Surgical Considerations in the Emergent Small Animal Patient

Jennifer J. Devey, DVM

In veterinary medicine, many critically ill, emergency patients will present with injuries or diseases that require surgery as part of resuscitation and/or definitive care. Although some surgical diseases or injuries require advanced training and a board-certified surgeon to perform the surgery (e.g., hemilaminectomy for a herniated disc), some of these patients will require surgery urgently. The emergency clinician should be prepared to perform potentially life-saving surgical procedures, including surgical cutdowns for airway and vascular access, procedures for control of severe hemorrhage, and emergency thoracotomy to control hemorrhage or perform open chest cardiac massage. Emergency celiotomy may be required to control hemorrhage from trauma (necessitating liver, splenic, or renal surgery), gastric derotation and gastro-pexy for correction of gastric volvulus, gastrotomy or enterotomy for removal of foreign bodies, gastric or intestinal resections, urinary bladder repair, Cesarean section, and ovariohysterectomy for pyometra. The veterinarian must also know how to debride, drain (if indicated), and suture wounds. Many seriously ill or injured patients

KEYWORDS
- Damage control
- Veterinary surgery
- Emergency surgery
- Hemostasis
- Surgery
- Wounds

KEY POINTS
- To ensure a successful outcome when performing emergency surgery, the clinician must have the knowledge to be able to assess the patient to determine that surgical intervention is necessary, and to determine the urgency of the procedure.
- The emergency clinician should be prepared to perform potentially life-saving surgical procedures, including surgical cutdowns for airway and vascular access, procedures for control of severe hemorrhage, and emergency thoracotomy to control hemorrhage or perform open chest cardiac massage.
- Constant evaluation and assessment of patients and attention to detail are essential to ensuring a positive outcome.
- Records of patients that experience morbidity or those that die or are euthanized should be regularly reviewed to assess team performance and to make improvements where necessary.
may require enteral nutritional support and the clinician should be competent at placing esophagostomy, gastrostomy, and enterostomy feeding tubes. The reader is referred to a surgical reference for more detail on the specifics of each surgical procedure.

“Time, trash, and trauma” must be minimized. Prolonged operative times have been associated with higher morbidity, making speed essential, especially in more critically ill or injured patients. In extremely critical patients it may be appropriate to have the surgeon gowned and packs open even before induction of anesthesia to minimize the amount of time the patient spends anesthetized. Indwelling implants or foreign material, such as drains and suture material (“trash”), should be minimized. The surgeon must have a thorough knowledge of anatomy, as surgery for the critically ill or injured can be complicated and challenging. Necrotic tissue should be removed. Surgical technique should be as precise as possible and tissues must be handled gently.

TIMING OF EMERGENCY SURGERY

In the case of a truly emergency life-saving surgical procedure where death is imminent, the surgery should not be delayed for any reason. An emergency primary survey evaluating the airway, breathing, circulation, and level of consciousness (dysfunction) (ABCDs) should be completed rapidly, but a secondary survey or complete physical examination may not have been performed, the patient may not have had a diagnostic workup, and the surgical site may not have been clipped and prepared. In the patient that is close to, or has experienced a cardiopulmonary arrest, the surgical procedure should be performed with little regard for asepsis; however, a clean surgery should be attempted.

In situations in which imminent life-saving surgery is not necessary, appropriate resuscitation and stabilization of the patient are essential before induction of anesthesia. If the patient is not responding to volume resuscitation and supportive care it should be kept in mind that the surgical procedure may be an integral part of the resuscitation and stabilization.

A team of a minimum of 3 people, surgeon, assistant surgeon, and anesthetist/circulating nurse, is very important in the management of more critical emergency surgical patients. If this team is not available, if the hospital does not have all the necessary equipment or instruments, or if the clinician does not have the necessary skills or knowledge, consideration should be given to referring the patient. Good judgment must be exercised, because the risks of performing the surgery must be weighed against the risks of transport and delayed surgery.

