Large-animal emergency and critical care has evolved as an emergency specialty in veterinary medicine over the last 10–15 yr, and many referral hospitals now employ clinicians with dual training in emergency/critical care and an allied specialty (medicine, surgery, or anesthesia). Practically speaking, it is the critical-care clinician’s job to synthesize advancements from the associated specialties to provide the highest level of care for the critically ill equine patient. Recent advances in large-animal surgery and their impact on the management of the emergency equine patient is the focus of this portion of the panel discussion. In the horse with acute abdominal disease, advancements include more rapid diagnosis, more experience with difficult bypass procedures, and more intensive post-operative management. In horses with wounds involving a synovial structure, more experience with local antimicrobial delivery techniques and timely referral have resulted in improved awareness and education of the referring veterinarian, and, in turn, these developments have improved outcomes. Advancement in orthopedic implant design, increased use of minimally invasive techniques, and development of anti-infective orthopedic hardware are recent developments that could improve survival in horses suffering from catastrophic musculoskeletal injury. In all critically ill equine patients, the role of the referring veterinarian is pivotal in patient outcome and client satisfaction, and it cannot be emphasized enough. Author’s address: University of Pennsylvania, School of Veterinary Medicine, New Bolton Center, 382 West Street Road, Kennett Square, Pennsylvania 19348; e-mail: bldallap@vet.upenn.edu. © 2009 AAEP.
of survival rates of 55–58%. Interestingly, seri-
lished almost concurrently reported similar findings
horses treated medically or surgically succumbed to
disease, which indicates that almost one-half of all
horses referred for treatment of acute abdominal
dehiscence of the ventral midline incision. Both

2. Role of the Criticalist in the Referral Hospital
There are currently >10 veterinary teaching hospi-
tals and several private referral facilities in the
United States and Europe that employ specialists in
large-animal critical-care and emergency medicine
(criticalists). With the exception of one, all individ-
uals have attained certification in another specialty
(surgery, medicine, or anesthesiology). This additional
training has advanced the treatment and assess-
ment of the equine emergency patient, regardless of
if it is a septic neonatal foal or a horse with an acute
abdomen. Skills of the criticalist should include
the ability to assess and initiate treatment on either
a surgical or medical emergency as well as address
the needs of the hospitalized critically ill horse.
In many teaching facilities, large-animal emergency
and critical care has become a separate, year-round
clinical service with dedicated critical-care, surgery,
and medicine clinicians whose primary mission is
admitting and attending to emergency and critically
ill patients. This is a significant departure from
the clinical approach of even 8–10 yr ago when most
horses having acute abdominal disease or present-
ing for emergency evaluation were operated on and
managed by surgeons with divergent daytime and
nighttime responsibilities. The increase in the
equine emergency caseload has allowed more re-
sources to be directed toward equine critical-care
services, and it has provided the impetus for cli-
cians to obtain additional training and certification
in the specialty of critical care. In the author’s
facility, the patient, client, and student benefit not
only from the knowledge of the trained criticalist but
also the additional specialists from other disciplines
assigned to the clinical rotation. This has in-
creased the collaboration among specialists from
different disciplines and resulted in patients receiv-
ing appropriate care in a more expedient fashion.
Furthermore, the criticalist has the responsibility
to incorporate veterinary advancements in the
associated other disciplines (medicine, surgery, or
anesthesia) into the emergency evaluation or man-
agement of the critically ill horse.

