Castration is one of the most common surgical procedures performed in equine practice. Although an elective and routine procedure, surgical complications of castration constitute the most common cause of malpractice claims against equine practitioners. Evisceration through the vaginal ring and open scrotal incision is uncommon and potentially fatal. Evisceration generally occurs within 4 hours, but may occur up to 6 days after castration. Evisceration of the small intestine makes up 67% of cases while omental prolapse compromises the remainder. A survival rate of 85 to 100% can be expected where appropriate treatment is carried out.

Post-castration evisceration is always a risk following open castrations, but the risk is increased in certain breeds with large inguinal rings, or after castration of an adult stallion. Standardbreds, Tennessee Walking Horses and Belgians are at greater risk because they have larger inguinal rings. Other predisposing factors include a pre-existing undetected inguinal hernia, presence of visceral structures adjacent to the internal inguinal ring, and increased abdominal pressure after surgery. Palpation of the scrotum and inguinal structures for hernias prior to castration is recommended.

Evisceration of omentum or small intestine can occur and must be appropriately identified prior to treatment. The main objective is to clean and protect the intestine and return it to the abdomen before it is excessively traumatized or contaminated. Prior to the
veterinarian’s arrival it is important to instruct the owner to keep the horse quiet. The structure should be supported by a moistened towel in a sling fashion to support the eviscerated structure to avoid further stretching or damage. Examination will quickly reveal what structure is involved so that treatment can be initiated.

**Treatment**

*Omental evisceration*

Prolapse of the omentum through the scrotal incision after castration generally is not an immediate emergency but signals the possibility for potential evisceration. A rectal palpation should be performed to ensure that there is no associated small intestinal involvement. Prolapse of the omentum through the inguinal ring can usually be managed using sedation and transecting the prolapsed omentum as far proximal as possible. In more severe cases a short-term general anesthetic is given. The omentum and scrotum are cleaned and prepped, and the omental segment is emasculated. The scrotum is packed with gauze and closed, and the horse is given systemic antibiotics. The packing can be removed after 2 days, and antibiotics are continued for 24 hours after removal of the pack.

*Small intestinal evisceration*

It is important to replace the intestine within the abdomen as soon as possible after
evisceration. Delay in repair of the evisceration puts undue stress on the mesenteric vessels leading to avulsion of the mesenteric vessels, thrombosis, and further damage to the intestine proper. In the field the intestine should be lavaged and where possible placed back within the scrotum which is then sutured.

The horse should be anesthetized immediately to minimize contamination and damage to prolapsed intestine. Intravenous fluids and hypertonic saline should be administered to minimize hypotension. The intestine is copiously lavaged and examined for damage. If avulsion of mesenteric vessels or strangulation has occurred, requiring intestinal resection, the scrotum is sutured closed containing the intestine and the horse is referred to a surgical facility.

If the intestine is clean and appears healthy, it is replaced in the abdomen. To replace the intestine in the abdomen, the internal inguinal ring often must be dilated. Care must be made that the intestine is replaced within the abdomen through the inguinal canal, and not through a separate iatrogenic opening. If the herniation cannot be reduced confidently, or if there is avulsion of mesenteric vessels or strangulation requiring resection the intestine is replaced in the scrotum, packed with gauze and the horse is referred to a surgical facility. The horse is placed in dorsal recumbency under general anesthesia. A ventral midline celiotomy is used to expose the abdomen for the presence of further damage to the intestine and associated mesenteric structures. To replace the intestine into the abdomen, dilation of the vaginal ring and traction on the intestines through the abdominal incision are usually necessary. Devitalized intestine outside the abdomen is resected and
healthy intestine anastomosed prior to replacing the intestine through the vaginal canal and into the abdomen. Lesions involving the ileum may require resection of the ileum and jejunocostomy.

If the herniation can be reduced successfully, the fundus of the vaginal sac is identified if it has not been shredded during the initial castration or reduction of the prolapse. The fundus of the vaginal sac is ligated with absorbable suture and transfixed to the edge of the superficial inguinal ring. This procedure seals the exit of the intestine. The superficial inguinal ring is then closed with double absorbable suture in a continuous pattern. The superficial layers of the wound are left unsutured if the wound is grossly contaminated. Sterile gauze can be packed into the inguinal canal and scrotum rather than suturing the superficial inguinal ring. Care must be taken to avoid introducing gauze into the abdomen. A short segment of gauze is left exposed through the scrotal closure. If the horse progresses well, the gauze packing can be removed in 48 hours, and the antibiotics discontinued 24 hours after removal of the packing. The deep inguinal ring should be palpated per rectum before the packing is removed to confirm that intestine is not adhered to the pack.

Broad spectrum antimicrobial therapy should be initiated, analgesic doses of flunixin meglumine (1 mg/kg IV) administered and the horse immediately referred to a surgical facility to be monitored closely for development of colic or ileus, indicating intestinal devitalization has occurred requiring immediate exploratory celiotomy.
References available from author upon request.
Clinical Signs: Most rectal tears occur in association with rectal palpation and should be suspected when a sudden decrease in the resistance to palpation is felt or when fresh blood is observed on the palpation sleeve. With grade three or four tears the horse will begin to sweat, develop an increased heart rate, fever, abdominal pain and splinted abdomen in 2-3 hours consistent with signs characteristic of septicemia, endotoxic shock, and peritonitis. Most rectal tears occur dorsally, in a longitudinal direction 25 to 30 cm cranial to the anus in the intra peritoneal portion of the rectum and dissect obliquely for a variable distance along the lateral wall. In this region there is a decrease in the circular muscle thickness that corresponds with the increase in thickness of the mesenteric taenial band of the small colon. The decrease in circular muscle thickness along with a lack of serosal surface of the bowel enclosed in the mesorectum could contribute to the inherent weakness at this site. Rectal tears that occur caudal to the peritoneal reflection may lead to a retroperitoneal abscess that could extend into the abdominal cavity or require draining into the rectum, vagina, or perineum.

Diagnosis
Rectal tears have been classified on a four-grade system. Grade one tears are restricted to the mucosa and submucosa and palpate as a small roughening or defect in the rectal wall associated with bleeding. Grade two tears involve only the muscular layers of the rectal
wall while the mucosa and serosa remain intact. No blood is seen on the rectal sleeve and these are considered to be incidental findings. Grade three lesions involve all tissue layers except the serosa or mesorectum. There are deep defects that are often filled with feces. Grade 3A tears have the serosal covering of the intact bowel, whereas Grade 3B tears occur dorsally into the fat filled mesorectum. Grade four tears involve a perforation of all layers of the rectal wall which permit direct communication between bowel contents and the abdominal cavity. Palpation of the abdominal organs directly is possible through a Grade 4 tear. Circumferential retroperitoneal rectal tears have been reported but are infrequent.

When a rectal tear occurs, prompt action will often improve the patient’s chance of survival and the veterinarian’s defense against litigation. An epidural anesthetic and sedation (xylazine 0.4 mg/kg intravenously and butorphanol tartrate 0.05 mg/kg IV) will help facilitate a careful examination of the rectum. Careful determination of the extent and exact location of the tear can be facilitated by bare arm palpation or cutting the fingers off a normal rectal sleeve and using a latex exam glove over the exposed fingers. The feces should be carefully removed from the rectum before beginning the rectal examination. The tear may then be located by sequentially inserting a hand into the rectum further each time until blood is observed. A vaginal speculum can help to visualize the tear; however the rectal mucosa usually folds around the speculum, making direct visualization difficult. Careful palpation will determine the severity of the tear once it is located. The tear should be very gently felt for position, distance from the anal sphincter, size and depth. Any feces in or around the tear should be very carefully
removed. The improper healing of grade one or two rectal tears can lead to abscess and/or fistula formation. Grade two tears may be felt upon subsequent rectal palpations as a variable-sized diverticulum that is more accurately described as a mucosal-submucosal hernia. These tears are usually incidental findings, as luminal bleeding is not associated with these tears. Grade 3A tears usually form a diverticulum lined by serosa, which fills with feces shortly after the injury. The 3B tears allow fecal contamination of the mesocolon. Fecal contamination of Grade 3 tears may progress to a Grade 4 tear. Grade four tears are easily detected with direct palpation of abdominal organs. Peritoneal fluid changes occur quickly in horses with Grade 3 and 4 rectal tears with nucleated cell counts exceeding 50,000 cells/µl in 30 minutes.

Treatment

Accurate and early treatment has a marked influence on case survival. Horses with Grade 1 tears are amenable to either medical treatment alone or can be treated using epidural anesthesia with direct suturing techniques in the standing animal. Broad-spectrum antibiotics should be administered with serial hemograms and peritoneal fluid analysis to aid in monitoring the patient. The horse should be monitored closely for one week and fed a laxative diet such as water-soaked alfalfa pellets, combined with regular administration of mineral oil by nasogastric tube. Oral or intravenous fluid replacement may be required to restore circulating volume, ensure tissue perfusion, and prevent bowel stasis and possible colon impaction.
Grade two tears are discovered as an incidental finding on subsequent rectal palpations as a variable-sized diverticulum that is commonly described as a mucosal-submucosal hernia. Horses with Grade 2 tears may present with signs of tenesmus or with rectal impactions. The hernia or diverticulum is usually detected after manual evaluation of the rectum. These tears occasionally lead to the formation of a pararectal abscess. These tears are frequently manageable with conservative measures such as dietary control aimed at keeping the feces soft. Horses with Grade 3 rectal tears require prompt and aggressive medical and surgical intervention. Early recognition of the condition, along with aggressive precautionary measures to arrest the further development of the tear are indicated. Surgical intervention should be instituted immediately, for delaying repair only increases the mortality rate associated with the disease.

The immediate goal is to prevent enlargement and development of a Grade 4 tear. This is accomplished by tranquilizing the horse, providing epidural anesthesia to eliminate straining, manually removing feces from the rectum, and packing the rectum to prevent fecal contamination and diverticulum formation. Epidural anesthesia should be maintained to prevent the horse from straining against the pack. A combination of xylazine and carbocaine may be useful to provide a long-acting effect. All feces within reach are removed from the rectum and small colon, and the rectum is packed with moist cotton inside a well lubricated 3 inch stockinette. The purpose of the packing is to fill, but not distend, the rectum. The pack should extend from the anus to approximately 10 cm cranial to the site of the tear. No material should be packed into the tear itself. The anus is then closed with towel clamps or a purse string suture to prevent the packing from
Vigorous medical management should be instituted. Atropine, a parasympatholytic drug, has been recommended by some clinicians to depress intestinal motility. When used correctly as a single dose (0.044 mg/kg IM or subcutaneously [20 mg for a 450-kg horse]), atropine will decrease intestinal motility for up to 12 hours. This can be a safe and excellent way to depress intestinal motility. Broad-spectrum systemic antimicrobials, tetanus toxoid, and fecal laxatives such as mineral oil should also be administered. Balanced polyionic fluids should be administered to rehydrate the horse in anticipation of an extensive surgical procedure and to counter the hemodynamic effects of endotoxins.

