"On the Front Lines"

Practical Emergency and Critical Care and Surgery

A Reference Guide for the Practicing Veterinarian

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Prolog

Formulated as a manual. I hope it will become a reference for all the veterinarians that I reach out to support and that request me to assist them with performing surgeries for them. It is meant to be a reference for practicing veterinary technicians, their assistants and aspiring students, interns and residents in surgery and emergency and critical care; and even EMTs and others that may find the information contained here to be helpful should they should find themselves helping in the emergency care of a dog or cat. The information provided in this manual will provide a framework of principles and procedures important in the management of emergency and surgery patients. Cases that are cited in the manual are meant to illustrate how the veterinary medical team managed serious life-threatening emergency conditions. These cases came from several practices I have been involved with, either as a visiting clinician – surgeon, a Director of the Trauma and Acute Care Surgery or as the Chief of Staff from at two specialty hospitals with greater than 12 doctors and 70 support staff. I still have fond memories (sprinkled with times of anxiousness and stress) that these cases provided. My prayer for you who read this or download a copy and use it will be blessed… and you will have success with your surgery and emergency patients. And call me anytime you may have a question or are in need. ☺ God bless you.

Introduction

The goal of this printed work is to provided information on protocols and procedures that will help in the management of various emergency and critical patients, from simple and straight forward repair of lacerations to complex surgical and medical conditions such as the GDV and 4 L of blood free in the abdomen secondary to multiple torn short gastric vessels… this patient, a 12 year old Great Dane survived, by giving *all that 4 L back to her intravenously through a large bore (14 g) cephalic vein catheter*. The spleen was removed, the stomach rotated back into normal position and then pexied to the right abdominal wall. Intravenous fluids continued post op and other supportive treatments were completed and she was discharged from the clinic 2 days later!

The manual is divided into sections based on specific topics from readiness and triage to body areas or major functions of body: airway, breathing, circulation, etc., but as we know in real life patient care is not divided; the care is a continuum and all areas are addressed, often at the same time, especially in critical emergencies. So dig in, wear the pages out and if you need more copies for other colleagues to have please feel free to contact me. If find any errors in the manual I do hope you will feel free to let me know so I can make corrections in the next edition ☺ If further presentation information is desired please call me at 706-296-7020 or e-mail me at mobilevetsurgeryGA@gmail.com. God Bless You and your practice and all that you do. ☺

Table of Contents: *** topics in the order they appear in the manual**

Chapter 2 – Review of Practical Emergency Care and Procedures- A through E pages 31-51

Care starts w/ clearing the airway, providing ventilation support, stopping hemorrhage.

Hypothermia again used for cell hibernation while the resuscitation is performed.

Blood pressure not accurate in determining blood volume or blood flow as Q= BP/r

Doppler flow as a monitor of flow – note BP when a vasodilator on board can be lower

Norman Shumway MD- heart transplant surgeon found 40 mmHg to be adequate in sx.

Future digital Laser Doppler microvascular flow and Doppler flow for macroscopic flow.

Doppler used on the palmar arterial arch or within the esophagus to determine flow.

Characteristics of the Doppler flow sound for practical effective blood flow assessment.

Doppler on cornea to determine CPR effectiveness – a flow sound w/each compression.

Awake or non-awake rapid tracheotomy and IPPV w/ PEEP for pulmonary / head injury.

Alternative - tracheal intubation using rapid sequence induction (suggested meds used)

Hydromorphone, fentanyl, butorphenol, ketamine, midazolam, etomidate, alfoxalone, etc.

O2 Jet blowby w/14 g IV catheter on IV admin set on a Y connector from an anesthetic machine

Non-invasive ventilation assistance using a bag-valve-mask and PEEP valve.

Work of breathing decrease – often requires some sedation -ace, butorphenol, ketamine, etc.

Use of acupuncture points that calm may also work to sedate enough to accept the mask.

Automatic "routine use" of mechanical ventilation immediately post first hours -24 hours.

Use of Barbiturates, hydromorphone, oxymorphone, acepromazine, propofol, etc.

Use of PEEP in lung protective strategies along with limited peek inspiratory pressures

Use of propofol induction and as a CRI drug to facilitate continuation of support ventilation

Atricurium to help effect pulmonary support when patient's cardiac function is poor, shock.

Hemostat (small curved) used to facilitate IV catheter placement including large bore (14-16g)

Rapid determination of peripheral venous pressure by gradual lowering IV bag w/flow returning.

TFAST and FAST rapid ultrasound examinations of the thorax + abdomen - our new stethoscope.

Augmentation of hemorrhage from liver, spleen, kidney, and aorta by use of counter-pressure.

Use of towels, bubble-wrap, and duct tape to provide the counter-pressure – proven effective

Protocol on use of the abdominal counter-pressure; when to use, continue, discontinue

Those in need of immediate abdominal surgery (regarding abdominal hemorrhage)

Access to both thorax and abdomen via a parasternotomy and abdominal midline exploration.

Use of a scalpel, curved Mayo scissors, and Balfour retractor to make effective rapid approach.

Hemostatic agents to control bleeding and "possible use" of e aminocaproic or transexamic acid.
Protocol for counterpressure use to control intra-abdominal hemorrhage: using lactate, PCV,etc.
AFAST scoring related to decision making w/hemoabdomen cases -surgery or no surgery, etc.
Rapid abdominal exploration for continued hemorrhage- Mayo scissors, Balfour, Electrocautery+
Red rubber feeding tube as a Rummel tourniquet or Satinsky forceps to control hemorrhage.
Hemostatic agents that are safe to use – Celox, Hemcon, Hemablock. Cyanoacrylic, etc.
Intraluminal occlusion of major vessels – something that *might* be tried w/ femoral a exposure.
Autotransfusion for severe hemorrhage; even used without blood filters – methods.
Example 1 – cat with a penetrating liver injury – used 4 60 ml syringes of blood, recovered.
Example 2 – dog w/thoracic & abdominal impalement ~1500 ml canister blood given, recovered.
Example 3 – G Dane w GDV – short gastric vessel tears – 4 L of canister blood given, recovered.
Thoracic catheter (nonstylet type) placed and used to aspirate thoracic blood and autotransfuse.
Pulsed hypertonic saline – hetastarch 2-3 ml each via monitoring & Doppler flow for shock Tx.
Patients post hemorrhage- recommend continued immobilization to prevent clot disruption.
Paw, limb, pelvis, abdomen counterpressure w/towels, bubble wrap, duct tape, etc. for bleeding
Teaching of animal first aid courses; service dog and EMS first respond emergency courses
Bleed out cases – rapid cavity exposure w/ Mayo scissors, encircling Miller's knot ligations, etc.
Increasing O2 delivery with supplemental O2, O2 carrying colloids, hyperbaric oxygen therapy.
Differences between infrared buccal or rectal & toe temperature as a perfusion index (Delta T).
GI support with glutamine (5%) and glucose (10-20%) and water/electrolytes microenterally.
Jejunostomy tube, or nasoduoduenal, nasojejunal feeding tubes, and esophagostomy tubes.
Emergency decompressive craniectomy /durotomy in head injured w/ medically unrespond TBI
Immobiliation of severe trauma – using cardboard as a backboard and duct tape; & sedation.
Emergency decompressive homemade minichest tube using 16-14 g catheter and added holes.
Immediate awake tracheostomy or RS intubation for severely difficult breathing patient and PPV
Autotransfusion for severe hemorrhage anywhere even if blood is contaminated.
Red rubber feeding tube placed into the right jugular vein for vascular access, & epinephrine use
Esophageal Doppler for beat by beat cardiovascular monitoring in unconscious or anesthetized.
Targeted pulsed EM field therapy (loop), photonic therapy, electrolyzed water.
Example: Sara – severe head trauma – emergency tracheotomy; emergency surgery, trach.care.
Detailed example – Cattle dog – severe impalement, bleeding out, surgery, autotransfusion, etc
Example – Boxer – HBC – pneumothorax, shock, jugular vein mon., Doppler, ultrasound, DPL.

Hollowell SA 2000 Anesthetic Ventilator; craniectomy; internal fixation, lactate, MLK for pain

Example – Boston Terrier – acute breathing difficulty – cardiac arrest – CPR, solving the cause.

Chapter 3 – Airway and breathing emergencies and procedures – pages 51-90

Supplemental O2 techniques – blow-by; plastic bag; nasal cannula; PEEP, O2 cage; jet-blow-by

Crowe collar; oxygen boat*; Nasal & nasopharyngeal catheter placement – unilateral, bilateral.

Sedation acupuncture points stimulated w/ 660 nm diode light that help in cath. placement.

Those not responding & ruled out pleural space disease w/ US or rads begin MVM ventilation.

Patients with significant shock and pulmonary injury begin Bi-PAP ventilation and r/o

Nasal and nasopharyngeal catheter placement techniques may require sedation or photonic AP

Nasotracheal oxygen catheter placement – indications and humidification requirement.

Crowe Collar manufacture and use and effectiveness and warning not to use a commercial one.

The O2 Boat – its manufacturer and use and its effectiveness over oxygen collars.

Positive Pressure Assist Ventilation with a Bi-PAP Technique to be used before intubation.

Combitube and King Airway as an alternative to endotracheal intubation.

Details for the emergency care for those presenting with dyspnea and cyanosis.

Patient assessment: breathing patterns; breath sounds; percussion, pantophany.

The new stethoscope –thoracic ultrasound; glide sign, rockets, free fluid, heart, pericardium, dia.

Example: cardiac arrest w/pericardial diaphragmatic hernia –jug veins distended – resuscitation

Example: severe tension pneumothorax from a ruptured pulmonary bulla.

Example: severe pneumothorax from a dog bite associated lung injury.

Example: severe pneumomediastinum and arrest caused by a peritracheal wound.

Example: severe pneumomediastinum and pneumothorax following tracheotomy.

Supplemental oxygen principles – reason why – pulse oximetry and wave form assessment.

Research supporting the use of supplemental oxygen in head injury: Shock 2004

Critical look at supplemental oxygen including high flow humidified oxygen cannula.

Sedation as a critical part of therapy for the dyspnea patient. Sedation Protocols

Anesthesia induction, intubation, and positive pressure breathing instituted.

Protocol – use of a BVM and assisted ventilation and a PEEP valve on arrival.

Summary of research by Mark Engelhart and DT Crowe, 2004 IVECCS Proceedings.

Non-invasive ventilation with BVM a few breaths a least before intubation in all CA patients

Protocol – those NOT responding to BVM & PEEP valve; RS intubation, ventilation types.

Example: newborn Germ Shorthaired Pointer ventilated 14 hours with 100% O2 – recovered.

Use of an intensive care ventilator with an air compressor and a humidifier.

High frequency or high frequency jet ventilation; high frequency oscillatory ventilation.

Alternatives to rapid sequence intubation – continued NIVent; direct awake tracheostomy,etc.

Example: Pneumonia that is progressive; 4 mo German Shepherd with severe pneumonia

Example: Lung trauma that leads to pulmonary edema; 2 mo Jack Russell squashed by a horse.

Example: CHF; 10 year old dog with an elderly woman also having breathing difficulty.

Example: Trauma to mouth, trachea, esophagus, and brachycephalic vein leading to air embolus.

Example: Brachycephalic syndrome; 4 mo English Bulldog w/ esophageal foreign body, edema.

Example: Golden Retriever HBC , head, eye injury, open nasal frontal region; tracheotomy, etc.

Oxidative stress generating ROS – and use of vitamin C as an electron donor decreases edema .

Continued case example (The Golden Retriever) OR readiness, Techni-Care, Op procedures

A Cell used as a covering over the frontal cavity to act as a scaffold to guide new bone over it.

Post op care Golden Retriever: breathing, cardiovascular, antibiotics, parenteral & enteral feeds

Thoracentesis; small bore and large bore chest tubes; caution against stylet use in its placement.

Hemostat controlled dissection to enter chest & deflate lung then gently insert tube or ET tube

Use of an underwater suction seal and drainage system needed for continued lung air leaks.

Transtracheal / nasothracheal catheter uses for upper airway cases and for O2 supplementation

Transtracheal catheter placement technique and use protocol.

Emergent resuscitative approach to the cervical trachea to gain access quickly.

Emergent resuscitative approach to the thoracic trachea to gain access – indications.

Immediate resuscitative parasternotomy and ET tube placement into the distal trachea.

Resuscitative parasternotomy procedure – the technique – recommend use of a head light.

Tracheal repair – thread smaller ET tube through trachea- debride, repair, anastomosis.

Parasternotomy closure methods following irrigation and chest tube placement.

Resuscitative incisional thoracostomy – to provide rapid tension pneumo decompression.

Lung lobe cross clamping and then ligation with a Miller's knot.

Thoracic cavity closure – shoelace technique for the chest wall leads to good rib apposition.

Aorta Cross-Clamping to increase heart and brain and lung blood flow.

Chapter 4: Cardiovascular Emergency Procedures – Damage Control Surgery pages 91-116

Definitions of damage control surgery – philosophy and introduction

OR readiness and trauma pack – bare minimum - instrument and materials.

Important instrumentation for damage control surgery. DeBakey, Finochietto, headlight, Rummel homemade tourniquet, Balfour retractor, Satinsky forceps, Right-angle forceps, etc

Compression and prepping – Trauma Team – Autotransfusion

Vascular Access – 2 IV catheters is goal; IO also good, 14 g Minicutdown, Central Vein Access

Red rubber feeding tube as a great central vein catheter.

Airway access and maintance – cervical tracheal access, thoracic tracheal and bronchial access

Thoracotomy – immediate - starts with airway access, ventilation, resuscitativee thoracotomy

Thoracic access, aortic occlusion, and airleak and hemorrhage control – resusc thoracotomy

Definitive hemorrhage control with hemostats, vascular clips, suture, US surgical TA V30

Counter pressure and blood transfusion and autotransfusion

Abdominal aortic occlusion and packing, rapid exploration,

Abdominal exposure with the parasternotomy

Thoracic cava and hepatic vein injury – steps to take in hemorrhage control

Lung lobectomy Procedure for damage control surgery

Thoracic Approach Closures

Abdominal assess and hemorrhage and contamination control

Coagulopathy, metabolic acidosis and hypothermia – a challenge – affording to do the surgery

Unfortunate situation – often owners can not afford another surgery for their beloved pet.

Emergency transportation and preparation – do not stop at the ER but do directly to the OR

Decrease oxygen carrying, glycocalex decrease, more microvascular leaks occurs with large vols.

Hypertonic saline and Hetastarch in fluid resuscitation – lack of renal failure as seen in humans

General damage control conduct & philosophy – rapid prep then xyphoid to pubis – poss higher

Cases of significant abdominal distension –do left lateral thoracotomy & cross clamp aorta first.

Abdominal aortic pressure may be necessary for rescue to improve BP as a stop gap measure

Proximal and distal vascular control techniques, for portal vein & vena cave cranial to kidneys

Examination of abdomen must be complete. Inspect all hematomas especially those expanding.

Inspection and prevention of further contamination - do rapid repair of all areas, anastomosis

Abdominal closure – rapid and continuous with polypropylene after irrigation

Abdominal compartment syndrome, IAP > 20-25 watch for – use a urinary catheter monometer

Example of damage control: Boston terrier – cardiac arrest

Example of damage control: Australian Cattle dog

Chapter 5: Cardiopulmonary Resuscitation Reviewed pages 116-160

Prevention better than treatment – Use of Doppler monitoring on all anesthesia patients.

Oxygen supplementation – provide ventilator support in all general anesthesia patients.

Avoid vasovagal inducted events when hypothermic, in shock, under general anesthesia, stress.

Pre-directive admission for patients recommended – select those with possible good outcome.

CAB but no good studies to say better than ABC if done rapidly; start w/ C makes sense.

Compressions at 100 per minute – active compression and active expansion w/ towel clamp.

Bag valve mask ventilate – to oxygenate before intubation – helps prevent vagal induced arrest.

Intubate , keeping head low – laryngoscope preferred – prevents decrease in brain blood flow.

Provide ventilations – AMBU & reservior prefer over anesthetic machine 1 Breath/10-15 comp.

Assess effectiveness of compressions – ocular Doppler – flow + and ETCO2 > 12.

Provide epinephrine 1 ml/20 kg if no defibrillator, 1 ml/10 kg if have one.

Atropine 1 ml/10 kg. If no IV access give both via a tracheal stick lung side of ET tube + saline.

Electrical defibrillation – silver chloride –wear gloves – clear before shock for insulation.

Second round of epinephrine and atropine if not responsive – if still none then open chest CPR.

Those that respond with good cardiac function and pulses – continue IPPV 20 min minimum.

Consider continuing local hypothermia – esp if not becoming conscious – ice pack head

No pupillary or light response and still unconscious longer than 1 hour post – poor outcome gen.

Some have post CPR effects such as blindness, cerebellar dysfunction, etc. May recover

Use of hyperbaric oxygen worth it as have seen surprising results in some –

Example- Mexican Camp Dog arrested w/ anesthesia for radiographs 2 wks postop – recovered.

Chapter 6: Shock Resuscitation Reviewed 120-133

Definition – poor blood flow such that oxygen demand is greater than oxygen delivered.

Most common organ systems involved dramatically initially = liver, gut, tips of villi slough.

Do no rectal exams before assuring IV access, supplemental oxygen to avoid vasovagal effects.

Levels of shock: Categories and Classes; Class I 20% Blood Loss up to 45% - O2, IV access

Hct, TS, glucose, lactate, E Poc, I sat PCV – Autotransfusion of interstitial fluid into circulation.

Facilitative maneuver, Mini-cutdown, Feeding tube in Jugular Vein, IO Access.

PlasmaLyte, Normosol , Hypertonic saline, hetastarch, gelatin, dextran, Oxyglobin.

Hyperbaric Oxygen is effective in the resuscitation of shocked organs.

Assess for cause – AFAST TFAST, Radiographs, labs, repeat exam.

Peripheral – Central Venous Pressure Assessment – with IV fluid administration tech.

Transfusion triggers – indications - blood transfusions, Autotransfusion technique.

Drugs: Vitamin C, Vitamin B1-B2-B3, etc., Steroids, Antibiotics, Analgesics, etc.

Hyperbaric oxygen as a drug used to increase oxygen levels deep into tissues post shock.

Supplemental O2 the first 12 -24 hrs post shock post op decreases wound infection rates

Bioresonance, photonic therapy, and targeted pulsed electromagnetic field therapy

Chapter 7: Gastric Dilation Volvulus   pages 133-137

History and clinical signs, Diagnosis, Treatment (medical and surgical -decompression, pexy)

When necrosis is present: Partial gastrectomy, tube gastropexy, jejunostomy

Summary protocol of GDV Treatment (medical and surgical)

Chapter 8: Bad Wounds and Fracture/Luxation Management   pages 133-143

Techniques to stop severe external hemorrhage: direct pressure, elevation,

Binding the wound with a tight dressing and Sharpie Report

Pressure on the supplying artery – femoral, brachial, external iliac, caudal aorta

Packing of the wound as deep as possible

Pressure above and below the bleeding wound; Tourniquets; Blood Pressure Cuff

Hemostatic agents - Chitasan shellfish skeleton, polysaccharide beads, zeolite, cyanoacrylates

Protect and prevent from becoming dehydrated; Use of sugar and honey

Irrigation with 2.5 pH electrolyzed oxidized water better over sterile saline

Sedation for wound cleaning, irrigation, and debridement, use of broad spec antibiotics

Closed Fracture & Dislocation Management Principles and Specific Recommendations

Open fracture management – splint application where they first arrive.

Spica splint application with newspaper, cardboard, fiberglass tape

Chapter 9: Management of Penetrating Injuries: Bites, Bullets & Other Objects pages 144-154

Initial management – and general wound management -

Bite Wound Management – exploration need with all – head light and the holes

Gunshot Wound Management and Impalement Wound Management

Tenets of Emergency Management of Wound and Open Fractures

Louie – Yellow Lab with severe leg injury – open hock and CF luxation on other rear leg

Chapter 10: Biophysics Principles used in Surgery, ER and ICU; Electrolyzed Water; Hyperbaric Oxygen Therapy; Targeted Pulsed EM Field Therapy; Photonic Therapy pages 155-187

Basic Biophysics Principles Used in the Surgical and ER/ICU Practice

1993 Start of it – RA Cowley Shock Trauma Center 10 day rotation –Hyperbaric Oxygen

Electrolyzed Water – process and principles, water changes, free electrons, etc.

Nano-clustering of the water in which there is a reduction in nuclear magnetic – resonance

A restructuring of the water via the change of the vibrational frequency of the water

Scientific medical studies of the oxidized and reduced forms of the water

Open clinical studies with the oxidized and the reduced water in dogs, cats, and humans
Case examples of the effects of the oxidized and the reduced water
Hyperbaric Oxygen Therapy (HBOT) - definition – indications – use at RIVER

Why use hyperbaric oxygen therapy –edema, hypoxia, ischemia decreased, stem cells released

Primary mechanisms of action discussed – oxidative stress associated with Low oxygen tensions

Indications for its use in spinal cord, head , spinal nerve, peripheral nerve injury, ischemia.
Contraindications, absolute, relative, Complications
Targeted Pulsed Electromagnetic Field Therapy – mechanisms of action

Research studies – 60% pain reduction, reduces proinflammatory cytokines, edema decreased

Positive effects in cardiovascular & neurological system conditions such as CHF, neuro diseases

Decreased infarct size in LAD occlusion rats with LOOP – decreased mitochondrial dysfunction

Basic science work supports its anti-inflammatory and regenerative effects in neuro diseases

Photonic therapy – 660 nm light – scientific basic science effects and clinical effects

References for the manuscript – and where these can be found.

Chapter 1 - Being Prepared - Prevention & Readiness and Triage

Readiness: From the very first time I was faced with the possibility of having to respond to an emergency when I was a young boy scout (at age 11) to just yesterday when I was an emergency clinician at the RIVER, the first task that I had to perform was to ensure that I was ready. ☺ At the veterinary hospital that means specifically to survey the hospital and ensure that every area of the facility is ready. This includes the lobby, exam rooms, treatment rooms, radiology, lab area, ORs and wards; This also includes then the entire staff, from receptionist to head tech and each veterinarian on duty… that all were prepared to care for the worst case that anyone has ever seen in their life! ooooooOO!!. AND "to make everything ready".

A pioneer in emergency care that coined the term "the Golden Hour" Dr. RA Cowley, was emphatic on carrying out of this goal. **Time** is one thing we all know can really make a difference in outcome when faced with a serious life-threatening emergency. The more ready we all can be (and that includes our entire team) the more effective and efficient we can be. The information presented here on practical readiness is provided to help each clinician and staff with the task of "making everything ready" which will allow management of each emergency patient to be done in the most efficient way possible. Some of this information and subsequent recommendations made comes from my experience and training as a surgeon and emergency and critical care specialist, while some also comes from my 20 plus years experience as a firefighter and medic. For those that need "scientific proof" which involve gaining solid evidenced based double blind randomized placebo controlled prospective trials that have been done and published I submit this: I remember attending a major critical care meeting a few years ago where I heard key speaker say that he would only accept strong evidenced based double blind randomized placebo controlled prospective trials for medical guidelines on the diagnosis and treatments for his patients… I was near the back of the room. The lecture hall was filled to capacity. After he was finished making his key points he asked the audience if there was anyone who would like to ask a question. I walked up a microphone and stand that were nearby. Several of these had been placed at various locations in the room in anticipation of questions from the floor; a common occurrence for scientific meetings such as this where many physicians would be attending. I got my courage up and asked the speaker the following question. "*What about parachutes and their use for as far as I knew no one had ever done a randomized placebo controlled trial to prove that they were absolutely needed and should be used by passengers if the plane they were in was crashing.* The lecturer said yes … a study like this would need to be done. I then asked him if he would volunteer to be one of the people in the control group, i.e., one of those that would jump out of the plane at elevation that was not wearing a parachute. He did not answer…and the entire room went silent! Common sense must prevail. In veterinary, as well as human medicine, much of what we do *must be done without evidence based proven guidelines*. Of course, ideally all the recommendations made for the care of the seriously ill or injured patient would be backed up by solid evidence based studies. But until these are completed and published and have also stood the test of time we do have to rely on our experiences, much of which yet still has not yet been published. At the conclusion of this manual you will find many reference articles to help provide some evidence based information; some are weak and only based on experience involving a few cases, while other evidence is stronger, based on a small series of emergency cases. Occasionally, such as the paper I published involving the closure of ventral abdominal incisions in 550 patients, there is strong evidence supporting the recommendations made.

Now for the rest of the story regarding being ready for all emergencies and being ready to care for *all the sick and injured that you may be confronted with.* Did you know you also have an obligation to care for humans as well (should there be a major disaster)?. **We, as veterinarians and veterinary technicians, are mandated to also care for people in catastrophic disasters by the US Public Health Service…since 1963**. For further information on this subject please e-mail Dr. Paul William who is very dedicated and can speak first hand about his experience. His e-mail address is: paul.williams@gema.ga.gov. He will, as I do, recommend taking both the Basic and Advanced Disaster Life-Support Courses (offered through the AMA) and are taught throughout the US and some foreign countries to provide information that would be helpful for all veterinarians and veterinary technicians to know. Some information about these can be gained by going to the following web site: http://ndlsf.org/course/search. As a member of the National Disaster Life Support Education Consortium I am encouraging each of you to consider enrolling and completing these two courses. In some cases there is a fee and some distance to travel. Some of the courses may be limited to who can enroll but in most others there is no fee and veterinarians and veterinary technicians are welcomed (although often the official signing you up will tell you that they have not had many or any vet techs or vets take the course before ☺. That is OK considering most that do take the courses are only in the human health care field and do not care any other species ☺

Example: Many people made their home at the Astrodome after Hurricane Katrina and the *initial* health care professionals were all veterinarians and veterinary technicians (*members of VMAT 4); there were no physicians or nurses present ☺. They treated multiple numbers of people with lacerations, dehydration, a few with suspected heart failure (people that did not have there heart medications); diabetic issues (again in people with out their medications), and other health issues (suspected pneumonia, stress induced GI issues, etc.). So it is highly recommended to get the training ☺

Here is a bit more information about the NDLS and the reason they are providing courses for all health care professionals (*including veterinarians and veterinary technicians and assistants that are not licensed but work in the veterinary medical field The NDLS Foundation (from www.ndlsf.org)…..*Years before the terrorist attacks in 2001, several academic centers began to develop disaster education programs to meet a perceived lack of medical disaster preparedness. Since the 9-11 attacks, demand has increased for a nationally recognized course in "all-hazards" training to better prepare health care professionals, emergency response personnel, and others for mass casualty incidents. While nationally recognized training programs existed for cardiac life support and trauma management, there was no standardized training program for disaster management. To meet this need, a coordinated "all-hazards" training program was developed by this consortium with financial support from a Congressional Appropriation through the Centers for Disease Control and Prevention (CDC). The members of this consortium were from the Medical College of Georgia, the University of Georgia, the University of Texas Southwestern Medical Center at Dallas, the University of Texas Health Science Center at Houston, School of Public Health and the Georgia Emergency Management Agency. In 2003, these professionals of established the National Disaster Life Support™ (NDLS™) training program to better prepare health care professionals and emergency response personnel for mass casualty events. The overarching goal was to standardize emergency response training nationwide and strengthen our nation's public health system. In order to oversee the rapidly-growing program, the principals established a non-profit foundation, the National Disaster Life Support Foundation™ (NDLSF™), in 2004. The goal of the NDLSF™ was and remains responsible for the establishment and accreditation of a national network of training centers. This (below) is taken from their website.