3. Improvements in Treating Horses With Surgical
Colic
Early reports evaluating survival after treatment
for surgical colic cite mortality rates that are consid-
erably worse than those expected today. A study in
1989 reported mortality rates from 39% to 48%1 in
horses referred for treatment of acute abdominal
disease, which indicates that almost one-half of all
horses treated medically or surgically succumbed to
abdominal disease. Two additional studies pub-
lished almost concurrently reported similar findings
of survival rates of 55–58%.2,3 Interestingly, seri-
ous complications contributing to morbidity and
mortality were related not only to the primary gas-
trointestinal disease but also incisional complica-
tions, and 2 of 78 horses suffered from acute major
dehiscence of the ventral midline incision. Both
horses had had only one celiotomy. Extrapolating
that dehiscence rate to current times, many hospi-
tals today would see acute dehiscence and failure
several times annually. Thankfully, this is not the
case.
More recent retrospective studies on equine sur-
gical colic report survival rates ranging from 57% to
95%, depending on the intestinal lesion.4–6 Many
studies reporting these mortality rates are describ-
ing the most severe surgical lesions, including
horses with strangulating small intestinal lesions4,5
and large colon resection.6,7 The relative improve-
ment in survival is obviously multifactorial, and it is
difficult to identify all of the factors contributing to
improved survival based solely on a literature re-
view. Common sense dictates that earlier referral
and more timely surgical intervention (rapid diag-
nosis) probably plays a significant role. Addition-
ally, increased experience gained from the growing
body of knowledge available to the equine surgeon
has improved the ability to successfully treat the
horse with acute abdominal disease.

Advances in Diagnostic Evaluation
In addition to experience, securing a rapid diagnosis
may be aided by improvements in imaging, such as
ultrasonography. Descriptions of the sonographic
evaluation of the normal and the acute equine ab-
domen have provided a visual library for those at-
tempering to diagnose various abdominal lesions.8–12
This information aids the clinician in making a more
rapid diagnosis of diseases ranging from simple dis-
placements of the large colon to strangulating small
intestinal disease, peritonitis, or inflammatory du-
odenal disease. In most hospitals, ultrasonography
has become a standard part of the routine work up of
the horse with acute abdomen, and it may play a role
in earlier identification of certain lesions as a result.
Ultrasonography is almost a necessity for evaluation
of the foal or miniature horse abdomen, where rectal
examination is often not possible. Historically, ra-
diography has not been as useful in diagnosing dis-
ease in the equine abdomen as it has been in small
animal or human medicine. However, a recent
study touted the advantages of radiography in com-
bination with ultrasonography to diagnose and mon-
it the resolution of sand accumulation in the large
colon.13
Abdominocentesis and evaluation of peritoneal
fluid have been mainstays of the colic work up for
many years, and they provide valuable information
regarding intestinal viability. Recent work report-
ing the importance of peritoneal lactate concen-
tration in predicting intestinal ischemia provides the
clinician with yet another potential indicator for
surgical intervention in situations where observa-
tion and reliance on less sensitive indicators may
have been the standard of care in past decades.14
Horses with intestinal ischemia secondary to stran-
gulating obstruction had significantly higher perito-
eal lactate (mean = 8.45 mmol/l) compared with
both plasma lactate levels (mean = 5.48 mmol/l) and peritoneal lactate in horses with non-strangulating lesions (mean = 2.09 mmol/l). The availability of hand-held lactate meters could make this a useful option in the future for ambulatory practitioners or those with limited laboratory capacity in an emergency setting.

Advances in Surgical Technique

Improvements in surgical technique may also be responsible for the decrease in mortality observed in horses requiring colic surgery in the last 20 yr. The increase in collective surgical experience likely results in shorter time to surgery and decreased surgery time, both proven to be factors in predicting positive outcome in acute abdominal surgery. Studies evaluating adhesion formation, one of the most common and devastating complications of colic surgery, have recommended that a pan-abdominal approach to adhesion prevention is critical, which emphasizes the importance of excellent tissue handling and technical skills of the surgical team. This emphasis is a departure from the focus of applying anti-adhesive products only at anastomoses sites. Further support for this pan-abdominal therapy can be found in studies reporting on the use of 1% sodium carboxymethylcellulose (CMC) applied intra-operatively before and after bowel handling for adhesion prevention; in these studies, both incidence of adhesion formation and death were decreased in treated horses.

