Damage Control Surgery

Dennis T. (Tim) Crowe, Jr., DVM, DACVS - Emeritus, Charter DACVECC, FCCM,

Mobile Veterinary Surgery of Georgia, Bogart, GA

Veterinary Surgery, Emergency and Critical Care Services and Consulting, Bogart, GA

Trauma, Acute Care Surgery and Critical Care Services,

VCA Regional Institute for Veterinary Emergencies and Referrals, Chattanooga, TN

Definition and Goals

Damage control surgery contrary to the definition used in human surgical centers at principally only involves abdominal surgery and packing to control major hemorrhage, in the veterinary trauma surgeon's play book, damage control surgery refers to surgery that must be done in a resuscitative fashion to gain vascular access, control of patients airway, maintain a patent airway, stop major air leaks from the trachea, bronchial tree or lung (thus preventing further decompensation), stop major hemorrhage from anywhere in the body but particularly from the thorax, abdomen, retroperitoneal space, head and neck, groin, and major trunk and extremity vessels, to prevent further contamination (by re-establishing luminal conduits in the GI and GU tracts in veterinary medicine (a difference that is present in human medicine by some) and to prevent further injury to important structures (which may include the brain and spinal cord in my opinion). *With this being said it is important to remember that with all of these goals, time is the enemy and the more time that passes from injury to definitive care the more loss of blood and the more loss of tissue oxygenation … leading to possible irreversible changes that can lead to major complications or death*

Philosophy and Introductory notes for the surgery being done for damage control

There is nothing magical about the OR BUT I do recommend when possible that the OR is the best place to perform damage control surgery. The OR should be set up and ready and the best time toi do this is right after the last surgery is completed. Suction, electro-cautery, anesthetic machine, anesthetic volume controlled pressure limited ventilator, emergency drugs, surgical lights,

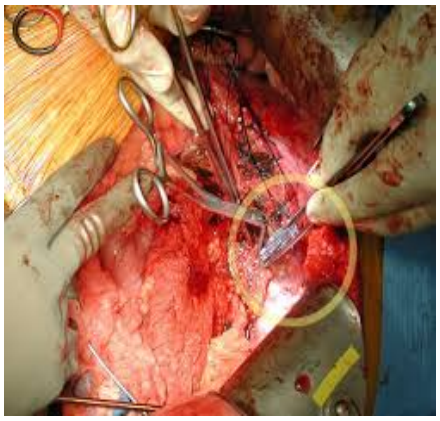
adjustable surgery table, back table and instrument table are the unusual items needed (as will all major surgery). Also a crash cart with all resuscitative medications (epinephrine, atropine, calcium gluconate, 50% dextrose that is diluted to 25%, intravenous fluids and homologous blood (stored or the ability to get it fresh) are included in this facilities supply needs list.

Also recommended is a **trauma pack** that can be easily accessed that has the instrumentation that is needed and there must be suction and a instrument stand. Although these can be used in the treatment area and should be portable so that the damage control surgery can be done outside the OR the best place to take the patient is in the OR ☺

TRAUMA PACK bare minimum = Mayo scissors (curved), 4 curved mosquitos, 4 curved Kellys, Debakey thumbs, curved Metzenbaums, long and short needle holders, Balfours (small and big), Poole suction tip and suction tubing, 5 and 8 Fr red rubber feeding tubes that can act as a "Satinsky – Debakey atraumatic forceps and an atraumatic occluder for wrapping around and constricting bleeding and air leaking lung lobes or segments or pedicels that used to be the base of something, with a curved hemostat to snug the tube up and hold it snug (like a saddle) around the leaking / bleeding structure, 10 4x4 gauze sponges, 5 lap pads and at least 2 packs of surgical towels or simple hand towels that can be used to pack the natural body cavities (hemothorax, abdomen, retroperitoneal, inguinal, axillary and to some extent the cervical region.

Important instrumentation recommended for damage control surgery is a a Balfour or Finochietto retractor which are inserted to maintain visualization of the injured structures. Although the Balfour is listed as an abdominal retractor it also can serve as a thoracic or sternal opening retractor in the dog and cat. Generally two sizes are needed to provide the instrumentation needed. Three other special surgical instruments that are very useful in these types of injuries are: DeBakey atraumatic thumb forceps, right angle forceps and Satinsky – Debakey forceps or a similar curved or angled vascular forceps that can clam, hold and stop leaks but not hurt or crush the tissues; perfect when visibility is poor due to hemorrhage and when in deep holes. A Sarot needle holder, and a headlight is must for much of damage control surgery as well as pair of magnifying 2.5 to 3 power loups are also recommended.

Loups and head light on and team of 3-4



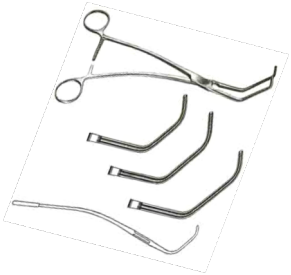
Use of curved atraumatic and thumb forceps

A Rummel homemade tourniquet used to loop around a vascular structure or pedicle made by using a section of feeding tube encircling the structure and then a curved hemostat is used to tighten the loop. Umbilical tape can also be used where it is used to loop around the vascular structure or pedicle and then brought through a larger and more rigid tube such as a sterile 3-5 mm endotracheal tube (ET) tube using a section of monofilament or orthopedic wire to guide it through the lumen and pulled out the other end and the ends of the umbilical tape ends are tagged with a hemostat. Then when ready to provide occlusion of the structure encircled the umbilical tape is drawn tight and to keep it snug the hemostat grasps both ends of the tape and goes across the top of the ET tube so that the tape cannot loosen.

balfour 'abdominal' retractor

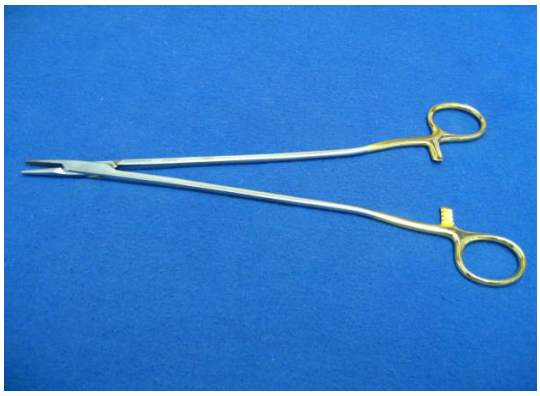
Finochietto retractor

Debakey forceps



Satinsky – Debakey atraumatic forceps - get a small size example 9.5 inches

Right Angle Forceps



Sarot Cardiovascular Needle Holder

Compression and Prepping

If a bleeding area is suspected compression is applied and prepping is done while the compression is continued to be applied. Clipping is done just enough to clear the hair to see where we are going. In long-haired animals this may be frustrating to keep the compression applied while clipping the hair. In short-haired dogs and cats the clip may be skipped entirely if the patient is crashing. In some situations I made the approach to a chest while someone else was making vascular access in the left jugular vein or left cephalic vein by cut down and feeding tube or catheter placement. In those that are completely collapsed and taking gasps the surgery is performed without any clipping or pepping and survivors without infections as complications have occurred. These have been previously published. Two examples of these a provided at the conclusion of this paper.

Trauma Team

Preferably at least two other individuals will be able to help as a team; with one scrubbed in and one acting as a circulator to grab things are needed. The anesthesia team ideally would be two people as well. One primarily being the monitor and the other being a gopher that grabs things needed for the anesthesia team. This team is in charge of providing the volume replacement necessary and helping with your infusion of the autotransfuse blood. In my opinion this is one of the most important parts of the resuscitation other than finding all the areas of hemorrhage been controlling them

Vascular Access

In small patients the cephalic vein approach is a waist of time if the facilitative maneuver is not done. This is done by making a gut over the vein until it can be seen and elevated with a small

curved mosquito hemostat and then with the vein pulled back toward the operator (distally) the catheter is inserted (18 g in most cats and small dogs, 16 in medium size and 14 g in large dogs) . Most bleeding to death cases also can use a jugular vein cut down and18-8 g IV catheters inserted (preferably those that are long enough to reach the cranial vena cava more accurately measure central venous pressure and do not become dislodged easily, but are not so long that causes a lot of dangling and added line resistance. Mila makes a catheter that can be cut to the length needed of various g sizes. There may be other companies as well.