Several surgical techniques have been described to repair rectal tears. These include direct surgical repair via a rectal approach, partial prolapse of the rectum, placement of a temporary diverting colostomy, placement of a temporary rectal liner and direct surgical approach and repair via a celiotomy. The technique chosen to repair the rectal injury depends largely on the location of the tear, the preference and expertise of the surgeon, and the availability of specialized surgical equipment.

Techniques used to repair Grade 3 tears also apply for Grade 4 tears. Because there is more direct contamination of the abdomen in Grade 4 tears, there is an increased expense due to the likelihood of multiple postoperative complications. As a result, a poorer prognosis is associated with Grade 4 tears so the value of the animal in perspective to the expense incurred should be taken into consideration.
Direct closure: Direct closure of Grade 3 tears can be done in the standing animal if the tear is less than 15 cm from the anus. The horse must be cooperative and have a rectum that is easily dilated. The surgeon must have good patience and the manual dexterity to close the wound without further damaging the edges of the tear or incorporating nearby mucosal folds into the tear that would reduce the rectal diameter.

An interrupted cruciate pattern utilizing size 0 or 1 absorbable suture material with a swaged-on taper point, half-circle needle incorporating all layers is the method of choice. The tear can be repaired blindly with the sewing hand inserted into the rectum. Incomplete suturing of the tear, however, will allow for continual packing of the defect with feces and eventual breakdown or submucosal dissection. The use of an expandable rectal speculum or wire basket (Robert A. Roland, Davis, CA) and long-handed instruments can facilitate closure of these tears for individuals inexperienced with the blind suturing method. Transection of the anus will improve access to the tear and facilitate defecation after surgery. Contraction of the wide muscular bands and circular smooth muscle increases the risk of dehiscence of the sutured tears. With proper patient selection (Grade 3-A tears), primary closure of the tear with sutures has yielded excellent results in six of 7 patients.

Direct suturing of the tear can also be achieved by prolapsing the small colon until the tear is exposed outside the anus. A hand is passed through the rectum to grasp the colon wall with a gauze sponge placed by an assistant through a laparotomy incision. Surgical stapling equipment (TA 90 premium, United States Surgical Corporation, Norwalk, CN)
has been successfully used to repair rectal tears exteriorized via suture traction of the rectum and wound edges. This procedure is more easily accomplished in thin horses as less pressure is applied on the mesenteric vessels during traction of the small colon.

Temporary rectal liner: Placement of a temporary rectal liner via a ventral midline celiotomy has been described for the treatment of Grade 3 or 4 tears. Each end of a 5 x 10 cm plastic rectal ring (Rectal Ring, Regal Plastic Co, Detroit Lakes, MN) is trimmed to form a 5 x 7-cm ring. Holes are drilled 1.5 cm apart in one edge of the central groove around the circumference of the ring and #5 Dacron suture material is laced through the holes, forming a continuous anchor suture. The rectal ring is inserted into the small end of an arthroscopy camera sleeve (Video Camera Cover, Surgical Resources, Inc. Darlington, MD). Modern rectal palpation sleeves have proven too unreliable creating the need to use the more durable camera sleeve. A rubber band is placed around the sleeve and over the center groove in the ring at the opposite end from the anchor suture. The sleeve is fastened to the end of the ring with cyanoacrylic and the sleeve is inverted over the ring and fastened to itself. Inversion of the sleeve protects the intestine against irritation by the rubber band, the cut edges of the sleeve, and the cyanoacrylic. An assistant passes the plastic rectal ring and sleeve through the anus and small colon until it can be surgically placed oral to the tear. Number 3 surgical catgut is passed around the colon and over the groove on the ring and is tied to constrict the serosal surface. Four interrupted retention sutures are placed equidistant through the colon wall to include the circumferential catgut suture and the dacron suture in the rectal ring. Absorbable
retention sutures (2-0) in a Lembert pattern are then oversewn over all previous sutures so as to infold the wall.

The large colon should be evacuated by a pelvic flexure enterotomy, and a stomach tube is passed retrograde from the anus up the sleeve to thoroughly flush the small colon with water and to infuse 4 L of mineral oil into the right dorsal colon. Feces that enter the ring are contained within the liner until passed through the anus. The anastomosis maintains continuity of the intestinal tract until the ring and circumferential suture slough nine to 12 days after surgery. The temporary indwelling liner effectively protects Grade 3 tears during healing, unless the tear converts to a Grade 4 tear. The horse is kept standing until the rectal tear heals because the sleeve could retract into the rectum if the horse becomes recumbent. Mineral oil and a pelleted ration are fed until the ring and liner detach.

Diverting colostomies can be performed with the horse standing, using sedation and local anesthesia or with the horse under general anesthesia. Advantages of the standing procedure include the elimination of risk of damage to the stoma during recovery from anesthesia, less expense and the elimination of possible complications incurred during general anesthesia. Advantages of performing the colostomy with the horse under general anesthesia include the greater ease of tissue handling with the horse in lateral or dorsal recumbency. In the presence of peritoneal inflammation, the un-anesthetized horse may be reluctant and unwilling to permit any traction and manipulation of the bowel.
Ileus is a common complication after repair of a rectal tear. Peritonitis from the tear and surgical manipulation of the small colon, as well as postoperative anesthetic depression of bowel motility contribute to this complication. Although these concerns will subside with time, neostigmine can be administered early to prevent ileus and decrease patient morbidity and mortality. It is generally administered intravenously via a slow-drip system (Travenol infusor, Deerfield, IL) at 2 ml per hour (0.01 mg/kg/hour) connected to the IV catheter. If the horse shows signs of discomfort, the rate of neostigmine administration can be decreased. Neostigmine administration is stopped in horses that continue to be painful. The drip is used for 48-96 hours postoperatively to enhance propulsive activity of the large colon. Metaclopramide, which enhances gastroduodenal motor activity, may be used separately or in combination to prevent or treat ileus. Correcting all electrolyte disturbances, walking the horse routinely, feeding a diet of lush green grass, administration of analgesics and control of peritonitis all play equally critical roles in minimizing occurrence of ileus. Waiting for the bowel to become severely distended or for other metabolic problems to arise impairs the intestinal motility and jeopardizes survival of the patient.

A warm water enema to keep the lumen open and to prevent reimpaction may be necessary as the colostomy site becomes edematous within the first 24 hours after surgery. It is important to treat local abscesses as they arise at the stoma by drainage and lavage so as to allow the tissues to heal before it is time for the reanastomosis procedure. Serial peritoneal fluid analysis can be used to assess the abdominal response to the tear, and peritoneal lavage can be performed as an adjunct to control inflammation. Serious
consideration should be given to the treatment of peritonitis if the patient is febrile, depressed, anorectic, or has ileus. Further evidence of peritonitis would be indicated by increased quantities of peritoneal fluid with a nucleated cell count exceeding 150,000 cells per mm³, karyolysis of the neutrophils or the presence of bacteria and a high total protein concentration in the fluid. A large bore (30 French) mushroom catheter may be inserted through the linea alba into the cranial abdomen and used to infuse three to 10 L of warmed lactated Ringers solution into the abdomen. After an hour, the fluid is allowed to drain out the same catheter.

The method of closure for the loop colostomy involves taking down the stoma. The attachments to the skin and external abdominal oblique muscles are carefully dissected free from the edge of the small colon. The antimesenteric band is closed with double-inverting layers, utilizing 2-0 absorbable suture, and the small colon is vigorously cleaned and replaced in the abdomen. If the small colon is excessively traumatized in this dissection, the effected small colon should be brought through the incision and a resection and end-to-end anastomosis performed. The flank incision is then closed in a routine manner.

Loop colostomy may be of benefit to horses with rectal tears provided it is done soon after the tear occurs. In two retrospective studies of 13 horses with grade 3 rectal tears, seven survived. Complications after loop colostomy include septic peritonitis, laminitis, incisional infections of the colostomy site, peristomal hernia and prolapse. Complications associated with colostomy include stoma abscesses, prolapse, dehiscence,
disuse atrophy of the distal portion of the small colon and intra-abdominal adhesion formation.

References available from author upon request.
Vaginal Lacerations Secondary to Breeding

Vaginal lacerations incurred during breeding most commonly involve the cranial dorsal vaginal wall close to the cervix. They are generally less than 5 cm long and are accompanied by minor transient hemorrhage. Minimal hemorrhage in maiden mares may result from perforation of a persistent hymen, does not require treatment, and must be differentiated from vaginal laceration. If not for the presence of fresh blood on the penis of the stallion after dismounting most of these lesions would go unnoticed. These lacerations have been attributed to the disproportionate size of the stallion’s penis and mare’s vagina or may be related to the copulatory technique of some stallions. The associated hemorrhage mixed with semen could have the same effect as hemospermia, which has been associated with reduced fertility. With minor lacerations spontaneous healing is rapid and complete as most lesions are usually undetectable by the next estrous cycle.

Extreme lacerations to the vagina after breeding can result in rupture of the vaginal wall. Evisceration of bowel or urinary bladder may present as bulging of these structures from the vulvar lips. Most commonly this affects the dorsal aspect of the cranial vagina. Unless the mare is examined after detection of fresh blood at the vulva or on the stallion’s penis, the possibility of vaginal rupture and contamination of the peritoneal cavity may be overlooked. A manual examination with a sterile glove and sleeve can help determine
whether the peritoneal cavity is penetrated. Peritoneal centesis may reveal the presence of peritonitis or spermatozoa. Discovery of the injury warrants prompt preventive antimicrobial therapy. If a vaginal rupture is overlooked, the mare becomes depressed in 2 to 3 days after breeding and shows signs of acute peritonitis. The peritoneal cavity is contaminated with bacteria from the stallion’s penis and mycolic acid from sperm cells.

For wounds not entering the peritoneal cavity the vagina should be gently lavaged with a sterile saline solution and infusion of a local antibiotic (Furacin). An epidural anesthetic may be indicated if tenesmus is present (5-8 ml 2% lidocaine). Systemic antibiotics are indicated for 7 days (procaine penicillin 22,000U/kg IM q12h; gentamicin, 6.6 mg/kg q24h)

For wounds entering the peritoneal cavity, local and systemic antibiotics should be initiated as described with the addition of metronidazole (15 mg/kg PO q8h). If a portion of the bowel eventrates through the rent, it should be washed with normal saline solution containing non irritating antimicrobials before replacement in the abdominal cavity. The vagina should be flushed with normal saline solution. Unless surgical repair of vaginal damage can be easily achieved it is not indicated. Peritoneal lavage with large volumes of sterile saline solution is indicated if severe inflammation of the peritoneum is present. Vaginal lacerations heal by second intention in 7 to 10 days. However, to prevent the evisceration of abdominal viscera, it is wise to keep the mare from lying down for 5 days with close observation during this time.
If extensive trauma to the herniated small intestine or gross contamination of the peritoneal cavity has occurred, the mare should be referred to a surgical facility. Triage prior to referral is indicated. The herniated intestine should be cleansed and replaced in the abdomen with interim suturing of the vaginal lips for transport. Intravenous fluids should be administered prior to and during shipment if the mare is showing signs of shock.