The approach to actual surgical correction of various gastrointestinal lesions has evolved. Jejunocecostomy, commonly performed in horses with strangulating lesions of the ileum, has been performed for several years. The clinical impression of many surgeons is that horses undergoing this bypass procedure have a poor prognosis compared with jejunojejunostomy. Although this procedure was often avoided in past years in favor of a jejunocecostomy, a recent retrospective study and a small clinical series support use of end-to-end anastomosis rather than bypass. Careful evaluation of the blood supply of the ileum and avoidance of jejunocecostomy is now an accepted procedure. Other intestinal bypass procedures are generally performed more commonly than in the past to address duodenal or right dorsal colon stricture.

The approach to surgical treatment of large colon volvulus has been debated among surgeons. Until recently, few reports have focused specifically on survival and complications associated with large colon resection. One recent retrospective study reported a 57.7% survival-to-discharge rate after large colon resection and anastomosis in 52 horses, which provides new evidence that resection should be considered as a viable technique. This survival rate approximates the mean reported ranges for surgical treatment of large colon volvulus. A second report describes a short-term survival rate (to discharge) of 74% in horses undergoing end-to-end large colon resection after strangulating large colon volvulus. This rate is certainly better than those reported by many studies, regardless of method of intervention. Survival may be linked to case population and timeliness of referral, but certainly, these reports provide valuable information to both surgeons and owners regarding treatment of large colon volvulus in which intestinal viability is in question. Research focused on developing appropriate models for studying potential therapeutic treatment for colonic ischemia is ongoing. A recent article reports on the evaluation of pulsatile perfusion of the devitalized colon with organ preservation solution. This may provide an excellent model to study multimodal approaches to the treatment of the devitalized colon, and it could potentially have therapeutic applications.

Advances in Peri-Operative Care

Post-operative management of the colic patient is often a focus of the large-animal critical-care specialist. The development of dedicated clinicians and staff for the intensive care unit (ICU) has likely improved the post-operative care of the patient with acute abdominal disease. Monitoring of these patients has evolved to include central venous pressure and direct or indirect blood pressure measurements as opposed to merely relying on insensitive indicators such as physical exam parameters, packed cell volume, and total solid concentrations. Given the size of the patient and the size of the potential fluid space in the intestine, a more accurate assessment of intravascular volume is critical. Early goal directed therapy (EGDT) is an algorithm applied to critically ill human patients in which central venous pressures, systolic and mean arterial pressures, and oxygen saturation are maintained at specific levels. This methodology would improve post-operative monitoring, and it could potentially benefit our equine colic patients. Prospective clinical trials evaluating the most severely affected equine gastrointestinal patients and their responses to EGDT are needed to assess the cost-benefit ratios of such treatment strategies, because implementation may increase costs to owners.

Hemostatic dysfunction is relatively common in horses with severe gastrointestinal disease. Monitoring of coagulation, or, at the very least, heightened awareness of possible hemostatic alterations, should be considered during the management of the post-operative colic patient. It has been suggested that focusing on restoration of physiologic hemostasis at an early stage in the disease process and carefully monitoring anticoagulant therapy could potentially improve outcome by preventing multi-organ dysfunction; this dysfunction has been associated with coagulopathy in humans. In critically ill equine patients at risk for coagulopathy (acute ischemic gastrointestinal disease, colitis, or sepsis), therapeutic interventions could include early administration of fresh frozen plasma (4–6 ml/kg), platelet-rich plasma, or anticoagulants (heparin [40–80 U/kg, q 6–8 h, SC], dalteparin [50–100...
Nutritional support of the adult gastrointestinal patient is commonly overlooked. Although cost is often a factor in the implementation of nutritional support in the horse, its importance is proven in human and small animal critical-care medicine. Studies showing a direct effect of nutritional support on outcome in the horse are lacking, but a growing body of information is becoming available on the nutritional support of these patients as clinical experience with total and partial parenteral nutrition increases. Development of hypertriglyceridaemia has been reported in a small number of horses with systemic inflammatory response syndrome and increased creatinine. If not treated in a timely manner, hypertriglyceridaemia could contribute to depression, anorexia, and fatty infiltration of the liver or other organs. Patients with hyperlipaemia or hypertriglyceridaemia can be treated with IV dextrose supplementation or partial parenteral nutrition formulated with dextrose and amino acids only (no lipids). Dextrose alone is often used if the period of anorexia is expected to be transient and resolution of the primary problem is relatively rapid. A typical approach using dextrose only includes a formulation targeted at delivering 10 kcal/kg/day or 125 mg/kg/h. If the hypertriglyceridaemia is severe or anorexia is prolonged, PPN delivering dextrose and amino acids may be indicated. This can be achieved by adding 0.5–1.0 g/kg/day of amino acids to the above dextrose formulation. Typically, partial parental nutrition or significant dextrose supplementation is started at one-quarter of the target infusion rate to be delivered, and it is doubled every 6 h to achieve target rate administration within 24 h. Such an approach typically results in resolution of the disorder if the primary disease process is treated successfully.