READINESS

Readiness includes a well-organized, prepared operating room in the event emergency surgery is indicated. The anesthetic machine should be set up appropriately with sufficient inhalant in the vaporizer and an attached breathing circuit. All electronic equipment should be set up and plugged in. Essential equipment in the operating room should include patient cardiorespiratory monitors, an anesthetic ventilator, fluid pumps, fluid warmers, forced air warming devices, suction, and electrocautery. The surgery table should be prepared (eg, heating blanket, cautery). Intravenous (IV) fluids (isotonic crystalloid and synthetic colloid) should be available, along with drip sets, extension sets, and a pressure infuser bag. Blood products should be accessible, and materials for autotransfusion should be available.

All vital sterile supplies should be set up and ready. This includes instrument packs, electrocautery handle, suction tubing, light handle covers, and scalpel blades. Ideally,
a headlight and magnification loupes should be available. A sterile suction canister should be available for collection of blood for possible autotransfusion.

Because of the limited availability of blood and blood products in most veterinary hospitals, autotransfusion may be required in the severely hemorrhaging patient. If a trauma patient is bleeding into a cavity, such as the thorax or abdomen, an attempt should be made to collect the blood aseptically for possible reinfusion. Blood should be collected into sterile containers and administered IV using a filter. Anticoagulant is not necessary unless the bleeding is very active, as blood within body cavities rapidly undergoes fibrinolysis, and is generally devoid of platelets and fibrinogen. For this reason, patients receiving massive blood transfusions of autotransfused blood will often need fresh frozen plasma transfusions to provide coagulation factors. Ideally, blood from the abdomen is not recommended for use for autotransfusion until it has been determined that there is no gross contamination from a ruptured bowel or neoplasia (eg, hemangiosarcoma). In dire situations, the blood may have to be autotransfused without aseptic collection, possibly contaminated with infectious organisms or cells from a neoplastic source, and delivered without a filter. Patients have survived under these conditions.

Readiness not only refers to the physical facility, but also to personnel. All personnel must possess the knowledge to rapidly recognize potentially life-threatening problems; they must also know how to find, set up, and use all equipment that might be necessary for emergency surgery. Staff training is vital and cannot be overemphasized. Training should take the form of didactic sessions in addition to mock emergency situations. Written and/or posted protocols are highly recommended, because during the panic of true emergencies, it is easy to forget important components of treatment and stabilization. Protocols should be easy to understand and follow, and should be regularly reviewed and revised as needed.

PREOPERATIVE PATIENT ASSESSMENT

In the stable patient, a complete physical examination should be performed before induction of anesthesia. This includes an objective assessment of the 5 vital signs: temperature, pulse, respiration, blood pressure, and pain. The respiratory pattern (eg, rate, effort), airway sounds in all quadrants of the thorax, and the presence of cough should be evaluated in all patients, as patients with abdominal disease or trauma many have concurrent pneumothorax, secondary aspiration pneumonia, or metastatic disease. The cardiovascular system should be assessed based on heart rate, pulse quality, capillary refill time, and blood pressure. In addition to blood pressure, an attempt should be made to evaluate venous volume as approximately 70% of the blood volume is in the venous side of the circulation. Although no studies have been performed, observation of jugular vein filling likely provides an estimation of central venous pressure (assuming no intrathoracic pathology). The jugular vein should be clipped and evaluated for distention when the vessel is held off at the thoracic inlet. A patient with a flat jugular vein is likely hypovolemic. Perfusion can be further assessed in some patients by measuring toe web temperature. A difference of greater than 4°C indicates altered peripheral perfusion either secondary to global hypoperfusion or limb injury.

The abdomen should be palpated, auscultated, and percussed with the goal of localizing pain, and detecting the presence of a fluid wave, gas-distended organs, or solid masses. Auscultation of the abdomen should precede palpation, as palpation can cause gut sounds to diminish. A rectal examination should be performed, and evidence of blood, melena, pelvic fractures, or other pathology should be noted. Periumbilical hemorrhage (Cullen’s sign) may be seen with a hemoabdomen. Distended
superficial epigastric veins are consistent with increased intra-abdominal pressure, which can be associated with decreased preload and, consequently, reduced cardiac output.

A neurologic assessment should be performed of both central and peripheral nerves, and any abnormalities should be noted. A neurovascular assessment of the paws should be performed whenever limb injuries are present or spinal injury is suspected. The skin and mucous membranes should be evaluated for petechiation or ecchymoses.

