Rehabilitating a Foal After Trauma

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A 3-week-old, 262-lb (119-kg) Gypsy Vanner filly was found recumbent at pasture and unable to rise. To expedite medical treatment, the foal was transported directly to the University of Missouri Veterinary Medical Teaching Hospital (VMTH) without the mare, which was delivered on day 2.

On presentation at the VMTH, the foal was semiconscious and recumbent. Occasional seizure activity was noted. The body condition score was considered to be normal. The rectal temperature was 102.5°F (normal range: 99°F to 101.5°F), heart rate was 92 bpm (normal range: 60 to 100 bpm), and respiratory rate was 66 breaths/min (normal range: 12 to 40 breaths/min). Other findings, which were normal, included strong arterial pulses, pink mucous membranes, a capillary refill time of <2 seconds, heart and lung field sounds on auscultation, and borborygmi. Left-sided head trauma was evident, with bleeding from the left ear and the presence of a corneal ulcer in the left eye. The foal was curled on its left side, and despite attempts to physically stimulate it, it could not achieve a sternal posture. In addition to a semiconscious state, other neurologic abnormalities included left-sided trigeminal (cranial nerve [CN] V) dysfunction, left-sided facial (CNVII) paralysis, left-sided head tilt (CNVII), and fast-phase, right-horizontal nystagmus (attributed to both central and peripheral [CNVIII] vestibular lesions). Essential sensory and motor functions that were compromised by these abnormalities included mastication, balance, facial symmetry, eye reflexes, and hearing. Defecation and urination were normal.

A 16-gauge, over-the-wire, antimicrobial-impregnated catheter was placed aseptically in the right jugular vein. Blood was collected for a complete blood count (CBC), plasma chemistry analysis, and bacteriologic culturing. The CBC identified slight leukocytosis (19,000 cells/µL; normal range: 5300 to 12,200 cells/µL) with a slight left shift (380 bands/µL; reference range: 0 to 50 bands/µL). Plasma biochemistry identified hypoproteinemia (5.1 g/dL; reference range: 5.8 to 6.6 g/dL), hypoglobulinemia (1.8 g/dL; reference range: 2.3 to 3.3 g/dL), and hyperalbuminemia (3.3 g/dL; reference range: 2.7 to 3.1 g/dL). According to ELISA testing, the foal’s plasma IgG level was low (<400 mg/dL; normal range: 400 to 800 mg/dL). Hypogammaglobulinemia suggested either partial failure of passive transfer or depletion of immunoglobulins due to protracted sepsis or another immune-deficiency condition.

Radiography of the skull revealed soft tissue swelling lateral to the left tympanic region, with narrowing of the left external auditory meatus. Radiographic evidence of skull fracture was not identified. Subsequently, the foal was anesthetized using thiopental and guaifenesin, and computed tomography of the skull was performed. Several slight osseous incongruities were discovered at the junction of the occipital bone and the basi-sphenoid bone, indicating a petrous temporal fracture in the region of the ventral condyloid fossa (FIGURE 1). This is the location at which CNIX and CNXII emerge.

After administration of commercial equine plasma (2 L IV), broad-spectrum antimicrobial treatment included amikacin sulfate (21 mg/kg IV q24h) and potassium penicillin (22,000 IU/kg IV q6h). Antiinflammatory treatments included flunixin meglumine (1.1 mg/kg IV q12h) and dimethyl sulfoxide (DMSO; 0.4 g/kg in 1 L lactated Ringer solution [LRS] IV q12h). Free radicals may be released from damaged central nervous system tissue and subsequently damage healthy tissue, slowing the healing process; therefore, using DMSO for free radical scavenging was considered warranted in this foal. LRS (1 L IV) was administered twice daily (in addition to DMSO) to maintain hydration and promote renal perfusion. An intravenous constant-rate infusion (CRI) might be preferable for promoting hydration, but a CRI would have been more difficult to maintain in this foal.

Microbiologic culturing of the corneal ulcer (left eye [OS]) using the blunt end of a scalpel blade to scrape the cornea yielded negative findings. Topical atropine sulfate was administered to promote mydriasis and ciliary body paralysis, treat pain, and reduce the risk of central iridial adhesion (synechiae) formation, which can lead to blindness secondary to uveitis. Topical triple-antibiotic ophthalmic ointment was applied to the corneal surfaces of both eyes six times daily to treat the ulcer (OS) and prevent ulcer formation in the right eye (OD) due to possible injury associated with recumbency or seizures.