The most common side effect of total or partial parental nutrition in the horse is hyperglycemia, which can be corrected with insulin therapy, either administered by repeated dose (insulin zinc suspension [0.1–0.3 IU/kg, q 12–24 h, SC]) or continuous rate infusion (regular insulin [0.05–0.10 IU/kg/h]). The large-animal critical-care specialist should be a resource for developing a nutritional plan for the critically ill adult horse. Increased use of nutritional support in the adult ICU patient, followed by appropriate investigations, may make the advantages and disadvantage of these therapeutic efforts more apparent.

The use of lidocaine infusion for management of post-operative ileus has become quite prevalent in the past 10 yr. Recent studies provide improved information on the benefits and possible mechanisms of lidocaine constant rate infusion (1.3 mg/kg/min for 15 min followed by 0.05 mg/kg/min constant rate infusion) in post-operative colic management, reporting both anti-inflammatory effects and amelioration of the inhibitory effect of flunixin meglumine on mucosal barrier function. A common dilemma in managing the horse with post-operative ileus is the decision to proceed to repeat laparotomy. Previously mentioned improvements in diagnostics can also aid in determining the need for a second celiotomy, including ultrasonography and measurement of peritoneal lactate concentration. Horses with refractory ileus/persistent reflux should be thoroughly investigated diagnostically to rule out the possibility of development of a new gastrointestinal lesion unrelated to the initial lesion. The literature suggests that repeat exploration and appropriate understanding of post-operative risk factors improves outcome. This is an important point for the surgeon or criticalist advising a client on how to proceed with a second surgery.

The referring veterinarian plays an invaluable role in the treatment of the horse with acute abdominal disease at a referral hospital. Their contribution begins with the initial decision-making process regarding the need for referral and the possibility for surgical intervention. Helping the client to understand the surgical process and possible post-operative complications is a vital role the referring veterinarian plays in the post-operative period. Post-operative care continues after discharge during the at-home convalescence period. In situations in which the referring veterinarian has an established relationship with the client, it is paramount to have them involved in the decision making process and post-operative plan for recovery. Daily communications regarding patient progress and specific concerns prepare the attending veterinarian for the level of care expected at discharge and aid in the communication with the owner. Additionally, because the surgical colic patient is at risk for colitis and surgical-site infection, the referring veterinarian is needed for on-farm infection control.

