# Equine Trauma and First Aid

Common emergencies involving the musculoskeletal system include fractures, luxations, lacerations, puncture wounds, synovial infections, and exertional rhabdomyolysis. Although many of these conditions cannot be treated in the field, an accurate diagnosis and provision of appropriate emergency treatment are essential for the possibility of a successful outcome.

**FRACTURES AND LUXATIONS**

A thorough physical examination is warranted but may be complicated by the severity of the injury and other factors (eg, pain, anxiety, exhaustion, dehydration, owner/trainer anxiety). The goals of initial coaptation of fractures are to relieve anxiety, prevent further injury, and allow for safe transportation for additional evaluation and possible treatment. Emergency coaptation of unstable limbs is key and should be performed before radiographic evaluation or transportation to a surgical facility.

## Initial Assessment

Fractures or luxations should be suspected if a loud crack is heard, if there is acute, non-weightbearing lameness, or if the limb has an abnormal angulation or is visibly unstable. The extent of the physical examination should be dictated by the situation, to avoid further injury to the horse or bystanders. If the horse is recumbent, full assessment of the limb should be completed before attempting to stand the horse. If the horse is standing, examination of the limb should be completed before attempting to move the horse. With an unstable fracture, the limb should be stabilized before any other treatment.

Sedation or a twitch can be used to aid restraint for the examination. For sedation, an $\alpha_2$-agonist such as xylazine or detomidine can be used. Because $\alpha_2$-agonists often cause the horse to lean forward, which may increase the weight on an injured forelimb or decrease the ability to manipulate the limb, the minimal effective dose is preferred to reduce ataxia. However, up to double the standard dose regimen may be required to achieve effective sedation after maximal exercise or if the horse is excited. Butorphanol may be used for horses not well controlled by $\alpha_2$-agonists alone. Acepromazine should be reserved for euvolemic horses because of its hypotensive effects. If the horse is recumbent and a serious injury is suspected, general anesthesia can be safely induced using sedation with xylazine followed by induction with ketamine and diazepam or tiletamine-zolazepam. Before sedation or anesthesia, the circulatory system should be briefly assessed by evaluating heart rate, mucous membrane color, capillary refill time, and pulse quality. A heart rate >80 bpm accompanied by a delayed capillary refill time and poor peripheral pulse quality indicate the need for IV fluid support. Laboratory determination of biochemistry profile indices are becoming more commonly available in field situations. If available,

parameters of hydration and electrolyte balance are useful to dictate fluid volume and type.

For limb stabilization, it is useful to divide the limbs into four levels, which help define the method of coaptation. Level 1 injuries involve the distal metacarpus/metatarsus and phalanges and include the fetlock joint and extensor and flexor tendon injuries located at the level of the metacarpus and metatarsus. Level 2 injuries involve the mid-metacarpus to distal radius, the carpal joint, and the mid- to proximal metatarsus. Level 3 injuries involve the mid- to proximal radius in the forelimb or the tarsus and tibia in the hindlimb. Level 4 injuries are noted in the forelimb proximal to and including the elbow joint, or in the hindlimb proximal to and including the stifle joint.

The presence of a fracture can be determined by instability, crepitus, abnormal angulation, palpation of bone fragments, or direct visualization of the fractured bone. Luxation should be suspected when there is abnormal lateral-to-medial motion at the level of a joint. Radiographs are indicated to confirm the presence or absence of a fracture or luxation but only after coaptation has been applied. If radiographic equipment is unavailable on site, the horse should be transported to a referral facility for further examination. Hairline or stress fractures can be difficult to demonstrate radiographically, particularly in field conditions. Therefore, in the presence of severe lameness with pain localized to a long bone, external coaptation should be applied before moving the horse, to avoid catastrophic displacement of an incomplete fracture.