In the emergent surgical patient, diagnostic tests are indicated to determine the extent of the illness or injury and to help confirm a diagnosis and the need for surgical intervention. The choice of tests will vary based on the presenting disease or injury. A previously healthy patient with a minor wound that can be sutured under sedation and local anesthesia may not require any tests, whereas a patient with a septic peritonitis will ideally have a complete diagnostic workup, including a complete blood count (CBC) with microscopic evaluation of a blood smear for the cell differential, cell morphology, and platelet estimate; electrolytes; blood gas (venous or arterial); coagulation profile; complete biochemical profile; and urinalysis. Cultures of wounds and abdominal fluid may also be indicated. Unstable patients ideally should have immediate diagnostics performed, including a packed cell volume (PCV) and total solids (TS), blood glucose (BG), blood urea nitrogen or creatinine, electrolytes, and a blood gas.

Thoracic radiographs should be evaluated in every trauma patient, and in any patient in which respiratory pathology is suspected. Abdominal radiographs are indicated in every patient with an abdominal injury or disease. Contrast studies, including a barium series, IV urography, cystography, or angiography may be required. When performing a barium series, water-soluble contrast material should be used instead of barium if there is any concern for gastrointestinal perforation or pulmonary aspiration. Abdominal ultrasound is useful for determining the presence of free fluid and for diagnosing many causes of acute abdomen, unless there is a significant amount of air within the peritoneal cavity.14,15 (Please see the article “The Use of Ultrasound for Dogs and Cats in the Emergency Room [AFAST and TFAST]” elsewhere in this issue for more information.)

Paracentesis should be performed in any patient with either pleural or abdominal effusion. For abdominocentesis a 4-quadrant centesis (unless ultrasound-guided centesis is available) should be performed in patients with suspected ascites, abdominal trauma, or peritonitis. Abdominocentesis may be falsely negative, and ultrasound-guided paracentesis or diagnostic peritoneal lavage may improve diagnostic yield.16 A PCV, TS, white blood cell count, and microscopic examination of the fluid should be performed to evaluate white blood cell morphology and to assess for the presence of bacteria. In the dog, an abdominal fluid glucose level that is at least 20 mg/dL less than the glucose level in the blood is strongly supportive of septic peritonitis.17 A fluid lactate greater than 2.5 mg/dL is also suggestive of septic peritonitis in the dog.18 Evidence of septic peritonitis is an indication for emergency surgery.

Other biochemical tests comparing blood versus abdominal fluid concentrations include alkaline phosphatase, total bilirubin, potassium, and creatinine. Alkaline phosphatase concentrations that are higher in the abdominal fluid compared with the serum suggest intestinal leakage.19 Bilirubin concentrations that are higher in the abdominal fluid than serum indicate a disruption of the biliary tract (eg, bile peritonitis) and the need for emergency surgery.20 Potassium and creatinine concentrations that are higher in the abdominal fluid than in the serum are consistent with urinary tract rupture and the need for urgent exploratory surgery, although temporary peritoneal drainage may be an appropriate course of action if the patient is too unstable for emergency surgery.21
INSTRUMENTS

Wound packs should be available and sterilized (Box 1). A major surgical pack must contain all the instruments for performing almost any major surgery (Box 2). Both should contain good-quality instruments. A hemostat that falls off a blood vessel at an inopportune moment may contribute to significant patient morbidity. Scissors should be sharp and should be checked regularly to ensure that sharpening or replacement is not indicated. Curved instruments are preferred over straight because they allow for better visualization of tissues to be cut and are more maneuverable.

The surgical instruments should be packed with the emergency surgery in mind and the instruments that the surgeon may require first should be placed on top. A separate peel pack (sterilized, but not sealed) should contain the necessary instruments for gaining rapid entry to an abdomen or thorax, as well as instruments needed for providing rapid hemostasis.