If not already done put your Headlight and loups on and get to work as venous access is vital and the better the vein is seen the better the chance for first time – large bore access☺ The goal should be at least two IV assess sites obtained and ideally one of those being one that accesses the central circulation. Intraosseous cannuals can also be used and counted as one of the two access sites however these need attached to a bag of fluids that are on a pressure bag and pressurized to 200 to 300 mmHg. This allows for good flows to be possible. (See more on vascular access later)

Vascular access is so very vital that these techniques MUST be mastered and the best way to master them is to practice on fairly fresh cadavers. These include animals that have been euthanized (with special permission from the owner to perform them), attendance that s continue education conferences where these are taught, and on selective elective patients in which it's important to have large bore vascular access such as in liver and kidney tumor resection cases. If vascular access cannot be performed percutaneously with the placement of two 18-14 g catheters depending on the patient's size, with the goal being able to have sufficient enough sizes of catheters to allow for rapid volume replacement (defined as the ability to infuse 90 ml per kilogram of fluids or blood within 15 minute) then a vascular cut down or mini- cut down should be done and the catheters placed with even the substitution of feeding tubes used in place of the catheters in some cases. These techniques have been described in articles and text books (Crowe, D.T.: Performing life-saving cardiovascular surgery. Vet Med 84:77-96, 1989 (January); Crowe D.T.: Intravenous facilitative maneuver; and Central vein access in shock in Emergency & Critical Care Manual 2nd ed, Karol Mathews (ed) Lifelearn Guelph Ontario Canada 2006) briefly summarized are the two main procedures are done :

Mini cut down - An incision is made with the 18 gauge needle in a 60° angle across the path of where the cephalic vein your other superficial vein is located. The curved mosquito hemostat Is used to dissect out the vein. The tip of the hemostat then is slipped underneath the vein and

the vein is pulled in a distal direction, toward the operator. A large bore IV catheter is then slipped into the vein as the vein is as tension is maintained on the vein by the pull of the hemostat in a distill direction. The catheters in the directly attached to IV tubing and everything secured in place with tape once the flow of fluids and vein is documented to be running well. Some operators may use skins staples to staple the opening in the skin closed. Note: the use of smaller T ports may slow the fluid flow rate down; so particularly large dogs only large bore T ports should be used or none at all.

Central vein cut down – The external jugular vein is most appropriate to be used for this technique. And incision is made in the jugular furrow and a hemostat used to dissect the vein away from other tissues. A DeBakey thumb forceps can also be used to gasp the vein and allow for rapid dissection of the vein and the curved mosquito or Kelly hemostat is guided underneath a vein to hold it in position. Two sutures are used to encircle vein and hemstats are used to tag them. They should be approximately 3-5 inches apart from each other. The most proximal (rostral) suture is tightened to prevent blood from entering the vein between the encirculing sutures. An No 11 blade is used to pierce the center of the vein and then it is twisted and brought through the outer half of the vein wall, thus making a venotomy large enough to accept a feeding tube. The feeding tube, previously prepared by inserting a stopcock on its flanged end and filling the catheter with saline and then closing the stopcock to form a saline lock. The feeding tube is then premeasured to ensure its tip will be within the thoracic inlet but not so deep that it enters the heart (if possible). Use of the tip of a curved most mosquito hemostat or a commercially available plastic vascular Introducer that looks like a small angled wedge may be helpful in introducting the feeding tube into the vein. The tip of a DeBakey thumb forceps or other fine tipped thumb forceps can also be used to elevate and partially open the venotomy to allow the tip of the feeding tube to be inserted into the vein and advanced. The more proximal encircling suture is opened to allow the catheter to be advanced. The encircling suture is slipped more snug once the catheter as been advanced to prevent retrograde hemorrhage and the chance of air to enter the vein as rare air emboli have occurred with any of these techniqes in which a relatively large central vein is opened when the patient is in shock. The stopcock is then attached to the IV administration line and flow begun. The flow should run unimpeded. If the flow is slow or not present the feeding tube is manipulated until a good flow is verified. The is most often done with an IV bag attached to the administration sent *without* the use of an IV pump being applied. Gravity is then used to provide the force initially needed to check line patency. The fluid bag may also be lowered to see the blood flash back into the line. This

demonstrates the patency of the system. The fluid bag is then raised and placed back on the IV pole and the fluids delivered as required while the catheter is secured. This is done by tightening and tying the distal (rostral) most suture around the vein and bringing the suture around the feeding tube and tying slightly loose so that the feeding tube can be removed later with a gentle pull without opening the entire incision. The proximal suture is then also tied as this encircles both the vein and the catheter inside the vein. It too should not be tied so very tight that the feeding tube cannot be later gently pulled out without opening up the entire incision.

The inserted feeding tube is then anchored to the Wing of the Atlas by the use of a suture that penetrates into the periosteum, then exits and is then wrapped around several times to produce a frictional knot, similar to a Chinese Finger Trap like knot. The skin incision is then closed with staples. Large for feeding tube in this position allows for very BC monitoring of the central venous pressure. This can be done by simply just lowering the bag and watching where the flow of the fluid stops. When the drip in the drip chamber “hangs” and does not continue this corresponds to CVP (measuring from the drip chamber fluid level to the manubrium).

The most common size red rubber or polyurethane feeding tube used for central vein excess for most medium to large size dogs is an 8 Fr . For small clip for small dogs and cats a 3 ½ to 5 Fr tube is used. With a smaller size tubes it is recommended that surgical loops be used to help excess the small diameter of the vein, this is especially true when animals under 3 kg in weight. Once the feeding tube is no longer needed coagulation should be checked to make sure that hemorrhage is not going to be a problem because of the tube is pulled it does leave a fairly large hole in the jugular vein. As the tube is pulled continuous pressure is applied to the site for at lest 10 minutes. In the more then 100 tubes that I have placed this way and removed none have required opening the incision to stop hemorrhage coming from the venotomy.

Experience with these techniques have demonstrated that the technique is safe and the tubes can be left in for at least several days provided that sterile conditions were maintained as they were placed and that careful central line care is performed daily until the tube is removed. Some hospitals substitute a t-port or catheter plug for the stopcock as the later can be a source for infection and they do require more due diligence in their use. However in the very early stages of the resuscitative surgery the use of the stopcock has facilitated the delivery of autotransfused blood and emergency medications and the placement of a sterile water

manometer to measure CVP. In an unpublished series of 20 dogs in which red rubber central vein feeding tubes were used in critically ill dogs with Parvovirus enteritis the tubes outperformed the use of commercial central catheters placed percutaneously and there was less infection, catheter occlusion, kinking and dislodgement. In two dogs that succumbed to the disease and had a necropsy performed (one with a percutaneous catheter and one with a feeding tube) there was more vasculitis seen inside the jugular vein containing the percutaneous placed polyethylene catheter, compared to the surgically placed red rubber feeding tube. (Crowe DT, Anderson J, 1989).

(Note: I have learned how to do these techniques on human, non-preserved human cadavers as well in critical care skills laboratories offered by the Society of Critical Care Medicine and am confident that if veterinarians needed to assist in the care of seriously injured and ill humans in a overwhelming mass casualty incident that these cut-down procedures you might do could save many lives)

Airway axis and maintenance

Cervical Tracheal Access - Airway access and maintenance is comparable to vascular access in terms of its need in the emergent decompensated trauma patient. The same applies to all emergency patients do you compensating from other causes. In trauma airways may be perforated, obstructed or literally torn apart. Airway access cannot be gained and maintained by the conventional means damage control resuscitative surgery will be indicated. For most cervical injuries access may require an emergent tracheal approach and whatever procedure is required to accomplish the airway access and maintenance goal. This commonly involves the performance of a surgical tracheotomy. This author applies a transverse incision across ventral aspect of the trachea, replacement of two traction sutures one proximal and one distal to the incision in the placement of endotracheal tube, the cuff inflated and then the tube secures with IV plastic tubing ties. The same or similar tube can be later fashioned to make a tracheotomy tube from it by cutting down the center of the tube on each side, preserving the cuff inflation line and then re-inserting the ET tube connector and using the split ends as butterfly ties to secure the tube with IV plastic ties,

Thoracic Tracheal and Bronchial Access - Damage control also includes stopping major air leaks involving the thoracic trachea and bronchial tree and extends onto the lung. Very significant decompensation can occur if a good amount of the inhaled air does not arrive into

lung segments that are functional. The term used could be traum associated bronchopleural "fistula" to designate a "fistulous like loss" of the air away from the pulmonary circuit. Correction of this necessitates a rapid approach to the leaking area, assessing the best way to arrest the leak and provide the resumption of airflow to functional lung segments. This is usually done by an emergency lateral thoracotomy but sometimes its also done via a parasternotomy.