## Emergency Treatment

Therapeutic aims of the initial management of traumatic injuries are to relieve anxiety, immobilize the fracture or luxation for transportation, prevent further damage, and provide safe transportation. The principles of emergency coaptation of traumatic injuries in horses include appropriate wound care before application of external coaptation, provision of adequate padding to prevent skin abrasions, immobilization of the joint below and above the area of injury, prevention of lateromedial and craniocaudal motion, and never ending a splint in the middle of a long bone segment or at the end of a fracture line.

Wounds should be carefully cleaned and debrided. A nonstick gauze bandage can be applied and held in place with conforming gauze. Cotton padding is applied to the entire length of the segment to be immobilized and held in place with gauze, followed by elastic bandage material. The bandage should be snug, to avoid loosening with compression of the cotton material. Splints are then applied and held in place, ideally with fiberglass casting tape. This is particularly useful in stabilizing a luxation. If casting tape is unavailable, heavy tape (duct tape or medical white tape) can be used. The splints must be well padded to avoid the development of sores.

## Immobilization of Level 1 Injuries

Level 1 injuries include phalangeal fractures, distal metacarpus and metatarsal fractures, sesamoid fractures, fetlock, pastern or coffin bone luxations, or severance of one or more flexor tendons. Not included are fractures of the coffin bone; they are supported by the hoof capsule and do not require a splint. Although technically level 1 injuries, extensor tendon lacerations require a different mode of splint application and are discussed separately.

Forelimb and hindlimb immobilization differ slightly because of the presence of the reciprocal apparatus in the hindlimb. In forelimb injuries, immobilization is best accomplished by aligning the cannon bone with the phalanges to establish a straight, weight-bearing column. The horse will bear weight, although not fully weight bearing, on its toe. To bandage the limb, an assistant holds the leg by the radius, allowing the limb distal to the carpus to hang in a straight line to facilitate bandaging. A modified Robert-Jones bandage is placed using cotton combine bandage, brown gauze, and elastic bandaging material to form a light bandage that will allow for soft-tissue swelling. Each layer of bandaging material is wrapped separately and in the same direction to prevent shifting of the splint. A splint is applied to the cranial aspect of the limb, extending from toe to carpus using 4–6 layers of overlapping, nonelastic tape (eg, white medical tape, duct tape). The splint should be padded proximally to prevent skin injury. If lateral to medial instability is noted, a lateral splint may be added or casting tape applied over the splint.

In the hindlimb, the reciprocal apparatus prevents extension of the distal limb if the horse is non-weightbearing. Therefore, the limb is best immobilized by applying the splint on the caudal aspect of the limb, from the toe, on the plantar aspect of the hoof, to the point of the hock. Dorsal alignment of the bony column will not be possible and is not necessary for adequate coaptation. Bandaging and splinting techniques are otherwise similar to those used for the forelimb.

A commercially available splint (Kimsey Legsaver®) may be used for some level 1 fractures or tendon injuries; however, it does not provide enough lateral-to-medial stability for joint luxations or severely comminuted fractures. The splint is readily available in a number of sizes, easy to apply, and effective to achieve immediate immobilization. Two configurations are available: one with a slightly forward-angled bar for a flexed position of the forelimb, and one with a backward angle at the level of the fetlock to improve weight bearing. The forward angle is more effective for most fore- and hindlimb injuries, when weight bearing is not advantageous. Nonslip tape should be placed on the foot plate after application to make it less slippery, particularly on cement floors.

Lacerations or rupture of the extensor tendons, unlike flexor tendons, require a different type of splint. When both extensor tendons are completely disrupted, the horse will knuckle over, which can lead to injury of the dorsal aspect of the fetlock and further disrupt any associated wound. In this instance, external coaptation is needed to prevent knuckling over at the fetlock. A splint is applied to the cranial aspect of the fore- or hindlimb with the hoof flat on the ground to prevent joint flexion.