"The NDLS™ courses stress a comprehensive, all-hazards approach to help physicians and other health professionals deal with catastrophic emergencies from terrorist acts as well as from explosions, fires, natural disasters (such as hurricanes and floods), and infectious diseases. Such non-terrorism events are much more likely to occur. By completing these courses, clinicians will better understand their integrated roles in the broader disaster response system. In large-scale, mass casualty events, physicians and other health care workers must be knowledgeable of the need for efficient coordination among local, state, and federal emergency response efforts; how to protect themselves and others from further harm; how to communicate effectively with other emergency personnel and the media; and how to address the unique psychological impacts and related social chaos that may ensue. "

As a member of the National Disaster Life Support Consortium and a contributor to the development of the BDLS and ADLS Veterinary Professional Manuals (both published by The College of Public Health at the University of Georgia) and the current training program offered through UGA College of Public Health and GA Emergency Management Agency)

In the teaching of the two Disaster Life Support courses (Basic and Advanced) to veterinarians our small team of instructors has taught approximately 250 students in the 2 day BDLS course and approximately 35 students in the 3 day ADLS course that provides significantly more hands on training using human manikins including those that are computer based simulation manikins. In the hands-on training parts of the courses the following were taught and include to taught in current and future courses: triage; immediate field assessment and care need to gain an open airway, stop hemorrhage, cover wounds; transport; and some training on more definitive care including the vaccination against small pox, starting IVs and IOs and providing fluids and even some surgery such as cricothyroidotomies, chest tube placements, definitive hemorrhage control and wound and fracture and burn care (debridement, irrigation, decisions on closure or no closure and splinting and dressing applications)

To sign up for this important training (beginning with Basic Disaster Life Support (generally at no cost) go to Foundation's website: www.ndlsf. The courses (Core, Basic and Advanced Disaster Life Support) are available throughout the world now. In Iowa they are given through the Security Institute Center for Disaster Medicine, Western Iowa Tech Community College, Regional Training Center, Sioux City, IA 712-274-8733 ext 1286 Ask for Ms LaDonna Crilly. The NDLSF office in Georgia can also be reached at 706-721-0969 for more information as well. Again you can also e-mail Dr. Paul Williams at Georgia Emergency Management Agency.

I have made presentations at the AVMA's Emergency and Disaster Issues Committee and have requested that they look into getting actively involved with the helping of sponsoring the BDLS and ADLS courses for veterinarians and veterinary technicians. Lets hope the Committee will respond positively. ☺ No matter what the outcome, we as veterinarians and veterinary technicians WILL someday (most likely) be involved in an emergency situation where you will be in a situation where you will be faced with an emergency at your practice or at your home or when on the highway involving a person or persons that are in desperate need of your help – Please heed this plea… **Get prepared**. I also politely ask that you call your AVMA representative (or delegate) and encourage them to get involved. In major disasters we ALL will be affected and the more we all are prepared ….as it's a basic understanding that we can all be call the better the outcome

Definition: "Readiness is centered on being ready to perform techniques that must be done *immediately* or nearly so when critical patients are first seen". Readiness also involves preparing the OR and making it ready to receive a patient that is in a major crisis from hemorrhage or air leak in a body cavity or a disrupted body cavity that requires immediate intervention. These emergency procedures are those one might not do very often so having a little "time padding" will help provide a little "breathing room" (pardon the pun)... allowing more time to get control of the life-ebbing leak. Regarding this. I highly recommend getting a Satinsky cardiovascular forceps off e-bay or keep looking for one there as they commonly sell for 250.00 and off ebay you my find them for 25.00 ☺ They can be applied to the base of a bleeding or air leaking lung and immediately stop the leak and do not hurt the tissues. They apply gentle pressure to tissues and are applied deep to where the leak is, thus stopping it, so the source of the leak now can seen clearly and can be managed directly with sutures to over sew it or a hemostat and a ligature or two can be applied. For further information see the section on "Damage Control Surgery" that is later in the text.

The "readiness" that I am referring to and the procedures than might need to be done not only apply to the emergency patient arriving at the hospital BUT can also be very helpful in a crisis that can occur even during "routine procedures" such as the OHE on a large in heat German Shepard where the ovarian pedicle pulls away from the clamps before the ligature is applied and blood starts filling up the right abdominal gutter ☺ Here the Satinsky forceps (you had purchased off of e-bay) comes as a "life-saver" as you can apply it deep to the torn pedicle and gain control of the hemorrhage and not have to sweat a possible injury to the ureter. The pedicle can then be found, as there is no further bleeding, after the puddle of blood has been soaked or suctioned up allowing you to see it and then ligate it directly. ☺ Other examples of emergency procedures needed in a "routine day*" caring for patients (* of course not at all routine) are:

1. A severe adverse drug reaction following a vaccination of a young happy English Bulldog leading to anaphylactic shock and severe airway compromise from swelling a vascular collapse. A vascular cut-down was necessary to place an IV catheter and a tracheostomy was

needed to prevent death from asphyxiation.. The owners were so thankful that you were able to save their dog…They understood that serious adverse reactions can occur from vaccinations. The educational pamphlet you had given them on their first visit did explain the rare but possible vaccine side-effect. Being prepared then even includes informing owners about risks to such routine procedures as vaccinations "just in case" something like what happened did happen. I recently witnessed a toy breed dog following fifteen minutes of her vaccination when she became acutely full of welts, and became weak. The owner unfortunately had not been fully informed of this risk and was very upset that she was not told of the dangers of vaccination. Fortunately the owner had had another dog also being seen on that same visit after the dog had gotten the vaccination and was still in the clinic when the angioedema/ anaphylactic reaction became evident so the clinician was able to start anaphylactic reaction care *immediately.* NOTE: recent data suggests that earliest these are treated the better the outcome. Most are best treated ***immediately with subcutaneous epinephrine as the main stay to treat the vasodilatory shock*** occurring as well as the giving of dexamenthasone and diphenhydramine and if needed IV fluid support and H2 blockers as well. In severe cases severe GI hemorrhage and death can occur. Although rare, informing owners provides a huge safety net and will get the condition often recognized much earlier (such as owners noting restlessness, itching, eye redness, vomiting, hives, lethargy and even diarrhea) and proper treatment can then be initiated much earlier.

2. An older Saint Bernard undergoing a dentistry procedure under anesthesia is rolled over to accomplish to complete the dentistry on the other side; and during the process has a **vasovagal inducted cardiac arrest**. (Note: I have taken calls from veterinarians in which this has happened. It might be more common in dogs that have **not** been being ventilated during the procedure **and when they are hypothermic**). Doppler blood flow monitoring done during the anesthesia alerted you to the arrest and CPR was started. Not hearing any blood flow during chest compressions when the *Doppler probe was placed on the eye* clued you in that due to the dog's size, closed chest CPR was not being effective, even after epinephrine, vasopressin and atropine were given and *abdominal counterpressure* was applied… so a rapid thoracotomy and cardiac massage was begun. The patient's anesthesia OF COURSE ☺ had been turned off and the rebreathing bag and corrugated tubing had been dumped, so only 100% oxygen was being given with rescue breathing being given at 12/minute… Yea! Within 1.5 minutes of the heart being directly massaged the heart started beating and massage was

able to be stopped. Aortic cross clamping with a red rubber feeding tube placed around the descending thoracic aorta was not required. It would have been used IF the heart on compression felt literally empty (indicating severe hypovolemia) and then removed slowly after the heart was beating well on its own and done very slowly as vascular volume had been rapidly replaced; and following irrigation the chest was closed after a chest tube had been inserted. The dog's breathing was continued to be supported by a vet tech giving positive pressure breathing until the dog was breathing very well on his own…A nasal oxygen catheter was placed, the dog woke up and the ET tube was removed **. He recovered completely!** The owners were so appreciative. NOTE: In those cases I have been able to follow post CPR that had an emergency thoracotomy with any preparation and the operator only wearing gloves infection rates have been 1 to 4 patients out of 20 surviving over the last 40 years. Bottom line, as exemplified by these "real case" scenarios, is that we must all be ready for critical life-and-death emergencies, *all the time,* even during a "routine" day.

In summary, readiness in every practice is do important! Its something that MUST be always worked on and strived for. It involves being ready in three areas: 1. *The Facility* - regarding equipment and supplies/drugs; 2. *The Knowledge* - regarding knowing how to perform emergency procedures, operative techniques, and having the memorized knowledge of protocols that will need to be followed for the successful management of common emergency conditions; 3. The Teamwork – requiring practice and working together to provide the most effective execution of the resuscitative procedures required for the most common and absolutely most devastating situations. These include: patients presented problems the BIG THREE: A – the obstructed airway; B – the difficult breathing case – that has common causes of congestive heart failure; acute aspiration and centroneurogenic pulmonary edema; and either a chest wall or diaphragm injury or lung injury or spontaneous pneumothorax..not common but not that uncommon as well in patients with pneumonia and acute pulmonary edema. Those that develop from centroneurogenic causes such as partial choking of being the are most common; There are also others that simply collapse from such causes as severe internal hemorrhage from a ruptured spleen due to a hemangiosarcoma or a benign splenic hemangioma (seeing more and more of these), an acute abdomen, pyometra, parvovirus like syndrome with diarrhea and dehydration/vomiting, gastric dilation-volvulus, acute poison agent that can be toxic such as chocolate ingestion, snake bite and spider bite-toxic envenomation, seizures, heat stroke, severe hypothermia or hyperthermia, severe sepsis, severe burns, acute paraparesis – paralysis, bite wounds and crush injuries, anaphylactic shock, aortic thromboembolism, severe hemorrhage, severe pancreatitis, peritonitis, severe wounds and fractures, and urethral obstruction, severe arrhythmias, head and spinal cord trauma, cardiac or near cardiac arrest from many causes and many others that may present like a "routine" case but things went wrong ☹.

Prevention Steps – *Those necessary steps in the anticipation that something could go wrong are also important to do in readiness*. An example is the older patient with dental disease that has renal and cardiac compromise that requires anesthesia for dental prophylaxis and the removal of a suspected tooth root abscess. Prior to the giving of the propofol there was placement of an intravenous catheter while the patient was receiving blow-by oxygen and there was an IV injection of a premed "a chemical courage" drug cocktail of alfaxanone (0.1 mg.kg), butorphenol (0.1 mg/kg) and midazolam (0.1 mg/kg) performed. These steps help preoxygenate the patient and decrease the patient's stress levels and provides a gentle and cardiovascular and renal protective strategy as a preanesthesia and the patient accepted, stress free, a mask for the delivery of 100% oxygen and assisted ventilation with the BVM (bag-valve) and reservoir attached. Isoflurane was then added as a small amount (2 mg/kg) of propofol was given for induction after continuous arterial blood flow Doppler monitoring with the probe taped to the dog's palmer arterial arch was added. (This was accomplished by clipping the hair over the palmar arterial arch and adding ultrasonic jelly onto the ultrasound flat probe and the probe fixed in place tightly with adhesive tape on the central portion of the metacarpal skin above the metacarpal pad (NOTE: very easy to achieve). (You can also find used Parks Medical Electronics Doppler Blood Flow detectors [Model 811-B] and the infant 9Hz flat flow probe and the charger on E-Bay or you can purchase new by going to the company's web site www.parksmed.com The model 811-B is $780.00 and the 9 Hz infant flat probe is $138.00 These will last a life time provided that the box does not fall and the probe is not pinched, pulled hard or cleaned with harsh chemicals or alcohol☺. Tips: Place a section of IV tubing around the handle of the box and tie in a loop and then always hang the box on something like the top of the anesthetic machine – that way it will not fall ☺; Use the plastic case of a 12 ml plastic syringe fitted over the probe and cable to protect the probe when its not connected. This is done by first by splitting the case, then making a hole at the base wide enough to accommodate the cable, and then placing the case halves back together over the probe and cable and taping them back together ☺

Here a photo of one of the Parks Medical Products units out of their internet. They come with a charger. The Infant Flat Probe is the one I suggest getting. The others are not needed. They also carry the blood pressure cuffs and the sphygmomomometer. There is also a place for ear phones but I prefer to hear the flow sound continuously as the patient is being monitored throughout the resuscitation period and in every general anesthesia. The photos below show a well used unit I have had for 25 years – and the Infant Flat Flow Probe attached. It

Since blood *flow* is the most important to monitor, much more than arterial blood pressure* (WHY is blood flow monitoring more important than blood pressure monitoring? – The answer to this question is that BP in heavily influenced by systemic resistance and Q or blood flow or Q ~ is determined by BP/systemic resistance), or pulse oximetry, the *<u>continuous flow</u>* <u>Doppler</u> monitoring provides a key to the knowledge of the patient's cardiovascular status on anesthesia depth and influence on the patient's heart and kidneys on a beat by beat basis.

Every swish heard on the Doppler represents the amount of arterial blood surging past the blow flow detector. Now with the addition of local anesthesia in the mouth where the tooth abscess is, with a combination of lidocaine, bupivicaine and the addition of diluted sodium bicarbonate to keep the injection for stinging, the pain that will caused by the tooth extraction and abscess debridement, is able to be managed *before it starts*. Techniques like this have saved many patient's lives and have "made my day" as one veterinarian said it. Yes many agree; doing a service like this for clients and their pets; being able to managed animal's medical conditions effectively, economically, and with safety make many a health professional team members day as well.

Anticipating and being ready are KEY. *Continuous Doppler blood flow monitoring is more accurate in the determination of adequate blood flow to tissues than is blood pressure monitoring.* It should be remembered that Q (tissue blood flow) is **proportional** to arterial blood pressure / resistance …and not just proportional to pressure alone. This understanding is crucial to the care of the patient, especially when under anesthesia or involved with an emergency patient.

Being "in the ready" involves three areas: Facility + supplies + medications;

1. The facility, drugs, equipment, supplies and layout-organization; having all areas "in the ready" for a critical emergency

When you go back to your practice look around and see how you can position materials such as drugs, supplies, and equipment, to make everything more ergonomicly efficient. An example is having a paper towel dispenser, and waste basket near the site where your hands are washed, and having this all necessary to do the washing. Having oxygen supplied to an AMBU bag with a cone mask attached and a PEEP valve also attached allows immediate oxygen delivery with positive pressure ventilation able to be perform. This BiPAP ventilation system has been very life saving in patients with congestive heart failure and pulmonary edema. A crash cart should be set up with suction, endotracheal tubes, laryngoscope, stylets, cuff inflation syringe, emergency drugs (epinephrine, atropine, sodium bicarbonate, calcium chloride, lidocaine, dopamine, etc.), ECG, defibrillator, Doppler unit, vascular cutdown and tracheostomy instruments, etc. (see below under Crash Cart)

I recommend setting up the OR with everything laid out (general pack, gowns, drapes, gloves, blade, suction, cautery, anesthetic machine and ventilator attached, monitors, IV pole with a bag of Plasmalyte hanging and the drip set coiled up and ready to be used, lap pads, Balfour retractor, feeding tubes) everything needed to perform a resuscitative thoracotomy and aortic cross clamping).

The operating room: This should be set up all the necessary equipment to perform emergency surgery at a moments notice. Having an instrument pack, gowns, drapes, headlight, electro surgery unit, and suture laid out in ready is highly recommended. Magnification loupes are also recommended to be part of the readiness.

Additional equipment: Simple things such as baby monitor, duct tape, cardboard back boards made from cardboard boxes, flashlight, bubble wrap, newspaper and towels for splints and bandages are also recommended.

The CRASH CART: A mechanics cart (3 or 4 drawers) can be used as a crash cart. All four wheels should be made into swivel wheels to allow greater mobility. Go to a fabrics store and buy 1 1 /2 inch thick foam rubber sheets and line the two top drawers with it after you cut holes as needed to hold the emergency equipment items needed. The cart should be used for emergencies only and be restocked after every use. MODULES OR DRAWERS within cart or at least drawers designated Airway, /Breathing. Drugs, Other:

<u>A. Airwav / breathing drawer:</u> This top drawer or module should contain CLEAR plastic endotracheal tubes that have low pressure - high volume cuffs. Pick one of every 2nd or 3rd size of the following :2.0, 2.5 (uncuffed) 3.0, 3.5, 4.0, 4.5, 5.0, 5.5, 6.0. 6.5, 7.0, 7.5, 8.0, 8.5, 9.0, 9.5. 10.0. 10.5, 11.0, 11.5 and 12.0 are the sizes that can be represented. Those made of silicone will require a stylet. Those made of PVC do not generally require the use of a stylet (wire or plastic). Both are "kind" to tracheal mucosa compared to the red rubber varieties. If a drawer is used there is enough room to have each ET tube attached to a syringe loaded with enough air to inflate the cuff moderately. Each of the ET tube and cuff inflation syringe should be nestled in a cut out area in a sheet of foam rubber that should line the drawer. Each ET tube should be fixed with a section of intravenous administration tubing or umbilical tape. *The polyvinylchloride*

tubing of the iv administration set variety when pulled tight around the ET tube, binds well and does not slip as gauze does. Attachment using a Larks Head knot is preferred in that it is very secure and can be adjusted easily, The PVC plastic tubing can be tied behind the head in a bow and can be untied very quickly. Bring the PVC tubing just behind the canine teeth and then below the patient's chin and cross the tubing under the chin and then bring behind the head 4.Tie the tubing firmly behind the patient's head in a bow. The airway drawer or module should contain a Laryngoscope handle and set of blades. A good inexpensive source is a set that has clear blades and lights the entire blade. They are disposable in EMS catalogs.

Other equipment needed in airway / breathing drawer should include:

1 Forrester sponge forceps, curved - to remove foreign bodies & grasp injured tongue/lung

2. Valsellum or towel clam to grasp slippery balls

3. Hemostatic forceps, curved -to remove foreign bodies. Etc. from small patients

4. Mayo scissors, curved. - to gain access to the trachea or chest

5. Strabismus scissors, curved - to gain access to the trachea in very small patients

6 Scalpel blades (10, 15, 11) for airway access and other accesses

7. Cole tubes 1, 2,and 2.5 mm – for very small airways and especially helpful for newborn puppies and kittens and rabbits 8. 14 g Nasal catheter with red rubber feeding tube with side port for attachment to 02

9. 14 g IV catheter, 12 ml syringe and No. 3.0 mm endotracheal tube connector for rapid transtracheal or transcricothyroid cannula placement. The No.3 mm connector allows connection to a BVM for breathing of high frequency ventilations (>150-200 breaths per minute of very small volumes) 10. Tracheal suction catheters - (4.7.11 Fr Yankauer and Dental suction tubing 11 12. Suction units. This should include a rubber ear syringe and a portable suction device. These can be purchased from EMT-Paramedic suppliers. A mechanics hand-held and activated system used to create negative pressure for engine work also can be used for airway suctioning and costs less than a medical hand activated system.

B. Breathing drawer (might be at the bottom where there is generally more room): Breathing assisting equipment such as Bag Valve Mask (BVM) AMBU bag w/ reservoir. oxygen w/ tubing. and masks (for positive ventilation breathing IPPB])

1. BVMs - should be each of three sizes: Adult (700 -900 ml), Pediatric (400-500 ml), and Infant (250 ml). Each must have a reservoir attached to provide 100 % oxygen. Without reservoir's the BVMs can only provide 45% oxygen concentrations. These are the best devices to be used for rescue breathing. The BVM's are attached to a source of oxygen such as an E cylinder and a regulator – flow meter combination.

2. PEEP valves - should be available and used to increase the functional residual capacity of the breaths because of the effect of the PEEP valve on exhalation. This is the best effective treatment for emergency treatment of cardiac congestive heart failure and other pulmonary conditions that decrease alveolar capacity and increase interstitial edema.

3. Y connector – to be used for connection into the anesthetic machine or other oxygen source after the flow meter, so that high flow oxygen can be provided.

4. Regulator and flow meter (attached to an E tank of oxygen) attached to a caddy - to be used as an oxygen source to run the Ambu bag or other oxygen system– *this allows oxygen to be taken anywhere in the hospital including the lobby – reception area – radiology – exam room.* NOTE: Save the human masks as you never know when they might become in need to provide oxygen to a person who has respiratory distress, or with the use of the AMBU bag and reservoir, is used to provide rescue breathing .

<u>C. Cardiovascular drawer or module:</u> Atropine, Epinephrine, Vasopressin, Norepinephrine, Lidocaine, Calcium chloride (or gluconate), Sodium bicarbonate, Hypertonic saline 23.4% or 6-7 %, Hetastarch 6%, DMSO, Desferoxamine, Dopamine, Dobutamine, Plasmalyte, Dextrose 50%, Diphenhydramine, Mannitol, Dexamethasone in PEG, Vitamin C, N-Actelcystine, one bottle of each should be considered as a minimum. Have each bottle of drug held within a space made in the foam rubber. This will keep the bottles from shifting. A space made next to each bottle should be filled with various sized syringes (1 ml-12 ml) loaded with 18 g and 22 g needles. Time will be saved when one can find the emergency drug immediately (a having it easily located also provides a simple way to inventory the cart to know the drug is present… but beware of the bottle that is almost empty ☹. It's the responsibility of the professional doing the crash cart checking to ensure that this is not going to ever a problem. This is the same with the oxygen bottle. It needs to be pressure checked to ensure that there is always a minimum of 500 psi of pressure in the tank and all is in working order and not leaking when it is turned on. Here is a regulator and flowmeter combination as an example (see photo below off a website

that I have ordered from before. This one costs approximately 75.00 and comes from Emergency Medical Products (empbuy.com)

A oxygen caddy – pictured above - that looks like a small golf cart can also be purchased and the benefit of it is that an e-cylinder can be attached and thus ready to be easily immobilized (when the regulator – flow meter is attached) and wheeled to any location in the hospital and used immediately to provide (from 1-20 LPM oxygen flow).

Access Trays for the ability to perform facilitative maneuver (minicutdown), formal venous cut-down, EZ-IO intraosseous cannula placement as well as Blumental (Kendal) IO access and the catheters and cannula's needed to perform these.

Fluids/ Hypertonic Saline/ Colloids/ Crystalloids and administration sets for the delivery of these. Need of a fluid administration pressure bag is important for the rapid delivery of intravenous or intraosseous fluids. It also helps gain control of the patient with severe hypovolemic shock in the rapid way possible… through the most rapid fluid delivery method. Its also important to have fluid pumps as well as these provide a very accurate way of delivering each ml of fluid and tally each up.

Access to fresh and stored whole blood and RBCs and plasma should be available.

D. Defibrillator and monitoring equipment. This includes a Doppler flow detector and pediatric flat probe. ultrasound gel. blood pressure cuffs (at least 2.3.4.5.6. and 7 cm widths or at least a newborn and infant cuffs. and an aneroid sphygmomanometer.. ECG. temperature & pulse oximeter, end tidal CO2 monitors. oscillometric blood pressure monitors and monitors that measure direct BP. ECG. Temperature, respiratory rate, etc. and are made specifically for veterinary use. Used defibrillators are important and can be generally found on the internet for several hundred dollars. It is very important to obtain a DC defibrillator as in CPR the heart, if it progresses to a fibrillatory rhythm will require this piece of equipment to be effective in causing defibrillation. Use approximately 10 Watt Seconds/kg body weight (external defibrillation) and 1 WS/kg body weight (internal defibrillation). In patients that easily convert to a pulsatile rhythm epinephrine may not be needed. However in many cases the arrest arrhythmia may be difficult to convert to a pulsatile rhythm. When this occurs higher doses of epinephrine or the addition of vasopressin will be needed to convert the ventricular asystole or fine fibrillation rhythm to a course fibrillation which can then be converted to a pulsatile rhythm using the defibrillator. When purchasing a defibrillator it should be electrically tested to ensure its output is what the settings indicate. The dose for Low dose epinephrine is 0.01 mg/kg and the dose for high dose epinephrine is 0.10 mg/kg.

E. Equipment (miscellaneous) that is essential. Suction tips: Yankauer for suctioning of the pharynx; Endotracheal tube as suction catheter for suctioning the pharynx and airway when large pieces of vomitus, clots, etc., are present. Tracheal suction catheters for aspiration of the trachea, Poole for the abdomen or thorax; Blankets and Plastic Bags are important to keep patients warm.; A warm water circulation system is also recommended. ThermoGear Warm Blanket, or Bair Huggar or Warm Touch patient warmer are very good units that keep patients warm or can be use to reverse hypothermia. The ThermoGear Warming Blanket comes from an FDA approved device that has been the main warming device used by the US Department of Defense for keeping soldiers warm following trauma. It uses microfiber technology. Although hypothermia is generally tried to be avoided in most cases, permissive hypothermia has also been proven to be responsible for the improvement rate in CPCR in infants and small children from <5% to >25%. In these cases it is recommended to also have ice cold fluids (saline, Plasmlyte, Normosol R) in liter bags in the refrigerator and in the frozen section as well. Simple ice bags are also recommended. New research has revealed that use of induced hypothermia to 31 degrees C to be life and heart and brain saving. In my practice I purposefully do not warm patients when they are in the OR and **use acepromazine as an "arrhythmia involved with the hypothermia protector "**. I also use permissive hypothermia with temperatures commonly reaching between 89-92 degrees F for patients receiving extensive surgeries. I ALWAYS use small doses of acepromazine (0.005-0.01 mg/kg IV) as a premedication as it prevents vasovagal inducted brady-arrhythmias and tachyarrhythmias as well. Use of various devices can be used to prevent severe hypothermia: warming blankets; warm air circulators, warm water circulation blankets; Are are made for anesthesia and postop recovery and in the ICU to help sustain core temperature but do not get worried if the patient's temperature drops below 90 degrees.

NOTE OF OBSERVATION: I have performed over 100 surgical cases in the last year alone that have had core temperatures averaging 94 degrees and with some reaching as low as 84 degrees *without any complications* as are being implicated in the literature (increased infection rates, coagulopathy and bleeding) – **so I recommend the use of permissive hypothermia as it has been shown to decrease oxygen radical formation and inflammatory cascading.**

<u>Surgical pack and sterile towels and laparotomy pads for emergency surgery</u>. **The sterile towels are useful for packing. protecting and absorbing.** Feeding tubes of various sizes and stopcocks are also needed to be used as IV catheters, and for vascular occlusion . Peritoneal dialysis catheters for diagnostic peritoneal lavage and for emergency dialysis. Thoracentesis sets made from an IV extension set with a stopcock attached on one side and an 18 gauge needed on the other side. A commercial centesis, minichest drain can also be used and is recommended. 14 g IV catheters make very good minichest tubes for small dogs and cats. Chest tubes with inner metal stylet* for guidance into the chest cavity (size 12 to 32) (Kendall or other suppliers). *BUT NEVER USE THE STYLET TO PUSH THE CHEST TUBE INTO THE PLEURAL SPACE AS DANEROUS PUNCTURES TO LUNGS, HEART OR VESSELS. These have, unfortunately been documented BUT the puncture technique has continued to be taught and was even pictured on the cover of a past *Vet Compendium.* You can use clear sterile disposable endotracheal tubes 2 mm to 10 mm OD as good substitutes for "chest" tubes. A section of metal coat hanger or aluminum rod of small diameter than the ET tube can be used to guide the tube in place with care not to have them protruding from the end when using them. Anesthetic ventilator.

Laboratory testing and imaging abilities (radiology and ultrasound) are also key as well as monitors for Doppler flow, BP. SpO2, ETCO3, temperature, etc.

2. The knowledge – knowing or having the ability to look up protocols

3. The team of care givers - beginning with a veterinarian and including the support staff (technicians, assistants, receptionists, etc.). A *minimum* of two people is recommended in the management of each emergency patient. Emergency care is stressful …**but keep smiling** ☺☺☺ **The Power of Positive Thinking is very important**. This also helps owners who are naturally worried and stressed. Communication skills are also important and each team member must be mentally ready to face the demands of emergencies; unscheduled, stressful, long hours, after hours, always seems to be with some limited resources (especially help) so macgyver tricks often necessary (example: using towel clamps to hold a flap of skin or even using safety pins to do the same) when short of manpower to hold the skin flap while debridement is being accomplished.

And the Practicing the assessments and emergency procedures, and knowledge of what to do as a team working together to perform the effectively and efficiently - a good idea but seldom gets accomplished. Having training sessions – even a few (done when its slow or snowing ☺ is recommended. Using cadavers to practice procedures and having drills where scenarios are worked through is a great way to keep the team "at the ready" and its FUN! Bring the Pizza ☺☺☺

What is provided first – Putting it prospective: That which we can provide first will have the most impact regarding how the patient ultimately does, such as applying that *spica newspaper splint to a dog with a midshaft* humeral fracture as apposed to putting on a Robert Jones dressing made of cotton... the former giving the dog what he needs: stability and pain with immobilization of the joints above and below the fracture, as apposed to the latter which only makes the dog more painful and provides him with a "Ball and chain" to wear below the fracture and possibly causing radial nerve injury that can lead to a real possibility or the dog needing the limb later **Unfortunately I have seen a number of these ☹.** The veterinarian's and his or her teams intensions were good but the dogs suffer irreparable damage.

