

A Perfect KILLER

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Horses are highly susceptible to botulism toxins; vaccination and feed/water management are key to prevention

Botulism is an often-lethal disease caused by a bacterial toxin. Although the disease can affect nearly all warmblooded animals, it is particularly deadly in horses, because they are more sensitive to the effects of the toxin than other animals.

The disease can strike suddenly and result in death in horses that were perfectly healthy the day before. Horses' best chance at survival lies in being treated with

antitoxin as quickly as possible, but the disease often leaves no tangible footprint for veterinarians to detect through testing. This makes it necessary to recognize the clinical signs that are suggestive of the disease and make the diagnosis on that basis alone.

The scenario has many elements of a good thriller novel: a terrible event happens, the clock is ticking on whether the diagnosis can be made and treatment provided in time to save the patient, and the killer is elusive and might never be found.

There the analogy ends, though, because there is nothing entertaining about botulism, a disease characterized by neuromuscular blockade (in which toxins block the communication between nerves and muscles) and flaccid paralysis (the horse can't move, but isn't stiff).

Toxin Attack

The disease is not caused by the bacterium *Clostridium botulinum*, but rather by the toxins that it produces. Clostridial



DUSTY PERIN, KIM AND KARI BAKER (INSET)

The hay your horse is eating might appear harmless, but deadly botulism-causing bacterial toxins—sometimes introduced by the baling of animal carcasses (inset)—could be lurking in anaerobic conditions deep in the bale.

organisms are strict anaerobes, meaning they do not grow in the presence of oxygen or in healthy, well-oxygenated tissues. *Clostridium botulinum* produces seven different neurotoxins (types A, B, C₁, D, E, F, and G), each of which is distinct and different enough from the others that antibodies against one type do not protect an animal against botulism from another type.

Botulinum toxin is one of the most potent biotoxins known, which is not surprising given that *C. botulinum* is a member of a family of lethal pathogens that are all capable of causing rapid, severe sickness and death. Tetanus, blackleg, and malignant edema are other diseases caused by members of the *Clostridium* genus. Sometimes the onset of clostridial disease is so rapid that no clinical signs are ever manifested; animals are simply found dead.

Clostridium botulinum can act just as rapidly and with the same lethal effects.

Exposure

Horses can get botulism toxin in three basic ways: ingestion of toxins, ingestion of the bacterium and internal production of toxins, and wounds.

The first mechanism of entry is ingestion of preformed toxin in feed. When horses are exposed to botulism toxin in the feed in this manner, the disease is sometimes called “forage poisoning,” usually involving type C toxin. Toxin might be present as a contaminant in feed, or if there are droppings or carcasses of small rodents in the feed bunk or water tub.

One problem occurs when rodents or other animals die in a field of forage, and a carcass is incorporated into a bale during baling. Because horses as a species are fastidious eaters, they will avoid consuming hay that is contaminated by animal remains when possible. However, when processed feeds such as cubes or pellets are fed, it is impossible for horses to eat around the contaminant, and consumption of the deadly spores can occur. Contaminated hay cubes have been responsible for at least one large outbreak of botulism in horses. Even if a carcass has undergone desiccation (it’s dried out) or is unrecognizable in a flake of hay, enough spores can remain to kill a horse.

Hay contaminated with animal carcasses is not the only route of foodborne exposure; the vegetation itself can also be a problem. When foodstuffs are improperly cured or dried, an anaerobic environment favorable for growth of the organism can



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Shaker foal disease is a form of botulism that affects young foals, usually those born to dams that were recently moved to an endemic area or not vaccinated during pregnancy.

develop. Anaerobic conditions can arise in wilted grass or vegetables, for example, and also in round hay bales. Outbreaks of botulism have been associated with feeding discarded produce (wilted unsold lettuce at a farmer’s market in one instance) and lawn clippings.