**Acute Septic Metritis**

Septic metritis occurs most commonly when there is extensive trauma and resulting contamination of the reproductive tract during a difficult dystocia. Because of the severe consequences, this condition must be managed rapidly and aggressively. Clinical signs may begin as early as 12 to 24 hours after foaling, with the mare becoming severely depressed, anorectic and painful. Signs of septicemia include increased temperature, pulse, and respiration, injected mucous membranes, dehydration, and cool extremities. Clinical signs of laminitis may become evident 12 hours to 5 days after the onset of acute septic metritis. Vaginal discharge is usually not copious but a thin watery discharge with a variable smell may be seen. Closer examination within the uterus reveals an enlarged thin-walled uterus distended with a chocolate colored, fetid fluid.

The treatment goals for acute septic metritis are directed at reducing the bacterial growth and eliminating toxins by supportive systemic therapy and removing the fluid accumulating in the uterus. Intravenous fluids are needed to correct shock and dehydration. Flunixin meglumine (0.3 mg/kg IV q8h) is indicated to lessen the effects of
endotoxemia. Aggressive systemic therapy should be initiated. Penicillin, gentamicin, and metronidazole are indicated until blood culture and sensitivities are reported. The predominant anaerobic bacteria cultured is *Bacteroides fragilis* and frequently is resistant to penicillins and aminoglycosides but is inhibited by systemic administration of metronidazole.

Large volumes of a warm 38°C saline solution or dilute povidone iodine solution can be infused into the uterus by gravity flow using a large bore nasogastric tube and funnel. Before lavage, the uterus should be palpated per rectum to evaluate the amount of fluid accumulating in the lumen between treatments. The uterine contents are then siphoned and repeated until the fluid drained out of the uterus is similar to the fluid being pumped into the uterus. The procedure is repeated 2 to 3 times daily, depending on the severity of the condition. Uterine involution can be evaluated by rectal palpation after lavage. Mares responding to treatment, with uterine involution, have a thickened corrugated uterine wall, whereas mares not responding have a thin, flaccid uterine wall. Uterine lavage is discontinued when intrauterine fluid is clear to slightly cloudy and the systemic WBC count is greater than 5000 cells/ul. Removal of the toxic uterine fluid should resolve systemic signs. Because the uterine fluid may continue to accumulate with fluid and cause toxemia, careful monitoring is needed until the infection is controlled.

Mares with acute septic metritis typically have severe leucopenia with WBC counts less than 2-3,000 cells/ul. There is usually a left shift, with toxic neutrophils and fibrinogen levels in excess of 600 mg/dl. As the acute toxemia resolves with therapy, the WBC
count will return to normal levels. The fibrinogen will become normal 2 to 3 days after WBC count becomes normal.

Laminitis is an aggravating and infrequent complication with acute septic metritis. Laminitis can develop suddenly with acute septic metritis and frequently has dire consequences. Laminitis should be treated with soft footing, caudal heel support, aspirin (90 grains /450-kg horse PO q48 h), acepromazine (0.02-0.05 mg/kg q 8h), pentoxyfylline (8.4 mg/kg PO q12h), nitroglycerine cream (topically q12h) and supportive therapy. Severe rotation of the third phalanx frequently results necessitating euthanasia.

**Uterine Torsion**

Aggressive rolling or trauma may play a role in the onset of uterine torsion. The exact cause, however, is not known. Suspension of the equine uterus from the broad ligament attached to the dorsolateral body wall makes torsion of the gravid uterus uncommon. Signs of abdominal discomfort in mares late in pregnancy suggest uterine torsion as a differential diagnosis. Colic signs may be mild to severe and related to tension on the broad ligaments or pressure on the uterine wall. Secondary gastrointestinal disturbances may result from altered position of the displaced uterus. Necrosis of the uterus, with subsequent rupture, may occur spontaneously.

The most diagnostic findings on transrectal examination are those related to tension and position of the broad ligaments. For a clockwise torsion of the uterus, the left broad
ligament is stretched across the dorsal aspect of the uterus from left to right and the right broad ligament disappears ventrally down the right body wall. The fetus usually is displaced cranially by torsion in the uterine body. Occasionally this twisting can be palpated just cranially to the cervix. Vaginal signs of uterine torsion are inconclusive. For torsions less than 180 degrees the cranial vagina may have signs of twisting to the point where the cervix cannot be palpated readily or observed through a speculum.

The foremost approach to correction of uterine torsion in the mare is surgical although they can be corrected with rolling in a manner similar to that used for cows. In cases of uterine torsion without uterine tissue necrosis the objective is to return the uterus to a normal position and allow pregnancy to continue to term. Most cases treated in this manner result in a normal delivery. Correction of uterine torsion in mares at term often results in the immediate delivery of a normal foal.

A standing flank laparotomy is the best approach for correction of uterine torsion. Torsion of 180 degrees or less can often be corrected through this approach simply by rolling the twisted uterus back into a normal position. The torsion is reduced by elevation from beneath and repulsion of the fetus rather than by grasping and pulling the fetus through the uterine wall. Pulling on the uterus and fetus incurs a greater risk of uterine rupture. Attempting to correct uterine torsions from a ventral midline approach in the gravid mare is counterproductive since the weight of the uterus prevents the safe and proper correction of the torsion.
The prognosis is grave when uterine rupture and escape of the fetus into the peritoneal cavity has occurred. If the laceration is small with only partial exposure of the fetus, these cases are occasionally successfully managed by removing the fetus and closing the defect in the uterus. Formation of adhesions or other damage to the peritoneal cavity and abdominal viscera typically result in loss of the mare.

**Uterine Prolapse**

Uterine prolapse may follow dystocia, retained placenta or normal delivery particularly in multiparous mares and should be treated as an emergency situation because mares are particularly predisposed to shock and hemorrhage under such circumstances. Treatment of shock associated with uterine prolapse is as essential as replacing the prolapsed uterus. Immediate attention at the time of injury includes elevating and covering the prolapsed uterus in a moistened towel to avoid further trauma or dehydration and to reduce edema of the uterine tissues until veterinary assistance is available.

Cleansing and replacement of the prolapsed uterus should be attempted as soon as possible. Epidural anesthesia (xylazine, 0.25 mg/kg, mixed in 8 ml saline solution) greatly facilitates replacement by reducing straining. Minimizing trauma to the exposed endometrium reduces straining. Large volumes of warm, mild antiseptic solution should be employed to cleanse the endometrial surface thoroughly. Carefully palpate to confirm that the bladder is not within the prolapsed uterus prior to attempting to replace the uterus. A distended bladder must be drained before attempting to replace the uterus by
passing a soft rubber stallion catheter through the urethra or placing a 5 cm 14-gauge needle through the uterine wall into the bladder.

Replacing the uterus is achieved by applying pressure first near the cervix and gradually working the everted uterus back through the cervix. Elevating the uterus with the help of an assistant greatly facilitates replacement of the uterus. It is important to be sure that the tips of the uterus are not inverted once the uterus is passed through the cervix. Using a long arm or extending the arm with the flat base of an empty clean wine bottle to elongate the tip of each uterine horn will facilitate this process. General anesthesia may be indicated in fractious mares.

Once the uterus is replaced, infusing 2 to 3 liters of warm saline solution should be repeated two times a day for 3 days using the siphoning technique previously described for acute septic metritis. Systemic treatment includes oxytocin (20 units IM) to involute the uterus and systemic antibiotics (gentamicin, 6.6 mg/kg IV SID and procaine penicillin, 44,000 IU/kg IM BID) along with flunixin meglumine (0.30 mg/kg IV TID) to prevent metritis and laminitis.

Hemorrhage can occur as a result of stretching of the broad ligaments after uterine prolapse. The combination of shock, hemorrhage, contamination, and/or uterine trauma warrants a poor prognosis in most cases.

**Ruptured Uterine Arteries**
Hemorrhage from the uterine artery or external celiac artery is common in multiparous broodmares older than 11 years of age and is a significant cause of death. Postpartum hemorrhage may occur in young mares as well. Once the mare has a history of periparturient hemorrhage, she is more likely to bleed in future pregnancies.

Hemorrhage can occur into the abdomen or into the broad ligament and is not always fatal. The hemorrhage may slowly dissect into a broad ligament between the myometrium and the serosa of the uterus, forming a hematoma. The resulting clot stops the arterial bleeding and the mare may not exsanguinate. If the broad ligament ruptures or the serosal surface of the uterus tears during the formation of the hematoma, the mare quickly bleeds to death.

As the tension in the broad ligament increases and uterine serosa stretches, the mare shows sign of colic with sweating, an increase in the pulse rate and pale mucous membranes. Transrectal examination reveals hemorrhage into the broad ligament. Palpation causes severe discomfort and the degree of enlargement of the uterus indicates the extent of the hemorrhage. Mares may not exhibit signs of colic if parturition was normal. The post foaling pain is mistakenly thought to be due to uterine contractions. It is not uncommon that many mares with post foaling hemorrhage are not discovered until they are weak or dead.

Confining the mare to a dark, quiet stall, using mild sedation usually results in the most successful treatment. Acepromazine, (0.01–0.02 mg/kg) should be administered only if
the mare is anxious. It is important to allow for “permissive hypotension” to allow the systemic blood pressure to fall between 70 to 90 mm Hg until it is clear that the bleeding has stopped. Therefore, crystalloids and colloid fluid therapy should be used with caution during this initial episode.

Administer fluids only if the mare is hypotensive. Such indicators would include tachycardia, poor pulse quality, cold extremities, or systolic blood pressure less than 70 mmHg measured with an indirect blood pressure cuff applied to the tail. Aminocaproic acid (Amicar, 10-20 mg/kg IV) is administered slowly in the fluids or by means of slow infusion if fluids are not being administered. Blood transfusions, plasma volume expanders and fluid therapy are controversial and may even be contraindicated if the mare becomes excited by the procedures. Other treatments that have been used include naloxone, formaldehyde and hypertonic saline solution.

The foal should be moved to an adjoining stall if the mare appears weak and a danger to the foal. Oxytocin decreases bleeding from the myometrium and intraluminal bleeding only. Since it does not affect bleeding form the external iliac or uterine artery it should not be used if a hematoma is present in the broad ligament. Surgical correction is unlikely to be successful because of the acute and rapid ongoing bleeding. The prognosis is poor with any treatment if there is uncontrolled bleeding into the abdominal cavity.