Another example is Jake that underwent an emergency surgery for the removal of a foreign body. This required the removal a good length of bowel (approx. 50% of the jejunum). The bowel anastomosis that was done with 4-0 PDS and the simple interrupted sutures only had ~~grasped~~ the submucosa slightly or not at all. Four days later the dog represented with fever, vomiting and a painful abdomen... the bowel anastomosis had broken down and the leak of intestinal contents had caused severe peritonitis. If only the bowel anastomosis had been done with each bite getting a very good bite of submucosa with a non-absorbable polypropylene or PDS and if in doubt then serosally patched with a section of nearby bowel loos would have prevented the catastrophic leak. This has been proven. The technique also has been very successful for the management of these breakdowns when a second surgery is needed. Crowe, DT: Serosal Patch: Use in 12 Animals, Vet Surgery 13:29-38, 1984

Triage: "The act of sorting" first used by the French in the time of Napoleon. The medical officers would determine which soldiers could go back to the fight and which were too injured to continue. It was not to sort them in to their priority of care needed. But that what the term today has meant " to sort into the priority of the care health need. As a patient first arrives the nurse (veterinary technician, veterinary assistant) or even a doctor does a quick assessment from a far and then closer up and then maybe even a stethoscope applied to determine the urgency of care needed. This is a quick Level of Consciousness, Airway, Breathing and Cardiovascular, Disability (walking or not) and Everything else. This assessment also involves gaining a brief history and applying the question "just how critical does this patient need to be seen?" Some have given the priority of need as the following: Red (needs to be cared for now); Yellow (second in priority); Green (stable – has time yet to fully evaluated).

Generally, in most practices, the initial act of triage is done by the receptionist so training in this initial assessment at the door is recommended. Not only is the dog or cat or other pet animal given a quick look but the owner or agent bringing in the dog. Safety is primary. Rarely would a person arrive with another intension. If that were suspected (rare) a means of alerting others (those inside behind the service doors, and the authorities). The patient is scanned for the LOC (level of consciousness). This is the primary way this at the receptionist would determine the *red* patients. Those in seizures or appearing unconscious are going to be the MOST urgent so when these are seen the receptionist should call for an "immediate care required STAT". The receptionist can also take a quick look for breathing difficulty and color and notify the triage nurse. He or she should do a quick assessment of the patients breathing and pulse / color by listening, looking and feeling. *Anything that suggests urgency should be followed with the triage nurse asking the owners to bring the pet with them to the ready area (treatment area) often through the next set of doors to the "action side of the hospital" where generally only the veterinarian(s)and staff work (the "BACK" as is often noted by all* This allows the owner(s) to see that actions will be immediately taken to begin stabilization. The nurse should have authority to ask the owners if an IV and oxygen administration can be started.* Further history from owners can be taken from them by the triage nurse or receiving doctor while these actions are started. Then after the oxygen is started (blow-by with a cover of clear plastic over them to concentrate the oxygen) and clipping and prepping of the leg for the IV catheter is started. NOTE: Chlorxylenol (Technicare by Care Tech Labs) is ideal to be used as the prep agent is sterile and not nearly as dangerous if it gets accidently in eyes and its killing is very broad spectrum and lasting and fast – seconds needed to decrease bacterial population.

A Critical Care form that literally states that the pet has a life threatening condition and this document they signs gives informed written consent to continue with care needed up to x dollars (generally from $300 to 500 but for some such as a GDV or other condition that will require emergency surgery the form may go to 1500 or more). This is what we do at RIVER and has worked well at other hospitals as well. IF the owners cannot go further we will need the IV catheter for humane euthanasia is that is appropriate. We attempt to get the minimal costs involved paid but will never turn down an owner if they have no funds. **We will always provide first aid care and exam assessment without a fee (and begin analgesics) while this is all sorted out. This is our philosophy and believe it goes well with all in mind. Providing Compassionate First Aid Care as our First Obligation. Hope that rings true with all other veterinary practices**.

NOTE: One exception the bringing the patient both to the BACK immediately is if the nurse believes that separating a dog from her owner might stress the dog so much that it could be life-threatening. An example is the following: a 10 year old toy poodle is obviously having trouble breathing and is being carried by an elderly lady who also appears stressed and having a bit of increased breathing effort herself. The triage nurse notices this and says "mam, just sit right here a second and the lady sits in a chair provided … the nurse walks 10 paces, gets the where portable oxygen tank, turns it one and dials 5 L/M oxygen and asks the owner to direct the stream of oxygen from the end of the oxygen hose to the patient's face. By doing this both the pet and the owner will receive supplemental oxygen and give them an opportunity to rest. In the mean time other preparations can be made to receive the difficult breathing patient. The owner can be reassessed and if she appears ok then fine, but if she is also having more difficulty more urgent steps can be taken such as calling 911 if necessary.

Word of Thanks: I thank all the veterinarians and support staff of the RIVER (The Regional Institute for Veterinary Emergencies and Referrals) for all they do and the ability to provide the teaching and training of vital life-saving techniques, many of which have been developed over the last 30 years.

Summary of Readiness: All care begins with a preparation of readiness, but especially those involving emergencies and especially bad trauma. The ready area must include preparation of a trauma resuscitation area, often determined best to be the anesthesia induction area. The operating room must also be held in a state of readiness as well. Items that are needed to be prepared include having the following items ready: suction, electrosurgery, monitors (Doppler blood flow, ECG, blood pressure, temperature, volume-cycled ventilator with the anesthetic machine, surgical clippers, IV poles, instrument pack to include special instruments such as Balfour retractors with the bladder blade, Satinsky forceps, DeBakey forceps, stapling devices (optional but preferred), and various types and sizes of suture of which must include polypropylene (6-0 to No.2) on swaged on taper curved needles. Readiness of course also includes having a radiology suite that is prepared and that includes to ability to provide supplemental oxygen delivery; It also means being ready to rapidly provide positive pressure ventilation, ultrasound and laboratory analysis capability. Staff must also be trained, and ready mentally and physically to provide emergency care for the most life-threatening traumatic (and non-traumatic) conditions. Having drills using canine and feline models and cadavers periodically to "practice" running "trauma care codes" is highly recommended.

Chapter 2 - Review of Practical Emergency Care and Procedures

The object of this review is to convey new scientific information and resultant practical techniques that have been developed that are applicable to the care of the severely injured patient. One near death, severely injured patient is then briefly presented to **exemplify A – airway, B-breathing C- cardiovascular, D – disability, E – everything else techniques that contributed to recovery.** Three others are then also discussed briefly to also emphasize important innovative care points or procedures that contributed to their survival and complete recovery. It is the opinion the author that without these that each one of the patients would not have survived.

Trauma and other emergency conditions can affect many body systems and a priority of need dictates the appropriate response. This priority concept is not new and is still based on the ABC's. However new experience has provided an increased emphasis on the importance of a clear airway, support of ventilation, early arrest or at least the augmentation of hemorrhage, and metabolic supportive techniques that are either designed to provide the oxygen and substrates that are necessary, or the augmentation of the bodies need of them. An example of this is use of hypothermia and induced coma or "anesthesia" that places the patient in a state of "cell hibernation" for a period of time. This time allows the shocked cells to recover enough that they can resume a gradual return to normal function. At this time we are using **mild hypothermia** (93-98 degrees) in resuscitation when surgery is not required and **moderate hypothermia** (89-92 degrees) during resuscitation when surgery is required very commonly during the initial phases of trauma care. Then after restitution of the patient's oxygen debit and hypovolemia active rewarming is done <u>slowly</u> over 6-8 hours. Its interesting that we have not seen coagulopathy effects being exaggerated by the hypothermia (exemplified by the cases we have documented)

Past scientific studies revealed that **blood pressure monitoring is not been accurate in determining that amount of volume needed in resuscitation** and recent experience I have had revealed that the use peripheral and core blood Doppler blood flow, peripheral temperature, and mucus membrane color and capillary refill time were criteria that could be used in the accurate evaluation of circulation rather than blood pressure. It is explained that the reason blood pressure monitoring is not accurate in evaluating cardiovascular status is because resistance (which is also very important in determining flow) is not able to be measured. Recalling that blood flow (Q) = blood pressure/ *vascular resistance* the author has, for the last eight years, accumulated data that supports the hypothesis that pulse flow and rate (by Doppler assessment) far more important than the actual blood pressure (systolic or mean) in the determining whether some type of intervention is required. In the author's experience in the management of greater than 500 patients under general anesthesia only when blood pressure is drastically low (mean below 35 systolic below 50) has blood pressure measurements coincided with cardiovascular decomposition or post anesthesia complications of renal dysfunction. It is reasoned that that basis of this finding is that these patients were under the influence of vasodilating substances (e.g., isoflurane). Thus, *because vascular resistance was significantly lowered the driving systemic pressure needed to provide adequate flow was also greatly decreased*. Others have noted this same observation but have not, in the author's investigation, ever published their results. This is the first publication and presentation, other than what the author published and presented in Europe in 2007 and 2008, where the data is provided.

Norman Shumway MD, FACS, who was a pioneer in heart and lung transplantation in the 1960's and who's team was responsible directly or indirectly for the success of the first transplants, including the now famous one done by Dr. Christian Bernard in South Africa. He found that in both dogs and humans that a mean blood pressure of 40 mm Hg was adequate to maintain GI, liver, renal, brain and heart perfusion when the subjects were under general anesthesia and were mildly to moderately hypothermic. He also gained an appreciation for the use of the "black box" Doppler flow detector as one of the key monitors in the perioperative period, including very small pediatric patients that required cardiovascular procedures. (Note: This was told me by Dr. Max Harry Weil when I was a Clinical Associate Professor at the Critical Care Institute in Palm Springs, CA in 2002; Dr. Weil had first hand experience working with Dr. Shumway and told me this observation Dr. Shumway had). In a nutshell… use the Doppler blood flow detector as your main method of determining adequate blood flow; its not ideal but it has been a reliable tool in the accurate assessment of such in my hands for the last 30 plus years. Waiting of Laser Doppler and digital reads of microvascular flow in combination of macrovascular flow that is easily applied in the future to take its place ☺ In the mean time… attach the Doppler flow probe to the clipped palmar side of the paw, place the probe in the middle with plenty of ultrasound gel, tape it securely there (just proximal to the metacarpal pad), turn on the unit and listen to the flow. A swish-swish sound with each heart beat provides input as to both dynamic systolic flow and diastolic flow; ideally if the animal is large enough, your should hear both quite well, indicating adequate flows; if the sounds become jerky and quieter and there is a loss of the second swish flows are becoming less and thus alerts you of this fact so measures can be done to reverse this. The Doppler probe can also be used as an esophageal probe by attaching it to an esophageal stethoscope or another endotracheal tube (with its connector taped shut so no one will inadvertently try attaching and anesthetic circuit or AMBU bag to it. The Doppler probe can also be used on the surface of the cornea to detect blood flow deep to the orbit. This provides and index to cardiac massage effectiveness during CPR as there should be a flow sound generated each time the chest is compressed or the heart is squeezed. No flow sound mean equals not effective flow.

The following techniques, most developed by the author, or adapted by the author from techniques in the care of humans, which have been found to be critical importance in the care of seriously injured small animal patients:

1. AB. **Rapid and aggressive use of the tracheostomy including awake tracheostomy followed by positive pressure assisted or completely controlled ventilation with PEEP and suctioning of the airway**. This is especially used in the severely pulmonary traumatized patient that allows tracheal toiletry and direct support of ventilation; It is

especially important in cases of severe head trauma with resultant hemorrhage, severe pulmonary contusion and intrapulmonic hemorrhage, and pneumonia.

An alternative is rapid sequence induction anesthesia with an opioid (hydromorphone 0.1 mg/kg or fentanyl 0.06 mg/kg or an opioid like drug such as butorphenol 0.2mg.kg) and a dissociative such as ketamine 1 mg/kg and a hypnotic such as midazolam 0.1 mg/kg – some cases a muscle blocker such as atricurium 0.25 mg/kg or pancuronium 1 mg/kg maye be used. Also etomidate 01 mg/kg or alfoxalone (same) can be used to allow airway intubation access. Very small doses of dexdomitor may also be used (120-150 mcg/M2 at 50.5 mg/ml the dose starts approximately at 0.12 ml for a 20 lb dog).

2. AB. **Jet-blow by oxygen stream ventilation, where, on arrival the spontaneously breathing trauma patient is provided a forceful stream of 100% oxygen delivered directly to their nose and mouth area**. The stream is generated by attaching a 14 g IV 1-2 inch catheter to a commercial oxygen tubing line or to an IV solution administration set that is connected to a flow-meter regulator or to one arm of a Y connector that is placed in-line with the oxygen supply line of an anesthetic machine prior to it entering into the circle-system part of the machine. The jet stream delivered to an animal that is open mouth breathing will assist that animal's ability to take in the fresh gas on each inhalation effort. The jet stream will also provide a small level of positive airway pressure during exhalation and assist in increasing functional residual capacity. This will decrease the patient's level of work of breathing and be particularly beneficial in those patients with pulmonary contusion, intrapulmonic hemorrhage and edema. It is used during the initial phases of care when IV access is being obtained.

3. AB. **Noninvasive ventilation by use of a bag-valve-mask and the attachment of a PEEP valve on the exhalation arm of the bag-valve.** This provides the trauma team the ability to administer Bi-PAP ventilation on almost on a moment's notice whenever any patient arrives that is having difficulty with breathing. The Bi-PAP ventilation involves the squeezing of the bag with each breath the patient attempts to take thus giving an assisted ventilation which lowers the patient's work of breathing. When the patient exhales the exhaled breath is somewhat impeded by the peep valve which causes in retainment of some of the exhaled breath which increases functional residual capacity**. Animals that arrive conscious enough to fight a mask are given an IM or IV injection of ketamine 1-2 mg/kg, butorphenol 0.1-0.2 mg/kg, acepromazine 0.01 – 0.02 mg/kg.** Other combinations can also be tried as well as the stimulation of acupressure points that are calming (behind the ears, at the median cubital space, on the top of the head between the ears, using pressure, 660 nm near infrared light, needles, pencil point). It is then recommended to perform immediate ultrasound focused examination on the thoracic cavity to determine whether pneumothorax is present. If present then the thoracentesis or a chest tube may be needed as this noninvasive support ventilation may cause additional increases in pleural air. The mask can also be taped to the patient's head or placed into a cloth muzzle to continue the Non-Invasive Ventilation with a mechanical ventilator.

4. AB. **The automatic "routine use" of mechanical ventilation for support of pulmonary function during the first few up to 12 to 24 hours immediately post admission in severely injured patients.** In the past when pentobarbital was available we would keep very sick patients on a barbiturate induced coma as it was organ, especially the brain, protective. After induction, generally done with a dose of hydromorphone or oxymorphone 0.1 mg/kg and possibly the addition of diazepam, midazolam or even a small dose of acepromazine (0.02 mg/kg) the patient would be gently intubated and the place him on a continuous rate infusion of pentobarbital to create a barbiturate coma and allow the patient to tolerate the use of the mechanical pressure support ventilation. This would be done with the lease of positive pressure needed to expand the lungs – called a protective lung strategy. Most cases could be ventilated well with peak inspiratory pressures of 15-17 cmH2O. Then PEEP or peak end expiratory pressure at the conclusion of the exhalation phase of each breath would be given, as this addition to the "protective lung strategy" would decrease shear stress on the airways, provide pressure during exhalation to prevent the "edematous alveolar walls from caving in, and decrease airway resistance by also helping to mobilize the lymphatic fluid and help "literally pump it into the pulmonary lymphatic system.

Cases this has especially be helpful have been bad pulmonary trauma, congestive heart failure, acute aspiration and pneumonitis, and pulmonary edema secondary to electric shock, choking, head trauma, post CPR, and acute sepsis. Now with the loss of pentobarbital we give phenobarbital or more often use propofol for induction at 2-4 mg/kg , and maintain the anesthesia with approximately 0.3 to 0.4 mg/kg/min. CRI (continuous rate infusion). This will generally keep the patient in a acceptable light plane of anesthesia, and the drip rate can be adjusted as needed. Rarely we have used atricurium, a nondepolarizing muscle blocker (0.25mg/kg initially and then approximately the same CRI dose of 0.25 mg/kg/hour to effect. This is generally used only for a short time (hours). The range with > 40 cases we have tracked has been a range of 2-48 hours with an average of 14 hours. Indications looking for that tell you can stop are cardiovascular stability, better and sustained oxygen and CO2 levels and other parameters such as the patient holding its body temperature and good urinary output.

5. C. **Hemostat assisted large-bore catheter venostotomy is performed at the onset of arrival of the severely injured patient.** An incision is made with an 18 gauge needle over the top of the intended peripheral vein, in most cases the cephalic vein. A curved Halstead mosquito hemostat is then used to quickly dissect out the vein. The hemostat is placed under the vein and pulled distally to stretch it out and place it under tension. Then a 14 to 18 gauge short intravenous catheter is inserted into the exposed and stretched vein with 14 gauge used in large dogs and 18 gauge used in small dogs or cats and 20-22 g for very small cats and dogs. The use of the small curved hemostat to isolate, expose and tense the vein is a key part of the technique that will allow placement of a catheter in less than a minute into vessels that are otherwise difficult to catheterize.

6. C. **Rapid determination of peripheral venous pressure is able to be performed utilizing gradual lowering of the fluid bag that is running at wide open during the initial fluid delivery phase**. When the drips in the drip chamber stopped this indicates the peripheral venous pressure has been reached. The height of the drip column is then noted and measured. Any negative number indicates a low venous pressure below normal. If hemorrhage is controlled then the fluid support is continued until the venous pressure is positive. Not until hemorrhage is arrested should fluid support being given as a rapid rate to overcome the negative pressure as this would allow further continued hemorrhage to occur any more rapid rate. Peripheral venous pressure is used as a barometer to indicate CENTRAL venous pressure when the leg is pulled out straight and this may be an index to venous volume (provided there is no other reason for elevation such as tension pneumothorax, or a medastinal mass. It is not the most ideal and so it is also recommended to utilized thoracic and abdominal ultrasound to assess the great vessels size and heart filling… a quick look TFAST and AFAST extended… see below

7. BCDE. **Rapid diagnostic ultrasonography of the abdominal and thoracic cavities (TFAST [Thoracic Focused Applied Sound for Trauma] and AFAST [Abdominal Focused Applied Sound for Trauma] are highly recommend as well as physical examination of the thoracic and abdominal cavity in most severely injured patients that are not immediately going to the operating room for surgery**. Thoracic ultrasound is very useful in the detection of pneumothorax, by noting a loss of the lung slipping of the plural surfaced or glide sign"; as there should always be a glide sign normally in all lung fields; pulmonary interstitial edema, by noting, "comet tales" in the lung parenchyma; hemothorax, by noting the sigmoid sign on M mode and free fluid in the pleural space; pulmonary contusions by noting changes in echotexture through the lung fields, and diaphragmatic hernia by noting the loops of bowel or liver or spleen within the thoracic cavity. It can be done very quickly and with less stress on the patient compared to thoracic radiographs. On short haired animals all that is generally necessary is wetting the hair was alcohol and the use of ultrasound jelly. I call this (the use of and ultrasound probe my "new stethoscope" Abdominal ultrasound, in the form of a focused abdominal systematic exam for trauma can also be completed within a matter of minutes and with the patient and the most positions of comfort, that of generally right or left lateral recumbency. In very some patients have breathing difficulty they can even have their chest lifted up and the US exam done with the patient "standing.

8. C. **Augmentation of the rate of hemorrhage by the use of counter-pressure**. When pressure is applied to an area of active hemorrhage four physical changes occur. A. The physical hole where the bleeding is coming from is made smaller. This greatly affects the flow of blood through the hole because of the physical law that applies [$Q = r^4$] where Q = flow rate through the hole and r = the radius of the hole. B. Making the hole smaller increases the luminal tension on the hole via the Law of Laplace [$T = l/r$] and this provides increased physical forces that tend to close the hole. C. The hole "channel" becomes thicker which proportionally increases the resistance of flow through the hole. D. The pressure gradient or differential across the hole decreases where Delta P = vessel lumen pressure

[Pvl] – pressure outside the vessel lumen [Pov], which also includes the tissue pressure of the hole itself [Pt]. Taking these physical changes into account, adding any amount of external pressure on the area hemorrhaging has the capability of make a substantial difference in the rate and amount of hemorrhage.

-Adding the external counter-pressure to a limb or abdominal cavity-pelvis and pelvic limbs can be done with simple materials such as the **application of towels or bubble wrap and then tightening with duct tape.** This also forces the patient to be immobilized which also decreases the chance for clot disruption. In some cases use of analgesics is required to prevent undue pain while the counter-pressure is applied. The amount of pressure needed to make a difference in blood loss has been found experimentally to be dependent on the pressure in the vessels that are hemorrhaging. Most hemorrhaging from the liver or spleen was found in a 1985 study to be able to be controlled with an abdominal pressure of 20 cmH2O and slowed down proportionally with pressures below that. The research showed that when towels and duct tape were used as a wrap around the abdomen, pelvis and pelvic limbs of anesthetized dogs that intrabdominal pressure could be easily increased to 30 cmH2O. In a critical high pressure abdominal hemorrhage research also has shown that even aortic and renal artery hemorrhage could be stopped or at least slowed by the use of sustained counter-pressure. In research dogs when enough pressure was used externally to control aortic hemorrhage the compression also caused grossly apparent ischemia to urinary bladder if the pressure was sustained for more than 1 hour. Therefore the recommendation is to gradually to start releasing the counter-pressure after a maximum of 30 minutes (the time thought necessary to provide stability to the clots formed at the hemorrhaging source.

Another clinical tool that might be tried to help hemorrhage stop is the use of epsilon aminocapric acid which as a anti-fibrinolytic agent that prevents the breakdown of fibrin. It is also used in the treatment of German Shepherds with degenerative myelopathy as it inhibits clot breakdown in the central nervous system thus preventing collateral severe collateral damage. It's action post trauma hemorrhage particulary in Grey Hounds where there is a higher amounts of hyperfibrinolysis and also possibly in surgery involved with cancer resections (especially when involving the lung, prostate, stomach, bladder, kidney). Urinary fibrinolysis, usually a normal physiological phenomenon, may be associated with life-theatening complications following severe trauma, anoxia, and shock. An indication for its use if hematuria is also observed post trauma or post surgery. The dose is 150 mg/kg IV and then 12.5-15 mg/kg/hr for 3-5 hours (extrapolated from human trials). Another drug that also has similar action is Tranexamic acid and this is given as 10-15 mg/kg IV slowly over 10-15 minutes and then 2 mg/kg/hr for 3 hours or in cases that will need surgery starting dose is 10 mg/kg IV just before the incision and then 1 mg/kg/hr IV until closure.

From clinical experience it has been noted most canine and feline patients that arrive at a veterinary hospital hemorrhaging are hemorrhaging from non-high pressure vessels. Those in which hemorrhage is coming from a high pressure vessel like the aorta, for the most part, never arrive alive. Therefore the type of external pressure that is generally used for those animals with suspected or confirmed internal hemorrhage is 10 to 30 centimeters of water. This amount of pressure is quite capable of slowing or stopping most hemorrhaging sites. It is left in place very tight for 30 minutes and then gradually decreased and when less than 10 cm H2O the wrap is left on fromn2 to 8 hours and then gradually decreased completely. **Those not stabilizing are provided with additional supportive care such as blood transfusions etc., the pressure reapplied and if the stabilization still cannot be established or not achievable, emergency surgery would be needed (and possibly the need for autotransfusion)**

If the stabilization did occur then the patient would be continued to be monitored (exam, PCV, TS, Glucose, Lactate) very carefully, the "operating room continued to in the ready" and with a mild (70 mmHg) amount of arterial hypotension allowed to continue for an hour. IF the PCV, TS, Glucose and Lactate (or venous pH, HCO3, oxygen tension, if available) remain stable and not worsening then the counter-pressure is continued for along with the permissive hypotension for an hour and then gradually released over 2 – 4 hours, again continuing to monitor carefully. A repeat **AFAST ultrasound can also help determine the ability to keep on a non-operating approach as the AFAST should reveal a not worsening AFAST score (1 = one quadrant showing hemorrhage, 2 = two quadrants showing free blood, 3 = three quadrants showing free blood, 4 = all four quadrants showing free blood, 5 more blood in all quadrants These scores also generally correspond to drops in PCV/TS and not improving lactate levels – 2 is normal, 4 is concerning, 6 is worrisome; so lactate level going higher rather than lower is a sign that the lactic acidosis and shock are continuing to bleed internally and exploratory surgery will be required.**

Those patients that are candidates for immediate surgery and internal counter-pressure are those in which it is clinically apparent that massive hemorrhage has occurred in either or both of these cavities and is continuing. These animals require immediate exposure of one or both body cavities and the application of the "direct" counter-pressure over the exposed bleeding sources. Rapid abdominal and thorax access can be performed via a parasternotomy and midline celiotomy and can be all performed with a scalpel and curved Mayo scissors. A Belfour retractor comes very nice to have to literally hold the abdomen open while exploration and repairs are completed.

Electrocautery units and Titanium Vascular Clips are useful to stop major vessel hemorrhage as the approach is completed, ie., the intercostal vessels as they are cut when the parasternotomy approach is made. **Sterile towels are used to pack hemorrhaging sites**. **Use of a Rommel tourniquet (feeding tube used as a loop around the structure hemorrhaging and then a hemostat slid down to tighten the loop)** or the use of a Satinsky forceps placed across the hemorrhaging structure are used as needed to control hemorrhage from such organs as the lung, liver, kidney, iliac and femoral artery or vein, or even larger structures such as the vena cava. **Aortic cross clamping** is performed prior to opening the abdominal cavity if blood pressure is nonexistent as this provides necessary flow to the brain and heart. Autotransfusion is needed with the blood that is present within the thoracic or abdominal cavity if it is large amounts. In some cases even blood that is grossly contaminated the blood is collected and used using a macro (170 micron) filter and micro (20-40 micron) filter.

9. C. **Use of hemostatic agents such as the methocellulose bead products, the shelf-fish exoskeleton based chitosan containing materials like Celox or HemCon, the thrombin and collagen based mixtures, and the tissue bonding cyanoacrylic glue materials have all have helped in the control of severe hemorrhage**, at the scene, in the ER and in the OR. Although only approved for use externally, some have been used internally without adverse effects. Temporary inflow occlusion of blood into the bleeding sight, the physical wiping of the blood away from the bleeding site, and the placement of the hemostatic agent into the bleeding site, have been important techniques to do to stop the hemorrhage. Ultrasound instrumentation to provide hemorrhage control has also been used.

10. C. **Use of intralumenal occlusion balloon typed catheters** have also been used effectively for the control of hemorrhage in people but only a limited extent in cats and dogs. They are routinely used in large trauma centers to provide "non'operative" invasive means of controlling bleeding sites particularly in difficult to expose and control areas. Interventional radiologists work as part of the trauma team and are "on call" when needed to provide occlusion to the vessels feeding the bleeding site. In some cases the site is completely controlled and requires no further intervention. In some cases however this technique is used to provide a temporary control until surgical exposure can be accomplished.