Toxicoinfectious botulism is the second-most common form of botulism in horses, and this arises when the bacterium itself is ingested from soil and colonizes the gastrointestinal tract. As it grows inside the body, it produces the toxin, and signs of disease become apparent as toxin is absorbed into the bloodstream from the intestinal tract. *Clostridium botulinum* type B predominates in the midwestern and Atlantic seaboard states, and it causes a manifestation of toxicoinfectious botulism called shaker foal disease. Shaker foal disease is a form of botulism that affects young foals, and it is mostly a problem in foals born to dams that were recently moved to an endemic area or that were not vaccinated during pregnancy. The disease takes its name from the muscle trembling seen in affected foals.

Wound botulism is the third and least-common form of botulism in horses. Deep puncture wounds or wounds in which tissue becomes devitalized can support growth of *C. botulinum*. When the bacterium grows and produces toxin, the toxin is absorbed into the bloodstream and the horse develops botulism.

Toxic Mechanisms

Irrespective of the route of exposure, the sequence of events that ensues is the same. Once toxin has been absorbed from the

gastrointestinal tract or inoculated through a wound, it enters the bloodstream and is dispersed to nerves bodywide. Nerves that conduct high-impulse traffic, like the fibers that innervate the muscles for swallowing or anti-gravity muscles (muscles that are tonically or continuously contracted during standing), are affected earliest. After a toxin molecule enters a nerve cell, it travels down the length of the nerve fiber to the endplate, where the nerve terminates in close proximity to a muscle cell. The toxin prevents transmission of the impulses that travel down nerve fibers, cross the tiny space between nerve ending and muscle, and induce movement in the muscle. The block occurs at the junction between the nerve and the muscle cell; the resultant neuromuscular blockade at the cellular level is recognized at the animal level as generalized weakness that progresses to paralysis.

Signs of Botulism

The first signs that owners typically notice are the horse’s inability to eat, drooling or profuse green nasal discharge, and recumbency (inability to rise). Dysphagia, or inability to swallow, manifests as milk exiting the nostrils in foals during nursing, and it is often accompanied by coughing as milk enters the trachea instead of the esophagus. In adults, feed material exits the nostrils when the horse attempts to swallow feed, resulting in green, foaming discharge coming from the nose.

Horses might immerse much of their face in a bucket of water in an attempt to drink, and grain might be dropped, covered

with saliva, or pushed around ineffectually in the feed tub as the horse tries to eat. Foals and adults both might drool as a result of paralysis of the swallowing muscles and resulting inability to swallow saliva.

Recumbency is also a common early sign of botulism. An affected horse might be unable to get up, or he might lie down for longer periods than usual. Closer observation reveals fine muscle fasciculations (involuntary contractions) or trembling, particularly in the shoulder and flank muscles. The horse might tread or shift weight frequently in the hind limbs, and he might pace around the stall with restlessness or anxiety as he feels muscle weakness progressing and tries to remain standing. Some horses adopt an "elephant-on-a-ball" posture, with all four feet placed

close together under the body.

When an affected horse does lie down, he might collapse abruptly rather than deliberately folding the limbs and lowering the body in the normal sequence. This is especially noticeable in foals.

Eyelid tone might be decreased, such that the upper lid can easily be moved open and closed (try this in your horse to see what the normal response is). Pupillary light reflexes, in which a light shone into the horse's eye induces the pupil to contract, might become sluggish or absent. Tongue tone might be poor, and it might take the horse several seconds to minutes to retract the tongue after gentle exteriorization out the side of the mouth.

(At this point it is important to note that until a neurologic horse is diagnosed, rabies



MATHEA KELLEY

Hyperimmune plasma contains high titers of antitoxin and is the most important element of treatment for botulism; horses should be treated

Botulism.

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should be considered a possibility and protection of humans is extremely important.)

These are the external signs of botulism; inside the horse's body, the toxin causes additional abnormalities. Toxin might obliterate gastrointestinal motility (leading to impactions or bowel displacements), voluntary bladder voiding, and, eventually, ability of the diaphragm to contract. The diaphragm is the large sheetlike muscle that separates the thorax from the abdomen, and its contractions are what facilitate breathing. The diaphragm is the last muscle to be paralyzed by the toxin, and as the horse approaches death, respiratory movements become weaker and weaker until the nerve impulses can no longer elicit a response from the muscle.