## Immobilization of Level 2 Injuries

Examples of level 2 injuries include mid to proximal cannon bone fractures, carpal bone fractures, distal radial fractures, and wounds of the carpus. The goal of coaptation is to prevent angulation and place the carpus in extension. In level 2 injuries of the forelimb, a moderately thick Robert-Jones bandage is applied up to the elbow, wrapping each layer separately to prevent slipping. The bandage should be ~3 times the diameter of the limb when finished, so that the entire splint lies flat against the bandage over its length. Two splints are applied, at a 90° angle, one lateral and one caudal. The splints should extend from the floor to the elbow, and the hoof should be flat on the floor. In hindlimb injuries, as in the forelimb, the bandage should be 3 times the diameter of the limb and extend from the floor to the stifle. Two splints are

needed. One splint will extend from the floor to the stifle laterally. However, because of interference with the reciprocal apparatus and the angulation of the hock, the caudal splint cannot extend to the stifle but should stop at the point of the hock.

## Immobilization of Level 3 Injuries

Level 3 injuries include fractures of the mid to proximal radius, tarsus, or tibia. Because of the nature of the fracture, the flexor muscles of the limb become abductors, resulting in a valgus angulation. The medial aspect of both the radius and tibia does not have a sufficient muscle mass to help prevent penetration of the skin by fractured bone, and open fractures are common. The goal of external coaptation is to prevent abduction of the limb and soft-tissue injury. On the forelimb, the splint is applied similar to that in level 2 injuries; however, the lateral splint must extend from the ground to the withers. The caudal splint is the same, extending up to the elbow. The lateral splint above the bandage should be well padded to improve fit and prevent skin injury. Once the horse is standing on the trailer, the splint can be secured to the chest with nonelastic tape in a figure-8 configuration for further stability, if needed. On the hindlimb, the splint is similar to that for a level 2 injury; however, the caudal splint is not needed, and the lateral splint should extend to the level of the tuber coxae. The splint can be a wide wooden board or a contoured metal splint made of electrical conduit. Adequate padding should be placed wherever the splint contacts skin above the bandage. Placing the hoof in extension can facilitate splint application.

## Immobilization of Level 4 Injuries

Level 4 injuries include fractures of the scapula, humerus, femur, and pelvis. They also include olecranon fractures and radial nerve paralysis because these injuries disrupt the passive stay apparatus in the forelimb. The flexion of the carpus that results can cause injury to the dorsal aspect of the limb and eventually tendon contracture. For forelimb fractures and radial nerve paralysis, a level 2 bandage and a caudal splint from the ground to the elbow is used to fix the carpus in extension. Although the fracture is not directly stabilized by this splint, it will prevent tendon contraction and allows the horse to prop the leg, which reduces anxiety. External coaptation is not indicated for fractures of the hindlimb at this level. The joint above and below the fracture cannot be immobilized, preventing fracture stabilization. Bandaging will only distract the fracture and make it more awkward to move the horse. Hematoma and soft-tissue swelling around the site of injury will provide functional immobilization. If the pelvis is fractured, the need for transportation and further diagnostics should be discussed, because motion during transit may displace fracture fragments, resulting in fatal hemorrhage.

### GUIDELINES FOR SAFE TRANSPORTATION

Before loading an injured horse, proper functioning of the vehicle should be assessed, the horse stabilized, and the injury immobilized as described. A low ramp facilitates loading and unloading. The trailer ideally should be brought to the horse if possible for loading. Once loaded in the trailer, the horse will lean on the wall and partitions to help balance and to reduce the load on the injured leg. It is never advised to transport a horse loose in a trailer or in a makeshift stall. A sling can be placed under the abdomen to help reduce the weight bearing on the limb. Many trailers have standing stalls at 45° angles (slant load trailers), which help horses balance during transport. If a regular, straight-load trailer is used, the horse should be loaded facing backward for a forelimb injury and forward for a hindlimb injury, to help cushion sudden stops. The head should be loosely tied, in case the horse falls, and a hay net provided to reduce

anxiety. Frequent stops should be made to check on the status of the horse and provide drinking water. If significant cardiovascular compromise exists, IV fluids can be administered while in transit.