**Hydrops of Fetal Membranes**
Excessive fluid accumulation in either the amniotic (hydramnios) or allantoic (hydroallantois) cavity is not a common occurrence in mares but can be fatal if not diagnosed and managed quickly. Hydramnios occurs most often in pregnancies with congenitally abnormal foals. Hydroallantois is caused by an abnormal chorioallantois and more commonly affects multiparous mares. Hydroallantois occurs more commonly than hydramnios in the mare. Distinguishing the two conditions does not alter the therapeutic regime.

Clinical signs generally become apparent at 7 – 10 months of gestation. The pregnant uterus is grossly distended with fluid, filling the abdominal cavity dorsally, sometimes into the pelvic inlet. This distention can be so severe as to prevent the successful ballottement of the fetus on transrectal examination. The sudden increase in abdominal distention usually occurs over a 10 to 14 day period. Severe ventral edema develops with associated abdominal pain. The mare is often reluctant to move, has an altered gait with dyspnea on recumbency. Inguinal herniation, rupture of the abdominal muscles, prepubic tendon or uterus can develop.

Abortion should be induced by means of gradual dilation of the cervix over 15 to 20 minutes. Intravenous fluids should be provided as the uterine fluid is removed to prevent cardiovascular collapse. A total of 120 to 220 L of allantoic fluid may be expelled on rupture of the chorioallantoic membrane. Hypertonic saline solution and hetastarch is generally indicated to stabilize the cardiovascular system. Forced extraction of the fetus is often necessary because uterine inertia is often present.
Induction of parturition with oxytocin (20-40 IU) is effective in some but not all cases. It is more effective if the fetus is near term. During parturition, the abdominal contractions are weak and assistance with delivery is often necessary. Following delivery, affected mares may develop hypovolemic shock and need to be treated accordingly.

Placental edema and cystic changes of the allantoic membrane have been observed on examination of the placenta. The prognosis for the future ability of the mare to have foals varies depending on uterine involution. Since most cases of hydramnios are caused by congenital abnormalities of the foal, it is necessary to breed the mare to a different stallion.

References available from author upon request.
Superficial burns and partial thickness burns are generally non-life threatening and simply managed. Topical therapy in the form of cool compresses, cold-water baths, and wound coverings may provide relief. Pain control can be accomplished with nonsteroidal anti-inflammatory drugs or narcotics.

Partial thickness burns are associated with vesicles and blisters. These vesicles should be left intact for the first 24 to 36 hours following formation. The fluid in a blister provides protection from infection. The presence of a blister is less painful than the denuded exposed surface. After this period of time the blister is partially excised and the area is protected with the plasma scab, an antibacterial protective ointment and/or dressing. The most crucial area of the wound is the interface between the migrating epithelium and the dermal edge beneath it.

Deep burns can be difficult to manage. The patient’s condition should be stabilized as rapidly as possible. Life threatening problems encountered in managing these patients include shock, multi organ system dysfunction, infection, reduced immunocompetency and malnutrition.

**BURN SHOCK**

With burn shock, large volumes of balanced electrolyte solution are generally the
fluid of choice unless results of serum electrolyte analysis dictate otherwise. An alternative is to use hypertonic saline solution, 4 ml/kg, with plasma, hetastarch, or both followed by additional isotonic fluids. An established rate of administration of isotonic fluids is 2 to 4 ml/kg for each percentage of surface area burned. If there has been smoke or heat inhalation injury, then crystalloids should be limited to the amount that normalizes circulatory volume and blood pressure. The same continued rate of administration of electrolyte solutions following the resolution of burn shock results in edema far in excess of any improvement in cardiovascular dynamics. A baseline hemogram, serum electrolytes, and creatinine should be obtained. Two to ten liters of plasma is an effective albumin source as well as an exogenous source of antithrombin III for coagulopathies. One should carefully monitor the hydration, lung sounds and cardiovascular status during fluid administration.

Flunixin meglumine, 0.25-1.0 mg/kg IV q 12-24h, and pentoxifylline, 8.0 mg/kg IV q12h, are effective analgesics and rheologic agents. DMSO, 1 g/kg IV, for the first 24 hours, 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.

ANTIBIOTICS

Systemic antibiotics do not favorably influence wound healing, mortality, fever, and can encourage the emergence of resistant microorganisms. Circulation to the burned
areas is often compromised; making it highly unlikely that parenterally administered antibiotics can achieve therapeutic levels at the wound. However, if there are respiratory signs or if smoke inhalation is suspected, systemic antimicrobial therapy should be initiated. Intramuscular penicillin is effective against oral contaminants colonizing the airway. If signs of respiratory disease worsen, transtracheal aspiration should be performed, and administration of additional broad-spectrum antibiotics initiated. Broad-spectrum antimicrobial therapy may encourage fungal growth.

**WOUND CARE**

Destruction of the dermis leaves a primary collagenous structure called an eschar. There are different approaches by clinicians in the management of eschars. Dry exposure is a treatment method that operates under the principle that bacteria do not thrive on a dry surface. The goals of this form of therapy are to keep the wound dry and protected from mechanical trauma. Heat and water loss from the uncovered wound, however, are a disadvantage of this therapy.

The surrounding hair should be clipped and the wound debrided of all devitalized tissue. Attempts should be made initially to cool the affected skin using an ice or cold-water bath. Copious lavage with sterile polyionic fluid in a 0.05% chlorhexidine solution should be performed. A water based antibiotic ointment should be applied liberally to the affected areas. All devitalized tissue should be debrided as it appears. The eschar should be allowed to remain intact.
The wound should be cleansed two or three times daily, and a topical antibiotic reapplied. Occlusive dressings should be avoided because of their tendency to produce a closed wound with bacterial proliferation and to delay healing. The most commonly used topical antibacterial for the treatment of burns is silver sulfadiazine, a painless, non-staining, broad-spectrum antibacterial agent with the ability to penetrate the eschar. Silver sulfadiazine is active against nearly all pathogenic bacteria and fungi and exerts a prominent antibacterial action against pseudomonas. It may, however, cause granulocyte depression and is relatively expensive. Other products have been used with mixed success. Nitrofurazone has a fairly narrow range of antibacterial activity, resistance can be developed to it and it does not penetrate the eschar well. Mafenide a sulfa medicine, is used to prevent and treat bacterial or fungal infections. Mafenide is bacteriostatic in which Staphylococci and Pseudomonas may become resistant. It is irritating and painful when applied, and does not penetrate into the eschar well. Suprainfection with Candida can be a problem. Mafenide is also a carbonic anhydrase inhibitor that can result in metabolic acidosis in the compromised patient. Chlorhexidine can be used as a solution or cream. Chlorhexidine is active in vitro against a number of gram-negative and gram-positive vegetative bacteria, yeasts and dermatophyte fungi. Because of its cationic nature, chlorhexidine binds strongly to skin, mucosa and other tissues and is thus very poorly absorbed. Povidone-iodine causes some patient discomfort but is effective against bacteria, yeast, and fungi. It should not be used on extensive burns because of the possibility of systemic absorption and a resultant high level of serum iodine and severe metabolic acidosis. Gentamicin ointment is excellent for serious gram-negative infections but should only be used in selected cases because resistance can develop. It
should also not be used in patients with renal disease. Amnion is an excellent cover for wounds as it decreases bacterial growth and pain. Aloe vera cream will relieve pain immediately, decrease inflammation, penetrate deeply, stimulate cell growth, kill bacteria and fungi, and has an antiprostaglandin effect in burned tissue. Many burned equine patients are pruritic, and measures must be taken to prevent self-mutilation of the wound.

**GRAFTS**

Burns heal slowly and many weeks may be required to allow for the wound to close by contraction, granulation and epithelialization. Because scarred skin is hairless and often depigmented, solar exposure should be limited. Grafts can be extremely useful to provide skin closure and should be used early in the course of a severely burned patient. Unfortunately grafts are expensive and difficult to maintain. Autografts and allografts provide the most effective physiologic wound closure.

Sterile starch graft copolymer of dry flakes or sheets is available and when mixed with water form a moldable gel. This material absorbs about 30 times its weight in wound exudates, prevents further eschar formation by keeping tissues moist, and will not interfere with topical antibiotics. These can be applied to the wound before gel application or mixed with the gel.

**NUTRITION**

Patients with severe burns have a negative nitrogen balance and an increased metabolic rate with high-energy demand. Gradually increasing the grain, adding fat in the form of 4-8 ounces of vegetable oil, and offering free-choice alfalfa hay increases
caloric intake. An anabolic steroid may be used to help restore a positive nitrogen balance. If smoke inhalation is a concern or there is evidence of burns around the face, the hay should be water soaked and fed on the ground with good ventilation provided.

References


Hoof wall injuries are a common event in horses. The extent of injury differs from insignificant to substantial and is often a symptom of a particular athletic endeavor, natural surroundings, or intrinsic structural difficulties. The management of equine hoof wounds involves the same surgical principles and can result in a successful outcome as other wounds to the body. Such wounds, however, are customarily contaminated and become infected rapidly. Successful outcome requires extensive labor, a determined commitment by the owner and the veterinarian, and a longer convalescence. Wounds extending to the corium or deeper require early surgical management in order to optimize the likelihood of an eventual return to performance. Prompt veterinary attention with the initial conversion of a contaminated wound to a clean wound, rather than dealing with an infected wound results in a more favorable outcome.

**Hoof anatomy**

The equine foot is comprised of the epidermal hoof with all the structures enclosed within. Hoof injuries can involve horny, sensitive, elastic, and/or boney tissues. The hoof is continuous with the epidermis, whereas the corium is continuous with the dermis of the skin proximal to the coronet. The bones contained in the equine foot are the second phalanx, third phalanx, and distal sesamoid bone, forming the distal interphalangeal joint, whose stability is maintained by two short collateral ligaments, the collateral sesamoidean ligaments, a distal sesamoid impar ligament, and the joint capsule.
Synovial pouches of the joint capsule are present on the palmar and/or plantar aspect of the joint dorsal and abaxial to the deep digital flexor tendon (DDFT) and axial to the collateral cartilages of the third phalanx. The pouches are also in close contact with the podotrochlear bursa (navicular) on either side of the DDFT and more proximally, with the digital flexor tendon synovial sheath. Therefore a penetrating injury just proximal and slightly axial to the cartilage of the third phalanx can involve any or all of these synovial structures. Wounds of the heal bulb and pastern area often involve the medial or lateral digital arteries, veins, and nerves and often bleed profusely because of involvement of the venous plexus lining the axial and abaxial surfaces of the cartilages of the distal phalanx. The terminal arch of the digital arteries allows the blood supply to the foot to be maintained if only one of the arteries remains intact.