Stapling equipment is invaluable in saving time and preventing patient morbidity when used appropriately. Stapling equipment can be used to perform rapid lung lobectomy, liver lobectomy, gastric resection, intestinal anastomosis, vascular ligation, and fascia and skin closure. The tissues must be able to be compressed to 2-mm thickness for use of the 4.8-mm staples, 1.5-mm thickness for the 3.5-mm staples, and 1.0-mm thickness for the 2.5-mm staples. Staple lines may need to be oversewn with suture. Vascular clips provide rapid, safe vascular ligation, provided the vessels are between one-third and two-thirds the diameter of the clip. A tissue bumper of 2 to 3 mm should be left to prevent the clip from slipping off of the blood vessel.

PATIENT PREPARATION

Wide surgical skin preparation is always indicated in the emergent patient, as the skin may need to be mobilized and tubes or drains may need to be placed outside of the direct surgical field. The dimensions of the prepared field will vary with the individual surgery but, ideally, should include a minimum of 6 to 8 in (15–20 cm) from the farthest extent of the anticipated surgical incision or incisions. When preparing for abdominal surgery, the thorax should be included, as access to the caudal thorax may be needed when performing cranial abdominal procedures. If catheterization of the femoral artery or vein might be indicated intraoperatively for large-bore vascular access, the inguinal region should be prepared.

<table>
<thead>
<tr>
<th>Box 1</th>
<th>Wound pack</th>
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<tr>
<td>Scalpel handle</td>
<td></td>
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<tr>
<td>Mayo-Hegar needle holder</td>
<td></td>
</tr>
<tr>
<td>Brown-Adson tissue forceps</td>
<td></td>
</tr>
<tr>
<td>Curved Metzenbaum scissors</td>
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<tr>
<td>Curved Halstead mosquito forceps (minimum 3)</td>
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<tr>
<td>Curved Kelly or Crile forceps (minimum 3)</td>
<td></td>
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<tr>
<td>Small bowl</td>
<td></td>
</tr>
<tr>
<td>4 x 4 sponges (minimum 10)</td>
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<tr>
<td>Skin drape</td>
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Appropriate skin antiseptics should be applied before the surgical procedure. Chlorhexidine and povidone iodine are the 2 most common surgical antiseptics used in veterinary medicine. Chlorhexidine, which acts by disrupting the cell wall and precipitating cell proteins, has a spectrum of activity against most gram-positive and some gram-negative bacteria (including *Escherichia coli* and *Pseudomonas aeruginosa*). Chlorhexidine is effective against yeast but it is ineffective against bacterial spores and mycobacteria. It is not inactivated by the presence of organic material and it binds to keratin, thus it has residual antibacterial activity. There is an approximately 90% bactericidal effect within 30 seconds of contact time. Although a 5-minute to 7-minute preparation time is recommended, it is possible that two 30-second scrubs are sufficient.

Povidone iodine solutions act by penetrating the cell wall where they oxidize the intracellular contents, replacing the microbial contents with iodine. Povidone iodine
has a broad spectrum of activity against gram-positive and gram-negative bacteria, fungi, yeast, and mycobacteria, but it is considered ineffective against bacterial spores. An approximately 90% bactericidal effect is expected within 30 seconds, although a minimum of 2 minutes of contact time is advised, and a 5-minute to 7-minute scrub time is recommended. Alternating the surgical solution with alcohol wipes may reduce efficacy because contact time of the iodine with the skin will be decreased. It is inactivated by the presence of blood, plasma, and organic material, so the presence of any of these rapidly diminishes the residual bactericidal activity.

*Pseudomonas* and *Serratia marcescens* can rapidly develop resistance to chlorhexidine by forming a biofilm. A similar problem has been noted with povidone iodine; therefore, keeping gauze squares soaked in either of these antiseptic solutions in containers for any long period of time should be avoided.

**PATIENT POSITIONING**

Appropriate patient positioning is essential to ensuring good surgical exposure; however, the position of the patient may have negative consequences on ventilation and hemodynamic status. Abdominal masses, a large spleen, or a gravid uterus can effectively occlude the abdominal vena cava when the patient is placed in dorsal recumbency, thus significantly decreasing preload and, therefore, cardiac output. Placing the patient at a slight angle may avoid this complication.