11. C. **Based on oxygen demand of the various tissues and "bleed out rate and total accumulation" most severely hemorrhaging trauma patients will require autotransfusion of the accumulated blood from either or both the thoracic and abdominal cavity for them to survive**. Or if its not blood that is accumulated where it can be harvested and then infused. If the blood loss can not be treated by autotransfusion then whole blood and packed red blood cells and fresh frozen plasma or banked plasma would have to transfused. Autotransfusion is best accomplished with commercial autotransfusion systems such as the SureTrans™ Autotransfusion system (Bard Devol, Inc., Warwick, RI, davolinfo@crbard.com) is an easy-to-use device providing simultaneous collection and reinfusion of autologous blood following orthopedic surgery. It can also be used for abdominal and thoracic collected blood; In emergency conditions the blood can be aspirated into a reservoir (suction canister, 60 ml syringe) and simply administered back to the patient immediately using a basic 170 micro blood filter. (Or in some cases no filtration can be done and there will be a risk of clot infusion but in some emergency cases this risk must be taken. Case examples have included the following:

1. DSH MN Cat – BB perforation through the hilus of the liver – used a 60 ml syringe and gauze sponge against the tip to act as a "filter" and aspirated the free blood from the

abdomen and transfused it into the jugular vein through a catheter; 4 60 ml syringes of blood was autotransfused. No anticoagulant was used – the source of the bleeding was found (a hepatic vein branch), isolated and ligated and the bleeding stopped. Fluids continued postoperatively for 24 hours and although ACT (activated coagulation times) increased that cat eventually recovered and was discharged well.

2. Mixed Breed MN 3 yo Blue merle cattle dog– ran into a long section of iron reinforcement rebar and it entered the thoracic inlet and penetrated the right lung, diaphragm, right lateral lobe of liver, several sections of small intestine and inguinal cavity. On transport into the hospital the dog became unconscious and very pale; he was taken to the OR after large bore IV catheters were placed by cut-down and Plasmalyte A 7.4pH was rapidly infused; the airway intubated, and he was placed on a mechanical ventilator; the thoracic and abdominal cavities were opened and blood autotransfused via the suction canister and the top side corner of the Plyte bag that was cut to make an opening to accept the blood being poured from the suction canister; The right lung lobes containing perforations were elevated, cross clamped and their bases ligated; the liver lobe was managed the same way, the openings in the bowel were closed and serosal patched. Approximately 1500 ml of blood was autotransfused despite the contamination with succus entericus. He remained on the anesthetic ventilator for a few hours and was gradually weaned off and other supportive care provided (analgesia, broad spectrum antibiotics, fluids, enteral feeding, etc.) and was discharged alive and well 5 days post injury (as memory serves me from the case files of 2000).

3. Great Dane, FS, 12 years old – GDV – 2 IV catheters were placed, 2 liter bags of Plyte rapidly infused, radiographs revealed a GDV of at least 180 degrees, analgesia begun and gastrocentesis was completed to cause some gastric decompression; ketamine and valium was used for induction, taken to the OR after rapid clipping, placed on an anesthetic ventilator and emergency abdominal exploration completed; the stomach as found rotated and it was centised again and then repositioned; the short gastric vessels were found torn and approximately 4 liters of free abdominal blood was aspirated; the spleen was removed and short gastric vessels clamped and ligated; 3 L of the blood was autotransfused (without any gross side- effects noted); a gastropexy was completed and following irrigation the abdomen was closed with a sentinel intra-abdominal suction drain placed; in ICU Recovery that last of the collected blood (one L) was also autotransfused as lactate was still elevated (began at 12mg/dL on admission, decreased to 8 postop and down to 4 after the last L of blood was given. IV fluids (Plasmalyte) were continued as well as analgesics, NG suctioning, IV antibiotics, GI protectants; The dog recovered and was discharged 4 days post GDV.

A series of trauma cases has proven this technique viable and life-saving. The accumulated blood can be directly collected from a body cavity, via a large bore thoracic cannula (commercial) or endotracheal tube placed by a non-styleting method that dissects through a hemostat created small hole into the thoracic or abdominal cavity. In most cases anticoagulant is not needed.

Use of pulsed doses of 7% hypertonic saline and 6% hetastarch at 2-3 ml/kg each boluses one to three times as needed to provide pulsatile perfusion as determined by Doppler Flow blood flow and LOC, pulses, breathing rates, toe temperature, membrane color and CRT monitoring and the g-r-a-d-u-a-l increase of pressures back to normal after a given time in the lower flow states, generally aiming for just enough time for clotting to become just firm enough not to blow as pressures go on to normal. This generally is done for several hours minimum.

Areas injured and source of hemorrhage MUST also be immobilized. A padded dressing / bandage for a leg or paw; **abdominal and pelvic counter pressure with a towel or bubble wrap** around the abdomen and pelvis and pelvic limbs and held in place with duct tape is a splinting maneuver that has worked in selected cases. Of course if the patient is bleeding so rapidly that this strategy would not work open resuscitation must be rapidly attempted. Fortunately this is observed rarely as most severe acute bleeding cases never make it to the hospital. Or at least that used to happen.

With the teaching of animal first aid courses and the teaching of service dog handlers and first responders EMS skills, there are more animals now being presented with these serious bleeding issues.

In these cases or in those that fail to stop hemorrhaging rapid exposure of both the thoracic cavity <u>and</u> the abdominal cavity may need to be done **using a Mayo scissors to gain cavity entry**, the **use of encircling Miller's knots** for rapid ligation of liver and lung lobes, kidney and closures also with auto-suture devices and with body cavity closure using continuous polypropylene or again, using auto-suture devices has been and continues to be life-saving. (example: the cattle dog presented earlier).

12. ABCDE. **Use of supplemental oxygen beginning early in the course of resuscitation, prior to the onset of fluid support, and following through with the use of oxygen carrying colloid substances such as Oxyglobin (a hemoglobin based oxygen carrier (HBOC), and hyperbaric oxygen (HBO) are also recommended as "new techniques" to use in the care of the trauma patient.** There are multiple veterinary centers currently involved in a patient registry that has been set up by the Veterinary Hyperbaric Society. There are many trauma cases in human medicine that have been documented to have significantly benefited from hyperbaric oxygen therapy. There also have been experimental studies concerning the used of HBO in trauma and shock that have demonstrated their effectiveness in carrying and off loading oxygen better than homologous blood transfusions by a factor of 4. Research has suggested that providing oxygen supplementation prior to fluid resuscitation is associated with less reperfusion injury and continuing the use of it postoperatively is associated with less wound complications including infection.

13. ABCDE. **Monitoring and assessing perfusion using infrared laser guided or non-guided thermometry**. The devices are relatively inexpensive and provide a digital read-out of the temperature within one second. The *difference between the surface temperature*

of the buccal area in the oral cavity (or rectal temperature) and the toe web space in a pelvic limb is dependent on perfusion and, although the concept is not new, the technology is and this allows for the rapid and accurate determination of the differential temperature. The infrared devices can be easily purchased at such stores such as Radio-Shack, or use of one that is used in for humans called the *Thermoscan* and available from pharmacies.

14. ABCDE - **Support of the gastrointestinal track with glutamine containing fluids that are given in small amounts by the enteral route and followed by gradual increases has been a main factor in survival. Often the placement of a nasogastric feeding tube will be helpful in providing trickle micro-enteral feeding** to start (at 0 .1-0.3 ml/kg/hr). In cases where the abdomen is already opened a jejunostomy tube or nasogastric or nasoduodenal or *nasojejunal (NJ) feeding tube* can be inserted and feeding progressed via this tube. **Esophagostomy tube placemen**t should be considered early in the course of care of the trauma patient and when any trauma surgery is completed E-tube placement should be performed if there is any doubt that the patient will be able to ingest at least 50% of the daily protein requirement (1-2 g/kg/day) and energy requirement (20 Kcal/kg/day). NJ tubes require placement from the nose by one person who will also advance the tube as the tip is then guided from the stomach and into the pylorus and then into the duodenum and around the pelvic flexure and up through the ascending duodenum and into the jejunum.

15. D. The **emergency decompressive craniectomy and durotomy** can be is life saving. In the head injured patient if deterioration is observed following emergency medical care then the patient should be taken to surgery and the cranium or spinal canal opened and hematoma, ruptured disc removed and the surgical site left with only a muscle - fat covering over it to allow for further decompression. The cranium can be opened using a #10 scalpel blade use to carve a small opening into the calvarium, then a small tipped ronguers is used to nibble the bone away. Generally the bone is removed until the opening is large enough to make sure that no free blood is present both extradurally and subdurally and allows the brain to expand and become decompressed. This is often approx 3-4 cm in small patients such as cats and small dogs and 5-6 cm in large dogs. The dura is opened using a bent 18 g hypodermic needle to tent it up and a No.11 blade is used to incise (with the tip kept in the bevel of the needle) to prevent the tip of the scalpel from injuring the deeper tissues.

16. E. In severe trauma patients it is important to immobilize them as quickly as possible as this will help in the stabilization of organs that may be bleeding and in the stabilization of blood clots. I recommend the **use of various sizes and thicknesses of cardboard made up as backboards and then duct tape or other types of tape to stabilize the patient and immobilize them onto the "backboard".** Initially published as a video in 1995 it is recommended to lay the patient in a lateral recumbent position with the tape coursing from under the back board then over the patient's shoulder and then back under the back board. Then a second section of tape is coursed over the wing of the ilium and to

each side and under the back board. A third section of tape is used to course over the wing of the Atlas. In patients that are stressed it is recommended to give 0.1-2 mg / kg of butrophenol and 0.01-0.02 mg/kg of acepromazine. This can be combined with 1-2 mg/kg of ketamine. This combination can be given in the same syringe slowly intramuscularly in the epaxial muscles or slowly intravenously. This combination may be just enough to provide sedation and analgesia to allow the patient to be eased and not struggling.

17. AB Use of a **homemade minichest tube for an emergency decompressive chest tap for a suspected early tension pneumothorax** can be also very useful in rescuing the patient with decreased breath sounds, generally worse on one side when auscultation is completed. If difficult breathing is getting to be severe but the airway is clear then either an awake tracheotomy is completed (as previously discussed) to gain access to the pulmonary system and begin ventilating with a bag-valve system or anesthetic machine or if the breath sounds are decreased compared to the patient's respiratory effort then the emergency thoracentesis should be performed as quickly as possible . It is also recommended to, as soon as IV access is obtained an opioid is given intravenously (1-2 mcg/kg fentanyl, 0.05 -0.1 mg/kg hydromorphone and then bag valve mask ventilation is commenced and the thoracic wall clipped and prepped and a multi-holed catheter (16-14 g catheter and a No. 15 blade used to make 3-5 small side holes in its shaft) is inserted through a skin relieved incision with the bevel of an 18 g needle after 1-3 ml lidocaine and 0.1-0.2 ml of sodium bicarbonate and a drop of this mixture placed over the top (hub) of the catheter/needle. When the drop flies off (indicating penetration into the pleural space and a tension pneumothorax) or is sucked (indicating penetration into the pleural space) the needle portion is removed enough to have the needle bevel inside the lumen of the catheter and protecting the lung as the catheter is advanced into the pleural space. Then an extension set, stop cock and large syringe is used to aspirate the pleural space. If a negative pressure is not able to be reached then either the patient is given a muscle blocker (0.1 mg/kg pancuronium or 0.25 mg/kg atricurium) and the trachea intubated and a chest tube inserted as ventilations are provided via a bag-valve system or via an anesthetic machine.

18. AB **In severe difficult breathing patients that were bluntly injured it is also recommended to provide pulmonary access via the rapid gaining of the airway via an awake tracheotomy OR by performing rapid induction with the use of an opioid and muscle blocker while bag-valve mask ventilating and then performing endotracheal intubation and then providing positive pressure ventilation. Then thoracic films are taken and then possibly or even before hand a rapid access into the pleural space is performed**. This is done BEFORE the thoracic films are taken.

19. C. **For severe hemorrhage ANYWHERE even if the blood is contaminated, can be autotransfusion of all the blood that can be obtained is performed.** A syringe is used to obtain the blood possibly aspirated through a gauze sponge, or a suction catheter and canister (even if it is not sterile) and then given back via the use of a filter (if possible). If no filter is accessible, the collected blood is administered back to the patient, as clinically

indicated. In cases of greater than 100 ml blood that needs to be given it is recommended that a corner of an IV bag be cut off and the blood poured into the bag and then administered.

20. C. **For cases that require significant volume support it is recommend that a red rubber feeding tube be placed into the right jugular vein as a vascular access catheter**. It will require a skin incision over the vein, its dissection, and loops of ligature material placed proximal and distal to the mid-body of the vein. Both loops are temporarily tightened with hemostat slid down the loops, and a venotomy made with a No. 11 blade punctured through the middle of the vein and then rotated to open the vein and then the tube, charged with saline and capped with either a stop-cock or catheter-plug, is advanced into the vain and continued until the tip is in the cranial section of the thoracic vena cava. The ligature loops are then both tied and the catheter anchored to fascia (and periosteum of the wing of the Atlas) and the skin closed. Anchoring and closing can also be temporarily completed with the use of towel clamps if other procedures such as an emergent thoracotomy and celiotomy must then be performed. The tube-catheter can be used to rapidly administer blood, colloids, hypertonic saline, and emergency drugs such as a small dose of epinephrine (0.001 mg/kg) if rescue from severe life threatening – death eminent hypotension is required. This dose is generally enough to buy time and enough pressure to get the volume infused that that is needed.

21.C. **The use of an esophageal Doppler for assessment of the patient's cardiovascular status (aortic blood flow) on a beat by beat basis by listening to the strength and characteristics of the sounds generated is recommended to be used on every patient that is unconscious or receiving general anesthesia.** It involves a Parks Medical Electronics Doppler with a pediatric flat flow probe attached to an esophageal stethoscope (preferred) or a second endotracheal tube so that the piezoelectric crystals are exposed to the esophagus and assess aortic blood flow. It is easy to insert and the flows of the aorta are able to be assessed, even in very low flow states and in cases here there is significant hypothermia.

22. ABCDE – Use of the following are effective in decreasing edema, decreasing pain, and decreasing inflammation: **targeted pulsed electromagnetic field therapy (tPEMF) loop** that is applied topically and contains enough battery power for 90 fifteen minutes treatments (ASSISIVETRX.com) (Assisianimalhealth.com). The loop generates a 23 Hz 0.005 g generated wave that induces calcium and calmodulin to combine and this combination causes an increase in nitric oxide synthetase and this increases vasodilation and results in increased tissue oxygen levels and a decrease in inflammatory cytokine production; **photonic therapy** which is performed with a 660 nm near infrared battery operated diode based light which increases nitric oxide synthetase locally and also can be used to active acupuncture points (photonictherapy.com.au); **Electrolyzed Reduced Water** that is water treated by electrodes and becomes electrolyzed restructured reduced and alkaline (pH 8.5 to 9.5) with a oxidative reduction potential (ORP) of – 600 mv and is a powerful antioxidant (compared to vitamin C which has an ORP of -30 mv. The water is

manufactured by an electrolysis –ionizer that contains 7 medical grade platinum coated tungsten electrodes after going through a high grade carbon filter. The countertop machine that generates the water at > 1/2 gallon per minute is made in Osaca, Japan by Enagic. (dtcrowedvm@gmail.com) or drraystewart@mac.com.

Cases that the author had that provide examples of emergency life saving trauma care:

Case 1 - Sara, a middle aged FeS Golden Retriever - A severe trauma case that recovered with the use of these techniques Sara was hit by an automobile. She sustained a very severe blow to the head which caused her frontal bones to shatter and her left eye to rupture, both externally and internally with eye contents being expressed into the depths of the sinuses. She arrived breathing but with a struggle and was barely conscious. A large opening in the frontal sinus was spewing blood in a steady rate and her breathing was being done principally through the opening in her sinus. I was not able to determined what other injuries were possibly present as her face was covered with blood. The following were performed:. Jet blow-by O2 to the face and "blow hole" in the sinus. Hemostat enhanced 14 g venostomy catheter placement in the right cephalic vein. A rapid "awake" tracheotomy & ventilation with 100% O2. Assessment of venous pressure via bag-drop-technique. Assessment of blood flow and pressure with a Doppler flow detector. Venous pressure and flow were very poor. Hypertonic saline/Hetastarch 50-50 combination bolused at 5 ml/kg. HBOC (Oxyglobin) and FFP 5 ml/kg (each) were started to provide pressures enough for Doppler flows to be heard well. Plasmalyte 15 ml/kg then 2 ml/kg/ hr and Hetastarch 2 ml/kg/hr during all of anesthesia. Ketamine 2 ml/kg with ace (0.2 mg), Hydromorphone 0.02mg/kg provided for pain relief, Acepromazine 0.02 mg/kg. Atricarium 0.25/kg IV to paralyze then ½ doses as needed were given during the surgery. Clipped the entire head and neck, applied a block with lidocaine /bupivicaine /bicarbonate. Sara was in surgery room within 20 minutes of arrival with the head clipped and the head and elevated with care taken not to placed compression on the jugular veins. IV cephazolin and enrofloxacin were provided. An incision over entire nasal and frontal region was accomplished. As I started to remove the bone fragments the severe bleeding resumed. The bleed was stopped with counter-pressure and a pack was left in as exposure of and carotid occlusion was needed. Bone fragments and eye contents were removed. ACell was applied to the nasal defect and sutured to bone and periostium. Temperature was 90 at conclusion of surgery. Ventilator support was continued for 14 hours with a CRI of pentobarbital, morphine, lidocaine and ketamine. Gradual rewarming was done during this time after 4 hours of continued hypothermia –monitored by thermometery. ICU monitoring, trickle feeding via an E tube, residual assessments Q 4 hr, tracheostomy care and physical therapy (range of motion activity, massage, standing, walking w/ assistance) was done Q 4 hr. HBOTx (1/2 ATA at 100% oxygen for brain contusion was completed. Tracheotomy care as required, (suctioning, humidification, tube changes Q 4-8 hrs) was done and following five days of continued care Sara was able to be discharged. She made a full recovery other than the loss of her left eye. ☺

Case 2: A 4 year old Male Australian Cattle Dog - Was running rapidly through a field of long grass and impaired himself on a 16" section of iron reinforcement rod. The owner pulled him off the rod, stating as he arrived with the dog, that the rod was buried in the dog at least a good foot. The dog was semiconscious, very pale and breathing rapidly and shallowly on arrival. The injury had taken place approximately 10-15 minutes prior.

CARRIED IN BARELY BREATHING - The dog being carried by the owner were escorted to the ready area. Blow-by oxygen was started and followed by bag mask valve ventilation and a 16 g 2 in IV catheter was established by mini-cut down. Plasmalyte was started at a rapid rate. There was no palpable pulse and no venous distension. Examination also revealed a 2-3 cm hole in the thoracic inlet and no exit hole. With complete loss of consciousness BVM ventilation was switched to en ET tube that was placed with the dog in supine position.

IMMEDIATE SURGERY - The dog was taken immediately to surgery, laid on the surgery table as hypertonic saline and hetastarch was administered. A rapid parasternotomy was performed with a Mayo scissors after a layer of TechniCare prep solution was applied. A right cranial and caudal lung lobe were found perforated and leaking air and blood. A cross "clamps" of red rubber tubes circling around the lobe bases were applied to these lobes to stop the leaks temporarily. The pericardium was torn but the heart was not punctured, only bruised. It was beating slowly and weakly.

AUTOTRANSFUSION - The blood in the pleural space was estimated to be 250 ml. It was aspirated via surgical suction and the canister's contents poured into the Plasmalyte fluid bag with its corner cut off to allow the blood to be poured into that bag. The diaphragm was opened as the abdomen was opened on the ventral midline. The abdomen was filled with blood. The blood was poured out of the dog and caught in a large sterile dog food bowel (estimated to be 400 -500 ml). This blood was poured into the same Plasmalyte bag after a 170 micron blood filter line was switched from a regular fluid line. The contents of the Plasmalyte bag was then rapidly transfused into the dog as blood noted to be oozing from the right liver lobe.

LIVER LOBE PACK - A pack was placed over this area and pressure applied. Torn mesentery was then noted and vessels torn were cross-clamped with hemostats. Two sections of intestine had a poor color and intestinal contents was oozing out slightly from one of these sites. These sites were covered with lap pads and the exploration continued. The pancreas was found torn away from the duodenum and was oozing blood. It was also wrapped in a lap pad.

DIAPHRAGMATIC VEIN-VENA CAVA - large diaphragmatic vein was found also oozing and was cross clamped. The vena cava at this area was noted to be torn slightly but fortunately the site was not bleeding much at the time. The patient's Doppler flow and pressure were poor. The left inguinal region was bruised and a small hematoma was present on inner its surface. This area was packed with lap pads and pressure applied. Pressure was then being applied to both the right liver and left inguinal regions. This continued for approximately 5-10 minutes while the blood/fluid mixture was being administered rapidly until Doppler flow could be heard, although it was poor.

DOPPLER FLOWS USED FOR MONITORING - With Doppler flows and pressures beginning to improve one dose of hydromorphone (0.03 mg/kg) was administered IV with a very small amount of acepromazine (0.001 mg/kg). Cephazolin (40 mg/kg) and enrofloxicin (10 mg/kg) was then administered IV and a small amount of isoflurane dialed in. Throughout this whole resuscitative time a Hallowell 2000 ventilator was being used to provide positive pressure ventilation.

MILLERS KNOT PARTIAL LOBECTOMIES - The two lung lobes were partially resected using the Miller's knot ligation technique. A chest tube was placed through the right 7th intercostals space by a gentle hemostat dissection technique as opposed to a more risk associate rapid stylet- puncture technique. The vena cava tear was suture –buttressed. The liver lobe that was tore was removed by the Miller's knot ligation technique as well.

INTESTINAL RESECTIONS The two intestinal sections continued to have poor color so all of both of these sections of small intestine were removed. This involved the mesenteric vessels that had been bleeding prior. These were ligated.

TORN PANCREAS LIGATION AND WRAPING – J TUBE PLACEMENT - The torn pancreas was irrigated and under magnification the vessel-duct areas were ligated. The duodenum where the pancreas was torn was irrigated and wrapped with omentum. Because of the pancreatic injury a jejunostomy tube was placed in the proximal jejunum for feeding.

DIAPHRAGM CLOSED AFTER CHEST TUBEPLACED - The diaphragm was closed following the placement of a 12 Fr chest tube.

ABDOPMINAL – PARTIAL CLOSURE ONLY – SUCTION DRAIN PLACED The abdominal and thoracic cavities were extensively irrigated and because of contamination of intestinal content and generalized intestinal swelling the abdomen was only partially closed and a sterile dressing applied with attention made to intra-abdominal pressure via an indwelling urinary catheter. An indwelling suction catheter was also

POST OPERATIVE ICU SUPPORT - The dog was continued on positive pressure ventilation with a "lung protective strategy" for another 8 hours while further supportive care and monitoring was instituted: these included the following:

Placement of a nasogastric tube for decompression and administration of sucrafate.
1.Placement of a right jugular vein catheter and CVP and lab assessments (vpO2, etc.).
2.Beginning of microenteral nutrition initially after surgery with Clinicare, glutamine.

3.The addition of PEEP (5 cmH20) and periodic coupage and postural drainage.
4.Continuous aspiratation on the chest tube with recording of amounts of fluid and air.
5.Continuous rate infusion of hydromorphone, ketamine, and lidocaine as required for pain.
6.Placement of a 5 mcg/ hr fentanyl patch for pain control (debated about placement of epidural catheter but this was ruled out when coagulation parameters were prolonged.
7.Continued support with CRIs of hetastarch, procalamine, b-complex w/ Plasmalyte
8.Periodic administrations of cefazolin, enrofloxacin, N-acetyl cystine, heparin
9.Placement of an arterial catheter in the right cranial tibial artery.
10.After the dog was weaned off the ventilator the dog was placed on nasopharyngeal oxygen for a few hours and finding that oxygenation continued to remain stable the dog was placed in the hyperbaric chamber with chest tube attached to a Heimlich valve and all IVs capped and heparin locked. He received two HBOTx of 60 minutes each at 1.8 ATA and with 100 % oxygen used. It was noted that his comfort level seemed to improve dramatically after these two treatments.

BACK TO THE OR DAY 3 POST INJURY - The dog was taken back to the operating room on the third postoperative day and the abdomen re-inspected carefully, irrigated, cultured and then closed with simple-continuous 0 polypropylene and the skin stapled. The jejunostomy tube was used for enteral feeding for 5 days.

DISCHARGE - The dog made a gradual recovery and was discharged from the hospital 5 days after the injury occurred. The surgery had taken 5 hours to complete and was started within approximately 10 minutes of arrival. The all major hemorrhage and air leaks had been stopped within 10 minutes after the beginning of the surgery. He had received a total of approximately 1 blood volume of his own blood administered by a crude and not-the-ideal means of autotransfusion and some of the blood given was contaminated with intestinal contents. It should be pointed out that the owner had numerous visits with the dog during his ICU stay and was very appreciative that we were able to save his dog. He left town with the dog, still owning approximately $2,500 on a $8-9,000 bill. He was supposed to provide cement work to pay off the debit he owed.

Case No. 3 - A 3 year old MN Boxer - History of being stuck by a car the previous day and was taken to a local emergency clinic. There the boxer was examined and found to have the following problems: open skull fracture, open fractured humerus, in shock, pulmonary contusions, and a mild pneumothorax. The dog received lactated Ringer's for shock, had the chest tapped, was placed in an oxygen cage, and given cephazolin and buprinorphine for pain. He remained at that clinic through the night and transported to us for further care the next morning.

ARRIVAL AND INITIAL CARE - On arrival at the specialty facility he was found to be semiconscious, with effortless breathing that was slightly rapid (32 bpm), heart rate of 160, CRT >5 seconds, membranes pale, with low arterial flow and pressure by Doppler (~60 mmHg systolic, but diastolic could not be determined). Hct was 28 and TP was 5.3 before the dog had left the emergency clinic. Initially it had been 43 and 6.6 respectively. The abdomen was moderately distended. History revealed that the dog had received approximately 8 liters of LRS. Immediately a towel wrap was applied to abdomen a quick look ultrasound revealed free fluid. A second IV catheter was placed (14 g, 2 inch) in the cephalic vein using a facilitative maneuver above the one that had been placed by emergency clinic (18g) and an entry peripheral venous pressure was determined to be 0 cmH20 as no flow returned through the attached T-port on its own. Upon lowering the limb some blood was able to be aspirated for analysis: Hct was now 18% and TP 3.5, lactate was 8, and vPO2 was 28. Blow by oxygen was begun.

COLLOID AND CRYSTALLOID FLUID SUPPORT - With a Doppler applied to the palmar arterial arch and monitoring flows and pressures hypertonic saline (7.5%) solution was begun to be delivered. Approximately 200 ml and 125 ml Oxyglobin was given to increase systemic pressures and help normalize flows (goal ~ Doppler flow stronger, JVD present, JVDT 5 sec., 1-2 cm peripheral venous pressure, and systolic arterial pressure of 70-80 mmHg) and a hunt for occult hemorrhage was made to confirm that most had been associated with abdominal and that associated with the humeral fracture and skull fracture that was associated with the left frontal sinus.

RAPID WORK-UP - lateral "trauma films" beginning at the tip of the nose and involved a lateral cervical, thoracic, abdominal and pelvic films were taken. He was carefully moved to get a DV thoracic and abdominal radiograph. Ultrasound examination of the thorax was then completed. Only "interstitial syndrome and some pulmonary contusions were observed and no evidence of a diaphragmatic injury or pneumothorax was observed. DPL was done to see whether the Hct of the lavage fluid was increasing. It was. Unfortunately the Hct in the DPL fluid effluent increased from 7 to 12 % over a 20 minute period. An 8 Fr red rubber feeding tube was inserted into the right jugular vein for more venous access.

EXPLORATORY SURGERY - Exploratory celiotomy surgery was then performed for continued abdominal hemorrhage. Approximately 3 L of bloody fluid was removed from the abdomen. This blood was autotransfused in a similar fashion to case number 1. The liver was found still hemorrhaging small amounts as well as the cranial pole of the right kidney. The liver was packed off and with continued bleeding the right lateral lobe was over sewed where the bleeding was coming from. A section of omentum was digitally manipulated and placed into the injured area just prior to the over-sewing. This contributed to the stoppage of the hemorrhage. The hemorrhage of the kidney responded to over-sewing and omental placing as well. As soon as the bleeding was stopped isoflurane was decreased and systemic arterial pressure allowed to return to 90-100 mmHg.