4. Improvements in Treating Horses With Traumatic Musculoskeletal Injuries

The emergency clinician is called on to evaluate a wide variety of musculoskeletal injuries ranging from fracture assessment to serious lacerations with suspected body cavity or synovial involvement. The most critical part of limb laceration evaluation is determining if a synovial structure has been contaminated and then implementing emergency therapy to prevent the contamination from progressing to an established infection. This is an important area of education for both the client and the referring veterinarian, because timeliness of treatment profoundly impacts outcome. In a study evaluating horses’ survival and return to function after open synovial-structure injury, referral and appropriate intervention within 24 h resulted in significantly better survival (65%) and return to function versus delayed referral (39% for 2–7 days post-injury). Although a thorough knowledge of anatomy is help-
ful in determining the likelihood of synovial involvement, assessment of wound location alone is not enough to rule out joint or synovial-sheath contamination or infection. In wounds with a high index of suspicion, the area should be aseptically prepared at a site distant from the wound, and synoviocentesis should be performed. The synovial structure should then be distended under pressure with sterile, polyionic fluids to identify any communication with the wound. If possible, synovial fluid samples should be obtained before distension to evaluate fluid color and character. Fluid analysis, including nucleated cell count, total solid concentration, culture, and sensitivity are performed if the laceration is confirmed to communicate with the joint or tendon sheath. Instillation of intrasynovial antimicrobials is recommended after synoviocentesis; amikacin (250–500 mg intrasynovially) is recommended by the author.

Radiography is useful in the field or referral setting to (1) rule out bony injury secondary to trauma, (2) detect any radiopaque foreign body, and (3) determine if gas is present in any synovial structures. Ultrasonography can be helpful in (1) characterizing the nature of synovial effusion, (2) identifying inflammation of synovium, (3) following a wound tract to a synovial structure, (4) identifying radiolucent foreign bodies such as wood, and (5) evaluating infection in soft tissue structures such as septic tendonitis or desmitis.

After communication between a laceration or puncture wound and a synovial structure has been established, therapy includes aggressive lavage and antimicrobial delivery. If the injury is very acute, lavage of the affected synovial structure can be accomplished with pressurized polyionic pH-balanced sterile fluids administered through a large-bore needle or large-bore cannula lavage system. Lavage can be performed either standing or under general anesthesia, depending on the location of synovial involvement, temperament of the patient, and severity and duration of the injury. Arthroscopic evaluation is sometimes indicated in horses with radiographic evidence of bone involvement or in cases in which fibrin is evident and requires removal. Advantages of arthroscopic examination include assessment of articular cartilage, excellent lavage, removal of fibrin and associated debris, and biopsy of synovial structures.

Systemic IV antimicrobial therapy is often initiated if there is high index of suspicion of synovial contamination or infection. Therapeutic options for local antimicrobial delivery for contaminated or septic synovial structures include intra-articular or intrathecal administration, regional limb perfusion, or intra-osseous administration. The focus of local antimicrobial therapy is to achieve antimicrobial concentrations several times the minimum inhibitor concentration (MIC) of the suspected causative organism without deleterious systemic effects. In recent years, IV regional limb perfusion has become increasingly prevalent in the treatment of distal limb infection in the horse, specifically in the treatment of septic arthritis or tenosynovitis. In a clinical setting, IV administration is often recommended over arterial administration because of the severe endothelium inflammatory response observed in arteries compared with veins. Antimicrobial selection usually includes a water-soluble, concentration-dependent drug such as amikacin. Regional limb perfusion can be performed under general anesthesia during surgery or repeated standing in situations where ongoing daily therapy is indicated. A recent study concluded that the type of tourniquet used in the standing horse is critical to obtaining appropriate levels of antimicrobials in the joint. The use of a pneumatic tourniquet resulted in the highest intra-articular MICs, although a wide rubber tourniquet also achieved levels above MIC. The use of narrow rubber tourniquets often resulted in significantly lower intra-articular antimicrobial levels. Other methods described for local antimicrobial delivery for treatment of septic arthritis can include the use of collagen sponges, constant rate infusion through an intra-articular catheter, or antimicrobial-loaded polymethylmethacrylate beads.

The referring veterinarian plays the most pivotal role in the outcome of the horse with a wound with suspected synovial involvement. Early recognition of possible synovial involvement, education of the client as to the potential risks of conservative management, and implementation of appropriate and timely therapy is essential to outcome. In cases in which referral is not possible or financially feasible, aggressive therapy is still possible, and when administered early, it can be successful. Aggressive intra-articular antimicrobial therapy, systemic antimicrobial administration, and synovial lavage can be successful in cases in which referral is delayed. Convincing clients of the need for radiographic or ultrasonographic evaluation in patients with suspected underlying orthopedic injury could also prevent further complications or catastrophic musculoskeletal injury during convalescence.