Damage control resuscitative lateral thoracotomy is indicated when cardiovascular collapse and death from major body cavity hemorrhage is eminent as in these cases the ONLY chance these patients have (which is still "slim") is to do a left lateral thoracotomy and cross clamp the aorta with a feeding tube placed around the proximal descending thoracic aorta. This approach also allows access for the left thoracic lung lobes, bronchus and trachea that could require access for the stoppage of major air and blood "leaks" that could sneak up on the trauma team. Thoracic radiographs and previous thoracentesis indicating these leaks as well as thoracic ultrasound findings may provide significant clues. IF the diagnosis of a pneumothorax was previously made where there is more air seen on the left side and suddenly the dog "crashes" there will be NO TIME to try and decompress the tension pneumothorax with a needle, catheter or chest tube (unless previously placed as a large bore chest tube and the stopcock is in place… then of course this is different BUT these situations are fairly rare. Most of the time I have witnessed the following: a trauma patient arrives with a history that he was hit by a car 30-60 minutes ago and he seemed to be OK for a while but then on the way to the hospital he started having difficulty in getting his breath. He arrives in extremis and while to give him some blow-by oxygen and start and IV he collapses and… there are no or very weak pulses… DO NOT GIVE UP ON THESE.

Immediately perform a left sided resuscitative thoracotomy. They either have a major air-leak and tension pneumothorax or a major bleed or both. The ones I have seen make a full recovery leave the hospital wagging their tail in a few days are the former where a lung lobe required resection; those with major hemorrhage on the other hand few, but some do make it. They need aortic cross clamping and autotransfusion and abdominal and occasional thoracic packing. But the faster the cross clamp (done with the feeding tube and the quicker the packs are applied as the vascular access with a large bore feeding tube, followed by autotransfusion that is RAPID the better their chances. IN ALL OF THESE THE ROUTINE ER TIME MUST BE MINIMIZED IF THEY HAVE ANY CHANCE TO SURVIVE.

Although the best place for these pets is in the OR it is very often that the crashing happens in the

ER –Triage area and then this is where the surgery might be done. An airway is achieved with a laryngoscope (a necessity in some and best in all because the head should be kept as low as possible and in some the patient is intubated in RT laterall recumbency or in dorsal recumbency. That way the head can remain down which helps maintain cerebral and overall brain and brain stem blood flow and vomitus and secretions already silently accumulating in the pharynx will not be found coursing down into the airway…. Later leading to "aspitation pneumonia" The ET is best secured with IV tubing that sticks as a loop around the tube and then the tubing is brought under the jaw, crossed and then brought behind the head and tied. This is the most secure means of anchoring ET tubes that I have found. The cuff should be lubed previously with water soluble Jelly as research has shown that the use of the soluble jelly helps also prevent silent aspiration of oral secretions. A portable anesthetic ventilator is ideal in these patients otherwise someone will have to continue doing positive pressure ventilation throughout the case

Thoracic Access, Aortic Occlusion, and Air Leak and Hemorrhage Control

Resuscitative thoracotomy – In crashing cases I do not take time to place surgical towels or drapes. Most of the time its done in the OR but might not get done in the prep room or treatment table (not really sure this much sense other than it seems like those that crash outside the OR are those that have gone into a deeper "south" than those that made it to the OR.

The approach is made through a left fifth or sixth intercostal space incision. Commonly a knife is used to make the incision. Following the incision a curved Mayo scissors is used to puncture the thoracic cavity and then using the caudal most rib as a guide, the blades of the scissors are partially opened and the instrument used in the sliding fashion with the tips curving cranially to open up the intercostal space.

Placement of the Balfour or Finochietto retractors is then performed and a fast inspection is performed. In cases were there has been an extreme amount of blood loss or hypotension the aorta is then isolated by moving the lungs in a caudal and ventral direction and a curved hemostat placed under the aorta and the tips exiting on the dorsal side. A feeding tube then grasped with the tips of the hemostat and pulled around the aorta. The tube end is then pulled up and the same hemostat used to "slide down the two ends of the feeding tube and the loop created is tightened by sliding the hemostat down on the loop and tightening the loop. With the loop encircled and tightened the aorta "occlusion time" is noted with the goal of having this time be a short as possible as research has shown that anything after 15 minutes can be threatening to the spinal cord. Occlusion of the aorta

increases coronary and cerebral perfusion pressure and increases the likelihood of preventing further brain and heart dysoxia and hopefully will buy time to allow find the sources of the hemorrhage, stop them and provide rapid refilling the volume of blood that has been lost.

Suctioning of free blood from the thoracic cavity is then performed and inspection for the sources of hemorrhage is done. If necessary the suction tip remains in the cavity and the packing is done, quadrant-by-quadrant, to find the bleeding sources. Packs are placed, then slowly pulled out, as the inspection of the area is done. Sometimes irrigation is done in the same region to look for “red roads of streaming”. The areas of obvious trauma are packed off and inspected first.

Definitive hemorrhage control is performed as rapidly as possible using the tips of hemostats, vascular clips, and, if necessary stick-ties of swaged on polypropylene on taper-point needles with the size depending on the source and size of the hemorrhaging areas involved. In most cases the size is from 3-0 to 5-0 and the needle size being from an SH to a BV (cardiovascular curved taper) Sometimes the areas of hemorrhage cannot be definitively found until the patients arterial and venous pressures are increased through rapid volume replacement. In this cases packs are replaced and then periodically removed to reassess. In these cases it is very important to consider hemorrhage that may also be outside the thoracic cavity. So as volume replacement is ongoing and pressures are increasing the team should consider where these other areas could be and do further inspection (head and neck, axillary and major pectoral limb regions, abdomen including the retroperitoneal space [the most common], inguinal and major pelvic limb regions. This survey is done quickly looking for expanding hematomas, muscle separations and skin penetrations and blood oozing from holes. If these are found pressure is applied and the area addressed, urgency depending on the amount of blood involved. In most cases the abdominal cavity is the main source area and first addressed.

The diaphragm should be inspected and if it appears distended toward the thoracic cavity either a small incision is made and free blood searched for or an ultrasound (US) probe is applied to the flank and free fluid inspected for. If there is free fluid noted a Poole suction tip can also be inserted into the peritoneal cavity through a small hole placed into the diaphragm and suction applied; If a considerable amount of blood is found then this blood is aspirated and autotransfusion begun and the abdomen opened via an lateral incision caudal to the diaphragm and the abdomen packed with appropriate sized materials. These might include surgical towels, lap packs or surgical sponges (opened and counted as they are placed) depending on the size of the patient. Another material

that can be used (author's invention) is the use of *small bubble wrap* ☺ . This material can be cut into various sizes, with strips 3" x 12" commonly used. These are packed into the abdomen and because this is compressible and does not soak up blood, more blood can be harvested for autotransfusion ☺. Following compression and assuring that major hemorrhage in the chest is controlled the next area of most hemorrhage is addressed. If it is the abdomen, in the vast majority of cases this is best done via a midline ventral abdominal approach and most packs are laid into the open chest and flank and the patient rotated into dorsal recumbency and this approach completed. The aortic occlusion feeding tube may still be left in place until the abdominal exposure is completed if necessary (very poor blood flow continues). A rapid inspection of the cranial, then right and then left gutter is done utilizing the mesodudenum and mesocolon to "wall off" the bowel from these gutters. Areas where hemorrhage is found are packed off and a priority made for these areas based on the amount of bleeding noted and the proximity or involvement of major vascular structures (such as hepatic, renal, mesenteric, peri-aortic, peri-caval, iliac). These are more definitively controlled with direct vascular pressure as needed and clamps applied as needed with care not cause further injury to these areas.

As soon as control is established the aortic clamp is slowly released and Doppler blood flow continuously monitored as the occlusion is relaxed. It is common that the occlusion may have to be temporarily re-established for one of two reasons: 1. Flow sounds fade indicating a BP pressure drop and the need for further rapid volume replacement (another bolus of collected blood, Plasma-lyte, or freshly obtained whole blood or last options of stored RBCs and FFP (fresh frozen plasma that has been thawed and warmed) with all of these being pre-warmed if at all possible before rapid infusion; 2. Further bleeding as been identified that could be slowed by blood flow diversion to the core (brain, heart, lungs and cord cranial to T7* as the sympathetic neuro tracts are most active above this area as a sympathetic blockade must be avoided).