GOAL DIRECTED THERAPY COINTINUED AS SURGERY (12 hrs) WAS PERFORMED - Doppler flows were considered adequate prior but improved further once hemorrhage was controlled and the autotransfusion of the 3 L of blood/fluid from the abdomen was completed. Mesenteric tearing was also present and some bleeding began that was managed with ligatures. Color of the involved bowel remained poor and a small area of leakage from the lumen note. This necessitated the removal of approximately 12 inches of necrotic small intestine using a open technique (GIA, TA 55) and following thorough irrigation the abdomen was closed with simple continuous No. 1 polypropylene. A nasogastric tube, nasoenteral tube were both placed before the closure was started. A urinary catheter was inserted and attached to a closed system.

ORTHOPEDIC INTERNAL FIXATION OF FX HUMERUS - Following the abdominal surgery the open fracture was then repaired under the same general anesthesia (isoflurane, and a CRI of ketamine, morphine and lidocaine using a regional block of lidocaine, bupivicaine, and sodium, bicarbonate) and while throughout the surgery a Hallowell SA 2000 ventilator was used (volume cycled, pressure limited) and with the use of supplemental pancuronium bromide. The humeral fracture was comminuted and required a 12 hole broad 4.5 mm DCP plate with intrafragmentary 2.7 and 3.5 mm lag screws. A cancellous bone graft was used. The fracture site was extensively irrigated prior to that and a JP suction drain inserted. A brachial plexus regional block was repeated. Open fracture in the skull war regionally block after prepping and head elevated and placed in a support frame with the dog in sternal position. The open frontal fracture was exposed, debrided and irrigated. Since pupils were symmetrical and responsive and exposure of the frontal calivarium revealed no fractures or cracks no cranietectomy was considered necessary (If these were present a craniectomy would have been done). A small JP was then added and the area closed. Throughout the surgery cephazolin had been given Q 3 and enrofloxicin repeated once. Total surgical time had been 12 hours and anesthesia time 14 hours. Periodic blood analysis had been done (Hct, venous blood gases, glucose, TP, lactate). Lactate levels initially were 11 and at the conclusion of the surgery were 3. Placing 6.5 ml Ketamine HCl in one L fluids is very effective for pain intra and postoperative pain.

POSTOPERATIVE CARE - Postoperatively the dog remained on a CRT of MLK and on the ventilator. Temperature was 88 degrees (core-esophageal) and peripheral temperature was 74. Over the course of the next 6 hours the dogs temperature was gently increased by bother core and surface rewarming. ETCO2s increased from 22 to 35 and core temperatures rose from 88 to 98 with peripheral temperature rising as well from 74 to 90 (delta T rising from 14 to 8 degrees F). An esophago-gastric (EG) tube was placed as well as nasal-pharyngeal oxygen catheter in the nasal passage on the uninjured side from the frontal fracture. Aspiration was done of the EG tube and trickle feeding stated at 20 ml per hour of 25% dextrose and 5 % glutamine in Plasmalyte. Pain was continued to be controlled with a CRI of MLK and a 100 mcg fentanyl patch was added. 4 units of FFP were given and he was placed on a CRI of hetastarch, Plasmalyte, and Procalamine with B complex added. Physical therapy (passive range of motion, massage) and respiratory therapy (active CPAP for 20 minutes) was done Q 4 hours and continued for the next 48 hours. The patient was weaned off the ventilator after approximately a total of 22 hours. He regained consciousness and began eating solid food the following day. The EG tube was used to supplement with glutamine and provide oral medications (cephalexin, enrofoxicin, tramadol),

DISCHARGE - He was discharged on the 5th postoperative day, able to walk, and tube free. The dog made a good recovery and was seen periodically for follow-up of his orthopedic injuries. The fractured humerus and frontal bone area healed well and he continued to do well at last follow-up 18 months later.

Case No. 4 - A 4 year old FS Boston Terrier – The owner stopped hearing her bark in the backyard; This was very unusual. She recognized very significant difficulties with breathing. Brought the dog rapidly to the hospital.

ARRIVAL - As the patient arrived an intern took the dog to radiology for an immediate radiograph of the thoracic cavity. As the lateral radiograph was taken the dog stopped breathing. No pulses could be felt. The intern then brought the unconscious and cyanotic dog to the anesthetic – prep room area.

CPR BEGAN – Following an attempt at BVM with a few breaths the larynx was visualized using a laryngoscope and the trachea intubated with a 6 mm ET tube. Ventilations were given but no lung sounds could be heard on auscultation with the ventilations. No gastric sounds either. The oxygen from the rebreathing bag went into the patient easily. The diagnosis of a ruptured trachea was made by deduction and an immediate approach to the trachea was made. No prepping of the hair or skin was done. The cervical trachea was found to be fine so a mayo scissors was used to extend the incision parasternal through the costosternal junction. The mediastinum was found billowed full of air and it was opened to find the trachea pulled apart and the end of the previously placed tracheostomy tube was found exposed through the torn end of the trachea. Another endotracheal tube was through the lung-side exposed tracheal lumen and ventilations with 100 % oxygen was started and the lungs could be seen inflating. The heart was not perceptibly beating but after a few compressions it began beating strong enough to be felt. The beating continued to become stronger. As the beating of his heart continued he began moving some on so isoflurane was added and morphine was titrated in IV with a completed dose of 0.2 mg/kg gradually given. The owner was told of the finding and the dog's arrest and immediate resuscitation results and was asked what she would want us to do with no guarantees the dog would be fine even if we were able to repair the tracheal tearing. She wanted us to continue so this was accomplished. An iv catheter was placed, and Cephazolin was begun intravenously as well as lactated Ringer's solution. The trachea was able to be repaired after a torn section of 4 rings needed to be removed. Simple interrupted 3-0 polypropylene sutures were used to join the two ends of the trachea together. The parasternotomy was closed with figure of eight #1 polypropylene and continuous 2-0 polypropylene with a chest tube inserted to drain off fluids and air was needed. A nasopharyngeal oxygen catheter was placed and supplemental oxygen used for secondary but dissipating pulmonary edema that had occurred following the arrest. The treatment was successful and following a 2 day stay in the ICU he was allowed to be discharged. He made an uneventful recovery.

Chapter 3 - Airway and breathing Emergencies and Procedures

The following chapter addresses need to know life saving techniques that may be required in the first few minutes in the management of the severe difficulty breathing patient. These may be helpful in the care of humans as well (needed to be known in the remote chance you will need to use them in disaster care of people).

When a pet arrives that is obviously having labored and difficult breathing (note: we did not use the word "dyspenia" because this is a symptom, where the patient has to verbally tell you "I am having trouble breathing" hence the word should not be used) an immediate course in treatment is to provide **supplemental oxygen at high concentrations.**

Oxygen Supplementation Techniques that can be used easily include the following:

The blow by technique : This is easy to perform by just directing a 2-5 LPM oxygen stream at the patient's face. This provides approx. 35% oxygen

The blow by technique with a clear loose fitting plastic bag placed over the patient's head: This increases the per cent oxygen to the patient to approx. 60-70-% depending on the flow rate and the placement of the tip of the oxygen tubing leading from the reservoir

An oxygen nasal cannula placed in the patient's nose: There are three sizes: adult, pediatric and infant. The cannula is commonly stapled in place and an e-collar attached. Some dog's tolerate the cannula well and it stays in place; others do not and some require sedation. A loose fitting plastic bag can also be used to increase the oxygen concentration. Commonly tape is attached to the cannula, brought over the top of the dog or cats nose and stapled to the side of the face.

Use of a tight fitting facemask that is attached to a bag valve system and reservoir: In human medicine this is available commercially called a "non-rebreather". In veterinary medicine, because of the lack of this system, the valve system needed is best met in emergencies by the use of a bag-valve-mask assembly or "AMBU bag" * The following is a photo of the unit made by AMBU (since 1956 ☺). Its called a "Spur" and costs approximately $15.00. It comes of course with a human facemask. So when you get one just change the human facemask for a cone-shaped veterinary facemask. Do keep the human adult one though… you may never know when you may need to use it in a crisis (Such as when you tell the owner that of the bill on a terribly septic pyometra you happen to pull through or you are suggesting what the estimated cost will be ☺). The BVM (bag valve mask) AMBU has an exhalation valve that directs the exhaled air out into the atmosphere, and an inhalation valve that allows the inhalation of oxygen from the reservoir which is part of the AMBU. Without the reservoir only 40% oxygen can be reached but with the reservoir nearly 100% oxygen on inhalation can be reached… So when possible on emergency cases use the reservoir ☺

Use of a PEEP valve attached to the bag valve (AMBU) to increase FRC (Functional Residual Capacity and provide resistance to alveolar collapse between breaths: To the end of the exhalation port a positive end expiratory pressure (PEEP) valve** can be attached. Using this added valve increases the amount of air left in the lung at the end of exhalation (increasing functional residual capacity). As the top of the valve is rotated it tightens a spring which increases pressure on a valve that controls the resistance to air flow out of the lungs. The reservoir is a clear plastic flexible bag which is filled with oxygen during the patient's exhalation time and empties during bag compression as seen in this photo of myself providing bag-valve mask ventilations in the emergency case:

Note the top like attachment to the right side of the AMBU bag valve – this is the PEEP valve. Note also how tight the facemask is held over the mouth and nose (up to the dog's eyes)☺ This allows all the oxygen to be gently pushed into the pet's airway and lungs – keeping the pressure generally below 20 cmH2O so that the esophagus and stomach do not fill up with the positive pressure ventilations but only the trachea and bronchi and alveolar segments. As the dog takes a breath the operator squeezes the AMBU bag thus assisting him with each breath. Then as he exhales the PEEP valve hold just enough exhaled breath behind to literally splint the alveolar segments and keeps them from snapping closed. This decreases the work of breathing for the patient, as he will not need as much force to taken in his next breath. The shear stress on the alveolar segments will also be decreased as there is less airway resistance and less "snapping" of the terminal bronchioles which thus also causes less lung injury.

This assisted bag-valve mask ventilation with PEEP has been a very important tool for the rescue of patients arriving with difficult breathing. In many cases, after a small dose of butorphenol the patients literally welcome the mask and the assisted breaths, and often they literally fall a asleep as they have been so exhausted from trying to get enough air and keep themselves from dying overnight – when in congestive heart failure or other causes of pulmonary failure including pneumonia.

The amount of oxygen in the reservoir needed to satisfy the patient's inhalation lung volume, which is frequently increased from the patient's stressed state, must be able to be easily supplied in the breath effort in the ¼ to 2 seconds inspiratory time. This requires a flow rate of oxygen at the patient's airway during inhalation calculated to be between 12and 100 Liters per minute (ave. 66 L/min)***. This calculation is based on the tidal volume, minute volume and inhalation time of each breath. As can be seen from examination of the data presented, it is impossible to provide this amount of flow rate of inhaled oxygen without the use of a reservoir that can be easily emptied that contains 100% oxygen. Any other systems involving a face mask, where there is no reservoir or valves to control the direction of inhaled and exhaled air is not recommended to be used in emergency settings where the work of breathing must not be increased and high concentrations of oxygen are required. During the inhalation phase of breathing if there is no reservoir attached to this same type of bag-valve-system the highest % of oxygen that can be achieved during inhalation is 40-50% while with the reservoir oxygen concentrations can reach 100%. Of course most animals having difficulty with breathing they resist the use of the tight fitting mask.

Oxygen cage use: Research that we performed and published in 2004 (Engelhardt, Crowe) revealed that although oxygen cages can be used for the treatment of these critical patients, they unfortunately force isolation of the pet away from the care givers and they require at least

20-25 minutes of oxygen delivery to see oxygen concentrations approach 40% delivered to the patient. This is of concern because of the time lag that is seen with the use of oxygen cages.

Jet blow-by using a nozzle attached to the oxygen hose line (reaching 40% oxygen within 2 minutes), placement of the patient in a smaller container (compared to the standard oxygen cage) (reaching 60% oxygen within 5 minutes),

A Crowe collar (; which is an Elizabethan collar that is one size larger that would otherwise be used and its most rostral ventral half covered with clear plastic wrap to provide a "boat effect" for the holding of the delivered oxygen around the patient's head (providing 70% oxygen within 2-3 minutes and 80% a a flow rate of 5 L/min.), A section of a plastic milk jug or cup can also be used to fashion an "oxygen boat" *

If after the oxygen has been administered for from a few to 30 minutes with any of these non-mask systems the patient continues to have serious respiratory effort (and a quick look ultrasound has ruled out significant pleural space disease) the patient may benefit <u>significantly</u> from the application of mild sedation and placement of a tight fitting mask on the patient's head and using an AMBU resuscitation bag, and adding breath assistance with the squeezing of the AMBU bag with each breath. The positive pressure breathing is begun, timing as best as possible, the squeezing of the bag with the onset of each spontaneous breath the patient takes. Within a few minutes the patient' respiratory rate and effort should be decreasing and becoming less labored. This simple but very effective technique called "assisted ventilation" is very effective in decreasing the effort the patient takes to continue to breath. It has been my experience with many patients that often as they get used to what is trying to be accomplished and settle into a rhythm, and literally fall asleep within a few minutes because they were so exhausted from trying to breath.

Emergency patients that arrive in significant shock and pulmonary injury should be managed immediately with this bidirectional positive airway pressure (Bi-PAP) ventilation technique if they are still conscious. Continuing the assisted ventilation for at least 30 minutes is recommended in most of these cases if they are still conscious and positive clinical effects are observed. Once the shock is being addressed the addition of a PEEP valve on the exhalation side of the AMBU bag can be instituted to treat pulmonary edema, contusions, etc., This valve has a spring that gets tighter and increases the amount of pressure needed to open up the exhalation valve. With the valve pressure set at 5 cmH20 the airway pressure at the end of exhalation is elevated, i.e., positive end exhalation pressure (PEEP). When positive pressure ventilation is added to the AMBU bag- valve-mask that is applied tightly BiPAP or Bi-directional positive airway pressure ventilation is being performed. If breathing is not assisted with the addition of positive pressure breathing is called CPAP (continuous positive airway pressure). Both types of breathing will increase the patient's functional residual cavity and is easily accepted by most patients. In most cases the addition positive pressure to assist inhalation with each breath with the PEEP valve set at 5-10 cmH2O (Bi-PAP) is begun initially with patients that are not responding to supplement oxygen alone. The Bi-PAP is done for 20-30 minutes and then the patient is re-evaluated. Re-evaluation may include watching the patient's breathing pattern and effort, auscultation of breath sounds, thoracic radiographs, thoracic ultrasound, and arterial blood gas analysis. ALWAYS rule out pneumothorax, diaphragmatic hernia, hemothorax, as these can occur with the pulmonary injury.

Hopefully there are changes that are positive such as the dog who had been hit by a car that received a repeated thoracic radiographs following Bi-PAP that showed a significant improvement. In patients that do not respond well invasive positive pressure ventilation with intubation of the trachea and placing the patient on continuous positive pressure ventilation and PEEP. In those patients that make improvement with the non-invasive ventilation it has been my experience that approximately 50% will only need a few more Bi-PAP treatment sessions and then provided with continued supplemental oxygen therapy with methods that are very effective, even if a small amount of sedation is required to keep the patient comfortable and accept the therapy such **as unilateral or bilateral nasal catheter placement or use of a Crowe collar:**

The nasal and nasopharyneal catheter is placed by pushing the nose up after instilling lidocaine, proparacaine or cocaine into the nostril and waiting a few minutes. In many patients a dose of butorphenol (0.1-0.2 mg/kg) will help make the placement much less stressful (approx. 60% but in some situations where the animal is under significant amounts of stress up to 100% of the patients will need sedation). Use of a photonic light focused behind the ear and into the area of the mastoid) can be very effective in calming the dog or cat; Governor vessel 20 and Large Intestine 11 acupuncture point stimulation with the photonic light works very good to help the patient tolerate the catheter placement.

Nasal oxygen catheter – 5 – 8 Fr red rubber catheter is placed in the nose and then directed in a ventromedial direction with the nose pushed up. The catheter is advanced to the mid nasal region in the ventral nasal meatus. It is then sutured to the base of the nose using a friction knot around the catheter; then sutures or a staple gun is used to secure the catheter to the side of the face or on the dorsum of the nose and over the top of the head and attached to a section of tape coursing around the neck and attached to a oxygen supply line.

Nasopharyngeal oxygen catheter - With this catheter rather than it stopping at the mid-nasal region it is continued until in the nasal pharynx just rostral to the rima glottis. This area corresponds to the lateral ocular meatus. The oxygen then will flow just in front of the airway and will raise the % of oxygen (FiO2) better than just nasal oxygen especially when the patient is breathing through the mouth; often by at least 20% (going from 50 % with nasal catheters to 70-80% with nasopharyngeal catheters when at the same 3-4 LPM oxygen flow rate)

Nasotracheal oxygen catheter - With this catheter rather than it stopping at the mid-nasal or pharyngeal area it is continued through the rima glottis of the larynx and into the trachea until the tip reaches the thoracic inlet. The tube is placed by first marking the outside with a Sharpie that corresponds to the nasopharynx just rostral to the larynx and this area corresponds to the lateral ocular meatus. Then as the patient takes in a breath the tip of the catheter rapidly advanced hoping that the tip was able to course through the rima glottis. If that did occur then aspiration of the other end of the catheter would result in the aspiration of air very easily and the injection of air would also be easily done and no pharyngeal sounds would be able to be heard. The catheter is then temporarily anchored with a suture at the base of the nose and a lateral thoracic radiograph taken to verify the placement of the NT catheter. These NT tubes are truly life saving in dogs that have laryngeal paralysis and other upper airway conditions such as severe elongated soft palate, everted laryngeal saccules and laryngeal collapse. These dogs have significant difficulty with inhalation and difficulty is greatly lessened with the placement and use of the NT catheter. When NT catheters are used it is important to humidify the oxygen that is being administered. And because the target area of where the oxygen is being delivered is much smaller (trachea, bronchus, and rest of the pulmonary tree) that with nasal or nasopharyngeal catheters the oxygen flow rates can be much smaller (such as 30 ml/kg/min rather than 50 ml/kg/min.)

Crowe O2 Collar – The next size up from the normal sized Elizabethan collar is placed on the patient and the oxygen line is taped to the inside going from the collar's narrow aspect and with the tip of the line positioned so it will be just under the chin and nose of the patient. Then a section of clear plastic wrap is taped to the front section of the collar covering approximately ½ to ¾ of the opening with the top section open. This will allow the flow of oxygen to be concentrated at the lower portion of the collar and warm gases including exhaled CO2 to evacuate easily out the top open section. Research has shown this device capable of easily exceeding the 40% that is the top end of oxygen concentration that can be achieved and is safe for commercial oxygen chambers. In most cases concentrations can reach 60-70% and with flow rates between 2-3 LPM for small dogs and cats and 5-6 LPM for medium sized dogs and 7-8 LPM for large dogs. If the dog is panting or has a fever the opening in front of the collar will need to be larger and flow rates higher to prevent heat build up and moisture condensation. Some patients will also need to be slightly sedated to have them tolerate the collar. This will also generally stop their panting and anxiety allowing better oxygenation in most. NOTE: There is a commercial oxygen collar that is NOT recommended to be used as there are multiple flaws in its design that are linked to poor toleration and heat related complications.

The O2 Boat – In human recovery rooms there is a boat looking device that is used that is fitted to the patients chin and held in place with elastic straps that course behind the head. This gave me an idea that we should be able to construct something similar for dogs and cats. The advantage of this would be that it would not obstruct the animal's vision to the side and therefore possibly decrease the anxiety often observed with the use of Elizabethan collars. This has been noted in the few patients we have moved from a Crowe O2 Collar to "The O2 Boat". The homemade ones that have been constructed have been made out of clear plastic cups, clear plastic jugs, and an old cracked oxygen mask. The container is generally split in half and thus it makes two boats. The container has to extend past the mouth and nose rostrally while the base extends to where the lower jaw and neck meet. Several sections of tape going from the sides of the container to the back of the neck and to the top of the head, something like a halter are then added and the oxygen line, often made out of IV administration set tubing, is placed in the bottom of the boat and taped so the flow of oxygen begins under the animal's mandible and courses forward. The same oxygen flow rates that are used for the collar are used for the boat. The percent of oxygen that is present with the varying flow rates has yet to be determined. But until that can be accomplished it is expected that they might be slightly less than with the collar as the boat's sides are not very steep and would tend to hold less oxygen in the reservoir area.

The use of this **Positive Pressure Assist Ventilation Bi-PAP Technique** has been used by the author in an estimated 600 patients over a period of 15 years, beginning in 1997. It is recommended to consider this life –saving technique as it has been very successful as a rescue procedure. I continue to use similar techniques in my human patients working as an advanced EMT and first responder on the rescue unit of the county***. I also recommend the use of non-invasive ventilation with a bag-valve - mask for a few breaths at least BEFORE intubation in cases of the pulseless non-breathing and unconscious patient. It has been my experience that if the patient is not oxygenated well and is acidotic that any movement can induce ventricular asystole or fibrillation caused by vasovagal and sympathetic stimulation***. Bag-valve mask ventilation only requires the head to be extended and the tongue pulled forward and the jaw closed and the application of the tight fitting mask, as opposed to all the manipulation necessary to perform endotracheal intubation. I have observed that noninvasive ventilation as described, provides a very rapid way to provide oxygen and lower CO2 in the blood stream and tissues, thus helps prevent catastrophic complete arrest in patients that were near arrest. It is recommended to perform non-invasive ventilation with the AMBU bag and reservoir connected to an oxygen supply and being delivered at from 5-15 L/minute immediately on all unconscious patients that are unresponsive and not already intubated. The technique has been one of the best life-saving procedures I have ever done.

A new technique - COMBITUBE – KING AIRWAY. These are emergency airway devices that have been recently found effective in providing a means of administering positive pressure ventilations with an attached AMBU bag and reservoir. They have a large pharyngeal balloon that is inflated after the tube is placed a designated distance into the pharynx and with the tip in the esophagus. Then a smaller esophageal balloon is also inflated. The devices are designed so that when oxygen or air is administered though the lumen it is directed into the trachea because the pharyngeal balloon prevents the air oxygen from escaping and the esophageal balloon prevents the air or oxygen from moving into the esophagus.

Details for the Emergency Care for Those Presenting with Dyspnea and Cyanosis

This presentation provides practical information to the emergency and general practice clinician on which diagnostic and therapeutic procedures need to be performed to gain the best possible resolution for dogs and cats presented with dyspnea and cyanosis. Unfortunately this emergency presentation is not uncommon and has many causes. It is vital that the cause be effectively determined in as efficient and rapid manner as possible before irreversible decompensation, leading to cardiac arrest occurs. Upper verses lower or mixed respiratory patterns and large and small airway sounds, resolution of clinical signs with various treatment modalities such as decrease in work of breathing and resolution of the cyanosis all help provide clues as to the cause of these signs. Recommendations for the diagnostic and therapeutic approach are provided in this presentation with concerns also for staff and time; special devices or equipment required; the ease of implementation; and how to avoid complications will be addressed based on experience at a merriad practice types, from the single person general mixed animal practice to that of several busy emergency and critical care referral facilities. NOTE: The true complete definition of dyspnea is that of a *symptom* of a patient *saying* that they are having difficulty in breathing, but the expanded definition includes the *clinical signs* noted of difficult breathing as judged by the owner and / or clinical professionals.

PATIENT ASSESSMENT of the difficult breathing patient:

Clinical assessment - By far and away the most important evaluation of the patient that is having difficulty breathing (*dyspnea) is a good observational assessment of signalment, history, and physical exam findings. ***Often the first few minutes of assessment and care determine the outcome if the patient*" is <u>breathing his or her last</u>"" Because oxygen is 20 times less diffusible than carbon dioxide the immediate need for most patients to provide supplemental oxygen and often sedation. SUPPLEMENTAL OXYGEN IS PROVIDED WITH OXYGEN TUBING ATTACHED TO A 14 G IV CATHETER AND THE OXYGEN STEAM BLOWN TO THE PATIENTS FACE LIKE A WATER STEAM AIMED AT A FIRE. A CLEAR PASTIC BAG CAN ALSO BE PLACED OVER THE ANIMAL LIKE A PORTABLE OXYGEN TENT FILLED WITH O2 AND THEN ASSESSMENT CONTINUED:**

<u>A, THE PATTERN OF BREATHING IS ASSESSED and BREATH SOUNDS ARE CHARACTERIZED</u>.

BLOW BY with CATHETER NOZZLE – to the face as the breathing pattern is noted:

Characterization of the breathing pattern:

<u>Short Rapid Difficult Breaths</u> = Restrictive Patterns = Lung can not expand – commonly associated with pneumothorax, pleural fluid buildup, diaphragmatic hernia, chylothorax, hemothorax – severe abdominal distension

<u>Long slow breaths with added effort to inhale (literally looking like the patient is sucking on a small straw)</u> = Upper Airway Resistance Pattern. Seen with upper airway obstruction such as that seen with laryngeal collapse or tracheal stenosis or masses.

<u>Longer slower breaths with additional force seen for exhalation</u> = noted with lung parenchyma and small airways problems such as asthma or pneumonia

Characterization of the breathing generated sound from a distance:

Sounds normally are quiet and not obvious other than hard panting. If these added sounds (called adventitial sounds) they are characterized:

<u>Low pitched guttural sounds heard on inhalation</u> = pharyngeal obstruction

High pitched sibilant sounds heard on inhalation = laryngeal obstruction

Characterization of breath sounds on stethoscope auscultation: Then listen to the breath sounds bilaterally – pneumothorax does occur unilaterally initially. Breath sounds are generally quiet with a slightly more soft F sound on exhalation - Sounds other than these are adventitial sounds and are characterized:

Increased sounds on inhalation = generally associated with larger airway resistance as what might be seen with a tracheal injury and some stenosis

Increased sounds on exhalation = generally associated with increases in resistance in the small airways such as that associated with an increase in interstitial edema (as observed in early fluid overload) or inflammation (as is seen in very early pneumonia). These are called bronchovesicular sounds.

Musical adventitial exhalation sounds = those that are musical like wheezes indicate some bronchial constriction as occurs with asthma.

Water like adventitial sounds = those associated with fluid or exudate within the bronchi which can be associated with pneumonia An older term was rales but these often are wet sounds and are heard with exudate within the airways. Rales are also seen with more advanced pulmonary edema, where fluid is accumulating into the small bronchial tubes. Rattles are more obvious and louder than rales and indicate an even more fluid accumulation within the small

Characterization of sounds heard and energy waves felt on percussion;

Percussion is difficult to do and interpret but can be useful in cases where air is accumulating rapidly as apposed to fluid that generally takes more time to do so. Immediate percussion done with one of the operators hands on the chest wall and the middle two fingers of the opposite hand used to thump the back of the opposite hand that is remaining on the chest wall. The operator does this procedure on both sides and compares the sound and the palpable characteristics of this thump. The sounds heard are then characterized:

Sounds same on both sides and are neither low base like or higher thud like = normal

Hollow sound like a base drum = air accumulation in the pleural space on that side

<u>Dull thud like sound</u> = fluid or solid mass or structure on that side

Auscultation of upper airway sounds generated with panting: Similar to the physical test called "**egophany**" where the human patient is told to say the sound E and the stethoscope is used to hear the referred upper airway laryngeal sound E (termed Egophany) through the patent's bronchi, the animal's upper airway panting sounds are transferred through the bronchi and is used to detect blocked main sections of the bronchi. This diagnostic test I have termed "**pantophany**" is not difficult to do and does help in the detection of lung collapse and major bronchi blockage.

The NEW STETHOSCOPE = THORACIC ULTRASOUND:

Ultrasound is becoming the new stethoscope in practice. All animals with dyspnea on arrival, after supplemental oxygen is begun, are soaked with alcohol, applied to the lateral thoracic wall on both sides and the ultrasound probe is then applied and used to assess for pneumothorax, free pleural fluid, pulmonary parenchyma, pericardium, myocardium contractility and chamber size, and diaphragm**:**

Probe placed on the thoracic wall dorsally and thoracic structures visualized:

<u>Examine for a glide sign</u> – if not seen = pneumothorax,

<u>Examine for lung rockets</u> - If seen indicate increased pulmonary density as may be seen with pulmonary edema, pulmonary contusions, and pneumonia. Three or more lung rockets seen per field = indicate more increased water content than normal lungs

<u>Examine for free fluid in the pleural space</u> - seen as fluid between the parietal pleura and the visceral pleura = see with blood, chyle, or other types of free fluid; the US probe can be then used to aspitate some of this fluid if there enough that can be withdrawn safely. Occasionally pulmonary masses can also be observed.