**Basics of hoof injury care**

Hoof wounds respond to injury in limited ways. The phases of wound healing described for skin and soft tissue elsewhere on the body do not necessarily apply to the hoof. The regeneration of hoof horn presents some unique features, compared with other soft tissues. If a hoof is superficial and does not traverse the germinal layer, subsequent keratinization is rapid. The horny cells of the stratum spinosum enlarge, and a leather-like coating of new horn is evident in 8-10 days. This is the process that follows most subsolar abscessation when proper drainage and bandaging are followed by a rapid return to soundness. Wounds that traverse corium, with a loss of the germinal layer and its supporting dermis, fill with granulation tissue just like any other epithelial injury that cannot be closed. Since the hoof is a semi-rigid structure, open wound healing differs
from that seen in other parts of the body in that wound contraction cannot occur. Healthy
granulation is necessary for proliferating epithelial cells from the stratum germinativum
of the surrounding corium to migrate across and cover the defect. Caution must be taken
with the use of full strength povidone-iodine solution, iodine tincture, Lugol solution, and
topical astringents. Overzealous application of caustic agents can destroy granulation
tissue and may further damage the deeper underlying structures and worsen the
prognosis. The time necessary for such proliferation and migration is directly
proportional to the size of the wound.

The severity of a hoof wound is determined by the depth of injury and length of delay.
Regardless of the number of foot structures damaged, the principles of wound
management are similar. Deep wounds require longer healing and may result in an
incomplete return to function. Lacerations may go unrecognized for an extended period,
allowing infection to be well established at the time of diagnosis. If the wound is fresh
and contamination is minor, a sterile, water-based gel should be used to protect the
exposed tissue while the skin is clipped and prepped with an antiseptic solution. Lavage
of the wound should be performed in the same manner as for other wounds. Coronary
band and heel bulb lacerations should be reconstructed whenever possible, either with
primary or delayed closure so as to retain the structural and functional properties of the
foot.

Dressing and immobilization of a hoof wound is very important for successful wound
healing. The type of dressing used is dependent upon the severity and extent of the
wound. Modified wet-to-dry dressings are commonly used and a waterproof layer usually completes the bandage. A treatment plate shoe may be used to provide solar protection in special cases with a severe sole injury or perforation in an attempt to reduce contamination from the environment. Casting provides for a more secure immobilization, protection, and waterproofing of the wound because a dressing bandage seldom gives sufficient stability to the hoof for wounds involving the coronary band or heel bulbs. It improves healing functional and cosmetic results as well as preventing the likelihood of persistent hoof wall defects. Although the hoof dries and contracts throughout the period of casting and bandaging, and may be an issue to contribute to lameness soon after the waterproof bandaging is discontinued, the problem is relieved as new hoof grows.

Most healing complications afflicting hoof injuries resemble those occurring in skin injuries, although excessive granulation tissue is rarely a problem. A hoof injury usually heals slowly and sometimes seems to be idle for no apparent reason. Light surface debridement of the granulation tissue, irritating ointments, and wet-to-dry dressings usually boost deficient healing.

**Superficial puncture injuries to the hoof**

*Superficial puncture injuries* (subsolar abscess) are among the most frequently diagnosed causes of lameness seen in equine practice. Subsolar abscesses may originate from
penetrating foreign objects, sole bruising, and placement of a nail into or too close to the sensitive lamina, allowing bacteria along the nail to induce an infection in close proximity to the sensitive lamina.

Lameness is usually acute and severe. The horse might be febrile and have increased warmth of the foot, with strongly pulsating digital palmar or plantar arteries. A generalized swelling of the distal limb may be noticed. Hoof tester examination often reveals a focal painful region. Local perineural anesthetic nerve blocks may aid in localizing the problem, although may not totally eliminate the lameness.

The shoe should be removed and each nail hole closely examined for wetness and odor. Subsequently the exact location of the abscess is established with the help of hoof testers. Location with the hoof tester can be difficult in the presence of a thick and hard sole horn. Foot poultices applied over night and foot baths with Epsom salts several times a day can be used to soften the horn, permitting localization of the abscess and subsequent drainage.

Treatment of superficial puncture wounds that do not involve underlying vital structures is usually straightforward and is aimed at establishing adequate drainage, removing infected and necrotic tissue, and protecting the site from subsequent infection. Careful and gentle trimming of the sole and frog may help to isolate the abscess. All undermined and necrotic horn is carefully removed until a smooth transition is achieved toward the surrounding normal sole. As soon as pink tissue or blood is encountered, debridement
should be discontinued to limit disruption of the solar corium and subsequent prolonged healing and painful sequelae. If the draining tract is open at the coronary band, debridement should be done carefully to prevent iatrogenic coffin joint contamination and further damage to the coronary band itself.

The infected area is cleaned and protected from the environment with a clean bandage, including a waterproof layer. Foot baths with warm water, Epson salts, and povidone-iodine solution should be continued until resolution of infection and inflammation. The defect is closely examined at bandage change and any additional undermined sole is carefully removed. As soon as the affected area is healed and dry and the epithelium is sufficiently keratinized, the shoe can be replaced. Select cases may benefit from the application of a pad or treatment plate under the shoe to provide better solar protection. If the abscess is not managed properly the abscess can break out through the coronary band or extend deeper into the foot and involve the distal phalanx. The draining tract has to be flushed daily with diluted povidone-iodine solution from the coronary band distad. Distal exit of the flushing solution is important. The foot must be kept in a bandage until drainage has stopped.

Antibiotics and nonsteroidal anti-inflammatory drugs are not usually indicated, unless infection is severe or spreads to deeper or more proximal structures. The prognosis is excellent unless deeper structure involvement has not been recognized in an appropriate time.
Deep puncture wounds of the sole and hoof wall

*Infectious osteitis of the distal phalanx* may frequently result from deep puncture wounds of the sole as well as from dissection by subsolar abscesses, hoof wall avulsions, soft tissue infections, solar margin fractures, or chronic laminitis with abscessation and ischemia. Deep puncture wounds through the hoof wall are rare. Clinical signs are variable and include moderate to severe intermittent and recurrent lameness, a unilaterally increased digital pulse, increased heat in the affected foot, and soft tissue swelling. A chronic, recurrent dark draining tract is usually noted at the solar surface of the coronary band. Gentle pairing of the hoof and poultice bandages applied to the sole for 24-48 hours is sometimes required to soften the horn and help find the tract. Occasionally the tract may not be identified.

Radiographic evaluation of the foot is needed to make a final diagnosis. Radiographic evaluation of a metal probe or injection of contrast medium into the tract is helpful to determine the direction and depth, as well as possible communication with adjacent synovial structures. Radiographic signs of infectious osteitis, although not immediately apparent, include osteolysis, gas shadows in contact with the bone, decreased bone radiodensity, and widening of the vascular channels of the distal phalanx. With progression of bone infection, blood supply to the affected area of the distal phalanx may be compromised, leading to sequestration of avascular fragments.

Surgical debridement and curettage of all infected soft tissue and necrotic bone is recommended and can be performed in the sedated standing horse. General anesthesia,
however, allows for better visualization of the lesion, aseptic technique, and homeostasis. Lesions on the parietal surface of the hoof wall are approached through the hoof wall while lesions on the solar margin of surface are approached through the sole. The horn and soft tissue surrounding the tract over the affected area are excised sharply, using a sterile hoof knife and scalpel. The edges of the horn defect must be thinned as previously described. The infected soft tissue, bone and all identifiable loose bony fragments are removed using bone curettes or motorized devices. The infected bone should be aggressively curetted until healthy bone margins are reached. Approximately 25% of the coffin bone can be removed with successful outcome. If the coronary band is involved, care must be taken during debridement to preserve the overlying coronary corium. A postoperative radiograph should be obtained to ensure complete debridement. The wound is then lavaged with sterile physiologic solution and packed with sterile gauze sponges soaked in an antiseptic or antimicrobial solution. A sterile pressure bandage is applied and the digit is further covered with a waterproof layer.

Systemic antimicrobial therapy is adjusted pending the results of culture and sensitivity results of the affected tissue. Antimicrobial therapy is usually continued for 2-3 weeks after resolution of clinical signs. Non sterioidals are administered during and after surgery to minimize inflammation and pain.

Granulation tissue usually covers the bone in approximately 10 days and the wound drains minimally. Bandage change depends on the amount of exudate present from the wound. A shoe or bar shoe with a treatment plate can be applied in case of sole injury.
With hoof wall defects the granulation tissue is covered by keratinized epithelium 4-6 weeks after surgery. At this point an acrylic resin can be applied in the defect to protect the wound. Extensive postoperative care and limited exercise for 2-4 months is necessary. The prognosis for return to soundness is good. The main complications are recurrence of infection, pathologic fracture of the distal phalanx, and contamination of the podotrochlear bursa or coffin joint.

*Infection of the collateral cartilage* (quitter or septic chondritis) can develop secondary to a penetrating wound to the cartilage itself or to the soft tissue surrounding it. Injury to a penetrating wound through the sole draining at the coronary band, puncture wound of the hoof wall, coronary band, or heel bulb, heel bulb lacerations, and deep hoof cracks. Clinical signs include enlargement of the affected cartilage, with one or more chronic sinus tracts that continue to drain. Diagnosis is based on moderate to severe swelling and pain over the affected cartilage, the presence of fistulous tracts draining proximal to the coronary band over the affected collateral cartilage and intermittent recurrent lameness. An important differential diagnosis is chronic ascending infection of the white line that breaks or drains at or slightly proximal to the coronary band. With quittor the swelling is usually diffuse and is located more proximally over the collateral cartilage. Radiography can be helpful to detect foreign bodies or to rule out involvement of the middle or distal phalanx. Insertion of a flexible metal probe or contrast medium is recommended to determine the depth and direction of the draining tracts and to rule out bone or coffin joint involvement.
Medical treatment is often ineffective due to chronicity of the injury and limited blood supply to the area. Surgical excision of all necrotic tissue and infected tissue (e.g., cartilage, surrounding soft tissue, draining tracts) is performed under general anesthesia.

The foot is carefully clipped, and the hoof is trimmed and rasped, scrubbed, and placed in a povidone-iodine soaked bandage overnight. Once the horse is anesthetized, a tourniquet is applied. The hoof is held in maximal extension during dissection to tighten the joint capsule and retract it from the area of dissection, minimizing the risk of accidental penetration into the coffin joint. A slightly curved incision is made over the infected cartilage and draining tracts (methylene blue dye can be injected in fistulous tracts to facilitate their identification) and a probe is used to identify the drain tract. Necrotic cartilage is recognized by a dark blue or reddish blue appearance. All necrotic tissue and cartilage is removed until healthy margins remain. If necrotic tissue extends distally below the coronary band and is inaccessible through the proximal skin incision, a hole can be made in the hoof wall with a trephine at the distal border of the affected cartilage. This portal allows better access and provides better drainage after surgery. Caution must be taken to avoid further damage to the coronary band. Afterward, arthrocentesis of the coffin joint is performed and the joint distended with polyionic fluid to access the integrity of the joint capsule axial to the removed portions of the collateral cartilages. The skin incision is closed, and the trephine hole is packed with sterile gauze sponges soaked in an antiseptic or antimicrobial solution.
The bandage is changed daily to remove exudate and evaluate drainage. A short limb cast is applied to the limb for approximately 2 weeks to minimize movement at the skin suture line. Exercise can usually be resumed 3 months after surgery.