One of the most unpleasant aspects of botulism is the fact that only motor nerves are affected; sensory function is unimpaired. This means that victims of botulism can fully experience hunger, thirst, fear, stiff muscles, a distended bladder, the effects of failing respiration, and all other sensations, but simply cannot move in response. In an animal as sensitive to danger and the devastating effects of prolonged recumbency as the horse, the disease is particularly insidious.

Treatment

The most important element of treatment is administration of hyperimmune plasma, which contains high titers of antitoxin. Knowledge of the type of toxin endemic to a given area is important, because attempts to conclusively diagnose botulism by having blood, feed, or water samples analyzed might yield negative results, and even positive results could take days or weeks to be returned. This turnaround time is far too long for a horse with a disease that can kill within hours or days. Therefore, prompt administration of antibodies against the toxin type most likely to be present in the horse's location constitutes the horse's best chance for survival.

Hyperimmune plasma obtained from horses immunized with botulinum toxin is commercially available. The plasma is costly, because the costs of licensure to handle and use the purified botulinum toxin for immunization are high. Botulinum toxin is the most potent biotoxin known, and the potential for misuse and need for strict security during shipping make the regulatory costs substantial. Horses that ingest a small dose of toxin might survive without receiving antitoxin, but it is usually impossible to



This foal is suffering from shaker foal disease and has indwelling tubes for supplying oxygen and nutrition.

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ascertain the quantity of toxin to which a horse has been exposed.

One of the lethal elements of botulism is the irreversibility of the bond that forms between the toxin molecule and the nerve cell. Once a toxin molecule has entered a nerve cell, disruption of function is irrevocable because not even antitoxin can remove toxin once it has bound to the nerve cell. The antibodies in hyperimmune plasma can bind to toxin molecules in the blood circulation and neutralize them before they bind to nerve cells, but they cannot reverse the effects of bound toxin. This underscores the importance of timely recognition of clinical signs and administration of antitoxin before enough toxin molecules have blocked neuromuscular junctions as to render the horse unsavable.

There is one bit of good news in this scenario, and that is the horse's body can make new neuromuscular junctions. However, this process requires seven to 10 days, and keeping a recumbent horse that cannot eat or drink alive for that interval necessitates skillful and dedicated nursing care.

In adult horses, recumbency from any cause can have severe consequences, including development of pressure sores, muscle damage, and colic. Humans with botulism are placed on mechanical ventilators if the disease progresses to diaphragmatic weakness and paralysis, but no machines exist that are large enough to ventilate an adult horse for the days or week that might be necessary. Foals can be ventilated for a week or longer, and this intervention is lifesaving in many instances. However, when paralysis extends to involve

the breathing muscles in adult horses, it is humane to euthanize the horse.

After administration of hyperimmune plasma, the most important features of treatment are maintaining hydration (by giving intravenous fluids or administering feed slurry and water through a nasogastric tube), administration of antimicrobials to manage aspiration pneumonia or wound infection, rolling the horse to minimize compression damage to muscles, placement of a urinary catheter to facilitate urination, rectal evacuation to facilitate defecation, application of eye ointments if the horse cannot blink, and bandaging of the limbs to prevent injury from paddling and flailing.

Adult horses and foals that recover from botulism appear to recover fully, with no residual nervous system deficits or muscle weakness. A vaccination against botulism type B is available for administration to pregnant mares; this immunization results in a high titer of anti-botulism antibodies in the colostrum and protection for the foal.

Diagnosis

Efforts to identify toxin in feedstuffs or in feces from an affected horse are not always successful. Results of routine blood tests, such as a complete blood count (CBC) and serum biochemistry, are typically normal; in fact, unremarkable blood work is one feature that should prompt suspicion of botulism in a horse with signs of weakness.

Samples of feed from a feed bunk, an animal carcass detected in hay bales or processed hay products, and fecal samples might be submitted to diagnostic laboratories for toxin identification. A sample of the horse's serum should also be submitted for toxin analysis. Samples that are submitted as soon as possible after clinical signs are noticed are most likely to yield diagnostic information.

Take-Home Message

Botulism can be a lethal and devastating disease, but prompt recognition of clinical signs and veterinary intervention, especially administration of the correct antitoxin, increase the odds that the outcome will be favorable once the disease is diagnosed. 🐾

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