Patients placed in dorsal recumbency with the limbs held in a fully extended position cannot ventilate well. Bending the thoracic limbs at the elbows to a 90° angle and then securing the patient to the table will help prevent ventilatory compromise (spontaneous or mechanical). Larger dogs placed in lateral recumbency rapidly develop atelectasis of the dependent lung and should be ventilated as soon as anesthesia is induced. Patients placed in sternal recumbency and held in position with sandbags or molded trays also may not be able to adequately ventilate. Patients placed in a tilted position with the head down may have difficulty moving their diaphragm on inspiration. These positions should be avoided whenever possible.

**HEMOSTASIS**

Accurate hemostasis is important in all patients, but is even more so in critically ill or injured patients. Coagulopathies are not uncommon in these patients, and even minor oozing of blood can lead to significant blood loss. Blood loss from subcutaneous vessels, omental vessels, and mesenteric vessels can be significant in patients that are hypocoagulable. Blood clots and hematomas should be avoided because both can lead to delayed healing and an increased likelihood of infection. To estimate losses for fluid replacement purposes, an estimate of the volume of blood loss should be made. A gross estimate is that a “fistful” of blood represents approximately 200 to 500 mL depending on the size of the fist. Likewise, a 4 × 4 sponge, when soaked, holds approximately 5 to 18 mL of blood, and a laparotomy sponge holds approximately 50 to 100 mL.

Temporary control of hemorrhage into parenchymal organs can be achieved by placing atraumatic vascular clamps (e.g., Satinsky clamp, bulldog clamp) or a Rumel tourniquet. A modified Rumel tourniquet can be formed by passing a small-bore red rubber tube around the vascular pedicle and then bringing the tube ends together. A pair of hemostatic forceps are slid down both tube ends until the vessel is approximated, at which point they are clamped. Many of the major abdominal vessels can be safely occluded for short periods of time (Table 1). The safety margin is likely less in the face of significant preexisting hypoperfusion, and these time limits should be
used as a guideline only. In patients with severe liver hemorrhage, temporary control may be achieved by performing a modified Pringle maneuver, which occludes the portal triad of the portal vein, hepatic artery, and common bile duct (Fig. 1). This will control approximately 70% of the blood flow to the liver, and provide a short period of time to clearly identify the injury and definitively control the hemorrhage.

Topical hemostatic agents can also be used to control hemorrhage in certain situations. Fibrin glues, collagen, gelatin sponges, and oxidized cellulose are available products. Newer kaolin-based products developed for use by the military appear to be extremely effective at controlling life-threatening hemorrhage.

Definitive hemostasis can be achieved by use of direct pressure, suturing of wounds (compression of vessels), electrosurgery, ligation of blood vessels, vascular clips, omental packing, cyanoacrylate, hemostatic agents, or removal of the hemorrhaging tissue.

Electrosurgery is indispensable for rapid and efficient control of hemorrhage. It causes heat-induced protein denaturation and tissue coagulation, and can be used to control hemorrhage from arteries up to 1 mm and veins up to 2 mm in diameter. Monopolar electrosurgery passes a current from the electrode through the patient to a ground plate, and requires a dry field. In contrast, bipolar electrosurgery passes

<table>
<thead>
<tr>
<th>Blood Vessel</th>
<th>Occlusion Time Limit</th>
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<tr>
<td>Ascending aorta (proximal to the left subclavian)</td>
<td>2–3 min</td>
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<tr>
<td>Descending thoracic aorta</td>
<td>5–10 min</td>
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<tr>
<td>Portal triad</td>
<td>10–15 min</td>
</tr>
<tr>
<td>Hepatic artery</td>
<td>30 min</td>
</tr>
<tr>
<td>Splenic artery and vein</td>
<td>15–20 min</td>
</tr>
<tr>
<td>Renal artery and vein</td>
<td>30 min</td>
</tr>
<tr>
<td>Abdominal aorta</td>
<td>30 min</td>
</tr>
<tr>
<td>Caudal vena cava (distal to liver)</td>
<td>Can ligate</td>
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Data from Refs. 31, 65, 68

Fig. 1. Modified Pringle maneuver (occlusion of the portal triad of the hepatic artery, portal vein, and common bile duct) using a modified Rumel tourniquet.
a current between 2 electrodes. When used inappropriately, thermal damage can result, leading to ischemia and delayed healing.