Enteral nutrition was provided through an indwelling, 18-French, polyurethane tube passed through the left nostril into...
the stomach and secured at the left nares. Satisfactory placement of the feeding tube was ascertained by radiographic examination. Placing the tube in the stomach lumen may prevent reflux of gastric fluid and subsequent aspiration pneumonia in a predominantly recumbent foal. Placement of the tube in the caudal aspect of the esophagus is favored by some veterinarians for minimizing damage to the gastric lining.

Before each feeding, the foal was positioned in sternal recumbency and checked for reflux (excessive fluid retention in the stomach suggestive of malassimilation or ileus that might necessitate adjustments to the feeding program). A mixture of the mare’s milk and commercial milk replacer was administered by gravity flow to the foal, which was maintained in sternal recumbency during feeding and for 15 minutes afterward. Although healthy foals may consume at least 25% of their body weight in mare’s milk per day, clinically ill (especially recumbent) foals have lower energy requirements.

Nutritional requirements for this foal were based on the foal’s individual needs and tolerance of oral feedings. The foal’s milk formula consisted of a mixture of the mare’s milk (~10% to 15%, depending on availability), powdered Foal-Lac milk replacer (~40% to 45%; Petag, Inc., Hampshire, Il), and a commercial pasteurized goat’s milk (~40% to 45%) and was administered every 2 hours. The foal was weighed daily to check for weight gain and ensure that the amount fed was gradually adjusted to meet the daily requirement. The blood glucose concentration and urine specific gravity were monitored four times daily to help assess hydration status and energy needs. If hypoglycemia developed (<80 mg/dL; reference range: 96 to 176 mg/dL) indicating trauma. The protein level (77 mg/dL) and the nucleated cell count (84 cells/µL) were within normal limits. Mannitol (0.5 g/kg as a 20% IV solution) was administered to reverse central nervous system edema. Mannitol can decrease intraocular and CSF pressures through osmotic effects and can decrease edema through stimulated diuresis.

Detomidine hydrochloride was initiated at a loading dose of 0.01 mg/kg IV and maintained at 0.4 µg/kg/min CRI in 1 L of LRS. In addition, diazepam (2 mg IV) was administered to treat seizures, which occurred three to four times daily for the first 3 days of hospitalization.

The foal’s mental status improved somewhat on day 2, but attempts to introduce the foal to the mare’s udder were unsuccessful because the foal exhibited no interest. Moreover, the mare attempted to kick the foal and responded aggressively to handling of the left side of the udder and the left teat. Subsequently, the foal was managed in a partitioned stall to maintain proximity to the mare in the hope that the mare might develop greater interest in the foal.

Physical therapy was instituted in the form of passive extension and flexion of all limbs several times daily to stimulate the foal and promote joint flexibility. This therapy was continued until the foal became strong enough to resist it (on day 6). The foal was maintained in sternal recumbency or, when laterally recumbent, turned from one side to the other hourly to promote circulation and encourage adequate expansion of the lungs.

Despite regular cleaning and towel drying of urine and feces as well as provision of deep, protective bedding, the foal developed superficial decubital ulcers at the elbow and stifle areas. The ulcers were treated using topical application of silver sulfadiazine cream. Decubital ulcers complicate the management of recumbent patients. These ulcers result from poor skin circulation, the pressure of bone against tissue, or friction from the patient sliding along bedding or supportive mats. Decubiti are also promoted by inhibited healing resulting from a relative catabolic state.

The detomidine hydrochloride CRI was discontinued for 3 hours on day 3 but restarted due to the foal’s increasing agitation. The rate of the CRI was gradually decreased until the CRI was discontinued on day 6. The foal’s IV catheter bandage was changed daily. On day 6, swelling associated with the catheter in the right jugular vein was noted. Therefore, the catheter was aseptically removed and its tip submitted for bacteriologic culture. No bacteria were cultured from the catheter tip, but the following bacteria were identified in cultured blood from the time of admission: an Actinomyces sp, Escherichia coli, and Pseudomonas aeruginosa, all of which were sensitive to amikacin and ceftiofur but resistant to penicillin. Cefiotour sodium (2.2 mg/kg IM q12h) was administered in the semitendinosus muscles, and all IV medications were discontinued.
A repeat CBC on day 6 revealed hyperfibrinogenemia (0.5 g/dL; reference range: 0.2 to 0.4 g/dL) and a decrease in the leukocyte count (5000 cells/µL). The previously noted leukocytosis may have been due to the injury, secondary to epinephrine release; therefore, the decrease in the leukocyte count did not necessarily indicate infection. Hyperfibrinogenemia indicated inflammation, probably due to sepsis, trauma, or both. By day 7, the foal began to maintain a sternal posture for longer periods, indicating increasing strength and decreasing vertigo. The foal also began to vocalize. Although nystagmus continued, the rate was substantially reduced.