If the horse is severely injured and needs to remain recumbent, it can be pulled onto the trailer after stabilizing the limb using a large tarp or blankets as a glide. The horse should be kept sedated during transport to avoid further injuries. A head protector, hay bales, or a bandage can be used to protect the head from self-trauma, and the down eye should be padded with a towel or blanket. The halter should be padded or removed to reduce the risk of facial nerve paralysis, with lower limb bandages applied to the remaining limbs to avoid trauma caused by paddling. Foals can be transported in recumbency with the help of restraint by a handler either in a trailer with the mare or separated from the mare in the vehicle with a handler.

**WOUNDS AND LACERATIONS**

Wounds and lacerations are common in horses. The steps involved in management of these injuries include control of hemorrhage, identification of all involved structures, and evaluation of the need for referral. Referral to a surgical facility is recommended if there are tendon injuries, penetration of a synovial structure, extensive degloving injury, severe blood loss, neurologic signs, or involvement of the thoracic or abdominal cavity. In addition to wound management, tetanus prophylaxis, analgesia, and appropriate antimicrobial therapy are indicated. If severe blood loss has occurred, cardiovascular support should be provided before and/or during transportation.

## Assessment

A brief physical examination should be completed before addressing the primary problem. If the wound is located on the limb, the presence and degree of lameness should be noted as indicators of a potentially more serious injury and the need for coaptation. The following characteristics are then evaluated: location, hemorrhage, configuration, penetration of a body cavity or synovial structure, and/or involvement of tendons. Assessment should first include application of a sterile, water-based lubricant, clipping of the hair, sterile preparation of the skin, and lavage of the wound. Wounds over joints, tendon sheaths, or tendons (particularly flexor tendons), puncture wounds, and those that expose or penetrate bone should be explored thoroughly for injury to important underlying structures. Hemorrhage may need to be controlled before further wound assessment is possible. Pressure bandages may be applied, and if the vessel can be located, it should be temporarily clamped or ligated. Certain wound configurations may significantly damage the blood supply to the skin and subcutaneous tissues and result in sloughing (eg, an inverted “V” configuration, crushing injuries with significant bruising). Wounds over the chest or abdomen may penetrate important organs. In the case of thoracic wounds, development of an open or closed pneumothorax can lead to severe respiratory distress. Any horse with chest trauma and dyspnea should have all open wounds sealed with plastic, airtight bandages and evaluated for a pneumothorax.

The potential involvement of a synovial structure should be immediately determined. The horse should be restrained and sedated as needed for the procedure. A site of entry into the joint or tendon sheath remote from the wound is chosen, clipped, and aseptically prepared. Using sterile technique, saline or a balanced electrolyte solution is injected into the synovial compartment. The amount needed to achieve distention and back-pressure can vary from a few milliliters, in the case of the distal tarsal joints, to >100 mL for the femoropatellar joint. All compartments of the joint should be

assessed. Synovial structure involvement may be confirmed if leakage of the injected solution is noted from the wound. If communication is not noted, the solution is aspirated from the joint, and the structure is injected with a prophylactic dose of an antibiotic (eg, amikacin). In chronic wounds or injuries caused by a puncture, the communication with the synovial cavity may have sealed. Horses should be reevaluated for increased lameness, heat, or effusion over the next 3–5 days, which could be evidence of an insidious infection. If there is significant edema, swelling, or skin trauma over all points of entry, the synovial structure should not be tapped to avoid the possibility of iatrogenic infection. In these cases, close monitoring or direct probing of the wound with a sterile instrument and radiographic assessment may be diagnostic.