Probe placed at midthoracic area (chest tube site) and structures visualized:

The same interpretations are made.

Probe placed at the ventral lung – pleural space area and structures visualized:

The same interpretations are made.

Probe placed over the heart, pericardium and diaphragm structures visualized;

Observe for pericardial fluid, or other – if seen is pericardial hemorrhage or fluid; Pericardial diaphragmatic hernia can be seen nicely with this technique. One case of dyspnea lead to acute cardiac arrest that occurred in our hospital lobby; jugular veins were distended – probe identified this possible reason for acute decompensation and immediate thoracotomy was completed and opening of the pericardium and CPR lead to a complete recovery with good neurological function

Observe cardiac contractility – provides a index of cardiac output and possible cause of dyspnea and very useful in tracking response to fluid resuscitation, diuretic response, etc. Occasionally other reasons for the dyspnea will be detected, e.g., heart base mass.

Observe the diaphragm – provides a means of noting significant diaphragmatic hernia as often liver parenchyma is observed in these cases and this leads to the operator having a diagnosis or preliminary diagnosis within minutes of admission and without any added manipulation of the dyspnea patient. This can then lead to immediate intubation with a rapid induction and moving on to definitive repair as these patients can not be "stabilized" without rapid intervention.

Probe placed on the abdominal side of the diaphragm: - The cranial portion of the abdomen is visualized as an AFAST (a focused abdominal sound for trauma, tumors, etc). Some animals with abdominal conditions such as extreme sepsis will present with dyspnea and free fluid or an abdominal mass can be found. This would lead to a clinical workup for such.

THERAPY REQUIRED: This may range from oxygen supplementation (SEE BELOW) to nearly immediate resuscitative thoracotomy such as might occur with sudden cardiac arrest. This author has not seen very many patients in which closed chest CPR in the face of dyspnea has been successful. Yet with open chest CPR he has observed noted "saves" when a resuscitative thoracotomy and subsequent CPR with recognition and resolution of the reason for the arrest was accomplished.

Examples of Dyspnic Animals that required a Resuscitative Thoracotomy- the reason noted for the decompensation and resolution leading to a successful outcome:

Pericardial tamponade from a pericardial- diaphragmatic hernia

Severe tension pneumothorac from a ruptured pulmonary bulla

Severe tension pneumothorax from a dog bite associated lung/bronchus injury

Severe tension pneumomediastinum caused by a peritracheal wound Severe tension

Pneumomedistainum then pneumothorax following the creation of a tracheotomy that was required to be able to perform a partial arytenoidectiomy

Supplemental Oxygen Principles: (Added information to what was already presented) - The first principle of resuscitative treatment of the dyspnic patient is to provide DtO2 to meet needs of all tissues of the Brain*, Heart, GI, etc. Therefore this commonly dictates the need for *supplemental oxygen*..* DtO2 is determined by FiO2 ~ pAO2~ paO2, [Hb], Q (t capillary), interstitial space. Since it is common to have VQ Mismatching in such conditions as shock, trauma, sepsis it is highly commended that supplemental O2 be provided in all critical patients especially if they exhibit dyspnea. The goal with supplemental oxygen therapy is to provide it as required to gain just enough increased FiO2 to allow for better tissue oxygenation to meet the metabolic oxygen demands for the cardiovascular, neurologic and gastrointestinal systems. The simplest and most clinically effective way to determine this initially is to observe the changes seen in both *breathing rate and effort*…. IF BREATING RATE AND EFFORT ARE BECOMING MORE NORMALIZED THESE OBSERVED SIGNS INDICATE that the supplemental oxygen is making a positive impact and should be continued as DO2 is at least getting close to satisfying the CNS VO2 (oxygen demand) and this includes the aortic arch.

Assessment may be also be enhanced through the attempted use of **PULSE OXIMETRY as this provides a digital means of determining the need and results of treatment.** Any SpO2 % above 94% is acceptable. HIGH FIDELETY SpO2 monitors like the Mosimo unit or those that provide nasal membrane oxygen placed saturation transducers may provide another means of oximetry. The common systems use transmissive oximetry methods that involve the detection of the amount of oxygen saturation in the red blood cells using a photodetector that is placed on one side of the tissue being interrogated and the other side where the photon beams are being generated. The device passes two wavelengths of light through the body part to the photodector. The changes in absorbance at each of the near infrared wavelengths is measured. These differences in absorbance are due to pulsing arterial blood in the small arterioles. Reflectance pulse oximetry may also be used as an alternative. It does not require the light beams to be transmitted through the skin or membranes and is therefore more effective when interrogating the chest, feet, and forehead. This technology has recently been introduced into smartphone technology such as the Samsung Galaxy S5. For pulse oximetry to been effective and reliable the pulse wave MUST be able to be seen and assessed (Photoplethysmography) so that the accuracy can be determined. There must be a good wave form for clinical interpretation.

Unfortunately in many cases pulse oximetry is NOT able to be used initially due to the difficulty in applying the sensor anywhere. As many experienced clinicians have said " These patients should not be messed with" and attempts to place a pulse oximeter, at least at the onset of therapy is contrainidicated. This also includes the procurement of blood samples for laboratory analysis and the procurement of radiographs.

Research has proven that supplemental oxygen might be a means of care that provides a buffer between catastrophic decompensation and getting by while the history and exam (as best as can be done safety) are completed

Research papers supporting supplemental oxygen: Head injury swine model supplemental O2 reduced the edema and improved outcome…. " The MOST important treatment for all head injured" Geoff Manley MD 2003; Chief Neuro-Trauma, Univ. California San Francisco, San Francisco General Hospital: 0% mortality w/ 100% O2 verses 71% mortality w/ 20% O2 in hemorrhagic shock pigs partially fluid resuscitated w/ hetastarch. .Meier J, et al: Hyperoxic ventilation reduces 6 hour mortality after partial fluid resuscitation from hemorrhagic shock. Shock 2004 Sept 22(3):240-247

NOTE ABOUT SUPPLEMENTAL OXYGEN: Please refer to the manuscript entitled:

A Critical Look at Supplemental Oxygen Delivery Methods - What is the evidence. And a look at a new method: Using a High Flow Humidified Oxygen Cannula - This presentation reviews all the current means of providing supplemental oxygen (blow by, cages of various types, open mask, sealed mask with BVM and reservoir, hood, collar, boat, nasal catheter, nasal cannula, bilateral nasal catheter, nasopharyngeal, bilateral nasopharyngeal, nasotracheal) and *relatively new method involving a nasal cannula fitted to deliver higher flow humidified oxygen.* These methods are compared regarding ease of use, patient acceptance, equipment/supplies needed and FiO2 achievable over given amounts of time, and oxygen flow rate required.(further information is provided that addresses these modalities is written in the proceedings entitled: A Critical Look at Supplemental Oxygen Delivery Methods

Sedation as a critical part of therapy for the dyspnea patient:

This is one of the most important therapies that should be completed for the patient having difficult breathing. If anyone has ever had a respiratory crisis it is commonly remembered as one of the most frightening times in his or her entire life. Although we can not truly know what our animal patients are sensing or thinking I have noted in their eyes a look of panic and fright. This appeared to be greatly heightened as their breathing effort increased. This often becomes more exaggerated as they arrive at the very place (veterinary hospital) were they might remember other visits were they were subjected to examinations, vaccinations, blood draws, etc., that were associated with a sense of fright. **THEREFORE, as many other authors have recommended – these animals need substantial and very early treatment for their physiologically induced PANIC.**

Protocols that have been critically examined and found to be effective in decreasing patient panic. I have not found any clinically reproducible studies that will fit every patient however. Each patient will need a protocol that is tailored to their needed and the response observed to assure as much clinically safety and effectiveness as possible:

Butorphenol 0.2 mg/kg IM with either Acepromazine 0.01 mg.kg IM or Midazolam 0.2 mg/kg IM – acupuncture point LI-11, GV -20 and the calming point located behind the mastoid process – each activated with either pressure, red photonic light, low level laser or needed. I prefer the use of the photonic “torch” as it very quickly activates the AC point and attendant light based meridian. NOTE: This protocol can then be supplemented with added doses once an IV catheter is placed.

Hydromorphone 0.1 mg/kg with either Acepromazine 0.01 mg/kg or Midazolam 0.2 mg/kg IM along with acupuncture points as well – Of course these protocols can be used without the ACPs but the effect is enhanced by their use and in some cases the can be used along. IV doses of these combinations will also work well in most cases as long as they are not given rapidly and it is recommended that only half doses are given initially.

Ketamine 2-4 mg/kg, butorphenol 0.1-0.2 mg/kg, and acepromazine 0.01-0.04 mg/kg mixture in the same syringe given IM in the epaxial muscles (if IV access is not already available).

Anesthesia Induction, Intubated and Positive Pressure Breathing Instituted:

Anesthesia Induction with IV doses of these drugs with a small dose of propofol may also be needed for the very critical difficult breathing patient on occasion. This may be indicated when the dog or cat is literally "breathing their last" Blow by oxygen is given until the IV hydromorphone and Midazolam are on board and then a bag valve mask is added and assist ventilation is given. Then a small amount of propofol is provided (generally 1-4 mg/kg starting with the lower end of the dose. The trachea is intubated with the assistance of a laryngoscope (if available – which is especially helpful in cats and those dogs with airway compromises such as those that are brachycephalic. Positive pressure ventilation will then be instituted while other diagnostics and therapy such as chest taps , chest tube placement, or thoracic surgery such as what might be needed for a small dog that was attached by a large dog and sustaining injury to both the right and left thoracic wall and lung tissue, those with severe pulmonary edema from congestive heart failure, or centroneurogenic pulmonary edema from a choking episode.

Protocol - use of a Bag Valve Mask (BVM), and assist ventilation with addition of a PEEP Valve:

When a pet arrives that is obviously having labored and difficult breathing an immediate course in treatment is to provide supplemental oxygen at high concentrations. This is may be best completed by use of a tight fitting face mask that is attached to a valve system and reservoir. Of course most of these patients will in a state of panic and will need the medications as discussed previously. Ideally a "non-rebreather" oxygen mask would be initially placed that would provide nearly 100% oxygen. In veterinary medicine, we lack this type of non-rebreather mask so the best option is to use a bag-valve-mask assembly or "AMBU bag" * attached to a cone-shaped veterinary facemask. The AMBU has an exhalation valve that directs the exhaled air out into the atmosphere, and an inhalation valve that allows the inhalation of oxygen from the reservoir which is part of the AMBU. To the end of the exhalation port a positive end expiratory pressure (PEEP) valve** can be attached. Using this added valve increases the amount of air left in the lung at the end of exhalation (increasing functional residual capacity). As the top of the valve is rotated it tightens a spring which increases pressure on a valve that controls the resistance to air flow out of the lungs. The reservoir is a clear plastic flexible bag which is filled with oxygen during the patient's exhalation time and empties during bag compression as seen in this photo of a firefighter-paramedic providing bag-valve mask ventilations in the emergency training scenario. The amount of oxygen in the reservoir needed to satisfy the patient's inhalation lung volume, which is frequently increased from the patient's stressed state, must be able to be easily supplied in the breath effort in the ¼ to 2 seconds inspiratory time. This requires a flow rate of oxygen at the patient's airway during inhalation calculated to be between 12and 100 Liters per minute (ave. 66 L/min)***. This calculation is based on the tidal volume, minute volume and inhalation time of each breath. As can be seen from examination of the data presented, it is impossible to provide this amount of flow rate of inhaled oxygen without the use of a reservoir that can be easily emptied that contains 100% oxygen. Any other systems involving a face mask, where there is no reservoir or valves to control the direction of inhaled and exhaled air is not recommended to be used in emergency settings where the work of breathing must not be increased and high concentrations of oxygen are required. During the inhalation phase of breathing if there is no reservoir attached to this same type of bag-valve-system the highest % of oxygen that can be achieved during inhalation is 40-50% while with the reservoir oxygen concentrations can reach 100%. Of course most animals having difficulty with breathing they resist the use of the tight fitting mask. In these cases other simple ways of providing supplemental oxygen should be tried first. This includes the methods discussed in more detain in the paper on oxygen supplementation that is also in this proceedings.

However, in summary research that we performed and published in 2004 IVECCS Proceedings (Mark Engelhardt, DT Crowe) revealed that although oxygen cages can be used for the treatment of these critical patients, they unfortunately force isolation of the pet away from the care givers and they require at least 20-25 minutes of oxygen delivery to see oxygen concentrations approach 40% delivered to the patient. This is of concern because of the time lag that is seen with the use of oxygen cages. Other alternatives that are available that provide higher concentrations of oxygen in a much shorter period of time include blow-by and jet blow-by (reaching 40% oxygen within 2 minutes), placement of the patient in a smaller container (compared to the standard oxygen cage) (reaching 60% oxygen within 5 minutes), use of a Crowe collar; which is an Elizabethan collar that is one size larger that would otherwise be used and its most rostral ventral half covered with clear plastic wrap to provide a "boat effect" for the holding of the delivered oxygen around the patient's head (providing 70% oxygen within 2-3 minutes and 80% a a flow rate of 5 L/min.), nasal cannula (providing 40% oxygen with in 1 minute with an oxygen flow rate of 4 – 5 L/min.) and nasal catheters that are flexible feeding tubes that can be placed unilaterally or bilaterally following slight sedation (providing 40-70% oxygen within 2-3 minutes of the beginning of oxygen delivery at 50-100 ml per kg), and even simply placing the patient in firm or flexible plastic bubble that is connected to an oxygen supply line (providing 50-70% oxygen within1-3 minutes with oxygen delivery at 5-10 L/min.)

If after the oxygen has been administered for from a few to 30 minutes with any of these non-mask systems the patient continues to have serious respiratory effort (and a quick look ultrasound has ruled out significant pleural space disease) the patient may benefit significantly from the application of mild sedation and placement of a tight fitting mask on the patient's head and using an AMBU resuscitation bag, and adding breath assistance with the squeezing of the AMBU bag with each breath. The positive pressure breathing is begun, timing as best as possible, the squeezing of the bag with the onset of each spontaneous breath the patient takes. Within a few minutes the patient' respiratory rate and effort should be decreasing and becoming less labored. This simple but very effective technique called "assisted ventilation" is very effective in decreasing the effort the patient takes to continue to breath. It has been my experience with many patients that often as they get used to what is trying to be accomplished and settle into a rhythm, and literally fall asleep within a few minutes because they were so exhausted from trying to breath. Emergency patients that arrive in significant shock and pulmonary injury should be managed immediately with this bidirectional positive airway pressure (Bi-PAP) ventilation technique if they are still conscious.

Continuing the assisted ventilation for at least 30 minutes is recommended in most of these cases if they are still conscious and positive clinical effects are observed. Once the shock is being addressed the addition of a PEEP valve on the exhalation side of the AMBU bag can be instituted to treat pulmonary edema, contusions, etc., This valve has a spring that gets tighter and increases the amount of pressure needed to open up the exhalation valve. With the valve pressure set at 5 cmH20 the airway pressure at the end of exhalation is elevated, i.e., positive end exhalation pressure (PEEP). When positive pressure ventilation is added to the AMBU bag-valve-mask that is applied tightly BiPAP or Bi-directional positive airway pressure ventilation is being performed. If breathing is not assisted with the addition of positive pressure breathing this is called CPAP (continuous positive airway pressure). Both types of breathing will increase the patient's functional residual capacity and is easily accepted by most patients. If not accepted then a small dose of butorphenol and very small dose of acepromazine generally works well to allow the animal to relax and accept the mask, which must be tight fitting to allow the positive pressure breathing to be successful.

In most cases the addition positive pressure to assist inhalation with each breath with the PEEP valve set at 5-10 cmH2O (Bi-PAP) is begun initially with patients that are not responding to supplement oxygen alone. The Bi-PAP is done for 20-30 minutes and then the patient is re-evaluated. Re-evaluation may include watching the patient's breathing pattern and effort, auscultation of breath sounds, thoracic radiographs, thoracic ultrasound, and arterial blood gas analysis. Hopefully there are changes that are positive such as the dog who had been hit by a car that received a repeated thoracic radiographs following Bi-PAP that showed a significant improvement.

In patients that do not respond well invasive positive pressure ventilation with intubation of the trachea and placing the patient on continuous positive pressure ventilation and PEEP. In those patients that make improvement with the non-invasive ventilation it has been my experience that approximately 50% will only need a few more Bi-PAP treatment sessions and then provided with continued supplemental oxygen therapy with methods that are very effective, even if a small amount of sedation is required to keep the patient comfortable and accept the therapy such as bilateral nasal catheter placement or Crowe collar. The use of this technique has been used by the author in an estimated 400 patients over a period of 10 years, beginning in 1997. It is recommended to consider this life –saving technique as it has been very successful as a rescue procedure. I continue to use similar techniques in my human patients working as an EMT Intermediate and first responder on the rescue unit of the county. I estimate that without the use of this technique mortality would have been 100%. But through its use over 80% were able to become salvaged.

I also recommend the use of non-invasive ventilation with a bag-valve - mask for a few breaths at least BEFORE intubation in cases of the pulseless non-breathing and unconscious patient. It has been my experience that if the patient is not oxygenated well and is acidotic that any movement can induce ventricular asystole or fibrillation caused by vasovagal and sympathetic stimulation. Bag-valve mask ventilation only requires the head to be extended and the tongue pulled forward and the jaw closed and the application of the tight fitting mask, as opposed to all the manipulation necessary to perform endotracheal intubation.

I have observed that noninvasive ventilation as described, provides a very rapid way to provide oxygen and lower CO2 in the blood stream and tissues, thus helps prevent catastrophic complete arrest in patients that were near arrest. It is recommended to perform non-invasive ventilation with the AMBU bag and reservoir connected to an oxygen supply and being delivered at from 5-15 L/minute immediately on all unconscious patients that are unresponsive and not already intubated. The technique has been one of the best life-saving procedures I have ever done.

Protocol for care in the dyspnic patient that is NOT responding to Supplemental Oxygen and Assist Ventilation with the Bag-Valve- Mask and PEEP Valve .

Response to supplemental oxygen therapy can usually be gauged by monitoring respiratory rate and effort, presence of cyanosis and pulse oximetry readings. Pulse oximetry readings may be unreliable in the animal with pigmented skin, where this is inappropriate thickness of skin between the oximetry clamp, and in the patient with poor perfusion.

If the patient does not respond to supplemental oxygen and assist ventilation with bag-valve-mask <u>and</u> pneumothorax is ruled out as well as diaphragmatic hernia or in the pleural space via auscultation, tap, ultrasound or rapid thoracic radiograph while assist-ventilation is being performed <u>then</u> rapid sequence induction, intubation and ventilation should be strongly considered. In many cases assisted ventilation with the use of sedation followed by placement of a tight fitting mask and positive pressure support ventilation, timed with each patient breath, is at least initially done. Artificial ventilation is indicated in the patient with ventilatory failure (inability to exhale carbon dioxide as well as inability to oxygenate) until the cause of the ventilatory failure can be resolved. It is important to recognize these patients early. Patients who have been working hard to breathe for an extended period of time may die from ventilatory failure secondary to exhaustion. The goal in these patients should be rapid induction, intubation and ventilation.

Before this is accomplished simply sedating with an IM injection in the epaxial muscles (if IV access is not already available) of a mixture of ketamine 2-4 mg/kg, butorphenol 0.1-0.2 mg/kg, and acepromazine 0.01-0.04 mg/kg as outlined prior can also be used to provide enough calming to allow the placement of a bag-valve-mask attached to reservoir and oxygen supply delivering 5-15L/minutes. The mask is applied firmly and with the patient's head and neck extended (and the tongue pulled out and the mouth closed over the extended tongue (if the patient allows) the bag is squeezed with every breath the patient takes, thus assisting him with positive pressure breathing. (see also the section below discussion CPAP). Timing each squeeze of the bag with the beginning of each beginning breath the patient takes gives tremendous relief to the patient's respiratory difficulty. This also helps oxygenate the patient before induction is proceeded rapidly with an IV administration of a mixture of ketamine (5 mg/kg) and diazepam (0.25 mg/kg), given to effect to allow tracheal intubation. Other drugs can be used such as 2.5% thiopental (5-10 mg/kg) and Propofol (3-8 mg/kg), but in my hands produce more significant cardiovascular depression and should are not my drugs of choice. Neuromuscular blockers (succinylcholine 0.01 mg/kg, or atracurium 0.25 mg/kg) can also be used for rapid induction after small amounts ketamine, diazepam, or an opioid are given. (Atricurium is preferred over succinylcholine as it does not cause muscular contractions as later does). In the compromised patients doses should always be titrated, as much less drug will generally be required than needed to induce the healthy patient. Once intubated (preferably with a laryngoscope, as this provides for less laryngeal manipulation and possible vaso-vagal response), positive pressure ventilation is continued. Another choice, being used frequently, is low dose dexdomitor (0.1 ml in a 10 kg dog) given along with hydromorphone (if severe pain is involved) or butorphenol. Then oxygen with isoflurane is provided as needed by gentle bagging with the relaxation of the limb to the point of being able to flex and extend easily (an indication that the patient now will allow orotracheal intubation (using a laryngoscope - preferred as less vagal stimulation will be possible).

After the patient is intubated the choices of ventilator include 1. By-hand bagging either with a bag-valve with reservoir (AMBU), or anesthetic machine; 2. Anesthetic ventilator; 3. ICU ventilator. At the same time the hunt for the cause should continue and specific therapy performed when the cause is determined.

One patient illustrating the use of an anesthetic ventilator for ICU ventilation in a newborn. This case seems to break all traditional dogma of the following: 1.you cannot ventilate with 100 % oxygen for more that 12 -18 hours as you will be irreversible oxygen toxicity and lung injury. 2 you can not give 100% oxygen to a newborn without causing significant eye, neuro and lung issues:

Case: A newborn German Short Haired Pointer – he and the rest of his littermates had been delivered by C-section and a number of the newborn were not thriving. He was given mouth to those ventilation and then moved onto a small Ambu bag and mouth to mask ventilation. You still did not ventilate despite several doses of naloxone. A eight French feeding tube was used to intubate the trachea and it was attached to a 3 mm ET tube connector using tape to secure the connection. Again a small AMBU bag-valve resuscitator was used to provide ventilations but the little one still did not begin to ventilate spontaneously. Therefore the Hallowell anesthetic ventilator was used to provide a means of positive pressure breathing using a pediatric circuit attached to the 3 mm ET tube connector. The lowest settings on the ventilator was used but this was still large an amount of oxygen to be given with each ventilator given breath. So this was remedied by making a hole on the inhalation side of the tubing going to the Y connector. The hole was continued to be made until the end of the Y connector and an attached thumb of a surgical glove provided just enough airflow that the surgical thumb tip would expand slightly as the ventilator circuit kicked on and gave a breath. The Y connector was then attached to the 3 mm ET connector and the chest rise of the newborn was observed as the ventilator kicked on. The patient was then left on the ventilator throughout the night and on into the next day, (estimated to on the ventilator for 14 hours) and he was able to be weaned off the ventilator and then supplemented with oxygen using a 3 Fr. nasal oxygen catheter. The dog recovered from the ordeal and became a national champion (as per conversations had with the veterinarians that had provided most of the care for the newborn until discharge. The owner was also a veterinary technician that worked at the hospital.

Use of an intensive care ventilator is very important and a critical piece of equipment necessary for intensive care of many of the most severe pulmonary cases. Many can you purchase used. It is recommended that when making a purchase that an air compressor be involved as then the amount of oxygen delivered can be tailored to just what is necessary. Some of the newer models do not require oxygen and air mixes outside the ventilator. It is beyond the scope of this paper to go into all the modalities of the use of ventilator support in sick patients, but suffice it to say that positive pressure support with simultaneous intermittent ventilation time with the patients ventilations are ideal. Units to provide humidification her also recommended.

The modality of high-frequency or high-frequency jet ventilation are also effective in some patients. Even in some of the older mechanical ventilators can be placed into a high-frequency mode ands may be of help in some patients who continue to have tachypnea. High frequency oscillatory ventilation allows movement of gases with the homeowner tree to be done without increasing airway pressure. The author has used these on occasion. Some people believe that they are very effective, especially in the neonates in human pulmonary critical care.

Alternatives to Rapid Sequence Intubation (RSI) - 1. Continued non-invasive ventilation with the AMBU BAG, anesthetic machine, or ventilator; 2. Direct awake tracheostomy tube placement generally under mild sedation and the use of lidocaine. 3. Following careful general anesthesia following initial sedation and tracheal intubation. This is the most common method used. The procedure I will describe I have as a video on VIN

Temporary Tracheostomy - in my experience I have been very impressed how placement of a tracheostomy tube has allowed time to get to the bottom of the problem. The tracheotomy also decreases the work of breathing (short straw breathing verses long straw breathing). It has been able to allow for tracheal toileting and clearing of the large airways via suctioning. It also allows the bronchial tree to be directly medicated. If a commercial tracheostomy tube is available that is OK however I have also found through the performance of well over a 100 tracheotomies that an endotracheal tube fashioned in to a tracheostomy tube also works well. It is cut along its top and bottom longitudinally and the balloon inflation mechanism spared. The plastic adaptor is reinserted and the long ends of the two split sections are cut off partway. Holes are placed through the split sections that are left. Through these holes are placed sections of IV tubing used to tie the tracheotomy tube in place. Tracheotomy tubes should be changed every 6-8 hours or as needed (blocked or near blocked). Pets with T-tubes in place must always be watched as obstruction can occur quickly.

Our experience has shown that the institution of temporary tracheotomy tubes has been life-saving in the following cases:

Pneumonia that is progressive where this significant exudate as the T-tube allows for direct suctioning of the exudate, humidification, direct irrigation with saline as this is a mucolytic and micronebulization of antibiotics such a Amikacin in the treatment of Gram negative associated pneumonia such as Klebsiella pneumonia. This organism is encapsuilated and a facultative anaerobic organism that now a very important cause of nosocomial pneumonia that often is very resistant to many other antibiotics. Having the ability to treat the lung infection by micronebulization of the amikacin via the trach tube has been a rescue technique in my hands. There are of course some Klebsiella organisms that seem to be resistant to every commercial antibiotic known. In this case the use of meropenem may produce the best bacterial clearing. Caution is advised with each of these serious infections and the organisms can be spread to humans as well so very good isolation and hygiene protocols be used.

Here is one example: A four month old female German Shepherd with severe pneumonia was referred after having seen several veterinarians who are diagnosed the significant pneumonia and had place the dog on several types of antibiotics. Despite the administration of the antibiotics the patient was getting worse. Radiographs revealed both right and left lung fields were significantly involved with and air bronchogram pattern. Consolidation was also seen in some areas of both right and left lung fields. A tracheotomy was performed under mild amount of sedation and a local block Pre oxygenation was performed and then suction applied. A large amount suppurative exudate was able to be removed and following irrigation with saline more exudate was aspirated. I went over to the local hospital and receive some nebulization and humidification equipment from the respiratory therapist who work there and took that back to the veterinary hospital and started treating the dog was intermittent ventilation with micronebulizer and added a tracheotomy cup or bowel that was attached to a humidifier. The culture and Gram stain of the exudate was done and systemic antibiotics were chosen based on what the Gram stain showed. It appeared that a gram-negative rod was most likely the prime organism involved in the infection and intravenous Amikacin was started as well as it being used in the micronebulization treatments that were being done every 4 hours. Oral Baytril was also administered. Intravenous fluids were also provided to keep the patient hydrated. The dog went on to have a successful recovery from the pneumonia after remaining in the hospital for three days at which time the tracheotomy tube was removed and the patient was discharged. She was seen on a daily basis to continue with the injectable Amikacin as well as receiving of postural drainage, coupage and oral antibiotics as described prior. Again she made a complete recovery.

