chiasm, and meninges. Pharyngitis, osteitis, and periosteitis surrounding the pituitary gland were seen in 1 horse. Finally, bacteria were seen in periorbital tissues secondary to trauma in the final horse.

In all 7 horses, suppurative meningitis was seen. Five horses had brain abscesses, and abscesses were localized to the pituitary gland region in 4 and to the brain stem in 1. Thromboemboli were located in meningeal vessels in the peripituitary region in 3 horses. Osteomyelitis of the basisphenoid bone was present in 3 horses. Bacterial colonization was present in the venous sinuses surrounding the pituitary gland and in the peripituitary region in 4 horses. Necrotizing meningoencephalitis localized to the cribiform plate with fungal elements extending along olfactory nerves was present in 1 horse. The meninges at the level of the optic chiasm contained numerous neutrophils and macrophages with necrosis of the inflammatory cells in 1 horse.

Results of bacterial culture—Despite histologic identification of bacterial organisms in brain tissues or CSF of all horses, bacterial growth was obtained from only 3 horses. In 1 horse, *A fumigatus* was associated with rhinitis; however, *Klebsiella pneumoniae* was isolated from the CSF. *Actinobacillus equuli*, *Streptococcus zooepidemicus*, and *Pasteurella caballi* were isolated from brain tissues from a second horse. In a third horse, *S equi* was isolated from brain tissues.

Discussion

In humans, suppurative intracranial complications may result from acute or chronic sinusitis and include meningitis, dural sinus thrombophlebitis, cavernous venous thrombosis, osteomyelitis, and epidural, subdural, intracerebral, and pituitary abscesses, all of which may occur alone or in combination.[5] Four of the 7 horses described in the present report had a history of maxillary sinusitis or rhinitis. In humans, extension of infection from the paranasal sinuses to the cranial vault occurs as a result of thrombophlebitis of communicating veins or diploic veins of the skull or ethmoid bone or by erosion through the intervening bone and meninges.[6] Similar anatomic pathways exist in veterinary patients.[24] The common anatomic locations and histologic abnormalities in the horses described in the present report suggest that the pathogenesis of intracranial lesions in horses with infections of the head may resemble the pathogenesis in humans.

Retrograde blood flow and thrombophlebitis of the maxillary sinus of the brain, as described in humans,[7] could explain the development of meningitis and peripituitary abscesses in 3 horses in the present study. In 1 of these horses, venous congestion adjacent to an abscess in the maxillary sinus was believed to be the source of infection of the venous sinuses and meninges. Blood vessels in the walls of the maxillary sinus abscess appeared markedly congested, and a fibrin thrombus was observed in the venous sinus surrounding the pituitary gland. Meningeal thrombosis was also seen in 2 other horses. In humans, thrombosis may follow maxillary sinusitis via the orbit.[8] In horses, the maxillary sinus is drained by the sphenopalatine vein and enters the valveless deep facial veins.[a] The deep facial veins are joined by the dorsal external ophthalmic vein draining the eye and continue as the ventral external ophthalmic vein.[a] This vein passes through the orbital fissure to the base of the brain where it empties into the cavernous venous sinuses surrounding the pituitary gland.[24] Each cavernous venous sinus is encased between the meningeal and periosteal layers of the dura and lies on the floor of the middle cranial fossa.[24] Intercavernous sinuses connect the left and right cavernous sinuses rostral and caudal to the pituitary gland.[24] Because the ventral venous sinuses are connected rostrally to veins outside the cranial cavity through only the orbital fissure, it seems possible that the intracranial lesions observed in 5 horses in the present report may have occurred by hematogenous spread from a rostral location, namely the orbit or paranasal sinuses.

Three horses in the present report had severe paranasal sinusitis, and erosion through the sphenopalatine sinus may have also contributed to the development of the peripituitary abscesses and bacterial meningitis observed at postmortem examination. The sphenopalatine sinus lies rostroventral to the hypophyseal fossa.[24] This fossa supports the overlying pituitary gland, which is surrounded by the cavernous venous sinuses.[24] The walls of the sphenopalatine sinus are thin, and erosion through this thin plate of bone to the adjacent cavernous venous sinus[9] could explain the development of peripituitary abscesses and subsequent meningitis. Thrombosis of the cavernous venous sinuses secondary to sphenoiditis in humans is commonly followed by septic meningitis.[8] Postmortem computed tomographic findings of a hypodense sphenoid bone in the skull in 1 horse lent further support to the suggestion that direct erosion contributed to the intracranial lesions. It is of interest that maxillary sinusitis in 2 horses in the present report was associated with dental disease. Sinusitis secondary to dental disease accounts for at least half of all cases of sinusitis in horses.[25] In humans, maxillary sinusitis resulting in secondary intracranial lesions is frequently caused by extraction of teeth or the presence of dental caries.[8]

Invasion of the cranial cavity via extension along cranial nerves is another potential route by which intracranial infections may develop. Extension of infection of the periocular tissues along the optic nerve may have allowed development of intracranial lesions in 3 of the horses in the present report. Migration of the infectious agent along olfactory nerves and erosion through the cribiform plate are the most likely explanations for the rapid intracranial extension of infection in a fourth horse.

Definitive antemortem diagnosis of bacterial meningitis and brain abscesses relies on CSF analysis.

Typical CSF abnormalities in horses with bacterial meningitis include a high nucleated cell count, mainly because of neutrophils, a high protein concentration, and detection of bacteria. Cerebrospinal fluid was analyzed from only 2 horses in the present report, and even though bacterial culture of brain tissues and CSF did not yield any growth, bacteria were seen in CSF from 1 of these horses and in brain tissues from both. The lack of bacterial growth could have been a result of previous antimicrobial administration or attributable to the fact that CSF collected from the lumbosacral region may not be representative in animals with a well-encapsulated abscess or a localized intracranial lesion.

Successful treatment of sinusitis and its intracranial complications in humans relies on early diagnosis and initiation of treatment, management of the primary site of infection, neurosurgical drainage, and IV antimicrobial administration.[7] Postmortem computed tomography in 1 horse in the present report was helpful in identifying a maxillary sinus abscess encasing the infraorbital canal and hypodensity of the sphenoid bone, but was not helpful in recognizing the pituitary abscess. It is possible that antemortem contrast computed tomography or magnetic resonance imaging may have been more helpful in identifying a pituitary abscess; however, even if a pituitary abscess were identified, treatment directed at draining or removing such an abscess would have been difficult because of the limited experience in performing craniotomies in horses.

Bacterial meningitis[11-15] and brain abscesses[16-18] in horses have been described mainly as sequelae of systemic disease processes. However, sinusitis, periocular lesions, dental disease, and other infectious processes occurring in the head, as is evident in the 7 horses described in the present report, can also lead to intracranial complications and death. All 7 horses died or were euthanatized because of rapid progression of neurologic abnormalities within a week of the onset of signs. Four of the 7 horses had evidence of a pituitary abscess or necrosis.

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