The foal was encouraged to drink water from a rubber nipple (intended for use with lambs). With the foal in sternal recumbency and its head and neck flexed to prevent aspiration (i.e., the mouth lower than the throat), the nipple was placed between the foal's lips and lowered into a bucket of water. This positioning allowed water that was not actively swallowed to run out of the mouth. Several times a day, the foal was supported in a standing position with a person moving each leg to simulate walking.

The foal's prognosis was regarded as unfavorable for return to pasture if it could not stand or eat independently; therefore, on day 8, therapy progressed to include taking the foal to a grassy area, where the footing was better for the foal to learn balance and to ambulate. The foal was transported on a low gurney, and the mare was led closely behind. The foal was placed in sternal recumbency on the grass, and its front legs were extended to encourage standing. The staff stimulated the foal until it attempted to stand and then assisted it to its feet by providing support around its shoulders and behind its hindquarters, as recommended. The foal's head tended to hang down to the left (due to paresis), disrupting its ability to balance. Extending the head and neck greatly improved the foal's ability to stand. The foal was always alert and interested in its surroundings during this activity.

Because of its demeanor, the mare required sedation, placement of a nose twitch, and hobbled application to the pelvic limbs in order to safely introduce the foal to the grass area. When introduced to the mare, the foal curled its tongue and searched for the udder. The foal was guided to the udder and nursed vigorously. However, because of the mare's kicking, the foal sometimes had to be withdrawn but continued to show strong interest and sucking motions.

Because of the risk of injury associated with reintroducing the foal to the mare, efforts were renewed to train the foal to drink milk replacer from a bucket. (It was considered likely that the foal's original injury might have been caused by the mare's kicking in response to the foal nursing from the painful left nipple). Attempts to train the foal included placing an arm over the foal's head (to simulate the mare's flank) and placing a rubber lamb nipple soaked with milk in the foal's mouth. Gradually, the foal's head was directed into a bucket of milk with the nipple. Several swallows indicated that the foal was drinking milk, but sometimes it would resist. The mare and the foal were returned to separate sides of the stall divider, and the mare appeared to call to the foal a few times. The foal was also fed through the feeding tube until day 15.

To increase its strength over the next several days, the foal was positioned in sternal recumbency on the grassy area and encouraged to stand multiple times while the staff assisted with positioning of the limbs and the head. More effort was required to stand the foal from left lateral recumbency than from right lateral recumbency because the foal tended to curl to the left (due to vestibular dysfunction). The left head tilt persisted, but nystagmus resolved. The foal was able to remain in sternal recumbency for progressively longer periods of time on the grass and to elevate its head independently. On day 10, the foal started to achieve sternal posture from right lateral recumbency without assistance. The foal also moved its ears and vocalized when people were close.

On day 14, the foal was independently placing its front legs in front of its body when encouraged to stand and only required assistance raising its hindquarters. Once standing, the foal could walk unassisted. To lie down, the foal would “collapse” to the ground but could lie in lateral or sternal recumbency and hold up its head. The foal was more alert and began to drink water from a bucket while standing unassisted. When milk replacer was offered from the bucket, the foal moved unassisted with jerky, uncoordinated steps. When Foal-Lac Pellets (Petag, Inc., Hampshire, IL) moistened with water were offered in a bucket, the foal ate a few bites but showed little interest. However, the foal gradually began to eat the pellets with greater interest and would walk to follow the bucket. Because of the risk of injury from the mare's kicking, attempts to have the foal nurse from the mare were discontinued.