The referring veterinarian also plays a critical role in the initial stabilization and transportation of the horse with a suspected fracture or unstable soft tissue injury. Immediate first aid provided by the referring veterinarian includes tentative diagnosis, fracture stabilization, safe transportation, and prognosis advice. Although most horses suffering from traumatic orthopedic injuries will ultimately be operated on by an orthopedic surgeon, the receiving emergency clinician must be prepared to provide evaluation and stabilization of these patients. Communicating proper information to clients or referring veterinarians on the recent developments in treating orthopedic injury is an essential part of the decision-making process.

A significant challenge in equine fracture repair is strength and stability of the resulting implant-bone...
construct. Evolving implant technology has resulted in many improvements, including increased implant strength, inertial properties, and development of surface modifications to resist bacterial colonization. Improving the biomechanical stability of the fracture-implant construct decreases the risk of catastrophic failure of the repair before complete healing. The limited contact-dynamic compression plate (LC-DCP) and locking compression plate (LCP) are two recently developed implants that have been explored for use in equine fracture repair. Advantages of the LC-DCP in equine long-bone fracture repair are improved inertial properties and minimization of the stress-concentration effect of the screw hole. The LCP, essentially an internally positioned external fixator, allows the screw to directly lock into a dynamic compression plate system at the thread-hole interface. Improved stability is provided by the fixed-angle construct of the locking screw-hole, making it unnecessary to rely solely on plate-to-bone compression and frictional forces for fracture stability. The unique shape of the screw hole also allows a standard cortical bone screw to be inserted at an angle if necessitated by fracture configuration. Use of the LCP has been described in a series of 31 cases of fracture repair or fetlock arthrodesis in which 27 horses survived to hospital discharge.

Modification of the implant to combat colonization with bacteria is under investigation. Implants in which an antimicrobial agent (vancomycin) is covalently bound to the surface is being investigated in a large-animal model for ultimate use in man and horses. In addition to implant improvements, the approach to the surgical-site exposure has also been modified. Minimally invasive techniques have been widely used in human orthopedics in an attempt to minimize disruption of the local vascular supply and decrease deep and SC infection rates. Experiences with a similar, minimally invasive percutaneous approach for plate placement were described in the horse. Although statistical significance was not achieved, infection rate and surgery time was reduced in horses treated with a minimally invasive approach. Using improved imaging modalities such as fluoroscopy and computed tomography intra-operatively facilitate the use of minimally invasive fixation techniques as well as improve anatomic reduction and decrease surgery time in difficult orthopedic cases.

After the orthopedic injury has been repaired and the horse successfully recovered, post-operative prevention of laminitis remains a significant challenge. Often, the development of surgical-site infection plays a role in decreased comfort and uneven weight bearing, initiating an inflammatory response in the contralateral limb. The use of sling apparatus and increased efforts toward pain control seem to aid in the prevention of laminitis in orthopedic patients. Although large prospective or retrospective trials are lacking in these types of patients, increased awareness of pain management and collective experience gained by treating horses with catastrophic orthopedic injuries should advance our understanding of how to best manage these patients in the post-operative period.

5. Role of the Referring Veterinarian

Perhaps the most “critical” element in the advancement of large animal emergency and critical care as a specialty is the evolution of the referring veterinarian’s role with both the patient and client. Without the referral of emergent or critically ill horses and the education and encouragement of the client by the referring veterinarian, there would be no specialty. The increased knowledge base and advanced training acquired by many practicing veterinarians in the position of initial patient assessment has provided the drive to further advance the specialty and the level of care offered. Communication between the emergency clinician, referring veterinarian, and client must be clear and consistent, and a definitive and respectful partnership must be forged for successful patient and client management.

References