**Deep puncture wounds of the frog and sulci**

Although puncture wounds of the sole can appear small, they are often deep and can have disastrous effects when structures such as the distal phalanx, distal sesamoid bone, distal interphalangeal joint, navicular bursa, deep digital flexor tendon, or tendon sheath are penetrated. Septic navicular bursitis with deep digital flexor tendonitis and osteomyelitis of the navicular bone are the most common complications and the most frequent reasons for euthanasia of horses with deep puncture wounds of the hoof region of the frog.

The penetrating object is usually contaminated with soil, rust, or manure, which can lead to serious infection. The superficial wound in the sole usually seals quickly, leaving no area for drainage. The anaerobic environment created favors the growth of *Clostridium tetani*. For these reasons, deep puncture wounds must be treated as an emergency to prevent infection of the bones, joints and tendons.

Lameness may be mild at the time of injury and then moderate to severe once inflammation and infection occur. The clinical signs, however, will vary with the structures involved and the duration of the injury. Most horses have a moderate to severe supporting leg lameness, often pointing the affected hoof and may be systemically
febrile. The hoof is warm with an increased pulse to the digital arteries. Hoof tester examination usually elicits a severe pain in the area of injury.

Careful examination of the foot must be performed. Radiographic examination should be performed immediately to determine the depth and orientation of the foreign body injury. Based on the location, direction, and depth of injury, the horse may be treated on site or referred to a clinic. When there is suspicion of injury to the deeper structures, such as the navicular bursa, distal interphalangeal joint, or the deep digital flexor tendon sheath, the horse must be referred immediately for surgical treatment.

The horse can be sedated and the foot desensitized with proximal perineural analgesia to facilitate further examination. The shoe is removed and the entire hoof is trimmed. The puncture site is carefully cleansed and disinfected. Because of the collapse of the sole and frog around the puncture site after removal of the foreign body, it may be difficult to locate the original entry site of the injury. Whenever a hole is identified, radiographic assessment using a sterile flexible probe or injection of contrast medium to determine affected underlying structures is necessary. Caution must be taken to avoid penetration of unaffected structures with the metal probe. Placing a needle into the navicular bursa using aseptic technique and injecting contrast medium can enhance the diagnosis. Cytology of the coffin joint should be evaluated for evidence of injury. Contrast medium is injected into the coffin joint and the hoof radiographed again to determine whether the contrast medium is exiting through the puncture tract. The same procedure is repeated for the deep digital flexor tendon sheath. If involvement of the navicular bursa, coffin
joint, deep digital flexor tendon sheath is suspected, synovial fluid should be collected from these cavities and cytologic evaluation and bacterial culture and microbial sensitivity tests should be conducted.

Unless economic considerations dictate otherwise, medical treatment should not be used alone but rather combined with surgical intervention. Medical treatment alone may be successful in some cases. Systemic broad spectrum antibiotics, non-steroidal anti-inflammatories, and tetanus prophylaxis is initiated. Systemic antibiotic therapy is usually modified according to microbial sensitivity and should be continued for at least 3 weeks after resolution of all clinical signs of infection. All necrotic tissue should be debrided and copious lavage of the wound with sterile physiologic saline is indicated. Administration of antibiotics intrasynovially or by regional perfusion should be performed. Lavage and local administration of antibiotics should be undertaken every other day and continued until significant improvement of synovial fluid parameters is noted.

Surgical debridement of puncture wounds is usually treated with the horse under general anesthesia and is considered the ideal approach for this condition. All affected structures around the puncture tract are excised. When the injury has penetrated the DDF tendon, a 1.5 by 1.5 cm area of the tendon is resected. Curettage is necessary if the foreign body penetrated the distal phalanx or the distal sesamoid bone. With perforation of the impar ligament and penetration of the distal interphalangeal joint, the ligament must be resected and the joint lavaged. If only the DDF tendon is involved, surgical debridement of the
infected tendon is carefully performed to prevent penetration of the navicular bursa. The surgical wound can be left open to heal by second intention or packed with autogenous cancellous bone graft or an antibiotic impregnated PMMA, which fills the dead space, reduces the opportunity for ascending contamination, and may help prevent desiccation of underlying tissue. Bone grafts also provide a scaffold to subsequent formation of granulation tissue, enhance the local immune systems’ chance of resolving infection and significantly decreases the convalescent period. The surgical wound is then covered with a sterile bandage and a waterproof layer. Drainage is often abundant in the first days after surgery. Once the wound has granulated enough and drainage has decreased, a shoe or bar shoe with treatment plate can be used. Drainage must be minimal as an ascending infection from the contaminated dressing may arise. Postoperative care resembles that for deep puncture wounds of the sole. A pressure bandage is applied, followed by a hoof bandage and a 4-8 degree wedge pad under the heel, as it provides relief for pressure on the DDF tendon and lessens the pain. The wedge pad is then gradually lowered over several months as the DDFT heals and strengthens.

Arthroscopy is useful for visualization of the synovium of the navicular bursa, the suspensory ligaments of the navicular bones, the flexor surface of the navicular bone, and the dorsal surface of the DDFT. The technique permits a less invasive approach to the penetrated structures because debridement is carried out under endoscopic guidance and allows for thorough lavage of the affected tissues. If a puncture site is present and draining, management of the wound is similar to that previously described.
Horses treated by endoscopy usually have a shorter hospitalization period, a shorter period of recovery, less intensive postoperative care, and fewer complications, especially in respect to necrosis of the DDFT. The prognosis for a forelimb is worse than for a hindlimb and significantly improved by surgical intervention within one week of injury. Therefore is it strongly recommended to treat puncture injuries involving the frog region promptly and to favor endoscopic treatment whenever the navicular bursa is involved. Injury to the navicular bone can eventually result in adhesions between the bone and the DDF tendon, necessitating neurectomy. Failure is most often attributable to osteomyelitis of the navicular bone, necrosis, and rupture of the DDF tendon and sepsis of the coffin joint of deep digital flexor tendon sheath.

**Lacerations involving the coronary band or heel bulb**

Coronary band lacerations often involve the heel bulb between the bulbs at the plantar or palmar aspect of the pastern, curving dorsally and then distally to reach the coronary band at the level of the quarter. Depending on their depth, coronary band lacerations may involve structures deep to the hoof wall such as the digital vessels and nerves, flexor tendons and tendon sheath, pastern joint, collateral ligament, cartilage of the third phalanx, navicular bone and bursa, and coffin joint. They may be caused by wires, ropes, or any kind of sharp object and may go unnoticed for several days. Fractures of the phalanges occasionally accompany these lacerations. Generally lacerations that do not involve vital structures will heal with complete cosmetic and functional end results if proper treatment is applied.
Lameness is variable and depends on the time elapsed since injury, the extent of the laceration, and whether the wound becomes infected. Generally, with the acute injury, the deeper the laceration the greater the degree of lameness. There can be an anesthetic effect improving the lameness if the digital nerve has been transected. Because the major digital artery and vein commonly are lacerated, hemorrhage can be excessive, resulting in shock. The bleeding is controlled most efficiently with a pressure bandage. Eventually, ligation of a major vessel may be necessary. Before any sedation is used to help evaluate the wound in a nervous horse, the cardiovascular status of the patient should be closely monitored and vascular volume re-established if necessary. In some cases, examination and cleansing of the wound must be delayed until all bleeding is effectively stopped and the cardiovascular status stable enough to allow the safe use of tranquilizers and perineural blocks. With a chronic laceration, the wound usually is infected and the horse may be reluctant to bear weight. The laceration is often gaping because of the tendency for these wounds, particularly in the heel bulb region, to separate during weight bearing. Varying degrees of exudate and granulation tissue will be observed.

After the wound is stabilized, bleeding is controlled, and the hair is clipped around the region. The wound should be cleansed with an antiseptic scrub, after which it is lavaged with a sterile physiologic saline solution. Loose and devitalized tissue are debrided and gross contaminants are removed during the cleansing process. Using sterile technique, the wound is evaluated to distinguish damage to deeper structures. The coffin joint and deep digital flexor tendon sheath can be distended with a physiologic saline solution to determine their involvement with the wound. Contrast radiographic studies are important
to assess soft tissue structures involved in a wound. Radiographic examination of the area is vital. Type 1 and type II fractures of the distal phalanx, fractures of the navicular bone, proximal phalanx, sagital fractures, or palmar or plantar eminence fractures have all been diagnosed incidentally during routine radiographic examination with moderate to severe wounds.

Treatment options are primary closure, delayed primary closure, or secondary closure. If the coronary bandage is involved, reconstructive surgery should be employed because treatment with bandages alone often leads to poor functional results, including horn spurs, permanent cracks, or deformation of the hoof wall. Primary closure can be used in cases where the laceration is acute, clean, with minimal soft tissue trauma, digital vessels have not been transected, and the synovial structures have not been penetrated. In this case debridement is performed by means of sharp dissection and kept superficial. Undermining the coronary cushion and aggressive thinning of the hoof wall distal to the laceration are sometimes required to allow sufficient apposition of the lacerated ends of the coronary band. A combination of vertical and horizontal mattress sutures with number 0 or 1 nonabsorbable monofilament material and simple interrupted sutures of the edges of the wound with number 2-0 suture is appropriate.

Closure is often delayed because of hemorrhage originating from the venous plexus of the heel bulb that must be controlled by pressure wraps rather than the extensive contamination of the wound. If synovial structures are involved, closure should be delayed for several days, even in the clean wound. Treatment should be immediate;
however, making sure the tissues surrounding the synovial structures are debrided adequately to allow free drainage. The synovial cavity should be flushed at an entry site remote from the injury with sterile physiologic saline. This technique allows for all the contaminants to be flushed from the cavity and out of the wound. The wound is then confined under a sterile bandage. Systemic antibiotic therapy is indicated in most cases. Intrasyonovial antibiotic injections and/or regional antibiotic delivery systems are effective in reaching very high antibiotic concentrations to the affected tissues in excess that can be achieved with systemic therapy.