Trauma to the lung that leads to severe pulmonary edema. The tracheotomy tube then allows for direct suctioning of blood and edema fluid. Here is an example:

Case: Puppy" a 2 mo old male Jack Russell "squashed by a horse" "stepped on bad": He arrived with difficult breathing, and crackles; Pale mm, CRT > 5, HR 200+, no pulses to speak of; breathing was very labored; Jet-blow-by O2, all peripheral vessels flat, IV established by CD on the rt. jugular, kept providing bag-valve-mask ventilation and oxygen while IV hypertonic saline and hetastarch was provided in 5 ml /kg increments, still remained unconscious, so intubated and provided IPPV and took radiographs that showed all ling fields white out; Performed a tracheotomy to allow tracheal toileting of all the blood and foam; Suctioned out red foamy fluid; Placed on an old Bird ventilator for 40 hrs using pentobarbital at 1 mg.kg.hour to keep him still. (now as there is no pentobarbital available we use hydromorphone or fentanyl as a CRI and acepromazine or midazolam **as a CRI as well)(Rarely need to paralyze the patient to allow the ventilator to do its work** and not have the patient buck it so hard). Were able to wean off and pull the ET trach and yet allowing the trach tube to be near so to still be able to replaced if it were necessary. Placed on a nasal O2 catheter + some CPAP (periodically for a day). Received Norm-R, Blood (fresh whole), HS and hetastarch. He went home day 4 post injury. The trach site healed well by second intension. A follow-up call at 6 month and a year later: Owners said he was doing very well!

Congestive heart failure that leads to severe and fulminant pulmonary edema as the tracheotomy tube allows for micronebulization of bronchodilators and suctioning of edema fluid and for ventilation of the edematous lung; Example: a 10 year old poodle arriving with fulminant pulmonary edema – there was loud mitral murmur that was brought in by an elderly woman who was also having difficulty breathing; The lady was asked to sit with her dog (she did not want to give it up to anyone). An oxygen caddy was brought to the lobby and blow by oxygen was begun – giving it directed to her and the dog. 911 was called and as the EMS providers arrived she let the vet team have her dog. Blow by was continued with the addition of a plastic bag over the dog's head and a TFAST was done and revealed many rockets and a glide sign, IM sedation with butorphenol was accomplished and an IV catheter was placed. IV Lasix 2mg/kg was bloused and a CRT of 2 mg/kg/hr was continued and BVM assist ventilation with a PEEP valve set at 5 cmH2O was begun as the sedation took effect further; Pemobendin and enalepril was begun orally and a LOOP was placed on the thoracic cavity research has shown that the device decreases bronchospasm, decreases vascular resistance and increases coronary blood flow. The dog became so comfortable and sedate that he fell asleep in the techs arms as the BVM ventilation was continued. Edema harsh lung sounds and rales and wheezes diminished and the work of breathing initially noticed on arrival was greatly reduced after 30 minutes. Radiographs were then able to be taken. Bilateral nasopharyngeal catheters were placed stated at 2 LPM each and to provide more comfort a dose of hydromorphone was given and fluids provided in a limited fashion. Over the next 12 hours the dog continued to receive the mediations, LOOP and oxygen by nasopharyngeal catheters and rest. The edema resolved and the dog was able to be discharged to her owner's caregiver as the owner was also at home recovering for an episode of CHF herself.

<u>Trauma to the mouth, larynx or trachea that leads to edema and decreases in the airway diameters</u> to the point of causing dyspnea – Example: A 3 year old male Dalmatian that pounched on a stick that was thrown by a young son and the dog cried out and the stick was lodged in the dog's mouth- The stick was pulled out by the son's father and the dog was brought to the hospital for care: On admission the dog was having respiratory difficulty and there was some blood coming from his mouth. There was air under the skin of the neck that was palpable. an IV catheter was placed and due to the significant breathing difficulty he was given IV propofol and the trachea immediately intubated. After this was done PPV was begun as he was placed on an anesthetic machine that also contained an ventilator. Isoflurane was give as needed to general anesthesia. This allowed the mouth and pharynx to be examined and a relatively large hole in the dorsum of the pharynx was noted. Radiographs revealed a large amount of subcutaneous air and air in the mediastinum. With the history of a 23-inch stick that was pulled out and pieces of the stick missing it was recommended to have the entire are explored. This was done and many shards of stick were removed from the cervical soft tissues with some having entered the trachea and esophagus, and one of the shards had entered into the brachiocephalic vein. As the shard of the stick was removed air entered into the vein and immediately the heart went into an arrest. CPR was begun via an open approach through the thoracic inlet. The pericardium was opened and as massage was done air could be seen in the coronary vessels. The heart did not recover even after epinephrine, atropine, etc. were given.

Brachycephalic syndrome that has the patient now in a respiratory crisis – Here is an example: 4 month old English Bulldog that ate a large soup bone which got lodged in the esophagus and caused him to panic as he was unable to accommodate the bone in the proximal esophagus and the elongated soft palate. The airway was thick with ropey saliva and suctioning was to no avail. He was given butoprphenol and ketamine to allow him to be quiet and the examination showed a very severe laryngeal compromise with severe averted laryngeal saccules and a severe elongated soft palate; difficulty occurred in gaining an ET tube placed into the airway as swelling was also significant. A tracheotomy was completed and then the esophageal foreign body was able to be pushed into the stomach. It appeared to be mostly gristle. The dog then underwent elongated soft palate resection and removal of the significant everted laryngeal saccules and recovery was uneventful as the trach was able to provide an open airway and as the swelling went down, in two days, the trach tube was able to be removed and the site healed by second intension.

Trauma to the head and neck - blunt or penetrating - Here is an example:

Case: Sara, a middle aged Fe Golden Retriever with a large hole in her head that she was breathing through: Its about 7 PM when we were all about to leave the hospital after a long day. You are tired! A man carrying in a Golden Retriever. Her name is Sara he says about 10 years old. She is motionless, unconscious, and dripping blood from nose. This can be seen easily as the blood is dripping at a fairly brisk rate. As you do a further survey you see the man appears in emotional shock. He says his dog was just hit by a car a block away and says "Do all you can to save her. She's my life!" He works as an accountant for the state he says. He is dressed in a suite and tie. His white shirt is covered in blood. On initial primary survey you note the following: A = bubbling – gurgling- large hole noted in the frontal sinus; B = breathing through this hole but not very effective; seems like little air is moving from the mouth and there is bubbling and gurgling sounds coming from the mouth; D = left eye appears possibly ruptured but difficult to tell because of all the blood covering her face; there is a poor but present gag reflex noted as an ET tube tries to be inserted. There's so much blood that it is difficult to see her rima glottis; she is not responding otherwise and breathing efforts are poor; it is assumed that she has a traumatic brain injury (TBI); E = no other obvious injuries are noted → Immediate therapy is started by providing jet blow-by oxygen to her mouth and face and head as ts been noted that with brain injury with a compromised airway oxygen is needed within minutes to prevent hypoxia.

Research has implicated that a lack of oxygen to brain cells leads to excitotoxicity, and oxidative stress. (Perlman JM. Pathogenesis of hypoxic-ischemic brain injury Journal of Perinatology (2007) 27, S39–S46). With TBI that was also apparent with Sara there is primarily and secondarily associated massive release of excitatory amino acid neurotransmitters, particularly glutamate. This excess in extracellular glutamate availability affects neurons and astrocytes and results intra-stimulation of ionotropic and metabotropic glutamate receptors with consecutive Ca^{2+}, Na^{+}, and K^{+}-fluxes. Although these events trigger catabolic processes including blood–brain barrier breakdown, the cellular attempt to compensate for ionic gradients increases Na^{+}/K^{+}-ATPase activity and in turn metabolic demand, creating a vicious circle of flow–metabolism uncoupling to the cell.

Oxidative stress relates to the generation of reactive oxygen species (oxygen free radicals and associated entities including superoxides, hydrogen peroxide, nitric oxide, and peroxinitrite) in response to TBI. The excessive production of reactive oxygen species due to excitotoxicity and exhaustion of the endogenous antioxidant system (e.g. superoxide dismutase, glutathione peroxidase, and catalase) induces peroxidation of cellular and vascular structures, protein oxidation, cleavage of DNA, and inhibition of the mitochondrial electron transport chain. Although these mechanisms are adequate to contribute to immediate cell death, inflammatory processes and early or late apoptotic programs are also induced by oxidative stress.

Therefore most guidelines are to provide supplemental oxygen as rapidly as possible to patients suffering from TBI or other hypoxic to anoxic associated conditions so that there might be an interruption of the build up all the elements that cause further brain cell disruption. (Bateman NT, Leach RM. ABC of oxygen: acute oxygen therapy. *BMJ* 1998; 317: 798-801).

New research also has recommended the use of intravenous vitamin C as it is an electron donor and data has revealed that this will prevent pore opening and capillary leaking caused by shock. Giving 50 mg/kg in early onset shock has shown that edema caused by the shock induced vascular leak will be substantially less. Shock. 2005 Aug;24(2):139-44.
High-dose vitamin C infusion reduces fluid requirements in the resuscitation of burn-injured sheep. Dubick MA, Williams C, Elgjo GI, Kramer GC. Abstract

"Fluid resuscitation to maintain adequate tissue perfusion while reducing edema in the severely burned patient remains a challenge. Recent studies suggest that reactive oxygen species generated by thermal injury are involved in edema formation associated with burn. The present study tested the hypothesis that adding a free radical scavenger to the resuscitation fluid would reduce total fluid requirements in the treatment of severe thermal injury. Anesthetized chronically instrumented sheep received a 40% total body surface area full-thickness flame burn. At 1 h after injury, animals were resuscitated with lactated Ringer's (LR, n = 14) as control, LR containing high doses of vitamin C (VC, n = 6), 1000 mOsM hypertonic saline (HS, n = 7), or 1000 HS containing VC (HS/VC, n = 7) in coded bags so that investigators were blinded to the treatment. Fluids were infused at an initial Parkland rate of 10 mL/kg/h, adjusted hourly to restore and maintain urine output at 1 to 2 mL/kg/h. Sheep in the VC or HS/VC group received 250 mg/kg VC in the first 500 mL of LR or HS, and then 15 mg/kg/h thereafter. Hemodynamic variables and indices of antioxidant status were measured. At 48 h postburn, sheep were euthanized, and heart, liver, lung, skeletal muscle, and ileum were evaluated for antioxidant status. All fluid resuscitation regimens were equally effective in restoring cardiac output to near baseline levels; no treatment effects were apparent on arterial pressure or heart rate. VC infusion significantly reduced fluid requirements and, therefore, net fluid balance (fluid in, urine out) by about 30% at 6 h and about 50% at 48 h in comparison with the LR group ($P < 0.05$). HS and HS/VC reduced fluid requirements by 30% and 65%, respectively, at 6 h, but the volume-sparing effect of HS was not observed after 36 h and that of HS/VC was lost after 12 h. Plasma total antioxidant potential increased about 25-fold ($P < 0.05$) at 2 and 3 h in response to VC infusion compared with the LR and HS groups, and remained about 5- to 10-fold higher throughout the rest of the study. VC infusion also prevented the 4-fold increase in plasma thiobarbituric acid reactive substances seen in the LR group early after burn ($P < 0.05$). Tissue antioxidant status was similar between groups. In this sheep burn model, continuous high-dose VC infusion reduced net fluid balance, reduced indices of plasma lipid peroxidation, and maintained overall antioxidant status in comparison with standard-of-care LR treatment.

Sara received the following: She was first treated with supplemental oxygen by blow by jet to her face as mentioned earlier; A quick discussion was accomplished with the owner and written permission with a estimate was signed for further emergency care including surgery and postop supportive care as required; Because of the significant airway compromise with the blood in her airway and the TBI a resuscitative tracheostomy was performed; Then ventilation was started, first by use of an AMBU bag-valve and reservoir and then she was switched to an anesthetic machine with a mechanical ventilator (Hallowell); A mini-cutdown and the placement of a 14 g IV catheter was then done and 7,5% hypertonic saline and 6% hetastarch in saline was administered at 5 ml/kg; Oxyglobin, a Hemoglobin Based Oxygen Carrier (HBOC)(Biopure) at 5 ml/kg and fresh frozen plasma (FFP)was also administered at 5 ml/kg; Plasmalyte-A at a 15 ml/kg bolus and Hetastarch alone at a 2 ml/kg boluses every 15 minutes were given as needed to produce a Doppler blood flow that was audible to the point that a dichroitic (tish tish) sound with each heart contraction was heard and systolic blood pressure (BP) was adequate at 60 mmHg. NOTE: a slight amount of isoflurane was begun and ketamine 2 mg/kg and hydromorphone 0.2mg/kg

Acepromazine 0.02 mg/kg was given intravenously; This was followed by IV atricarium 0.25/kg, and together with the isoflurane, it was felt that adequate hypnosis, analgesia, and muscle relaxation were achieved. Preoperative IV cefazolin at 40 mg/kg and enrofloxicin at 10mg/kg were administered. The OR was already in a state of readiness as we always set it up right after each previous surgery.

The Operating Room – Readiness Protocol is the following:
All set up for a major surgery and anesthesia (machine and ventilator)
Emergency drugs: atropine/glyco, epi., P-lyte, HS
Suction with canister + suction tube set
Electro-surgery and “pencil” ValleyLab - Foremost
Monitor (ECG, ETCO2 , SPO2, Temp, BP)– Blue Tooth; a Doppler

Gowns, gloves, major pack, drapes, suture laid out

Warming blanket (Chill Buster), towels, plastic bag

IV pole, fluid warmer, “blood stop”, etc.

Surgical headlight and loupes and juice boxes (for quick energy)

Sara was taken to surgery after the areas were clipped and prepped w/ Techni-Care a product containing chloroxylenol 3% (Care-Tech Labs 1- 800-325-9681). This product is safe to be placed into wounds including those around the eye. This is apposed to chlorhexidine that causes irreversible neuro cell and corneal cell injury on contact. After draping the nasal and frontal areas were explored and many free sections of bone from the frontal sinus required removal and other sections of bone just moved back into place. The bleeding became severe at one point while removing and replacing the sections of bone and the frontal sinus and nasal cavity required packing and it was noted that there was a crack in the ethmoid region. The bleeding stopped with the pressure packing. It was noted that there were internal contents of the left globe in the sinus cavity. All the contents and debris were removed and an enucleation of the rest of the eye was completed. A doubled sheet of commercially available porcine submucosa material from the small intestine was then used to cover the opening over the nasal passage and frontal cavity (A-Cell). This material acts as a scaffold in which osteoid tissue migrates over the scaffold and new bone is thus able to be laid down. Following its application the subcutaneous tissue was able to then be advanced over the A-Cell cover and closed.

Post-operative care involved the following (briefly listed only): Ventilated for 4 hours with mild positive end expiratory pressure (PEEP) of 5 cmH2O; Respiratory and physical therapy; A continuous rate infusion (CRI) of Lidocaine, ketamine, morphine, and acepromazine; Enrofloxicin, metronidazole, and ampicillin IV; Partial parenteral feeding 2mg/kg/hr using FreAmine 3.5% with electrolytes; Trickle enteral feeding beginning 4 hr post-op, giving 2 ml per Kg slowly every 4 hours; Critical care continuous monitoring for 24 hr and HBOT was provided every 12 hours for 2 days; Discharged after several days with strict confinement. Remove the staples in the head, eye, and nasal regions in 2 weeks post injury and she was doing well. The tracheotomy had been left to granulate closed with only ostomy wound cleaning with saline needed.

Modalities critical in patients with respiratory difficulty include the following:

Thoracocentesis; both done with a needle or with a catheter

Placement of small bore with guide-wire thoracic drainage catheters

Placement of large bore chest tubes without the use of the trocar

NOTE: In the opinion of this author it is important and vital never to use a trocar point in pushing a chest tube through tissues and into the pleural space… ever. There have been major instances where the use of trocars has caused the death of both dogs, cats and humans. It is always best to gently penetrate the chest wall with a well controlled dissection with a curved hemostat and then allowing the lung just under the penetration area to deflate. That allows the chest tube to be placed into the pleural space without it causing any injury to the lung. Then with aspiration on the chest to the lung will re-inflate. A sterile ET tube could also be used as a chest tube as these are very inexpensive (2-5.00) and are clear and flexible enough to be used effectively. The cuff can be removed and a few added side holes. Size to use depends on the reason for the tube. A small tube (14 g to 1/3 main stem bronchus) can be used for some air, clear fluid, and for some blood; a larger tube (1/2 to same size as main stem bronchus) is needed for a great deal of air such as from a bronchial leak, large amounts of blood, pyothorax and chylothorax.

The use of an underwater suction seal and drainage system is also critical in patients in which the lung continues to leak either blood or air following some type of penetration or injury. An indication for its use would be if there is either air or blood that continues to leak and have to be removed by periodic aspiration of the chest tube. Fortunately in most cases if continuous suction approximately 20 cm is placed on the plural space the leaking lung will generally re-expand and over the course of 24 to 48 hours the leak will stop. Having only a stopcock on the end of the chest tube and using a syringe to evacuate the air and blood intermittently may prevent the lung from expanding to the point of sealing and continue to stay sealed.

Two critical techniques that the will be addressed that has been found to be very successful are the use of either transtracheal oxygen or nasotracheal oxygen provided to the upper respiratory compromised patient with laryngeal paralysis. These techniques offer a way to support the dog in a relatively noninvasive way until the patient can have the tieback procedure done. The procedure also works on patients with tracheal collapse or laryngeal collapse as an effective stopgap measure that can be done and will lessen the stress these patients have while waiting until a more definitive procedure can be done. The principle is simple in that the insufflation of oxygen is provided distal to the area where the anatomic region of the blockage is. It is also critical when using his procedures to also keep the patient quiet and calm, as they cannot keep up with the oxygen demand in an excited or stress animal because of the limitations of the insufflation rate.

Transtracheal catheter placement – a 14 g -16 2"catheter with stylet needle is attached to a 10 **ml** syringe. The fur is clipped over the trachea and the skin prepped. An 18 g hypodermic needle is used to make a cut through the skin over the mid cervical trachea to make a release incision so the catheter will be more easily inserted into the trachea. Then the catheter is inserted and once into the lumen and verified that it is in the trachea by aspirating on the syringe. Air should be easily aspirated with no obstruction. The catheter is then directed in a distal direction and the needle is removed. The catheter is then the guided until its hub is at skin level. Aspiration should then be again done to ensure the catheter is still within the tracheal lumen. The hub is fixed to the skin using tape and sutures and the hub attached to an IV administration set which will serve as an oxygen supply line. Ideally a bubble humidifier – O2 flow meter should be used to provide humidified oxygen with flow rates varying with patient size (50-100/Kg to start and then tailored to the patient's clinical respiratory effort and rate.

Emergent resuscitative approach to the cervical trachea to gain access to a major tracheal disruption – as may occur in a dog fight.   This procedure is indicted with sometimes obvious clinical signs, such as ~~the~~ patient struggling to breath and air is moving to and out of the skin around the neck and there maybe a almost bull-frog appearance to the in and out movement of the skin of the neck with every breath. At other times the neck on examination is not clinically indicating major tracheal injury other than abnormal inhalational breath sounds – loud, or very silent obstructive with the patient cyanotic. Time is sometimes of the essence as without a patient and functional trachea the patient can decompensate very quickly. Penetrating wounds may or not be easy to detect. These are what cause most of the tracheal injuries. Some have been so severe that complete tracheal disruptions have occurred under even intact skin or with only a few small puncture wounds available.

The procedure might require an emergent and rapid approach if the airway is significantly compromised. In that case an approach to perform an "awake" tracheotomy might have to be done. In very long haired dogs clipping quickly will help in finding the midsection of the trachea and after a rapid prep (20 sec) an incision is made in the midline and using a pair or curved hemostats and/or a Mayo or Metzenbaum scissors the trachea is isolated, the injury found and a patent airway established. This is often done by placing an ET tube in the isolated section of the non-injured trachea via a separate tracheal incision done with an ventral tracheal incision between two rings. In other cases the tracheal opening is found and a possibly smaller than normal ET tube is threaded through it and into the lumen downstream and the cuff inflated and ventilations begun. In cases where the trachea is pulled or cut in half the distal end may have to grasped with 1-3 hemostats to open it and retract it so that an ET tube can be inserted.

Emergent resuscitative approach to the thoracic trachea to gain access to major tracheal disruption. This is only commonly recognized as a possible problem when a standard ET tube is placed into the larynx and then advanced into the thoracic inlet region. Upon providing some positive pressure ventilations the lungs do not expand as they should in inhalation and the air either seems to have more resistance or very little resistance at all and if using an anesthetic machine to give the positive pressure breath. In some cases cardiovascular collapse is also occurring or has already occurred; and only when the ET tube is passed so that PPV (positive pressure ventilation) can be given do you recognize the tracheal disruption because the lungs do not inflate with the PPV. When this is recognized the most effective and really the only treatment that can be done that might save the patient's life is to perform an immediate resuscitative parasternotomy, isolate the thoracic trachea, retract of the distal end of the trachea and place an ET tube in the lumen, inflate the cuff and begin PPVs. Often by the time the problem is recognized CPR via an open chest cardiac massage is required.

The resuscitative parasternotomy procedure- This is done by making a skin incision with a blade or Mayo scissiors and then the costosternal (CS) junction is separated using a blade or Mayo scissors as well. The separation begins at the thoracic inlet and all CS junctions are separated at least until the trachea can be exposed by opening up the mediastinum and observing it. A surgical head light or even a hunter's or biker/hiker's headlight helps with this exposure. The internal thoracic artery and vein may be injured with this rapid approach and intercostal arteries and veins will also have been severed at each CS junction. After the resuscitative steps of gaining an airway, beginning PPVs, and getting the heart back with a spontaneous and sustainable beat and with enough strength to be causing hemorrhage at these sites then these bleeding sites will need to be controlled with hemostats, stick tie sutures/ligatures and possibly electrocautery.

Repair of tracheal injures – This often requires removal of the injured segments of the trachea or the ends were separation has occurred. The best way to complete this in most cases has been to advance an ET tube (generally smaller than normally used for standard intubation) into the injured site and then threading it to the distal side that has extending from it the now working ET tube that has been used to provide the effective PPVs. The exchange from the rescue ET tube to the smaller ET tube is best delayed until the heart is quite stable and generally is not done until the patient is moved into the OR for the definitive tracheal repair. In some cases however it may be deemed to dangerous to move the patient and the repair will be accomplished at the site were the thoracic cavity was initially opened and airway access gained.

After both the proximal and distal sections of the trachea are intubated with the same ET tube and it is secured – placing it deep enough so that the cuff can be inflated without causing interference with were the sutures for closure will be needed. Often an injured section of trachea will need to be removed to provide healthy proximal and distal ends that can be anastomosed. Most patients will tolerate up to 4 rings being removed.* Suturing is most commonly done with simple interrupted polypropylene on a swaged on taper point small needle. Common sizes include 2-0 for large and 3-0 for smaller patients. Another alternative may be PDS. The sutures encompass at least one ring on both proximal and distal segments and do purposefully enter the lumen. After the interrupted sutures are continuous pattern is also generally placed. This pattern is often of smaller sized suture (3-0 to 4-0). Irrigation saline is used to check for air leaks with PPVs. Small leaks may be addressed with a cover made of the patient's pericardium which can be a free or pedicle graft. There is no need to close the pericardium. Care is taken to ensure the cuff of the ET tube has not been accidently snagged with any of the sutures. * NOTE:when added length is needed to accomplish the anastomosis the neck is flexed and a nose band used to tether the head and neck into a flexed position via a thoracic harness and a Martingale like strap used to connect the nose band to the vental aspect of the harness between the front legs.

Closer of the emergent parasternotomy – This is completed following irrigation by using figure of eight polypropylene or wire or the use of a continuous closure with large polypropylene (0-No2) depending on the patient's size. A chest tube is inserted prior to the closure.

Resuscitative incisional thoracostomy– to provide decompression of a rapidly expanding and worsening tension pneumothorax. If it is noted that a patient is literally dying, color very cyanotic, blood flow via Doppler is significantly worsening, especially occurring when the patient who has been injured in the chest is intubated and some PPVs have been started the chest is incised immediately and a hemostat used to dissect quickly into the pleural space allowing immediate release or air under pressure in the pleural space. Following this air release from the pleural space a positive effect should be seen: Doppler flow returns, color improves and PPVs becomes much easier to provide (less pressure needed to expand the lungs). If the pleural pressure release does not happen quick enough catastrophic arrest will occur as a result and it should be always understood that a simple to and fro air going in and out of the pleural space (a simple pneumothorax) will be much more tolerated than air build up (tension pneumothorax).

Emergent resuscitative thoracotomy – This may also necessary for access to the pleural space on a rapid basis for rapid decompensation caused by penetrating trauma to the lung or larger thoracic vessels , a severe bronchial or lung injury leading to a rapid air leak.
Other indications include traumatic inducted near and full cardiac arrest; catastrophic respiratory failure due to acute severe diaphragmatic hernia; catastrophic failure from acute heart failure from acute pericardial tamponade caused by herniation of intestinal or other abdominal visceral structures; severe thoracic hemorrhage caused by a gunshot or other penetrating trauma; severe open chest wall injury that caused severe pulmonary collapse. Following IV catheter placement and tracheal intubation and a few breaths given by an AMBU resuscitator or anesthetic machine rebreathing bag, the chest wall is clipped with a few swipes with a clippers if long hair is involved or not at all if medium to short hair is involved. In most cases hair clipping is not performed. The 6^{th} intercostal space is generally chosen for the lateral thoracotomy and a skin incision is made or the skin is lifted up and a Mayo scissors used to take a sliver or elongated wedge of skin away. The Mayo scissors is then slid dorsally and ventrally to divide the skin and then using the scissors the lateral thoracic muscle (latissimus dorsi) is cut and

then the scissors is used to control – push into the thoracic cavity. The scissors is then used in a sliding motion to open the thoracic cavity up by dividing the intercostal muscles dorsally and then ventrally between the 5th and 6th or 6th and 7th ribs. This division must include most all the intercostal space up to the top of the rib and down to near the sternum. If there is not enough room to gain good access to the pleural space, the costochondral junction of the most caudal rib can be divided (Such as 6th rib when the incision is at the 5th intercostal space). Later a stick tie suture using a 3-0 PDS for example can be used to control intercostal hemorrhage. A Balfour retractor or Finiochetto retractor is then inserted to open the exposure and allow further inspection and see what the pathology is as IPPV is continued.

Ligation of a lung lobe – This technique is done if there is injury to a lung lobe that results in a significant leak. The lung lobe is freed up, possibly needing to cut the triangular ligament. The injured lobe is lifted up and two curved hemostats are placed on the base of the lung lobe, cross clamping the artery, vein and bronchus. A third clamp is applied if there is room, as this will prevent A Miller's knot is then placed under the bottom clamp and then bottom clamp is loosened and the knot pulled snuggly but not removed completely; When the ligature is tight the ends of the suture are brought around again and retightened.

Closure of the resuscitative thoracotomy – this is done after saline irrigation is completed copiously. Any lung lobe pedicle is irrigated with saline and any air bubbles are noted and if seen then a few more sutures placed in the area of where the leak was identified. Seeing no further air leaks nor any further hemorrhage noted then preparations are made for thoracic closure. A chest tube is placed and then a No 0, No 1 or No 2 polypropylene on a large taper needle is used to close the rib cage in a simple continuous closure. Sterile (autoclaved) monofilament fishing line nylon can also be used for this closure. Here the nylon is passed behind the ribs in the intercostal spaces just cranial and caudal to the two ribs that were separated. The suture pattern is a simple continuous one and it starts at the top or bottom of the incision and the suture is not tied but rather a hemostat is used to tag its end. The suture courses back to where the first bite had been taken. The two ends are then drawn up tight, which brings the intercostal gap closed and the suture is then tied. This one-knot shoe-lace closure is a very effect way to provide apposition of the chest wall. The thoracic muscles are then closed using PDS and the subcutaneous sutures likewise. The skin is generally stapled.