On day 15, the foal was consuming most of the provided food (moistened Equine Junior Pellets [Purina Mills, LLC] and Foal-Lac Pellets, replenished every 6 hours, as needed). The feeding tube was removed, and the foal was able to ambulate independently. Treatment using ceftiofur, ophthalmic ointments (OS), and omeprazole (4.4 mg/kg PO q24h; prophylactically for stress-induced gastric ulceration) was continued. The foal's gait was still unsteady and choppy, but the foal was ambulating without assistance around the stall and to the food and water buckets. The foal could lie down on the grass and stand up independently from the right side, but it continued to need assistance to stand from the left side. The foal was vocalizing more and, although still slightly uncoordinated, began to run and play a little when out of the stall.

Glossary

- **Borborygmi**—audible gurgling noises due to gas and fluid moving through the intestines
- **Guaienesin**—a centrally acting muscle relaxant used in many equine anesthetic procedures; the drug causes muscle relaxation, has some analgesic and sedative properties, and allows decreased dosing of other anesthetics
- **Ileus**—disruption of the normal propulsive ability of the gastrointestinal tract
- **Mydriasis**—dilation of the pupil
- **Nystagmus**—involuntary rhythmic movement of the eyes
- **Synechiae**—a condition in which the iris adheres to the cornea or lens
- **Thiopental**—a barbiturate that produces profound hypnosis and anesthesia; it takes effect rapidly and has a short duration of action
On day 16, the foal was seen standing in its stall eating from the bucket. Because of the owners’ financial constraints, the foal was due to be discharged from the VMTH. Therefore, efforts were increased to teach the foal to stand from its left and right sides. Ceftiofur administration was discontinued, but the ophthalmic treatments were continued.

On day 18, the foal was discharged into the owners’ care. It was recommended that the owners manage the mare and the foal separately and continue feeding the foal moistened Equine Junior Pellets and Foal-Lac Pellets.

**Conclusion**

Likely a consequence of the mare kicking the foal’s head, the foal sustained brain trauma and presented to the VMTH with several acute neurologic problems, including recumbency, disequilibrium, seizures, and facial paralysis. The foal also had septicemia, possibly due to partial failure of passive transfer. Critical care improved the foal’s condition, allowing the foal to regain independence in terms of its ability to stand up, ambulate, and eat. This treatment success was significantly due to extensive technical support, physical therapy, and rehabilitation.

This case provided the opportunity to spend 18 days rehabilitating a foal that presented with a poor prognosis for recovery. Often, financial constraints necessitate that care be terminated much sooner, especially in cases of traumatic brain injury. The foal afforded an excellent opportunity to learn about the benefits of rehabilitation.

**References**

1. Which signs are associated with central and peripheral vestibular lesions?
   a. ataxia and an increased heart rate
   b. nystagmus and head tilt
   c. a decreased heart rate and seizures
   d. a low neutrophil count and diarrhea

2. For which of the following was dimethyl sulfoxide used in this case?
   a. to reduce inflammation and scavenge free radicals
   b. to sedate the patient and decrease the heart rate
   c. to decrease pain associated with the fracture
   d. to improve mental status

3. Which of the following is true regarding free radicals?
   a. They are released from damaged central nervous system tissue.
   b. They expedite healing.
   c. Their effects can be reduced by administration of antibiotics.
   d. They have no effect on healthy tissue.

4. How much mare’s milk (as a percentage of a foal’s body weight per day) does a healthy foal normally consume?
   a. 15%
   b. 25%
   c. 35%
   d. 45%

5. Mannitol is used to
   a. achieve intraocular penetration.
   b. reduce seizure activity.
   c. deliver osmotic effects by diuresis.
   d. stimulate nerve regeneration.

6. What does a foal with failure of passive transfer require?
   a. amino acids
   b. immunoglobulins
   c. vaccinations
   d. milk-replacer feeding

7. Nystagmus refers to movement of the
   a. head.
   b. legs.
   c. eyes.
   d. vestibular nerve.

8. Flunixin meglumine is used for its ____________ effects.
   a. antiinflammatory
   b. antiseizure
   c. antibiotic
   d. antiregulatory

9. Which of the following is used to treat failure of passive transfer?
   a. milk replacer
   b. antibiotics
   c. dimethyl sulfoxide
   d. plasma

10. How should a foal be lifted to a standing position?
    a. around the chest and abdomen
    b. by the halter and tail
    c. around the shoulders and behind the hindquarters
    d. by the shoulders and abdomen