Extensor tendon injury of the distal limbs results in the inability to appropriately place the hoof on the ground, and knuckling over. This suggests involvement of both extensor tendons in the proximal metacarpus or metatarsus, or the common digital extensor tendon more distally. Flexor tendon injuries result in hyperextension of the fetlock (superficial digital flexor), lifting of the toe (deep digital flexor), or complete dropping of the fetlock to the ground (severance or rupture of the suspensory ligament). For this to be seen, the horse must bear weight on the limb at least transiently, but this is not advised. In complete suspensory breakdown, severe stretching of the digital vessels can lead to thrombosis and avascular injury and necrosis of the distal limb. It is important to support the fetlock and not allow weight bearing until the limb is stabilized in a flexed position.

The goals of initial wound care are to decontaminate the wound as much as possible and prevent further contamination during transportation. After clipping and sterile preparation of the intact skin, the injured tissue is lavaged with sterile saline and cleaned by sharp debridement of gross contamination. The wound should be dressed with a sterile, nonstick bandage and a support wrap or padded bandage. Immobilization of the limb (see Immobilization of Level 1 Injuries) will be needed if there is injury to a supporting structure (bone, tendon) or significant instability (luxation).

## Pneumothorax

A penetrating chest wound can result in development of a pneumothorax and lead to respiratory distress. If untreated, pneumomediastinum can result, and this or the primary pneumothorax can be fatal. On examination, a restrictive pattern to the respirations is noted. Auscultation of the thorax will reveal a lack of breath sounds in the dorsal lung fields. Because of the incomplete mediastinum in horses, a unilateral chest wound can lead to bilateral pneumothorax. An open pneumothorax is managed by providing a temporary seal over the chest wound. The wound is cleansed and bandaged with a layer of airtight plastic wrap and sealed with elastic adhesive tape. The chest is then evacuated by inserting a 14-gauge catheter, using aseptic technique, in the dorsal aspect of the 12th intercostal space. Aspiration can be facilitated by use of a 3-way stopcock and 60-mL syringe or by negative suction. A closed pneumothorax may require an indwelling chest tube and Heimlich valve until the cause is resolved.

## Hemothorax

Hemothorax is a possible complication of a penetrating chest wound and can lead to respiratory distress similar to that seen in pneumothorax. Auscultation of the thorax will reveal a lack of breath sounds in the ventral lung fields, with muffled heart sounds.

If dyspnea is noted, the hemothorax should be drained; however, if ventilation is adequate the chest should not be tapped, and the blood will gradually resorb. To evacuate the chest, a 14-gauge catheter or thoracic trocar is placed using aseptic technique in the ventral aspect of the 6th–8th intercostal space. Ultrasound helps guide placement, to prevent accidental penetration of vital structures. Aspiration can be facilitated by use of a 3-way stopcock and 60-mL syringe or provided by passive drainage with a Heimlich valve. Complications of trocarization can include pleuritis due to introduction of bacteria, continued hemorrhage, and hypovolemic shock if the fluid in the third space is removed too quickly. Conservative fluid therapy should be provided for cardiovascular support, and a transfusion may be needed.

## Penetrating Abdominal Wounds

Penetration of the abdominal cavity is a serious and potentially fatal injury that can lead to hemorrhage, penetration of an abdominal organ, or development of peritonitis. If a penetrating wound is suspected, it should be sterilely prepared, cleansed with saline and low-pressure lavage, explored for the presence of a foreign body, and debrided. A transabdominal ultrasound may reveal free fluid. Abdominocentesis can be performed to detect fecal contamination, indicating a ruptured viscus, or internal hemorrhage. However, abdominocentesis may not be diagnostic initially, because indicators of peritonitis (eg, increased total protein, WBCs, bacterial organisms) take several hours to develop. The wound should be bandaged, and broad-spectrum systemic antibiotics and pain management initiated. In the presence of a large wound, or if the abdominal musculature is involved, the abdomen can be supported with a compressive support bandage.

### HEAD INJURIES

Head injuries can result in severe CNS damage. Injuries can be primary (eg, contusion, laceration, fracture, hemorrhage) or secondary (eg, subsequent edema, reperfusion injury, secondary necrosis). Therapy of head injury is designed to minimize secondary CNS damage.