Parasternotomy – Combined Often With a Ventral Abdominal Approach – For cranial thoracic penetrating trauma this has been life-saving on multiple occasions. On all trauma patients that have multiple areas of injury based on physical examination, ultrasound of both the thorax and abdomen, history of penetration of both the thorax and abdomen, this approach is often the best. It's advisable that prepping be done from the ventral cervical neck region through the inguinal areas when patients like this are addressed. Incision is made from the thoracic inlet region through to the midsection of the abdomen initially with a scalpel and this is followed with an opening made just caudal to the xyphoid with the blade. A Mayo is utilized to extend the cranial incision in the

abdomen to paraxiphoid and then on to a parasternal one, moving forward with either the use of the scissors or the blade to bisect the junction between the rib and the sternum at the costosternal junction. The internal thoracic artery and vein may get injured as the approach continues cranially and may require stick-ties to be placed if the bleeding is brisk. Often the use of surgical electrocoagulation is enough to provide the hemostasis need as the intercostal vessels are severed as the approach continues. A Balfour or Finochietto retractor is then placed, with the blades anchored with a towel clamp on each side and immediately the thoracic cavity is explored, areas of hemorrhage packed off and if necessary the caudal thoracic aorta can be isolated and looped and occluded, as discussed prior.

Abdominal Exposure with the Parasternotomy - Some abdominal exposure is required to open the approach into the thoracic cavity as wide as needed to perform the expiration. The diaphragm must be divided or split to allow for this expansion to occur. Hemorrhage is looked for in the abdomen as well and the abdomen packed if this is found. Abdominal injuries will be addressed the abdominal section (next). The mediastinum can be opened and the cava and midline structures examined.

Thoracic Cava and Hepatic Vein Injury - If there is hemorrhage from the thoracic vena cava it is often associated with injury to the hepatic veins as well if blunt trauma was the inciting cause of the injury. These patients might be presented still alive because of clot as it's a low pressure venous system, or because of a diaphragmatic rupture and either liver, bowel, or stomach herniating through the area tamponade the hemorrhage. As the approach I made the clot becomes disrupted or the herniated structures move the hemorrhage begins again. This hemorrhage can become catastrophic.

Injury to these vessels must be addressed immediately for two reasons: 1. Air can enter into the venous system and with the patient in shock and in dorsal recumbency the air embolus causes an air-block in the right ventricle leading to acute cardiac arrest; 2. The hemorrhage is massive and often difficult to control and the cava can not be clamped off as a sudden loss of blood flow back into the right atrium can cause immediate pump failure and secondary arrest.

The following steps are recommended if this type of injury is discovered: 1. Packing is immediately performed and while a finger is placed at the hole to cause some of it's opening to be occluded; 2. The hole is addresses with placement of a suture of polypropylene into each side and lifted

ventrally.
3. A Satinsky – DeBakey forceps is then applied at the base of the hole as it is lifted ventrally and the clamp closed to cause occlusion of the hole and stopping the hemorrhage, yet allowing some blood to flow through the cava and into the right atrium. Additional polypropylene sutures are used to close the hole, often is a continuous pattern and doubled back to ensure a tight leak proof closure.

4. In these cases, if necessary, a section of large diameter feeding tube or even the use of an ET tube or chest tube can be placed through the right atrium after a side hole is placed so it will be just inside the atrium to allow blood to flow back into the atrium once the tube is in placed across the injured area via the atriotomy. The atriotomy should have a purse-string suture in it to prevent the blood returning to the heart from leaking out. A clamp is placed on the end of the conduit tube after allowing it to fill with the patient's blood. The tip of the conduit tube is slid past the site of injury and smaller sized feeding tubes, tape ends of lap pads or umbilical tape encircled around the cava (one proximal to the injury area and one distal to it) are then drawn snug and the bleeding through the cava and hepatic veins will be greatly diminished. After the caval – hepatic vein injury is closed the encircling tape of feeding tubes are loosened and the site checked for hemorrhage. Additional sutures are added as needed to stop the hemorrhage and after assurance that no further bleeding is present the feeding tube intra-caval conduit is removed and the atrial opening sutured closed. NOTE: This large feeding tube conduit can also be used to deliver blood and fluids into the central circulation if needed.

Lung Lobectomy Procedure in Damage Control Surgery – Under damage control conditions when there is significant injury to a lung lobe (either penetration or crush) the lobe is removed. This is rapidly accomplished by applying 2-3 curved hemostats across the entire lung lobe pedicle distal enough to prevent compromise to the bronchus, and pulmonary vessels (artery and vein) when tied. The lung section end is then cut away (make sure two clamps are on the pedicle) when thus is done. An encircling suture of 2-0 to 0 polypropylene is done twice around the pedicle and then the end passed underneath both loops of the suture. This Miller's knot is then slowly tightened as the lower pedicle clamp is opened (flashed) and then closed back again. The ends of the ligature are then brought around the again from each side and tied again. This if for insurance ☺. The hemostats are then released and the pedicle tagged and observation for leaks is then done. Saline irrigation is used to detect any bubbles indicating an air leak when the airway pressure is increased to 35 cm H2O. Added sutures on the pedicle end are used if this or bleeding is seen from the area.

NOTE: This Damage Control Lung Lobectomy procedure as been done by the author greater tan 40 times with out any leak complications or long term AV Fistula occurrences known and is much more rapid technique that the conventional lobectomy described in surgical text books where the bronchus, artery and vein are dealt with separately.

Thoracic Approach Closures – All thoracic closures are done after the placement of the chest tube in routine fashion. Polypropylene is preferred for continues closure of thoracotomy and the parasternotomy. In most lateral thoracotomy cases the suture goes around the ribs from dorsal to ventral as a continuous pattern and then coursed back to the beginning thus having a crisscross pattern when completed and the one knot is tied well (6 throws ☺). The soft tissues are then closed routinely with continuous suture and the skin stapled. The parasternotomy closure is done either with preplaced polypropylene, single or cruciate pattern, with the suture needle coming close to the periosteum of the rib on the cranial side near is end and then around the sternum and then brought back to include the periosteum of the rib on the caudal side. The ends of the suture are tagged with a hemostat. In most cases approximately 7-8 sutures are preplaced and then when all are done the sutures are brought tight with good apposition between the rib end and the sternum accomplished. In small dogs and cats he continues closure to be done Where the placement of the propylene is the same. All the sutures are replaced in a loose fashion and when done the entire closure is tightened. This continuous closure has been completed in dogs as karge as 35 kg in weight and No. 2 polypropylene on a large taper needed used without know complications. NOTE: As the sutures are pre-placed it is important to check to make sure that passage did not cause significant hemorrhage to occur as this might indicate that the suture caused injury to the internal thoracic artery and vein. If bleeding is seen (noted by using a 4x4 gauze to check the areas were the sutures penetrate into the tissues), small stick-tight sutures are general necessary to stop it. The pectoral muscles and other soft tissues and fascia are then closed in a continuous fashion and the subcutaneous tissue is closed with a continuous suture pattern and the skin stapled.

Abdominal Access and Hemorrhage and Contamination Control

In most of the human surgical literature when surgeons refer to damage control surgery they are referring to damage control for *abdominal* injuries (those causing major internal hemorrhage for the most part). Much of what is written in this section comes from trauma.org from a human surgical organization that I take part in. Suffice it to say damage control in the veterinary side is a little bit more complex and must also include not only abdominal hemorrhage that is difficult to control with

external counter-pressure but also that involving the cervical, thoracic, retroperitoneal and proximal appendage areas . Because of financial constraints often the pet owner can only afford one major surgery. *So rather than just packing off a bleeding liver lobe and exteriorizing a section of colon that is perforated these injuries must be addressed more definitively*. Examples of a few these cases are provided at the end of this presentation for illustration.

The reason for damage control is because of the metabolic issues associated with both penetrating and blunt trauma that may be difficult to overcome following surgery especially if the surgery is complex and takes a great deal of time. But one of the best sayings I've ever heard from a trauma surgeon is "It better to take longer to do the surgery that to risk a major postop complication". This has to be taken into consideration. The surgery has to be done as precisely as possible and with as little time as possible, to gain the best outcome.

As taken from Damage Control in Trauma.org "Damage control surgery is one of the major advances in surgical technique in the past 20 years. The principles of damage control have been slow to be accepted by surgeons around the world, as they contravene most standard surgical teaching practices - that the best operation for a patient is one, definitive procedure.
However it is now well recognized that ***multiple trauma patients are more likely to die from their intra-operative metabolic failure that from a failure to complete operative repairs.*** Patients with major exsanguinating injuries will not survive complex procedures such as formal hepatic resection or pancreaticoduodenectomy. The operating team must undergo a paradigm shift in their 'mindset' if the patient is to survive such devastating injuries. The central tenet of damage control surgery is that patients die from a triad of ***coagulopathy, hypothermia and metabolic acidosis***. Once this metabolic failure has become established it is extremely difficult to control hemorrhage and correct the derangements. If the patient is to survive the operation must be foreshortened so that they can be transferred to a critical care facility where they can be warmed and the hypothermia and acidosis is corrected. Once this is achieved the definitive surgical procedure can be carried out as necessary - the 'staged procedure'."