**FEEDING TUBES AND NASOGASTRIC DECOMPRESSION**

A conscious decision should be made with regard to placement of a feeding tube in each patient undergoing major surgery. Ideally, a nasogastric tube should be placed in all dogs for postoperative decompression and early enteral feeding, and in cats with evidence of gastroparesis. Gastric decompression helps decrease the chance for bloat, decreases interference with diaphragmatic excursions, and has been proven to significantly decrease the time for normal gastric motility to return. A gastrojejunostomy or jejunostomy feeding tube should be placed in all patients with upper gastrointestinal surgery (including hepatobiliary and pancreatic surgery), if there are any concerns that enteral nutrition will not be tolerated within 24 to 36 hours.

**PERITONEAL LAVAGE**

Before closing the abdomen, the abdominal cavity should be flushed with warm isotonic fluids, with the number of liters of saline used depending on the degree of contamination. It has been recommended that approximately 200 to 300 mL/kg minimum, or until the lavage effluent is clear, be used to lavage a contaminated or infected abdomen. The use of intraperitoneal antibiotics is not indicated, as they have not been shown to have any beneficial effects. No benefit has been demonstrated with the use of antiseptics in the lavage fluid and negative effects can include chemical peritonitis, increased adhesion formation, and delayed healing of intestinal anastomoses.

**PERITONEAL DRAINAGE**

In cases of peritonitis, peritoneal drainage is indicated if the source of the contamination has not been completely controlled, if an anaerobic infection is likely, if a second laparotomy is planned, or if significant peritonitis exists. The 2 main options for peritoneal drainage include open peritoneal drainage and closed suction drainage. Open abdominal drainage has many disadvantages, including protein loss, electrolyte abnormalities, fluid loss, potential for ascending infection, and risk of evisceration. Closed suction drainage is an effective alternative to open abdominal drainage in many situations. After irrigation, closed suction drains are placed in the cranial abdomen and the abdomen is closed. The drains are left in place until the amount of fluid being produced is within physiologic limits (1–2 mL/kg per day) and the fluid cytology shows no signs of active inflammation or infection. This method of drainage is effective in many patients and minimizes morbidity.

**TRAUMA TRIAD OF DEATH**

The trauma triad of death is defined in human medicine as hypothermia, acidosis, and coagulopathy. Hypothermia can develop secondary to evaporative or conductive losses, cold air in the anesthetic circuits, use of room-temperature fluids (especially boluses of cold fluid to patients that develop hypotension intraoperatively), and the presence of open body cavities or extensive tissue exposure. To counteract this, warming circuits should be used on anesthetic machines, fluids should be warmed, surgery tables should be heated, and patients should be kept warm with warm water circulating blankets, forced warm air circuits, and warm lavage fluids.
Acidosis may develop secondary to poor tissue perfusion.\textsuperscript{46,47} Concurrent respiratory acidosis may develop secondary to hypoventilation.\textsuperscript{46,47} Because almost all anesthetic drugs have a negative impact on respiration, all anesthetized patients should be ventilated (ideally mechanically) and the carbon dioxide tension should be monitored using capnography or frequent blood gas assessment. Euvolemia and normal blood pressure should be maintained using synthetic colloid fluids and blood products, as indicated. Infusion of large volumes of crystalloid fluids should be avoided to minimize dilution of hemoglobin, blood proteins, and clotting factors. Blood pressure ideally should be measured directly via an arterial catheter; however, if this is not possible, then blood pressure should be measured indirectly using a Doppler ultrasonic flow detector. Doppler is preferred over oscillometric devices, because it is more accurate in smaller and hypotensive patients and allows the surgeon and anesthetist to assess flow in addition to blood pressure.\textsuperscript{48} Red blood cell transfusions may be indicated when there has been an acute blood loss of more than 20\% of the patient’s blood volume, or if perfusion parameters are not improving with fluid resuscitation with non–hemoglobin-containing fluids.\textsuperscript{49,50} Patients with acute blood loss should have a hemoglobin concentration of at least 7 g/dL before undergoing major surgery.\textsuperscript{49,50}

Coagulopathy may develop secondary to ongoing blood loss and hemodilution with crystalloid fluids and synthetic colloid fluids.\textsuperscript{46,47} In addition, acidosis and hypothermia alter the efficiency of the coagulation cascade, which is a series of enzyme reactions. A high index of suspicion must be maintained in patients at risk for bleeding disorders and fresh frozen plasma should be administered before evidence of a clinical coagulopathy whenever possible. Close attention should be paid to accurate hemostasis and active measures should be taken to avoid acidosis and hypothermia.