Causes of head injury in horses include direct trauma from a fall or blows to the head. A common cause of head injury is when the horse falls over backward onto the poll. Injuries associated with this fall include basisphenoid fractures and avulsion of the ventral straight muscles (longus capitus and/or rectus capitus ventralis muscles) from the base of the skull. Basisphenoid fractures can result in acute optic nerve damage and cerebral signs. Temporary or permanent blindness may result. Rupture of the ventral straight muscles may cause severe epistaxis, requiring transfusion, and avulsion fractures at the muscular insertion onto the skull may contribute to additional CNS injury.

The diagnosis is made by radiographs or CT to identify skull fractures, avulsion fractures, or a soft-tissue opacity in the guttural pouch (consistent with a hematoma from rupture of the ventral straight muscles). Endoscopy may show hemorrhage from the guttural pouch originating from the base of the stylohyoid bone or medial wall of the guttural pouch. Hematomas may be noted in the guttural pouch septum where the ventral straight muscles lie. Hemorrhage caused by fractures may also be seen draining from the ethmoid turbinates.

## Treatment

Treatment of head injuries is mainly supportive to reduce secondary CNS damage. Horses with head injuries can be severely ataxic and should be handled and moved with extreme caution. If the horse is recumbent, short-term general anesthesia is best to transport the horse to a referral facility for further evaluation. Opioids should be avoided for sedation of horses with head trauma because of the risk of decreased cerebral perfusion pressure. The horse should be given IV fluids to maintain normal blood pressure and reduce the risk of cerebral ischemia. Diuretics are contraindicated. If hypoventilation develops, the horse should be intubated, and ventilation assistance provided to prevent hypercapnea. If the blood-brain barrier has been breached by a fracture, broad-spectrum antibiotics should be started. NSAIDs are administered to minimize inflammation, and seizures should be managed with diazepam (0.5–0.44 mg/kg, IV) or phenobarbital (5–15 mg/kg, given slowly IV). Although controversial for traumatic brain injury in human medicine, corticosteroids may be indicated in the acute phase of injury (eg, dexamethasone, 40–100 mg, IV). DMSO (1 g/kg, IV, in 5 L balanced electrolyte solution every 12 hr) has also been used to minimize secondary edema and decrease intracranial pressure. More effective for treatment and prevention of edema is 20% mannitol (1 mg/kg, IV, every 6–12 hr) or 7.5% hypertonic saline (4–6 mL/kg, IV, every 6–12 hr). Magnesium (0.05 mg/kg, IV, over 30 min) has also been proposed as a therapeutic agent to reduce cerebral ischemia.

**OCULAR INJURIES**

Ocular injuries are usually traumatic in origin and include periocular lacerations, corneal lacerations, foreign body penetrating injuries, and direct blows to the eye, causing retinal detachment. (Also see Ophthalmic Emergencies.) Evaluation of acute ocular injury includes a thorough evaluation of the structures of the eye (including the eyelids, conjunctiva, cornea, and lens), a fundic examination, and evaluation of cranial nerve function to assess the degree of damage. Vision can be assessed by the menace response and obstacle course testing. Oculomotor, trochlear, and abducens nerve function are assessed by the position of the eye and pupillary light responses. Facial nerve and sympathetic innervation to the eye are assessed by eyelid tone and position of the eyelashes.

Treatment of acute ocular injuries includes minimizing pain and inflammation, preventing infection, and preventing further injuries. If penetration by a foreign body is suspected, rapid surgical intervention is indicated. Eyelid lacerations should be sutured, with assistance of a palpebral nerve block and local infiltration of an anesthetic. Sutures should be placed carefully to prevent corneal abrasion, and skin should be preserved during debridement. Anti-inflammatory medications administered to minimize pain and inflammation include NSAIDs and topical osmotic agents. Pain from pupillary spasm can be minimized by dilating the pupil with atropine and covering the eye to prevent myosis in bright sunlight. Acute injuries can be associated with corneal ulceration and secondary bacterial or fungal invasion. Use of broad-spectrum topical antibiotic and an antifungal medication may prevent secondary infection of a corneal ulcer. Horses that are acutely blind cannot move around their environment well. Further injury should be prevented by protecting the blind eye and by careful handling.