Unfortunately, in veterinary medicine, there is a significant cost to take patients back to the OR for a second time or third time following the trauma incident so the tents of damage control surgery that have been described above, have been "bent a bit" (this cowboy's lingo) in this veterinary applied application of trauma control surgery. There is a balance that must be achieved – where the patient will survive after stopping all hemorrhage and stopping further contamination, repairing all visceral

structure injuries so that the GI and GU tracts will regain function and allow for the patient to have a full recovery.

Preparation

Animals need to be transported quickly. If there is pre-hospital care it should be done in haste. When arriving at the ER to docs and techs should also do things very hastily to get the patient into the operating room in short order. All unnecessary and superfluous investigations that will not immediately affect patient management should be deferred. **Cyclic fluid resuscitation prior to surgery is futile and will worsen hypothermia and coagulopathy.** All fluids including colloid solutions will interfere with clot quality and decrease oxygen carrying and decrease the glycocalex and provide for more microvascular leaks. Therefore these MIPs (multiple injured patients) should be *transferred rapidly to the operating room without repeated attempts to restore circulating volume*. They require **operative control of hemorrhage and simultaneous vigorous resuscitation**, preferably with fresh blood that contains clotting factors, platelets, albumin and globulin that is not stored and the blood is warm.

Anesthesia should be induced either in the prep room IF much hair will need to be removed or in the operating room if the patient is very critical and where hair removal is not going to be much of an issue (short haired) and then prepping is done by just laying a layer of prep solution (povidone or chlorxyenol) sprayed or draped on where the solutions are soaked into the drape) on the neck, thorax, abdomen, and inguinal regions including the lateral thorax and abdominal regions. The shocked patient usually requires minimal anesthesia and a careful, hemodynamically-neutral induction method should be used. An arterial line is valuable for patient monitoring peroperatively but time must not be taken to place but rather a Doppler flow detector probe should be applied to the palmar arterial arch and taped in place or a Doppler probe attached to an esophageal stethoscope and this inserted into the esophagus to monitoir aortic blood flow. If further venous access is needed the draping should include the ventral neck so that a jugular vein cut down and insertion of a large bore feeding tube can be idone. This is needed for autotransfused blood, fresh frozen plasma, cryoprecipitate and if available. These should be administered rapidly once control of major vascular hemorrhage has been achieved. *All fluids should be warmed and as much of the patient covered and actively warmed as possible. NOTE: Rapid fluid administration must NOT be withheld if it is believed that cardiovascular collapse is eminent before the surgery can be started. This author also likes to give "turbostarch" in eminent collapse cases to buy time if needed. This is 6.5-7.5% hypertonic saline and 6% hetastarch given in the same syringe 50:50*

and given at a total volume of 5-10 ml/kg of this mixture. Despite what some literature suggests renal failure or concerns with coagulation have not been experienced in my veterinary patients as has been reported in human patients.

General Conduct and Philosophy

The patient should be rapidly prepped from neck to knees with large abdominal packs soaked in antiseptic skin preparation solution. The incision should be made from the xyphoid to the pubis. This incision may require extension into the right chest or as a parasternotomy depending on the injury found. Relief of intraperitoneal pressure with opening of the abdominal wall may result in dramatic hemorrhage and hypotension. Immediate control is necessary and this is initially achieved with four quadrant packing with multiple large abdominal packs. Each of the four quadrants of the abdomen are inspected. The packs are carefully removed one at a time as pinpoint irrigation (using an18 catheter attached to 20-35 ml syringe of saline) and suction is done to identify the sources of the bleeding. Clamps or stick-ties are applied as needed. As each bleeding source is identified it frequently again controlled by re-packing the area and the clamp and suture are readied.

In cases where significant abdominal distension is present and blood pressure is poor a lateral thoracotomy and aortic occlusion (cross clamping) with a feeding tube is recommended to be done first, before the abdomen is opened. This is especially indicated if near arrest is thought to be eminent.

Abdominal aortic pressure may be necessary if Doppler flow greatly diminishes and BP falls; This a can be done by having compression applied digitally on the aorta just cranial to the left adrenal glar as this area is easily accessible and can be maintained with finger pressure done by an assistant. T area is found by moving the intestines all to the right of the mesocolon and the colon lifted up and th left kidney is observed. Then the left adrenal gland is found. The aorta and celiac artery is found jus cranial to it and can be palpated. The aorta may be difficult to identify in the severely hypovolemic patient so it must be able to be found by locating the adrenal gland and used as a landmark as the aorta is just cranial and midline from it. It is recommended that this aortic compression maneuver be practiced in routine abdominal exploration cases so it can be completed quickly and accurately shou it be needed in hemorrhaging trauma cases when needed.

Proximal and distal control techniques are rarely useful in the acute stage but may be necessary as

described earlier when severe liver bleeding at the hilus is encountered or vascular injuries that must be repaired are found. This includes those of the portal vein, aorta and vena cava (cranial to the kidneys) Caudal to this ligation will generally be effective as there are good collateral venous loops that can take over the venous flow back to the central circulation. This also applies to the distal aorta as well so long as there is not a clot within the lumen of the artery.

Examination of the abdomen must be complete. All intraabdominal and most retroperitoneal hematomas require exploration and evacuation. Even a small perienteric or peripancreatic hematoma may mask a serious vascular or enteric injury so these need to be gently investigated to ensure that there is not a vessel injured that may rupture or start bleeding later when in recovery. There have been many a torn vessel found with a small clot on their end that are easily disrupted and resulting streams of blood then commencing

Exploration should proceed regardless of whether the hematoma is pulsatile, expanding or stable or due to blunt or penetrating trauma. Nonexpanding perirenal hematomas, retrohepatic hematomas or blunt pelvic hematomas do not be generally need to be explored (as long as blood pressure is above 80mmHg) and are generally able to be treated by abdominal packing. If there is any doubt the hematoma should be investigated.

Inspection and prevention of further contamination

Inspection and prevention of further contamination is achieved by rapid repair of all hollow viscus injuries found. Debridement and closure with continuous closure with 3-0 to 4-0 polypropylene or PDS is recommended for all structures including the stomach, small intestine, large intestine, urinary bladder and gall bladder. Resection and closure or anastomosis is needed for those structures that exhibit loss of blood supply and necrosis. In some a second surgery to check viability 24-48 hours later is recommended. Irrigation is thorough and done with warm saline. Inspection to insure no sponges, laparotomy pads, etc. are left behind. Rarely these are intentionally left behind to control hemorrhage that was difficult to control. Theses obligate a repeat exploration in 24-48 hours.

Abdominal closure

Abdominal closure is rapid. It is done with 2-0 to 2 polypropylene in the abdominal fascia and after saline irrigation the skin stapled. If it is known that a second surgery will be needed in 24-48 hours possible, then skin only is closed with a rapid continuous suture or even multiple towel

clips. Although abdominal compartment syndrome (ACS) can occur in some of these patients it is not as common as in humans where edema can be very severe. If there is any doubt this being present either a urinary catheter is placed and attached to a monometer and the pressure measured as the abdomen is closed OR the abdomen should be left open as a laparostomy. An IV bag is opened and stapled to the skin a gentle absorbable bandage applied. Normal abdominal pressures should be 0-10 cmH2O If the measured pressure is 25 this is diagnostic for ACS. If this is noted then the abdomen must be decompressed as signs for reperfusion injury watched for and treatment performed if noted [11].Another indication to keep the abdomen open is when there is severe contamination such as what might occur with a perforation of the colon and spread of fecal material throughout the peritoneal cavity. The abdomen in all these cases is left open and a continuous polypropylene suture is loosely placed in the rectus fascia to prevent intestinal spillage yet allow unencumbered drainage. The other alternative is to place 2 suction drains into the abdominal cavity and the abdomen is closed with simple continuous polypropylene in the rectus fascia and following irrigation of the subcutaneous tissues and close them with continuous PDS or Monocryl and close the skin with staples.