Delayed primary closure for 2-3 days before granulation tissue forms, is therefore generally recommended for the acute laceration, and secondary closure for the older lacerations in which granulation tissue has already formed. Debulking of the wound is performed as soon as an established granulation bed is obtained so as to decrease the bacterial population and to provide enough space to allow good apposition of the wound edges without excessive tension.

Following suturing, a sterile semiocclusive dressing is applied to the wound and covered with sterile elastic gauze. A lower limb cast or foot cast is applied. The cast is generally left in place for 10-21 days, depending on the amount of tension required to close the wound, and the amount of tissue deficit that will have to heal by second intention.

With appropriate management, a good functional and cosmetic result can be achieved unless significant structures in the pastern or deep hoof region have been injured such as
the flexor tendons, deep digital flexor tendon sheath, collateral ligaments, pastern or coffin joint.

**Avulsion injuries of the hoof**

Acute partial or complete hoof wall avulsions should be treated as emergencies as they may involve any of the structures contained in the hoof. These type of injuries are usually caused by overreaching, where one foot treads on the heel or coronary band of another foot. These injuries are usually quite painful in the acute stages and can cause severe lameness. Although they are relatively uncommon, these injuries may severely limit the function of the horse.

Avulsion injuries may be complete in that the tissue is removed totally or incomplete where a border of tissue remains intact with the foot. Structures involved with avulsion injuries include, hoof wall, coronary band, pastern region, sole, and deep synovial structures within the hoof. Although the hoof has a capacity to heal completely, this occurs more slowly because contraction does not contribute to repair. If the structures are treated properly for a long enough period, reformation of the hoof wall structures will occur.

With incomplete partial avulsions in which the coronary band is not displaced, the loose portion of the hoof wall is excised after regional perineural anesthesia. Any part of the lamellar corium is left in place in an attempt to maintain stability. Thinning or removal of the horn just distal to the coronary band is important if the coronary band is swollen or
traumatized and bulges above the hoof wall still attached to the lamellar corium. The hoof wall should be trimmed and thinned in a gentle slope around the exposed lamellar epidermis. The wound is then bandaged until sufficiently healed. Once new horn growth is visible at the coronary band and a fully keratinized surface is present in the wound, the area is filled with hoof acrylic. Subsequently, a bar shoe with side clips and acrylic repair not fully weight bearing on the shoe surface is recommended.

Incomplete avulsions with the coronary band still intact results in elevation of the coronary band from the subcutis and elevated proximately. If the injury is clean and acute, it is best sutured back in place with the detached wall partially removed and thinned to allow suturing. Debulking of the granulation tissue is necessary in more chronic cases before reconstruction and apposition of the coronary band is possible. A half limb or foot cast is applied for 2-3 weeks to allow for complete healing. If left untreated, these incomplete avulsion injuries of the coronary band remain elevated, eventually producing a horny spur at the distal extremity of the avulsion while the remaining underlying tissue heals by scarring and epithelialization. Since the avulsions invariably protrude above the skin and hoof wall surface they are subject to trauma and are often painful. Surgical reconstruction of the tissue is necessary because if the avulsed tissue is removed, a hoof wall defect may remain and the lesion will recur.

Complete avulsion injuries of the hoof require a thorough debridement of the affected tissue and distension lavage of all affected synovial structures. Bandaging of the area is necessary until all infectious complications are resolved after which cast application is
necessary for 2-3 weeks. These injuries are life threatening and require prolonged care in which a prognosis can only be determined after several weeks.

References
ETIOLOGY

Joint or tendon sheath infection should be considered in the differential diagnosis of any foal with an acute onset of joint swelling and lameness. Osteomyelitis or osteitis may be at hand without obvious clinical signs of joint swelling. This typically occurs in foals less than 4 months of age, but may occur in older foals as well.

The majority of cases of septic arthritis are due to a hematogenous spread from a gain of access through the umbilicus, respiratory tract or gastrointestinal tract. Infectious arthritis can also be caused by straight penetration of the joint either by means of a wound or by extension of an inflammatory process from tissues adjacent to the joint.

Hematogenous dissemination of bacteria allows localization into metaphyseal, physeal, or epiphyseal cartilage. This is believed to be linked with the rich vascular network comprised of metaphyseal loops, sinusoidal veins and epiphyseal and transphyseal vessels that supply the end of the long bones and synovium.\textsuperscript{1,2} Because of the relatively slow-moving blood flow and vascular stasis of nutrient vessels approaching a cartilage interface, bacteria are allowed to proliferate and colonize. Bacterial colonization incites an acute inflammatory response associated with kinin, complement, and coagulation system activation, eventually leading to cartilage destruction. Further compromise of cartilage occurs because of poor nutrition of the chondrocytes caused primarily by fibrin
clot formation over the articular surface, and by thrombosis in the synovial membrane vasculature. The primary mediators of infectious arthritis and eventual cartilage destruction, are toxic metabolites released from chondrocytes. Cartilage matrix degradation and proteoglycan loss may occur within two days and collagen loss by nine days after bacterial inoculation.\textsuperscript{2-4}

The stifle, hock, and fetlock appear to be affected more frequently than other joints most probably due to their larger size. There is no clear certainty if the infection will develop in the physis, metaphysis, epiphysis or in the joint. Infectious arthritis and osteomyelitis of hematogenous origin have been classified as 5 types, based on location of the structure involved.\textsuperscript{1, 5}

Infectious synovitis (S-type) affects foals within the first 10 days of life. Multiple joints are usually involved and few, if any radiographic changes are seen. Predominant clinical signs include periarticular soft tissue swelling, effusion, and lameness. Arthrocentesis reveals an elevation in nucleated cell count, in excess of 50,000 cells, with the primary cell type as degenerate neutrophils.

Epiphyseal type (E-type) infectious arthritis involves the joint and adjacent epiphysis. Foals are generally several weeks of age or older. Multiple or single joints may be infected and other systemic illnesses may occur concurrently. Radiographic evidence of epiphyseal involvement is commonly seen.
Physeal type (P-type) may occur in foals from one week to four months of age. There may be varying degrees of soft tissue swelling and lameness, and generally only one site is involved. There may be evidence of effusion closely associated synovial structures. Lesions may be seen radiographically in the metaphysis, physis or epiphysis. Pathologic fracture may result because of weakening of the involved structure.

Tarsal or carpal bone (T-type) infectious arthritis may result in collapse of the associated small carpal or tarsal bones, resulting in collapse of the associated structures. Multiple joint are commonly affected.

Periarticular soft tissue abscesses (I-Type) can infect a physis or joint. Joints of the upper limb, such as the hip or stifle, are more commonly involved.

**CLINICAL SIGNS**

The first clinical signs may be that the foal appears to spend most of its time recumbent. This is an indication of bone or joint pain. Foals, however, are not typically non-weight-bearing, as compared to the adult horse. The degree of lameness varies depending on the duration of infection and the pathogenicity of the infecting organism. Careful palpation of the joints and the bone proximal to the physeal regions of the long bone should be part of the physical examination. Distention with pain of the involved joint is a consistent sign that can be detected visually, or by palpation of the joint pouches. Peri articular edema,
cellulites, or both, however, may make palpation of joint effusion difficult. Foals with open joint lacerations are not as painful as those with closed joint infections.

**DIAGNOSIS**

Septic arthritis or osteomyelitis is the tentative diagnosis in any foal with joint effusion and lameness, until proven otherwise. Diagnosis is facilitated by radiography of the suspected joint or bone and by arthrocentesis. Osteomyelitis may be seen as lytic areas in the bone in the region of the physis or epiphysis. Lesions in the bone may not be evident radiographically in the initial stages of the infection, but can appear rapidly in a course of one to two weeks with erosions, sclerosis, and proliferation of new bone. It is therefore important to perform follow-up radiographs to monitor the progression of the disease.

Ultrasonographic imaging is useful in imaging the degree of joint swelling, the nature of the synovial fluid, and in identifying soft tissue injuries or inflammatory processes of the limb. Abscessation of the soft tissue adjacent to the infected bone is a common finding in foals with physeal infection. Abscesses can be localized and aspirated with ultrasonographic imaging for culture, susceptibility testing, drainage, and lavage.

Nuclear scintigraphy is of limited value in young foals because of the high metabolic activity of developing bone. White cell imaging using nuclear medicine techniques is useful, but adds expense, radiation exposure, and has not gained pervasive approval.
It is important to obtain a sample of synovial fluid for cytology and analysis. Aspiration of synovial fluid for cytology and culture are essential diagnostic aids. The synovial fluid should be collected in EDTA tubes to evaluate the nucleated cell count, differential, protein, and cytology. The predominant cell type in inflamed synovial fluid is the neutrophil. The neutrophil will be well preserved in nonseptic suppurative effusions and are predominantly degenerative and karyolitic in septic effusions. Nucleated cell counts higher than 20,000 cells/ul in foals with hematogenously acquired septic arthritis are essentially diagnostic. Inflamed painful joints with nucleated cell counts higher than 10,000 cells/ul must be presumed to be infected, until proven otherwise. Other synovial fluid components that change with sepsis are an elevation in the total protein (>2 g/dl), a decrease in the mucin clot formation, and viscosity.

Anaerobic and aerobic culture and susceptibility tests should be performed. The use of antimicrobial devices may be beneficial in promoting a positive synovial fluid or blood culture if previous systemic antimicrobials have been used. Synovial fluid cultures are positive 40-64% of the time. The low positive isolates may be attributable to the low concentration of bacteria and bacteriostatic properties of synovial fluid. Culture of synovial membrane does not usually enhance the ability to recover organisms from septic joints.

Bacteria usually do not colonize the synovial membrane itself but exists in fibrin clots coating the synovial lining and floating free in the joint. Positive culture of synovial fluid is achieved by one of two methods. As large a volume of synovial fluid as possible is
obtained and the synovial fluid centrifuged, with the resulting pellet cultured. The fluid may be stored in a sterile container such as a capped syringe under refrigeration until presentation to the laboratory. Alternatively, a large volume of synovial fluid may be inoculated into blood culture media. The media should be inoculated for 24 hours under aerobic and anaerobic conditions, and then subcultured on blood agar. This method has the disadvantage of adding 24 hours to the time before initial culture results can be obtained. The use of antibiotic removal devices or sodium polyanetholsulfonate tubes should be considered for submission of synovial fluid samples obtained after the administration of antibiotics. All positive culture results from aseptically obtained joint fluid should be considered significant. Organisms that are not typical equine pathogens such as Staphylococcus epidermis, Aspergillus and Candida species can cause septic arthritis if inoculated into joints.

Histopathologic evaluation of synovial membrane biopsy specimens as an aid in distinguishing infectious arthritis from other causes of joint inflammation in horses is of little or no value. The organisms are rarely identified in the synovium of biopsy specimens from infected joints, even with the use of special stains. A wide degree of varying synovial membrane responses can be seen in synovial membrane biopsies taken from different areas of the joint.