**THERMAL INJURIES**

Thermal injury to a horse is rare. Most cases involve barn fires, lightning, electricity, caustic chemicals, or friction. Most burns are superficial, easily managed, inexpensive to treat, and heal in a short time.

## Classification

Like those in people, burns in horses are classified according to the depth of injury. First-degree burns involve only the most superficial layers of the epidermis. These burns are painful and characterized by erythema, edema, and desquamation of the superficial layers of the skin. The germinal layer of the epidermis is spared, and the burns heal without complication.

Second-degree burn, superficial, horse

Second-degree burn, deep, horse

Second-degree burns involve the epidermis and can be superficial or deep. Superficial second-degree burns involve the stratum corneum, stratum granulosum, and a few cells of the basal layer. Tactile and pain receptors remain intact. Because the basal layers remain relatively uninjured, superficial second-degree burns heal rapidly with minimal scarring, within 14–17 days. Deep second-degree burns involve all layers of the epidermis, including the basal layers. These burns are characterized by erythema and edema at the epidermal-dermal junction, necrosis of the epidermis, accumulation of WBCs at the base of the burn zone, eschar (slough produced by a thermal burn) formation, and minimal pain. The only germinal cells spared are those within the ducts of sweat glands and hair follicles. Deep second-degree burn wounds may heal spontaneously in 3–4 wk if care is taken to prevent further dermal ischemia that may lead to full-thickness necrosis.

Third-degree burn, horse

Third-degree burns are characterized by loss of the epidermal and dermal components, including the adnexa. These burns, when fresh, range in color from white to black. There is fluid loss and a marked cellular response at the margins and deeper tissue, eschar formation, lack of pain, shock, wound infection, and possible bacteremia and septicemia. Healing occurs by contraction and epithelialization from the wound margins, or acceptance of an autograft. These burns are frequently complicated by infection.

Fourth-degree burn, horse

Fourth-degree burns involve all of the skin and underlying muscle, bone, ligaments, fat, and fascia.

## Pathophysiology

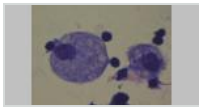
After severe burns, there is a dramatic cardiovascular effect termed burn shock, which resembles hypovolemic shock. Local and systemic capillary permeability increases dramatically in response to heat and the release of cytokines, prostaglandins, nitric oxide, vasoactive leukotrienes, serotonin, histamine, and oxygen radicals. Because heat is slow to dissipate from burn wounds, it is often difficult to accurately evaluate the amount of tissue damage in the first 24–72 hr after injury. The extent of the burn depends on the size of the area exposed, while the severity relates to the maximum temperature the tissue attains and the duration of overheating. This explains why skin injury often extends beyond the boundaries of the original burn.

## Management

Administration of isotonic fluids, at a rate of 4 mL/kg/% burn, in the first 24 hr (one-half of which is given in the first 8 hr) is recommended, but fluid resuscitation is best titrated to maintain stable and adequate blood pressure. An alternative is to use

hypertonic saline solution (4 mL/kg) followed by administration of isotonic fluids. If there has been smoke or heat inhalation injury, crystalloid administration should be limited to the amount that normalizes circulatory volume and blood pressure. Continuing to administer electrolyte solutions at the same rate after burn shock has resolved leads to edema, which counters any improvement in cardiovascular dynamics. During fluid administration, hydration, lung sounds, and cardiovascular status should be monitored carefully by clinical assessment and PCV and total protein measurement.