Two Case Examples of Demonstrating Damage Control Surgery

Boston Terrier: On July 2, 1987 at the University of Georgia College of Veterinary Medicine Small Animal Teaching Hospital a middle aged FS Boston Terrier arrived in state of acute breathing difficultly. The history was that the dog had been perfectly fine just 30 minutes before. She was taken immediately from the lobby to radiology for thoracic radiograph. As the radiograph was being taken the dog had a cardiac arrest. The new intern then ran with the dog ton the anesthesia prep area and asked for help. The dog was unconscious, not breathing and obviously cyanotic. I then took over and intubated the dog as no masks and AMBU bags were available. Following tracheal intubation I checked for breath sounds when the anesthetic circuit from the anesthetic machine was attached and the oxygen filled rebreathing bag was squeeze. No breath sounds were heard so the position of the ET tube coursing through the rima glottis was checked. It was found to be coursing through the larynx correctly but again not breath sounds were heard when the rebreathing bag full of oxygen was squeezed. Immediately

The thought raced through my head that the trachea itself had somehow been compromised. Again listening bilaterally there were no lung sounds but O2 was going into the ET tube quite easily when the rebreathing bag was squeezed, but no oxygen or other gases were returning back out into the rebreathing bag…

Immediately I performed a rapid exposure to the trachea through midline cervical incision. The cervical trachea was found intact. Next a parasternal approach to thoracic trachea was completed. When this was completed it was noted that there was a good amount of air within the mediastinum. I then felt for the trachea and found the end of the ET tube projecting out into the mediastimym. I then opened the mediastinum further and by blunt dissection found the distal end of the trachea. The trachea had been completely ruptured with frayed ends. I grasped the broncial end of trachea with a hemostat and pulled it rostral and while holding it straight I placed another ET tube into it and inflated the balloon began providing positive pressure ventilations and started CPR. Soon after the ventilations direct cardiac compressions were started the heart began having spontaneous contractions and soon after that the patient began moving slightly so isoflurane was begun and one of the anesthesia students continued to bag and I left to briefly talk with the owner who was still in the lobby I explained to the owner what had happened and what we had found and that her dog was now under some anesthesia. A guarded prognosis was given as we did not know how the patient would recover since a cardiac arrest had occurred and there could have been a significant insult to the brain and the trachea had been literally pulled apart and it would remain to be seen if we could fix it. She elected to want us to try and repair the injured trachea and do what we could to provide the support that would be needed post CPR and following the surgery. She also went home to see if she could determine what might have happened to cause this very unusual tracheal injury.

The Boston was taken to surgery after prepping the fur. No clipping of the fur was done. Surgery involved the removal of 3 rings of the torn section of the trachea as there were pulled apart too much for their salvage. The tracheal ends were brought together and held together with simple interrupted 3-0 polypropylene suture on a swaged on small taper needle. These sutures were preplaced as the reconstruction was somewhat difficult to perform as the proximal segment required the use of the ET tube placed and connected to the anesthetic circuit and a technician providing intermittent positive pressure ventilations. The sutures were especially difficult to place on the dorsal side and necessitated preplacing them. The placement of the sutures also necessitated lifting the heart ventrally to gain enough access to the proximal segment to provide visualization. A surgical headlight was also used to gain needed visualization. After the sutures were preplaced a ET tube was then placed, coursing from the distal to the proximal segments and spanning the anastomosis site and the sutures all tightened and tied. Then the tube was moved distally past the repair and the balloon re-expanded and the anastomosis site leak tested using saline and watching for bubbles as positive pressure ventilations with test pressures up to 30

cmH2O were provided. The tracheal anastomosis site passed the leak test as no bubbles were observed. A chest tube was then placed and the parasternotomy was closed with no.1 polypropylene. After the subcutaneous and skin sutures were placed a nasopharyngeal catheter was inserted and sutured in placed. Positive pressure ventilations were able to stop after 2 hr and the ET tube removed and supplemental oxygen continued via the NP catheter overnight . The Boston made a complete recovery, with no deficits, and with no infection.

The owner's investigation discovered scratch marks on the wooden back porch that suggested the dog had placed his head between two of the wooden 2" x 4" vertical slats of the porch railing and gotten his head caught and then struggled to get free and either literally pulled his trachea apart or he had fallen and rotated and the rotation had literally twisted the trachea apart. This physical evidence matches the history that the owner gave "He was barking outside and running around in the back yard. I was doing dishes in the kitchen and then suddenly it became awfully quiet… I was concerned… and when out to check on him he was standing near the back porch steps and making terrible gasping like sounds and struggling to breath. I immediately placed in him in the car and raced here, literally.

The Boston was a survivor…against all odds. No one will ever know the exact cause of the trachea that was literally found at surgery like a pulled apart slinky toy. Complete tracheal disruptions from hanging attempts in humans have been reported and successful emergent repair has also been reported. (Costache VS, Renaud C, Brouchet L, et al. Complete tracheal rupture after a failed suicide attempt. Ann Thorac Surg. 2004;77(4):1422-3). It is believed this is the first one documented in a veterinary patient.

Cowboy – A 2 year old MN Australian Cattle Dog was running after a ball in a field with many weeds where their had previously been an abandon building. The owner had stopped his pick up truck to allow the dog to run in the field for a few minutes. He threw the ball out in the field and the dog aggressively ran after it. The owner then said he heard the dog scream. He ran to where he had heard the dog screaming. He found the dog impaled on a section of iron reinforcement rod jutting out from the concrete foundation that had been part of the abandon building. The owner pulled the dog off the rod and was surprised when he found that the rod had been buried so far into the dog; the owner guessed at more than a foot and a half. Is the dog was losing consciousness be noted that the field was next to a fire station He ran to the station, dog in his arms, and knocked on the door the fire station. Two firefighters gave him directions as to where

he could take his dog. Fortunately it was only a mile from the station and we had just gotten finished with our first surgical patient for the day when the owner arrived carrying the dog. The dog was unconscious, breathing shallowly, mucus membranes very pale and heart just barely perceptible with a guessed rate of approximately 80 prm.
After a verbal permission from the owner was received to provide emergency surgical care to assess and care for the injuries found the dog was taken to the OR. The airway was intubated and ventilations begun (with an anesthetic ventilator) and a clippers was used to rapidly clip and expose the neck, thorax, abdomen and inguinal area. A penetration hole was noted at the thoracic inlet on the right of the manubrium and bruise noted at the left inguinal region. A 16 g IV catheter was placed via a mini-cutdown into the left cephalic vein and Plasmalyte was initiated as rapidly as possible.

The dog was paced in dorsal recumbency and following spraying with Betadine and draping out from an incision was started from below the angle of the jaw on the right and ending mid cervical region and from the manubrium and extending all the way to the pubis. Electerosurgery was used for a few oozing vessels. The dog has not made any response yet. The right jugular vein was isolated and an 8 Fr red rubber feeding tube was inserted through a venotomy and secured in place using towel clamps and this was connected to a unit of Oxyglobin and this was begun briskly. The approach was made to the thoracic cavity by completing a right parasternotomy; electrosurgery was used on a few bleeding vessels (as there was some bleeding now but still very poor). The suction was placed in the thoracic cavity and blood started to be aspirated into suction canister and after approximately 100 ml was retrieved it was started to be transfused in the central venous jugular feeding tube. A Balfour retractor was inserted and the edges of the thoracic opening retracted open as best as possible. Then the incision was carried into the abdominal cavity and the diaphragm split with the incision coursing toward an torn opening seen its right side. As the Balfour was opened further bubbles were seen coming from the right lung lobes (cranial and caudal) and these lobes were the bubbles were coming from were occluded rapidly using feeding tubes encircled around their bases and hemostats used to tighten the loops thus stopping the air leaks and blood loss (temporarily).

The approach was then carried further into into the peritoneal cavity with packs placed into the cranial quadrants of the abdominal cavity and the assistant placed pressure on the area were bleeding was believed to have been the most aggressive (right liver lobes). A second Balfour retractor was inserted into the abdomen and opened wide and both fixed so they would not rotate

with towel clamps in their arms. Autotransfusion of the blood in both the thoracic and abdominal cavities were continued. Abdominal aortic compression was then added by the assistant and packs were inserted into the two caudal abdominal quadrants. Then with irrigation and suctioning it was noted that most of the hemorrhage into the abdomen had been coming from the right diaphragmatic hole where there was a fairly large vein and this area was clamped and then the other area of concern was the right middle lobe of the liver and repacking was added here. The assistant provided pressure here. The two caudal abdominal quadrants were inspected with initially the colon "elevated" and examined and no perforations were noted the left gutter was also inspected and no injury to left kidney or other gutter structures were noted. As the caudal packs were removed several openings into the small intestine were noted and these were repacked. The left inguinal region had a fairly extensive bruise that was opened and no obvious active bleed was noted. The area was also repacked and the right gutter was inspected by "elevating" the duodenum and bruising was noted on the ventral aspect of the kidney capsule and the right limb of the pancreas was torn from the duodenum. No active hemorrhage was noted but there was some distal pancreas injury that was oozing some.

As further blood was continued to be transfused including a unit of paced red cells and a unit of fresh froze plasma bleeding in the liver lobe region was noted and the torn areas were addressed with a partial lobectomy using Carmalt forceps and a Miller's know of polypropylene and stick ties going through the base were some fractures were present deep to the lobe ligation area. Hemablock hemostatic power was added to the surface of the liver lobe. The area was then repacked. The clamp across the torn area in the diaphragm was over sewn with polypropylene and removed and the suture tightened and tied. No further bleeding was noted. Ketamine and diazepam was used IV now as the dog began responding.