**DAMAGE CONTROL**

In cases of severe trauma that require surgery to control life-threatening hemorrhage, current human recommendations are to keep the operative time to 90 minutes or less to avoid the trauma triad of death.\textsuperscript{51} The goal of damage control is to control major hemorrhage, control leakage from hollow organs, provide diversions for the bowel or urinary tract as needed, pack the abdomen, and recover the patient as soon as possible.\textsuperscript{45,52} Deviating from these principles has been shown to worsen mortality.\textsuperscript{53} Packing of the abdomen is performed using towels, which provide direct pressure to oozing wounds. Once packing is complete, the abdomen may not be able to be closed primarily without causing excessive intra-abdominal pressure. This increase in intra-abdominal pressure can lead to abdominal compartment syndrome, which may lead to decreased organ perfusion and secondary renal and gut failure.\textsuperscript{47} To avoid excessive pressure during closure of the linea alba, a vacuum-assisted dressing should be placed.\textsuperscript{54} Alternatively, a sterile sheet of plastic (eg, large IV fluid bag cut open into a sheet) may need to be sutured to the edges of the linea alba. Both provide a waterproof dressing, which helps to prevent heat loss and protein loss, while simultaneously minimizing the likelihood that abdominal compartment syndrome will develop. The patient is rewarmed, the acidosis is treated, and coagulation is normalized. Once the patient is more stable, the abdomen is reexplored (usually within 24 hours), and more definitive surgery is performed as indicated.\textsuperscript{46,47}

**WOUNDS**

Trauma-induced wounds are a common presenting complaint in emergency patients. Initial wound handling can significantly affect the long-term outcome. Secondary
problems with wound healing and patient morbidity often relate to inappropriate wound handling during the initial stages. Generally, tissues heal the fastest when there is good blood supply, no tension, and no movement. Problems with sepsis secondary to wounds come from inadequate debridement of necrotic tissue, insufficient irrigation, inappropriate choice of antibiotics, and inadequate resuscitation. Attention should always be paid to ensure the patient is receiving appropriate systemic treatment and proper nutrition during the healing process.

Gloves should be worn during initial wound handling and the wound should be protected immediately from desiccation and contamination. Initially, a sterile water-soluble gel followed by a sterile dressing or sterile saline-soaked gauze sponges should be placed on the wound.

The wound should be cleaned and irrigated and nonviable tissue should be debrided as soon as possible. Many wounds will require the use of general anesthesia; however, superficial wounds that do not require extensive debridement can be managed under sedation and local anesthesia.

Animals may present with fairly extensive wounds that can be severely contaminated with ground-in road dirt. These wounds require extensive irrigation using sterile isotonic fluids delivered under pressure. Although the exact volume of irrigation is unknown, 50 to 100 mL per centimeter of laceration has been suggested. The ideal pressure generated by the irrigator is unknown, but a pressure of 8 to 12 psi will reduce infection without causing damage to the tissues. This can be performed using an 18-gauge needle and a 35-mL syringe, which typically generates 11 to 13 psi, or by using mechanical lavage systems. Irrigation should not be done blindly as this may force infection or foreign material farther into the wound and potentially into healthy tissues. Tap water can be used for irrigation of extremely large wounds. Although it is not ideal, it has not be associated with a worse outcome in humans when compared with the use of saline.

The goal of surgical management of wounds should be to explore and remove any foreign material, control hemorrhage, and remove necrotic tissue. Tissue viability is assessed by evaluating the blood flow: edges should bleed and the color should be pink, and the tissue should be warm. Muscle should contract when incised. Floating fat is nonviable and should be removed. Bone fragments with no periosteum or muscle attachment are likely nonviable and should be removed or used for a cortical bone graft, if needed.