Flunixin meglumine (0.25–1 mg/kg, IV, 1–2 times daily) is an effective analgesic. Firocoxib (0.1 mg/kg/day, PO) is a COX-2 inhibitor for horses. Although COX-2 inhibitors would seem beneficial in the management of burn patients, firocoxib is approved only to alleviate musculoskeletal pain. Human studies have found a synergistic effect of ketamine and morphine to ameliorate pain of skin burn injuries. Pentoxyfylline (8 mg/kg, IV, bid) is used to improve the flow properties of blood by decreasing its viscosity. Administration of dimethylsulfoxide (DMSO) at 1 g/kg, IV, for the first 24 hr, may decrease inflammation and pulmonary edema. If pulmonary edema is present and is unresponsive to DMSO and furosemide treatment, dexamethasone can be administered once at 0.5 mg/kg, IV.


Bronchial alveolar wash after inhalation smoke injury

The cornerstones of therapy for smoke inhalation injury are maintenance of airway patency, adequate oxygenation and ventilation, and stabilization of hemodynamic status. Antibiotics and corticosteroids do not influence survival rates and should not be routinely administered. Systemic antimicrobials are indicated only for proven infections, the incidence of which increases 2–3 days after smoke inhalation. Procaine penicillin IM is effective against oral contaminants colonizing the airway. If signs of respiratory disease worsen, a transtracheal aspirate should be submitted for culture and sensitivity testing, and the antibiotic regimen adapted accordingly. Horses with suspected significant smoke inhalation should be observed closely for several hours and hospitalized if burns are extensive. Successful treatment depends on continual patient reassessment, as well as early and aggressive care.

First-degree burns are generally not life-threatening and thus simply managed. Second-degree burns are associated with vesicles and blisters. These vesicles should be left intact, because blister fluid provides protection from infection and an intact blister is less painful than the denuded exposed surface. An antibacterial dressing such as silver sulfadiazine is applied to the wounds while an eschar is allowed to form. Third-degree burns can be difficult to manage. The horse's systemic condition should be stabilized as rapidly as possible before undertaking wound management. Destruction of the dermis leaves a primary collagenous structure called an eschar. The eschar does not prevent bacterial contamination or evaporation of heat or water. The eschar should be covered with an antibacterial agent twice daily. Wound contraction does not occur while the eschar is intact. The eschar is sloughed by bacterial collagenase activity within 4 wk. The exposed bed can then be grafted or allowed to contract.

Although bacterial colonization of large burns in horses is not preventable, the wound should be cleansed 2–3 times daily, and a topical antibiotic reapplied to reduce the bacterial load to the wound. Occlusive dressings should be avoided because of their ability to produce a closed wound environment, which may both encourage bacterial

proliferation and delay healing. Amnion can decrease the pain of the wound and is antibacterial. It is more useful in areas of the body where it can be firmly pressed into the wound, such as the distal limbs. Additionally, circulation to the burned areas is often compromised, making it highly unlikely that parenteral administration of antibiotics can achieve therapeutic levels within the wound.

The most commonly used topical antibacterial for the treatment of burns is silver sulfadiazine in a 1% water miscible cream. It is a broad-spectrum, antibacterial agent able to penetrate the eschar. Silver sulfadiazine is active against gram-negative bacteria, especially *Pseudomonas*, with additional effectiveness against *Staphylococcus aureus*, *Escherichia coli*, *Proteus*, Enterobacteriaceae, and *Candida albicans*. It causes minimal pain on application but must be used twice a day because it is inactivated by tissue secretions.

Many burn patients suffer pruritus such that measures must be taken to prevent self-mutilation of the wound. Reserpine (2.5 mg, PO, for 7–10 days), normally used in horses as a long-acting tranquilizer, can effectively decrease the urge to scratch by successfully breaking the itch-scratch cycle. Weight loss of 10%–15% during the course of illness is indicative of inadequate nutritional intake. Gradually increasing concentrate, adding fat in the form of vegetable oil, and offering free-choice alfalfa hay increase caloric intake.

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