Attention was then turned back to the thoracic cavity and the two lung lobes that had been torn were removed using Kelly forceps and Miller's knots. Warmed fluids used to inspect this area and no further air leaks or hemorrhage were noted. Lap pads were replaced into the thoracic cavity to prevent added heat loss.

The injured pancreas was addresses buy removing the torn area and 4-0 polypropylene sutures used to ligate the ends. Then the injured sections of bowel were addressed requiring on area of resection and anastomosis (continuous 4-0 polypropylene) and 3 areas requiring debridement and enterotomy closures (debriding longitudinally and closing transversely) using 4-0

polypropylene sutures. The abdomen and thoracic cavities were extensively irrigated with warm saline and then a chest tube was placed as well as a urinary catheter. Omentum was used to wrap around each of the small intestinal surgical sites and placed lover the liver resection area. A nasogastric feeding tube was placed and its tip verified by palpation of the stomach. The diaphragm was closed with continuous 2-0 polypropylene. The parasternotomy and ventral abdominal approaches were closed using 0 continuous polypropylene, after inspection to ensure no packs, etc., were left behind.

The patient was maintained on a ventilator overnight and ICU care provided for another 3 days (nasal oxygen overnight, chest tube aspiration, nasogastric decompression and feeding, urine output monitoring and fluid monitoring and continued Doppler Blood Pressure and blood flow monitoring, massage, range of motion joint and muscle therapy, analgesia with fentanyl and lidocaine, and IV enrofloxicin, metronidazole, and cefazolin for several days, etc). He also received hyperbaric oxygen therapy treatments beginning the next morning and continuing receiving 2 treatments per day 3 days and he recovered enough to be discharged on day 5 postop and he made a complete recovery. The owner remained in the area until he was given the “green light” that the dog could travel (approximately 2 weeks) and after his skin staples were removed.

Closing Comments

It is hoped that this article will act as a guide for the trauma team, whether in a small private facility or a major academic institution.“The principles of the first 'damage control' procedure then are control of hemorrhage, prevention of contamination and protection from further injury. Damage control surgery is the most technically demanding and challenging surgery a trauma surgeon can perform. There is no margin for error and no place for careless surgery” from *Karim Brohi,* Damage Control Surgery *trauma.org 5:6, June 2000 "The modern operation is safe for the patient. The modern surgeon must make the patient safe for the modern operation" - Lord Moynihan*

Additional reading references:

1. Rotondo MF, Schwab CW, McGonigal MD et al. 'Damage Control - an approach for improved survival in exsanguinating penetrating abdminal injury' J Trauma 1993;35:375-382
2. Hirshberg A, Mattox KL. 'Planned reoperation for severe trauma' Ann Surg 1995;222:3-8
3. Moore EE. 'Staged laparotomy for the hypothermia, acidosis and coagulopathy syndrome' Am J Surg

1996;172:405-410
4. Cue JI, Cryer HG, Miller FB et al. 'Packing and planned reexploration for hepatic and retroperitoneal hemorrhage - critical refinements of a useful technique' J Trauma 1990;30:1007-1013
5. Carvillo C, Fogler RJ, Shafton GW. 'Delayed gastrointestinal reconstruction following massive abdominal trauma' J Trauma 1993;34:233-235
6. Richardson JD; Bergamini TM; Spain DA et al. 'Operative strategies for management of abdominal aortic gunshot wounds' Surgery 1996; 120:667-671
7. Reilly PM, Rotondo MF, Carpenter JP et al. 'Temporary vascular continuity during damage control - intraluminal shunting for proximal superior mesenteric artery injury' J Trauma 1995;39:757-760
8. Velmahos GC; Baker C; Demetriades D et al. 'Lung-sparing surgery after penetrating trauma using tractotomy, partial lobectomy, and pneumonorrhaphy' Arch Surg 1999;134:86-9
9. Wall MJ Jr; Villavicencio RT; Miller CC et al. 'Pulmonary tractotomy as an abbreviated thoracotomy technique' J Trauma 1998;45:1015-23
10. Schein M, Wittman DH, Aprahamian CC, Condon RE. 'The abdominal compartment syndrome - the physiological and clinical consequences of raised intra-abdominal pressure' J Am Coll Surg 1995;180:745-753
11. Morris JA, Eddy VA, Blinman TA. 'The staged celiotomy for trauma - issues in unpacking and reconstruction' Ann Surg 1993;217:576-586
12. Crowe DT. Airway Assessment and Management. Proceedings – Atlantic Coast Veterinary Conference, Atlantic City, NJ, Oct 14-16, 2008

13. Crowe DT. A Common Abdominal Emergency: Hemo-abdomen in Trauma. – Atlantic Coast Veterinary Conference, Atlantic City, NJ, Oct 14-16, 2008

14. Crowe DT. Practical Patient Management in Moments of Crisis. Atlantic Coast Veterinary Conference, Atlantic City, NJ, Oct 14-16, 2008

15. Crowe DT. New method of closing thoracotomies using a continuous one-knot closure. DVM Best Practices Oct 2002

16. Crowe DT. Use of aortic cross clamping with a red rubber feeding tube for brain resuscitation during CPCR. DVM Nov 2002

17. Crowe DT. A new paradigm shift in CPCR (emphasizing open chest CPR and aortic cross clamping). DVM Oct 2002

18. Crowe DT. Applying vertical mattress wound closure for emergency wounds (so that no subcutaneous sutures will be buried in contaminated cases). DVM Best Practices Oct 2003

19. Crowe DT. Canine Resuscitation from Shock: An update for the practitioner: The concept that a combination of hypertonic saline and a hemoglobin based oxygen carrying colloid and using Doppler "field assessed" blood flow as the main indicator of sufficient resuscitation and the concept that colloids are significantly superior to crystalloids in the treatment of severe shock (class 3 or higher). Blood flow is more important than pressure was also suggested. Advances in Critical Care Medicine: Vet Practitioners Dec 2003

20. Crowe DT. Canine Resuscitation from Shock: An update for the specialist: The concept of limited resuscitation, especially with HBOCs, in those patients suggestive of having a continued hemorrhage, and only enough volume given to produce Doppler flow; surgery is then performed to control the hemorrhage. Further resuscitation is then accomplished as required, bringing blood pressure back to normal or above. The use of human albumin 5% and 25% for resuscitation and hypoalbuminemia was also suggested. Advances in Critical Care Medicine: Vet Specialists Dec 2003

21. Crowe DT. The Use of Hemoglobin Based Oxygen Carriers in Life Treating Hemorrhage (first limited to only that amount needed to sustain life but then after the stoppage of the bleeding then full resuscitation). Also the use of HBOCs for the treatment of global as well as local but key ischemia such as seen with spinal cord injury, local GI blood flow compromising conditions, tissue flap compromises, and pancreatitis. Proceedings of the 43rd Annual Critical Care, Trauma, and Emergency Medicine Symposium, Feb 2004

22. Crowe DT. The use of nasal-tracheal oxygen and jet blow by ventilation as well as a review of know methods and the study of the methods that were investigated (oxygen cages, box, collar, plastic bag covering the patient, and blow-by). Oxygen therapy: Techniques and monitoring in Proceedings IVECCS 2004,

23. Crowe DT. The management of the severe multiple injured patient involving severe thoracoabdominal hemorrhage with clinical recovery. Proceedings IVECCS 2004

24. The successful management of severe diaphragmatic hernia resulting in acute collapse and cardiac arrest. Proceedings IVECCS 2004

25. Crowe DT. First aid, transport and triage of the multiple trauma victim both at the scene, during transport in the pet ambulance and at the receiving veterinary hospital. Proceedings IVECCS 2004

26. Crowe DT. One Knot Continuous Shoe-Lace Technique for Thoracic Wall Close (Abstract) Proceedings IVECCS 2004

27. Crowe DT. Cranial Tibial Artery Catheter for Monitoring Pressures and Sampling (Abstract) Proceedings IVECCS 2004

28. Crowe DT. Simple Autotransfusion in Severe Hemorrhage: Success in 8 of 12 Dogs (Abstract) Proceedings IVECCS 2004

29. Crowe DT. Rapid Miller's Knot Method for Emergency Lung Removal (Abstract) Proceedings IVECCS 2004

30. Crowe DT. Comparison of Six Non-Invasive Supplemental Oxygen Techniques in Dogs and Cats. The first author was my intern that I trained when I was in the specialty practice in Carson City, Nevada Mark Engelhardt, (Abstract) Proceedings IVECCS 2004