The debridement technique varies depending on the tissue. Gentle tissue handling is very important because traumatic tissue handling can lead to vascular compromise, direct tissue damage, poor healing, and increased likelihood of infection. Skin should be cut back to clean, bleeding (ideally) edges using sharp dissection with a scalpel blade. Staged debridement may be required if there is limited skin present. Fat and fascia should be liberally excised to clean, healthy tissue. Mayo scissors are used for cutting heavy tissue, such as fascia. Metzenbaum scissors are finer and used for cutting thin tissue. Muscle should be debrided if it does not bleed or contract in response to being incised. Tendons should be removed if there is no peritenon or if it is contaminated; however, if it is vital to the area, it should be saved, and anastomosed if possible. Embedded debris should be removed from exposed bone using the edge of a scalpel blade. Manipulation of bone fragments should be minimized so as to avoid disrupting blood supply from the periosteum and surrounding soft tissues.

Drains are often used in the management of wounds. Indications include a need for dead space obliteration, elimination of fluid accumulation, and prevention of air or fluid accumulation. Drains are classified as either active or passive. An active drain (eg, Jackson Pratt) has a suction system attached, whereas a passive drain
(eg, penrose) does not. Active drains are preferred over passive drains because they decrease the likelihood of infection, keep the skin dry, provide continuous drainage, and allow the effluent to be monitored.

Closing a wound inappropriately will lead to complications. Wounds that should not be closed include nondissecting puncture wounds, wounds that could not be debrided or irrigated adequately, wounds that are more than 6 hours old and could not be converted to fresh wounds, and infected wounds. Wounds that are closed under significant tension will likely dehisce, and these wounds also should not be closed.

Extensive degloving injuries and large open wounds may benefit from the use of vacuum-assisted closure, which places the wound under negative pressure, thus promoting removal of fluid, improving circulation, and encouraging the development of granulation tissue.54 This technique should be used with caution in wounds that have not been adequately debrided because premature placement may lead to complications, including infection and delayed healing.54 Wounds should be bandaged in such a way as to promote healing. A sterile dressing should be placed over every incision until a fibrin seal has formed (minimum 24 hours) to prevent contamination of the wound from external sources.58,59

POSTOPERATIVE CARE

Following major surgery, patients will require close monitoring and treatment with fluid therapy, analgesics, and antibiotics. Pain should be managed aggressively. Analgesics should be given on a scheduled basis, and the analgesic plan reassessed as needed, because every patient’s injury and tolerance to pain is different. Good intraoperative pain control will help with postoperative pain control. Constant rate infusions are very effective at keeping patients comfortable and pain-free. Supplemental oxygen and/or ventilatory support may also be required. More critical patients and those that have had an intestinal resection and anastomosis performed may benefit from being provided with supplemental oxygen for at least 2 hours postoperatively, as this has been shown to improve tissue healing and reduce the risk of infection.60 Urinary catheters should be placed in patients with difficulties with either ambulation or urination. Other treatment, such as chest tube aspiration and care, care of suction drains, and bandage changes will vary depending on the type of injury and the surgery performed. Monitoring will be dictated by the underlying trauma and status of the patient; however, a minimum of temperature, heart rate, respiratory rate and effort, and blood pressure should be assessed hourly until the patient is normothermic and stable. Critical patients will usually require blood work postoperatively; the tests will vary with the patient, but typically include PCV/TS/BG, albumin, electrolyte, blood gas, CBC and coagulation profile monitoring. In hemodynamically stable patients, an attempt should be made to start enteral nutritional support as soon as 6 to 12 hours postoperatively, and certainly within 24 to 48 hours.61–64

SUMMARY

Every hospital, whether a general practice, referral hospital, or emergency clinic, admits emergency patients. Some have minor illnesses and injuries, and some are extremely critical. Some of these patients will require surgery within a matter of minutes to hours of arrival. Ensuring the hospital is always prepared to deal with these patients, if and when they arrive, is paramount to ensuring a successful outcome. This preparation includes ensuring the hospital is appropriately equipped, and ensuring the veterinary team has the necessary knowledge and skills. Constant evaluation and assessment of patients and attention to detail is also essential to ensuring a positive
outcome. Records of patients that experience morbidity or those that die or are euthanized should be regularly reviewed to assess team performance and to make improvements where necessary.

REFERENCES