Since the infection is often localized, a complete blood count and fibrinogen level are often within normal limits. Serial hemograms may yield more useful information. Any elevation in the white blood cell count or fibrinogen level in a lame foal with fever should
be assumed to be bone or joint infection, until proven otherwise. Normal hemograms
does not rule out infectious arthritis or osteomyelitis. Foals less than one month of age
should have IgG levels checked to evaluate for failure of passive transfer.

A bone biopsy or obtaining bone debris using a 2.5 or 3.2 mm drill can be performed if
there is radiographic evidence of osteomyelitis away from the joint. The remaining tract
may then be used for intraosseous infusion of an antimicrobial agent.

TREATMENT
Joint lavage is indicated in foals with a septic joint. The decision to perform the lavage
through needles or under arthroscopic guidance is usually based on the length of the
infection and the degree of clinical signs. Acute cases may respond fine to a thorough
lavage accomplished with 14 or 16-gauge needles placed on opposite sides of the joint.
Joint lavage may be repeated every one to three days, depending on the clinical response.
Broad spectrum systemic antimicrobials should be started immediately and adjusted
accordingly, based on the clinical progression and culture and susceptibility testing.
Chronic septic joints frequently have a coagulum of fibrin and thickened synovium that
makes adequate lavage via needles difficult. If present, fibrin and chronically thickened
synovium can be removed from the joint when lavage is accomplished under arthroscopic
guidance. In addition, the health of the articular cartilage can be evaluated, and localized
areas osteitis/osteomyelitis can be debrided. The longer the infection has been present,
and the more inflamed the joint, the more likely that arthroscopic surgery will be
necessary to achieve effective lavage. Osteomyelitis in the subchondral epiphyseal bone requires surgical debridement under arthroscopic guidance, even in very acute cases.

A sterile, balanced electrolyte solution rather than antiseptic solutions are recommended for flushing septic joints. Antiseptics such as chlorhexidine are too irritating to the joint. Even the minimal inflammatory response caused by 0.1% and 0.01% povidone-iodine solutions does not offer an advantage over a balanced electrolyte solution. Antibiotics can be included in the lavage solution, but because of the transient contact time of the fluid with the synovium, antibiotics are usually injected after the lavage to achieve higher synovial concentrations. Dimethyl sulfoxide in the lavage solution does not cause irritation or significant inflammation in synovial structures. The benefits of DMSO include its superoxide radical-scavenging activity and suppression of prostaglandins decreases inflammation. The drug theoretically may help antibiotics penetrate the synovium.

Other treatments for joint and bone infection include local intra-osseous injection or regional perfusion with antimicrobial agents. To perform intraosseous injection, an 18 or 20 gauge needle is inserted into the physis or adjacent bone. An aminoglycoside such as amikacin (250-500 mg) may be used.

Regional limb perfusion may be used to manage septic arthritis in foals. The technique maximizes penetration of the antibiotic into the vascularized tissues around the joint. It is of particular value in foals when penetration of bone and surrounding soft tissue is
needed in sites of bacterial colonization. The technique does not achieve synovial fluid concentration as high as can be obtained through direct injection into the joint space, but synovial fluid levels more than 55 times greater than the MIC reported for most organisms can be reached with gentamicin. This is an effective way to achieve high concentrations of antibiotics in both the synovial fluid and the surrounding tissues. Most foals can be managed with sedation, local anesthesia, and restraint on a foal bed. Systemic antibiotics are necessary for all foals with infectious arthritis to avoid hematogenous dissemination of the infection to another synovial structure.

The antibiotic, generally an aminoglycoside or cephalosporin, is injected into one of the local superficial veins while the Esmarch’s bandage is in place. The skin over the vein is surgically prepared using an antiseptic technique. A 23-gauge butterfly catheter with an incorporated extension set works well for this purpose. The palmar/plantar medial and lateral veins are used when the infusion is performed at the level of the fetlock. The cephalic and saphenous veins are used when the tissues intended to be perfused are localized at the levels of the carpal and the tarsal joints.

The volume of infusion varies between 20 to 60-ml, but smaller volumes can be used for treating foals. Different recommendations for the rate of infusion are reported. The rate of infusion can be as fast as 60 ml per minute, or 2-ml per minute for a total delivery time of 30 minutes for a 60-ml volume. For standing treatment, a fast rate of administration is more convenient and seems to offer satisfactory results. Once the catheter is withdrawn, several gauze sponges are applied over the venipuncture site and the site is wrapped with
an elastic bandage to avoid a hematoma formation. The Esmarch’s bandage is maintained in place after antibiotic infusion for a period of 30 to 40 minutes and then released.

Hyperbaric therapy is utilized presently in treatment of septic arthritis and appears to have merit in some cases. Objective data is lacking at this time on its clinical efficacy in treating foals with septic joints.

Foals with infectious arthritis should have exercise restriction a minimum of 3 to 4 weeks to prevent further traumatic cartilage damage. After the elimination of the infecting organism, anti-inflammatory medication returns the joint to normal and minimizes damage to the articular cartilage. Systemic administration of chondroprotective agents or intraarticular administration of hyaluron may benefit treatment. This appears to help resolve the synovitis and joint capsule thickening that occurs in infected joints.

**PROGNOSIS**

The prognosis for foals with infectious arthritis and osteomyelitis depends on the antimicrobial susceptibility of the organism and how early effective treatment is instituted. Generally, foals treated early for infections have a good prognosis for full recovery. Foals with articular infection with subchondral bone involvement have a poor prognosis, and the clinical course of disease and treatment is prolonged. Foals with focal bony lesions involving only the physis, without bone instability, have a good prognosis. Severe erosive lesions of the physis and metaphysis may result in pathologic fractures.
and collapse of the boney column, resulting in an unstable fracture or severe angular limb deviation. Surgery may be indicated, but prognosis is poor for soundness if this occurs.

REFERENCES:
Horses often incur traumatic wounds and other injuries of their legs that may result in infection of synovial structures such as joints, tendon sheaths and bursas. The prognosis for return to function is guarded when a synovial structure is infected and reported mortality rates are as high as 40-50%. The duration of the infection and the effects of the therapy directly affect the prognosis of the horses for survival or to resume their athletic careers. Elimination of the infection before irreversible damage occurs in the synovial structures is of primary importance.

To eliminate the infection, the appropriate antibiotic at a concentration higher than the minimum inhibitory concentration for the infectious agent must be delivered to the infected tissues. Vascular trauma and inflammation associated with infection may adversely affect the delivery of the antibiotics to the synovial structure, allowing bacteria to proliferate in the affected tissues. Infection is also associated with collection of cellular debris and low pH, each of which can decrease the activity of some antibiotics. In these cases it is necessary to increase the antibiotic dose to effectively eliminate the infectious organism.

Regional intravenous infusion achieves high concentrations of antibiotic by diffusion from the vascular space into the traumatized and infected synovial membranes. Survival rates of horses treated with systemically injected antibiotics in conjunction with regional
intravenous antibiotic infusion were reportedly as high as 75% and 86% in two different studies. Regional intraosseous injection of antibiotics has also been used, but in a recent report, higher concentrations of antibiotic were detected sooner in joints after regional intravenous compared with regional intraosseous antibiotic infusion.

**TECHNIQUE**

To perform standing regional intravenous perfusion, the horse is sedated with a combination of detomidine and butorphanol. A high volar block is performed using mepivacaine when the synovial structure to be treated is located at or below the fetlock. Anesthesia of the ulnar and median nerves, or tibial and peroneal nerves is performed when the area to be treated is located at the level of the carpal or tarsal joints, respectively.

An Esmarch’s bandage or a pneumatic tourniquet is applied proximal to the affected synovial structure to occlude the venous system. Usually the bandage or tourniquet is applied to the mid-metacarpus or metatarsus, but in cases of infection of the carpal or tarsal structures, the bandage or the tourniquet is applied to the distal aspect of the radius or the gaskin. The Esmarch’s bandage is maintained in place after antibiotic infusion for a period of 30 to 40 minutes and then released.

The antibiotic, generally an aminoglycoside or cephalosporin, is injected into one of the local superficial veins when the Esmarch’s bandage is in place. The palmar/plantar medial and lateral veins are used when the infusion is performed at the level of the fetlock. The cephalic and saphenous veins are used when the tissues intended to be
perfused are localized at the levels of the carpal and the tarsal joints. The skin over the vein is surgically prepared using an antiseptic technique. The vein is catheterized using a 22-gauge, 2.5-cm catheter with an infusion plug. A 23-gauge butterfly catheter with an incorporated extension set also works well for this purpose.

The volume of infusion varies between 20 to 60-ml, but smaller volumes can be used for treating foals. Different recommendations for the rate of infusion are reported. The rate of infusion can be as fast as 60 mls per minute or 2-ml per minute for a total delivery time of 30 min for a 60-ml volume. For standing treatment a fast rate of administration is more convenient and seems to offer satisfactory results. Once the catheter is withdrawn several gauze sponges are applied over the venipuncture site and the site is wrapped with an elastic bandage to avoid a hematoma formation.

**CLINICAL USE**

Regional intravenous infusion with an antibiotic is an adjunctive therapy, which should be applied in conjunction with systemic and/or surgical therapy. Survival and the ability to return to the original level of performance is improved where regional intravenous infusion is used in conjunction with other forms of conventional therapy. Concentrations of antibiotic after local perfusion are significantly higher in the synovial fluid than in serum, and the minimum inhibitory concentrations for the antibiotic used is higher than is necessary for treatment of most organisms sensitive to the antibiotic. Because the synovial membrane is the site of bacterial colonization, regional antibiotic therapy is very effective.
We have used aminoglycosides for regional perfusion with good results, but lately and because some of our horses have had synovial structures infected with methicillin resistant staphylococcus aureus, we have been using cephotaxim (a third generation cephalosporin) for regional perfusion. The results of the clinical cases treated at our hospital are encouraging.

We have treated horses with infection of the digital tendon sheath, coffin joint, carpal and tarsal joints, or navicular bursa with regional intravenous infusion of antibiotic, usually combined with medical and surgical therapies. Affected horses are treated with regional intravenous antibiotic infusion either standing or while under general anesthesia. Prior to the surgical procedure a regional intravenous infusion with antibiotics is performed. We leave the tourniquet in place for 30 to 40 minutes. Subsequent regional perfusion with antibiotic (up to 6 treatments in some cases) has been performed daily with the horses standing. We alternate the lateral and medial side for the vein infusion, and no complications have been observed associated with this type of therapy.

**ANTIBIOTIC DOSES**

Amikacin: 250-500 mg diluted in 20 to 60 ml of saline solution.

Gentamicin: 1 gm diluted in 60-ml of saline solution.

Cephotaxim (Claforan): 1-2 gm diluted in 20 to 60 ml of saline solution.

**References:**