31. Crowe DT. Critical Care: Cutting-Edge Concepts, Procedures, and Protocols. Proceedings 2005 Nestle Purina Veterinary Symposium on Companion Animal Medicine. 9-15, 2005

32. Crowe DT. Advanced Abdominal Surgical Procedures Lectures and Laboratory. Team taught with Dr. Mann, Spreng and Lichtenberger at the 12th International Veterinary Emergency and Critical Care Symposium. Proceedings IVECCS 2006

33. Crowe DT. Surgical Treatment of Vascular Emergencies. Proceedings IVECCS 2006

34. Crowe DT. Hypotension – Physiology/Pathophysiology as it Applies to Tissue Perfusion in Clinical Practice. Proceedings Europ Coll Vet Inter Med –Comp An. Budapest, Hungary 2007

35. Blood Pressure Monitoring in Emergency and Critical Care – Methods and Goal Directed Therapy Applications. Proceedings Europ Coll Vet Inter Med –Comp An. Budapest, Hungary 2007

36. Crowe DT. Advanced Abdominal Surgical Procedures Lectures and Laboratory. Taught the use of Flashing in the technique of the Rapid Splenectomy with 5-7 clamping sites. Team taught with Dr. Mann, at the 13th International Veterinary Emergency and Critical Care Symposium. Proceedings IVECCS 2007

37. Crowe DT. Intravenous facilitative maneuver. In Emergency & Critical Care Manual 2nd ed, Karol Mathews (ed) Lifelearn Guelph Ontario Canada 2006.

38. Crowe DT. Central vein access in shock. In Emergency & Critical Care Manual 2nd ed, Karol Mathews (ed) Lifelearn Guelph Ontario Canada 2006.

39. Crowe DT. Care of the Multiple Injured Patient emphasizing the Use of New Hemostatic Agents. Proceedings IVECCS 2007

40. Crowe DT. Hypotension and Hypothermia as a Tool in the Perioperative Period to Decrease Oxygen Need. Proceedings Europ Coll Vet Inter Med –Comp An. Ghent, Belgium, 2008

41. Crowe DT. Use of High Definition Oscillometric Blood Pressure Monitoring in Emergency and Critical Care. Proceedings European Coll Vet Inter Med –Comp An. Ghent, Belgium, 2008

42. Crowe DT, Shimizu RK, Robelo RC. Critical Decision Making in the Major Polytraumatized Patient in the First 24 Hours of (Tomada de Decisao para o Paciente Gravemente Traumatizado com Enfase nas Primeiras 24 horas de Cuidado). In Fundamentals of Intensive Care for the Small Animal Veterinarian: In Portuguese: Fundamentos de Terapia Intensiva Veterinaria em Pequenos Animais – Condutas no Paciente Critico, Rabelo RC, Crowe DT (eds). LF Livros de Venterinaria, Rio de Janeiro, Brazil, 2005

43. Crowe DT. Closure of abdominal incisions using a continuous polypropylene suture: Clinical experience in 550 dogs and cats. Vet Surg 7:74-77, 1978 (July).

44. Crowe DT. Autotransfusion in the critically injured patient: a historic review and current recommendations. J Vet Critical Care 4:14-39, 1981 (April).

45. Crowe DT, Todoroff RJ. Umbilical masses and discolorations as signs of intraabdominal disease. JAAHA. Vol 18 No. 2, 295-298, 1982 (March-April).

46. Bjorling DE, Crowe DT, Kolata RJ, Rawlings CA. Penetrating abdominal wounds in dogs and cats. JAAHA Vol 18, No. 5, 742-748, 1982 (September-October).

47. Crowe D.T. Enteral nutrition for the critically ill or injured patient. J Vet Critical Care 5:8-31, 1982 (October).

48. Crowe DT. Nutritional support for the seriously ill or injured patient: an overview. J Vet Emerg Crit Care 1:1-7, 1986 (February).

49. Crowe DT. Tube feeding diets for nutritional support of critically ill or injured patients. J Vet Emerg Crit Care 1:8-18, 1986 (February).

50. Fitzpatrick RK. Crowe DT. Nasal oxygen administration in dogs and cats: experimental and clinical investigations. JAAHA 10:293-300, 1986 (May and June).

51. Crowe DT. Ventral verses dorsal cystotomy: an experimental investigation. JAAHA 20:382-386, 1986 (May and June).

52. Crowe DT. Use of a nasogastric tube for gastric and esophageal decompression in the dog and cat. JAVMA 188:1178-1182, 1986 (May).

53. Crowe DT. The technicians key role in emergency care. Vet Tech 7:297-305, 1986 (July and August).

54. Crowe DT. Help for the patient with thoracic hemorrhage - Vet Med 83:578-588, 1988 (June).

55. Crowe DT. The acute abdomen. Vet Med 83:652, 1988 (July).

56. Crowe DT. The first steps in handling the acute abdomen patient. Vet Med 83:654-674, 1988 (July).

57. Crowe DT. The first steps in arresting abdominal hemorrhage. Vet Med 83:676-681, 1988 (July).

58. Crowe DT. Dealing with visceral injuries of the cranial abdomen. Vet Med 83:682-699, 1988 (July).

59. Crowe DT. What to do with disorders of the caudal abdomen. Vet Med 83:700-709, 1988 (July).

60. Crowe D.T. Cardiopulmonary resuscitation in the dog: a review and proposed new guidelines (part 1). Seminars Vet Med & Surg (Small An) 3:321-327, 1988 (November).

61. Crowe DT. Cardiopulmonary resuscitation in the dog: a review and proposed new guidelines (part 2). Seminar Vet & Surg (Small An) 3:329-348, 1988 (November).

62. Crowe DT. Understanding the nutritional needs of critically ill or injured patients. Vet Med 83:1224-1249, 1988 (December).

63. Crowe DT. Responding to the needs of the critically ill or injured pet. Vet Med 84:33, 1989 (January).

64. Crowe DT. Handling the critical patient: getting past the initial crisis. Vet Med 84:34-54, 1989 (January).

65. Crowe DT. Managing respiration in the critical patient. Vet Med 84:55-76, 1989 (January).

66. Crowe DT. Performing life-saving cardiovascular surgery. Vet Med 84:77-96, 1989 (January).

67. Crowe DT. Nutrition in critical patients: administering the support therapies. Vet Med 84:152-180, 1989 (February).

68. Otto CM, Kaufman GM, Crowe DT. Intraosseous infusion of fluids and therapeutics. Comp Cont Ed Pract Vet Sm. Anim., 11:421-431, 1989 (October).

69. Crowe DT. Tube Feeding: Administering the nutritional support therapies. Comp Cont Educ Pract Vet Sm Anim, 12:1255-1258, 1990 (December).

70. Spreng DE, DeBehnke DJ, Crowe DT, Swart GL. Evaluation of an esophageal Doppler probe for the identification of experimental pseudo-EMD: A preliminary Study. Resusc 129: 153-156, 1995.

71. Rudloff E,Crowe DT, Kirby R. Suspected tension pneumomediastinum in a dog: A case report. J Vet Emerg Crit Care 6: 103-107, 1996.

72. Crowe DT. Assessment and management of the severe polytraumatized small animal patient. J Vet Emerg Crit Care 17:1-11, 2005.

73. Braswell C, Crowe DT. Hyperbaric oxygen therapy. Compendium: Continuing Education for Veterinarians. E1-E6, March 2012.

74. Crowe DT. Autotransfusion in the trauma patient. Vet Clin N Am (Sm Anim Pract) 10:581-597, 1980 (August).

75. Crowe DT, Devey JJ. Assessment and management of the hemorrhaging patient. Vet Clin North Am (Small An Pract) 24: 1095-1122, 1994.

76. Gfeller R, Crowe DT. The emergency care of traumatic wounds: Current recommendations. Vet Clin North Am (Small An Pract) 24: 1249-1274, 1994

77. Crowe DT: Simple autotransfusion in severe hemorrhage: Success in 8 of 12 dogs (abstract). Proceedings of the 10th International Veterinary Emergency and Critical Care Symposium, San Diego, CA Sept 8-12, 2004 pg 981.

78. Crowe DT: Rapid Miller's knot method of emergency lung lobe removal (abstract). Proceedings of the 10th International Veterinary Emergency and Critical Care Symposium, San Diego, CA Sept 8-12, 2004 pg 981.

79. Crowe DT: Combined thoacoabdominal approach (featuring the parasternotomy and ventral abdominal exposure and closure with polypropylene). In Current Veterinary Surgery IV J Bojrab (ed), Lippincott Publishing 1986.