All of these techniques will be rarely needed but should the need arises not much time may be available to provide a watch and wait attitude as catastrophic hypoxia is occurring. A rapid limited thoracotomy may be the most common procedure needed to deflate the rapidly progressive tension pneumothorax. In other cases the dyspnic animal may go a full arrest and in these cases only an open chest CPR technique may be successful in resuscitation.

Aorta-Cross-Clamping to aid the heart and brain blood flow- In some cases when there is severe blood loss from a thoracic injury or tumor rupture it will be necessary to perform aorta cross-clamping (done by placing a feeding tube around the thoracic aorta as it becomes the descending aorta and sliding a hemostat down on it to tighten the loop created. Then the blood flow will be to only the brain and heart and this will help in the prevention of further hemorrhage. The same maneuver can be used to stop hemorrhage and air leaks when involving lung lobes. The stoppage of a major air leak caused by the injury at a major bronchial segment will be critical as it would stop most all of the inhaled air from moving into the pleural space and direct it to go to the lung, thus treating effectively the severe mechanical hypoxia caused by a bronchopleural fistula.

Summary - There are many therapeutic procedures that are useful in the care of the difficulty breathing (dyspnic) patient. Most are simple to perform. Studies are lacking that provide answers to which ones are the most effective. Some of the procedures like the use of an oxygen cage, have really never been critically examined in a large research project, and it's always been assumed that the use if these is best thing for the dyspnic patient. This presentation provided an overview of many other procedures that may be required to definitively treat dyspnea. In some cases certain conditions, such as tension pneumothorax, must be recognized and specifically treated in an urgent manner to prevent catastrophic consequences. Further critical analysis of many of the procedures that are used such as the use oxygen cages is required. It is hoped that this review may act as a start for everyone's "critical analysis" of the techniques we do and think they are the best to do for our difficult breathing patients.….the use of oxygen cages for a start. "Unless we investigate we will never know"

CHAPTER 4 CARDIOVASCULAR EMERGENCY CARE AND PROCEDURES

Damage Control Surgery - Definition and Goals

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

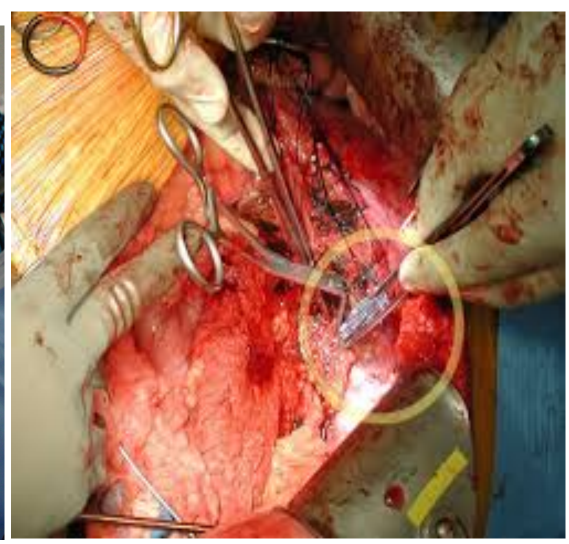
There is nothing magical about the OR BUT I do recommend when possible that the OR is the best place to perform damage control surgery. The OR should be set up and ready and the best time toi do this is right after the last surgery is completed. Suction, electocautery, anesthestic machine, ventilator, emergency drugs, surgical lights, adjustable surgery table, back table and instrument table are the unusual items needed (as will all major surgery)

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 a pack of surgical towels

Other key important pieces of equipment for damage control surgery are the following:

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



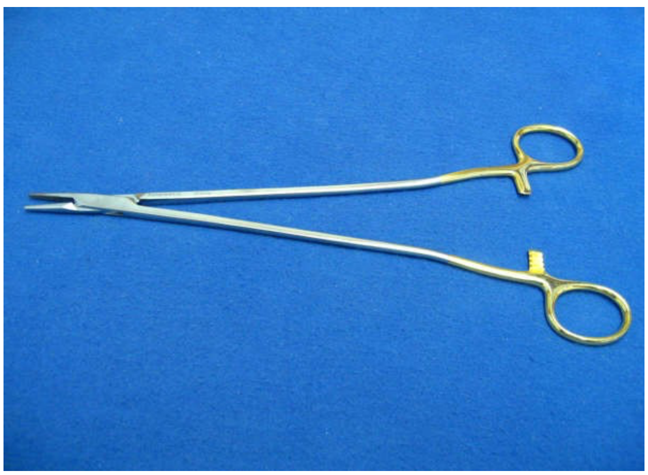
Loups and head light on and team of 3-4   Use of curved atraumatic and thumb forceps

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 access 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 l 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 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). Use of a TA 30

V Autosuture devices are also good to control hemorrhage as it provides three rows of titanium staples. Occasionally a larger TA 55 Autosuture device can also be used to control hemorrhage – this is especially when using the blue cartridges with 3.5 mm staple lengths.

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 ☺. (DT Crowe, Autotransfusion in the Trauma Patient. Vet Clin No Amer Small Animal Pract. 1980; 10(3))

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 H_2O. 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. Therefore there has been a lot written in this area. Much of what is written in the 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. 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 haemorrhage 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 and can b done by having compression applied digitally on the aorta just cranial to the left adrenal gland as this area i easily accessible and can be maintained with finger pressure done by an assistant. This area is found by mo the intestines all to the right of the mesocolon and the colon lifted up and the left kidney is observed. Then left adrenal gland is found. The aorta and celiac artery is found just cranial to it and can be palpated. The a may be difficult to identify in the severely hypovolemic patient so it must be able to be found by locating th adrenal gland and used as a landmark as the aorta is just cranial and midline from it. It is recommended tha this aortic compression maneuver be practiced in routine abdominal exploration cases so it can be complet quickly and accurately should 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 describe 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 liga will generally be effective as there are good collateral venous loops that can take over the venous flow bac the central circulation. This also applies to the distal aorta as well so long as there is not a clot within the lu 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.

<u>Cowboy</u> – 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 discussion 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*

Chapter 5 Cardiopulmonary Resuscitation Reviewed

Best is to prevent – use the ***Doppler on all anesthesia patients*** and those critical for requiring monitoring; Provide oxygen preanesthesia on all cases with age, airway compromise;

Provide anesthesia ventilator support especially in all older or have medical / surgical need for the anesthesia. Ideally ALL general anesthesia patients should be supported with the use of an anesthetic ventilator. The Hallowell ventilator can be used to ventilate any size patient and very easy to run. Most all veterinary assistants, technicians and veterinarians, after beginning to use this ventilator when asked about their experience with this ventilator as well as other bellows type support ventilators have responded that they would never go back to not using it and that it has made general anesthesia easier to do safely and provides a stable state of anesthesia with less isoflurane percent needed as well.

Hypothermia – When anesthesia is completed most patients have some hypothermia effecting them. This heightens their vasovagal response so it is very important to move them slowly and especially when rolling the patient over. My experience is that as long as moving is slowly done that hypothermia is generally very well tolerated no how much is there. In fact I am a big believer in using permissive hypothermia as a tool to help prevent acidosis and the effects of low flow states when critical anesthesia (with or without surgery) is needed.

Early detection – a key to success and anticipate when at high risk – example – cold and under anesthesia without any ventilator support and the dog is rolled over to get his teeth cleaned on the other side and the roll over was done quickly… causing a vagal inducted arrest (set up by the hypothermia and the respiratory acidosis)

Selection of pets to have CPR that have a fighting chance and have non-terminal illness. Example young pup getting neutered verses old dog with a septic prostate. Have predirective decided and identify with Red NO or Green Yes cage cards

Some say C before A and B… do we really have the best answer here? Not yet, except in adult humans that get sudden myocardial infarctions and subsequent ventricular fibrillation – in these cases of sudden cardiac arrest we know C (compressions) are key and this is followed by electrical defibrillation as soon as possible.

… Otherwise its probably not all that important as all must be done as quickly and effectively as possible.

C. 100 chest compressions per minute, "da da da da….staying alive, staying alive" rhythm

Do not stop for 2 minutes at least - In cases were additional help is not available perform the compressions as long and as effectively as possible. I have given chest compressions at 100 per minute for 25 minutes as the lone chest compressor on the back of an ambulance without stopping and seeing effectiveness – the man (in his 40's) following a witnessed arrest and the immediate beginning of CPR eventually responded to defibrillation and return to spontaneous pulsatile rhythm in the ambulance as we 3 EMTs were within 5 minutes of the hospital. The patient made a complete recovery after he was intubated in the ER bay and ventilations continued to be provided and he was taken to the cath. lab and had his LAD unblocked and a stent placed.

ACD (Active Compression and Decompression) Best method to make the chest compressions the most effective is to perform active compressions and expansions using a towel clamp placed in the rib about heart level and pull out and push in with every compression – This gives an active compression ands then an active expansion with cycle - This has consistently caused an estimated 20% increase in cardiac output (CO) based on Doppler sound strength generated. This is believed to more effective than other methods used to increase CO: 1. Compressions of the abdomen either simultaneously or in a counterpulsation rhythm; 2. Simultaneous ventilations with compressions; 3. The addition of an Inspiratory Impedance Threshold Valve

In cases where no Doppler flow is detected from vessels behind the eye when the probe with Aquasonic gel is placed on the cornea and compressions are done it is suggested to open the chest rapidly and begin direct cardiac massage (with or without aortic occlusion – with being reserved for cases where poor filling is noted with compressions).

AB. Extend head and neck, pull tongue out and close mouth on the tongue and fit a tight fitting cone mask on the face and give ventilations - 1 every 15 compressions   Helps decrease vaso vagal induced arrest from near arrest as seen in research study in dogs (Med Coll Wisc 1993-94) when the trachea is intubated. Also seen clinically when patient is near arrest and being intubated.

A. Intubate keeping head low – laryngoscope or Glide scope preferred – as preserves brain blood flow and prevents possible aspiration - now as C is being done and begin B - best with an Provide ventilations: AMBU as anesth. machines not as easy to just give breaths. Use reservoir with the AMBU bag and O2 flow rate to keep it full.

Another possible alternative to tracheal intubation is the use of Combitube or King-airway placement and ventilation via these devices. A recent study was completed that revealed that the commercially available double lumen esophageal –tracheal device (Combitube) was effective in canine ventilation:

A blind insertion airway device in dogs as an alternative to traditional endotracheal intubation. The Veterinary Journal 203(2) · December 2011 James, Timothy. Lane, Michael. Crowe, Dennis, Pulen, William. Regional Institute for Veterinary Emergencies and Referrals, Chattanooga, TN **. Abstract -** Endotracheal intubation is the standard of care to establish a secure airway; however, laryngeal airway management systems are increasingly being used in human patients for elective surgical procedures and in emergency settings. In this study, a double lumen, blind insertion airway device (BIAD) was placed in the esophagus of dogs and evaluated for its ability to ventilate the lungs. Initially, 10 euthanased dogs were evaluated, followed by a group of 15 mixed breed dogs that were undergoing elective spay or neuter procedures, and a group of 10 healthy dogs. Post-procedure evaluation included visual examination with a laryngoscope to inspect for signs of inflammation or mucosal damage. The device provided adequate ventilation in all subjects; the dogs were under anesthesia or heavily sedated for 10 min to 2 h and recovered uneventfully. No evidence of esophagitis, aspiration pneumonia, tracheitis, subcutaneous emphysema or esophageal laceration was observed. In conclusion, the use of double lumen airway devices warrants further study as an alternative airway management system in dogs.

We are currently evaluating the Combitube use in spontaneous canine cardiac arrest at our hospital but cannot make any recommendations on its use in this scenario currently. Other possible advanced airway devices that might also be effective include the King Airway which as a single lumen pharyngeal esophageal airway and a laryngeal mask airway. Research evaluation is still pending on these

Regardless - it must be that when intubation of the airway is performed the head must remain horizontally in-line with the heart to prevent loss of blood flow to the brain via the effect of gravity and to prevent possible aspiration of any pharyngeal contents – which may occur if the head is elevated.

B. give 1 breath every 15 compressions (unless know of previous hypoxia / resp acidosis then if so increase the rate of breaths to 1 every 10 compressions)

D. Assess effective compressions - with Ocular Doppler (hear pulse flow) and ETCO2 (> 12)

D. Drugs – epinephrine (high dose 1 ml/20 kg if no defibrillator, 1 ml/10 kg if have one).

D. Atropine 1 ml / 10 kg If no IV access give both epi and atropine via trachea stick after adding saline as a carrier * always give a good 5-10 ml saline behind the IV bolus of the drug

E. Electrical defibrillation - care to be taken to maintain safety. 1-2 J/kg internal and use wet saline sponges of also silver chloride; 20 J/kg external (use silver chloride) (no alcohol please ☺) always have area clear before pull the trigger and do not be touching patient or table - Wear exam gloves for electrical insulation. Shock and observe results - Repeat all drugs as CPR continued in progress if no return to noting contractions – consider open chest CPR next round if still not responsive.

G. Those that respond with return to good cardiac function and pulses – continue breathing for the patient with IPPV for at least 20 minutes and monitor carefully; ECG Doppler flow etc. Move very slowly as all are highly vagal. And most are hypothermic. Warm slowly. Use of hypothermia can be helpful if the CPR was prolonged.. Take at least several hours to completely warm.

Consider local hypothermia to continue if patient not becoming conscious = ice packs at head, neck, axillary and groin regions with protective dry cloth between the packs and the skin

If greater than 1 hour of no pupillary or light responses and still unconscious = poor chance of recovery; If have responses – worth a good try as many might be temp blind but gradually recover sight as well.

Example: Mexican Camp Dog – was getting 2 week postop TPO films under general anesthesia. Arrest in radiology when under Isoflurane and on fluids – did not respond to closed chest CPR in radiology after 10 minutes – then opened chest and did massage direct for another 12 minutes – the had good Doppler flows and finally saw good fibrillation following epinephrine – then defibrillated successfully and resulted in good cardiac function and this continued as patient was taken to the OR and the chest closed after irrigation; On a ventilator for several hours as he became more awake and was extubated. Had cerebral palsy post CPR when awake with a very abnormal posture – could not stand; performed hyperbaric oxygen therapy and post therapy (3 hyperbaric treatments, at 100% O2 at 14 psi and 12 hours apart) palsy dissipated. Patient recovered completely and was observed multiple times over the course of a year for his TPO surgery postop follow-up.

Chapter 6: Shock Resuscitation Reviewed

"Shock is a rude unhinging of the machinery of life"

Shock Definition = poor blood flow such that oxygen demand is greater than oxygen delivered

Most common organ systems involved dramatically initially = liver, gut, tips of villi slough, subtle – always do rectal exams; but not before assuring IV access and supplemental oxygen started. Why? Because of the possibility of causing a vasovagal response with bradycardia, further hypotension, loss of consciousness, possible arrest.

Levels of Shock:

<u>Category/ Class 1</u> - Early shock – not easily detectable - only signs are slight increase in breathing rate; no other signs except possibly slight anxiousness   Corresponds to 15-20% blood loss

<u>Category/ Class 2</u> - Moderate shock – now detectable – only added signs are slightly rapid heart beat and more increased breathing rate Corresponds to 25-30% blood loss

<u>Category/ Class 3</u> - Obvious clinical shock – see more mentation changes; depression, CRT 3-5 sec, membranes pale, pulse weakness appreciated, increased pulse and breathing rate; first time now see clinical hypotension and Doppler detection of abnormal arterial blood sounds and waveforms , jugular veins not distending easily – delayed (> 3-5 seconds), toes cool, pale membranes; Corresponds to a blood loss of 35% Often thought of as the most common clinical signs of shock we see just because the clinical signs are very apparent.

<u>Category/ Class 4</u> – Severe shock – totally decompensated; either very anxious or most see significant depression and close to unconsciousness; Loss of arterial blood pressure and flow is now profound; jugular vein flat, poor capillary refill > 5 sec.; Corresponds to a blood loss of 40%.

<u>Category/ Class 5</u> – Near death shock – unconscious, only minimal heart tones, almost pulses, veins all flat, no Doppler flow sounds except by esophageal Doppler, membranes ashen, no capillary refill, breathing is slow and to the point of seeing gasping; Corresponds to a blood loss of 45% or greater. Not long until the last gasps are seen… minutes at lost.

General Shock Treatment Protocol:

1. start blow-by **Oxygen** and use canopy to concentrate oxygen - > 80% ideal

2. always **IV access**

and **get small amount of blood to check HCT, TS, glucose. Lactate** also recommended and using a Accusport lactate meter this can be determined w/ one drop and within 2 minute. Normal 2, 3-5 mild lactate elevation, 6-8 moderate, 9-12 high This baseline generally corresponds to the depth of the shock state at the time; also generally corresponds to blood pH as an acidosis (metabolic). Ideally other point of care testing would be also helpful – Epoc and I stat that give pH, HCO3, pCO2, pO2, Hct, Na, K, Cl. These provide information about acid base and oxygen tension levels in the venous circulation – low O2 = high O2 extraction level – if below 30 (normal > 35) generally means oxygen demand is not being met.

- of pH below 7.3 generally means acidosis, below 7.2 very serious metabolic consequences at cell level as enzymes begin to fail in activity, below 7.1 indicates some irreversible cell deaths on a global scale.

NOTE ABOUT PCV not corresponding to level of hemorrhage acutely: Hct (PCV) may be normal or even slightly higher than normal in acute severe hemorrhage whereas TP is often lower than normal – due to autotransfusion of interstitial fluid into the capillaries when microcirculation hydrostatic pressures became lower with the shock. Interstitial fluid only has 1/3 max the amount of protein within it (water, lytes, and albumin pool is large in the interstitial space and easily movable but not nearly as abundant in concentration so as this fluid dumps into the circulation it lowers the plasma albumin (and Total Protein) levels. Lower TP levels immediately post trauma are often associated with some hemorrhage that has occurred.

Facilitative maneuver - Cut over the cephalic vein with 18 g needle – place 18 to 14 g catheter – best 2 catheters in Class 3 and especially if going to surgery

Mini-cutdown - In signif shock w/ no vein filling and poor flow do a minicutdown – use curved Mosquito hemostat, isolate the vein, go under the vein, pull back on it and then place the IV catheter

Feeding tube (large bore – 3.5 Fr.cats; very small dogs, 5.0 Fr; In some cases may also place IV cath in the external jugular vein or place a feeding tube through a veinotomy. Secure all catheters well – staple skin closed – apply bandage – consider Technicare as a cover – is 3% chlorxylenol and OK for open wounds; great as a cover over IV catheter sites to prevent infection.

Abdominal Compressions – The rapid circumferential placement of a towel around the abdomen and pelvis and then tightening with wide tape is a means to help cause Autotransfusion of venous blood to the central brain, heart, lung circulation and also may then be helpful in gaining IV access with venous vessels are collapsed from shock. It also helps increase arterial blood pressure (both systolic and diastolic) and increase Doppler monitored arterial blood flow. It also helps stop hemorrhage within the abdomen and pelvis. Although abandon by civilian EMS authorities in the US abdominal counter-pressure devices are used in the military with some amazing results (where soldiers injured in Iraq and Afghanistan have had there life saved with these. I interviewed one soldier that had an IED explode and traumatically amputate is right leg at the groin level and he was bleeding severely and out of control. A military surgeon order the placement of the anti-shock garment and it stopped the bleeding and allowed his heart, brain and lungs continue to function with minimally adequate blood flow while efforts were made to restore his lost blood. An aortic balloon was placed in the distal aorta via his brachial artery and expanded. This prevented further arterial blood loss. The anti-shock pneumatic garment was deflated after blood volume was restored and anesthesia begun and the iliac artery that was found shredded was ligated, the other vessels on the stump area ligated and the wound stump debrided and irrigated, suction drains placed and the wound partially closed. He is now fully recovered and still in the US Army as a competing rife –marksman.

IO access also an alternative – EZ IO, 18 g needle, other; in greater tubercle of the humerus

IV PlasmaLyte A 7.4 pH best, Normosol R, others LRS OK but has calcium rather than magnesium; magnesium = a natural mild calcium channel blocker; prevents calcium enhanced mitochondrial dysfunction – mild microvascular dilator – increases capillary flow.

Saline a distant 3rd; Give 20 ml/kg bolus rapidly –dogs (10 ml/kg cats); reassess; HR, pulse pressure (by palpation or measuring both systolic and diastolic pressure and subtract the diastolic from the systolic to get perfusion pressure).

Hetastarch - Give one dose of hetastarch, gelatin, dextran if available – 5 ml/kg dogs, 2 ml/kg cats– also mobilizes fluid from the interstitium, and also also blunt WBCactivation and decrease need for as much crystalloid. Research has shown that its use does decrease the strength of clots that are formed. This is more pronounced the more that is given. Up to 20 ml/kg have been given without untoward effects. More than that has also been given but is generally not recommended if there is any chance of continued active bleeding. So subsequently the hetastarch may be dosed 2-3 times further as needed via the monitoring of blood flow and pressure and pulse palpation.

Continue to reassess and in most cases Plasmalyte-A 7.4 or Normosol-R (also is pH adjusted to make its pH 7.4). Each 1000 ml of these contains the following: sodium 140 mEq; potassium 5 mEq; magnesium 3 mEq; chloride 98 mEq; acetate 27 mEq; gluconate 23 mEq.

In each 1000 ml bag also can be noted that there are 5260 mg of sodium chloride; 3680 mg of sodium acetate (trihydrate); 5020 mg of sodium gluconate; 370 mg of potassium chloride; 300 mg of magnesium chloride hexahydrate. It also may contain hydrochloric acid and/or sodium hydroxide for pH adjustment. The pH range acceptable per the manufactures standards is 6.5 to 8.0 (average 7.4) and with 295 mOsmol/liter (calc) and a physiologic osmolarity range of 280-310 and a caloric content of 21 kcal/L.

This is apposed to Lactated Ringers Solution: As with each L of LRS it contains 6000 mg sodium chloride; 3100 mg sodium lactate; 300 mg potassium chloride; and 200 mg calcium chloride; with a pH of 6.5 (range 6.0-7.5) and mEq per L of sodium 130, potassium 4; calcium 3; chloride 109; lactate 28; and a osmolarity 273 mOsol/L (calc).

Remember this: saline (or normal saline) is 0.90% w/v of sodium chloride; and it contains 308 mOsm/L and is considered isotonic. It contains 9.0 grams per L of sodium chloride in water. The pH of saline is 5.0 (with a range of 4.5-7.0). Since the molecular weight of sodium chloride is 58.5 grams per mole and 9 grams / 58.5 g/mole = 0.154 mole per Liter. Since NaCl dissociates into 2 ions – sodium and chloride – 1 molar NaCl = 2 osmolar, thus normal saline contains 154 mEq/L of Na^+ and 154 mEq of Cl^-

Reassess and be prepared to give another round of all three (P lyte, HS and hetastartch).

It should also be remembered that all the products are primarily crystalloids and more than 75% of the isotonic crystalloid administered IV can move into the extravascular space within 1 hr in a healthy animal. In shocked animals with loss of capillary poor integrity crystalloids might be totally out of the circulation by this time (one hour). In a study by Cervera and Moss (Circ Shock 1978; 5:357) have shown that crystalloid resuscitation of hemorrhage for re-expansion of the lost plasma volume may require much larger volumes than appreciated by most clinicians. In surgical human patients the infusion of one liter of crystalloid in the postoperative period resulted in a remaining plasma volume expansion of only 200ml after 90 minutes (Lamke and Liljedahl, Resuscitation 1976;5:93) . This fluid then is found in the interstitial fluid compartment and this can become detrimental if overzealous amounts are given (edema and decreased oxygen tissue uptake via an increased oxygen diffusion distance that can occur in all organs).

NOTE: a mounting discussion now occurring about latest human medicine finding of more acute renal dysfunction occurring with hetastarch is used. However hard to know if this is true in dogs and cats. Years of using it in dogs and cats for shock and in critical illness by this author has not seen the renal dysfunction nor acute renal failure that is being reported with its use in humans. Suspect it might also be associated with their higher use of saline as a principle fluid in resuscitation. Why they continue to do this? Saline pH 5.4, 154 mEq/L Na and 154 mEq/L Cl so a hugh salt load to a kidney that is working hard to conserve water and has poorer flow and GFR. Might be we don't see this because we use other salt solutions (P-lyte and Norm R) that are much more physiologic pH and electrolyte balanced. Still we may see the loss of hetastarch on the market and being able to be purchased soon.. Same thing that happened to Oxyglobin ☹ as this was a very good colloid with the added advantage of being able to carry oxygen 4 times better than red blood cells… Now its only available in Europe and Canada. Along this same line: oxygen delivery – Hyperbaric Oxygen is effective in the resuscitation of shocked organs

Continue with a continuous rate infusion of P lyte at least a surgical rate of 5ml/kg/hr (2.5 ml/kg/he cats

Hydroxyethyl starches favor retention of intravascular fluid and prevent washout of interstitial proteins. In hypooncotic situations, HES infusion has a great advantage over other colloids because the larger molecules remain intravascular, limiting pulmonary fluid flux. It is nontoxic and nonallergenic in dosages as high as 100 mL/kg in dogs. Many cats have a moderate reaction—nausea and occasional vomiting—with rapid infusion.

However, when hetastarch is given slowly (throughout 5–15 min), this adverse effect is minimal. Renal injury, reported to occur from an osmotic nephrosis in people, has been poorly documented in dogs and cats, and allergic reactions are rare.

Hetastarch is associated with minor alterations in laboratory coagulation measurements but not with clinical bleeding unless daily minimal dosages (20–50 mL/kg/day) are exceeded. Molecular weight seems to have the biggest impact on coagulation, with larger molecular weight starches impacting coagulation to a greater degree. The proposed mechanisms of impact on coagulation include "coating" platelets or impeded platelet receptor signaling, dilution of coagulation factors, and interference with von Willebrand factor/factor VIII interaction. Dilutional effects on coagulation, cells, and proteins are produced in response to the volume expansion of the plasma. Animals that receive large volumes of HES solutions may have more oozing if surgery is performed, and diligent hemostasis is warranted. A variety of HES solutions are currently available, each with its own advantages and disadvantages based on its molecular composition. Dextran 70; Hextend 670/0.7; VetStarch/Voluven 130/0.4; Hespan 600/0.4 Stroma-free hemoglobin

A word about the glycocalex – This is an important new area that appears to be critical in sick and injured patients (dogs, cats, humans, etc). The endothelial glycocalyx (EG) plays an essential role in endothelium integrity and may be compromised by hemorrhagic shock. If this protein based matrix on the surface of the endothelium is compromised capillary leak is increased . It appears that most all shock states cause a degradation of it. The effects of currently available resuscitation fluids such as Hextend (HEX) or lactated Ringer's solution (LR) on vascular function and coagulation are not well understood. The aim of the present study was to compare the effects of fresh frozen plasma (FFP) with HEX or LR in their ability to repair EG structure, promote volume expansion, increase blood flow, and prevent coagulopathy. In a well done research study in rat vessels (from muscles) a 40% of the blood volume of the rats was completed and coagulation and EG thickness was measured. The following findings were noted: Respiratory rate, blood pH, base excess, and lactate returned to near-baseline levels in all treatments. Hemodilution caused by LR and HEX decreased firmness, prolonged clotting time, and lowered platelet counts. EG thickness in HEX- and LR-treated rats was 50% lower, and plasma syndecan 1 was 50% higher than sham and FFP groups. Blood flow and shear rate were restored in the HEX group. Resuscitation with FFP improved coagulation and blood flow. These findings suggest that the best resuscitation fluid was FFP, followed by the hetastarch Hextend and the poorest restorer was LRS to support cardiovascular microvascular stabilization. In the ideal world it would be best to infused FFP. However this cost would be not practical and its supply also not obtainable. Therefore my recommendation is to do use hetastartch in all resuscitation cases IF possible to increase microvascular perfusion and in the optimal resuscitation strategy, when cost and FFP are available then use FFP – especially when coagulopathy is also suspected.

Home Made Activated Coagulation Test: A simple means to check on bodies ability to coagulate is to place a pinch of clay in a small 2-5 ml test tube or red top blood collection tube (prewarmed with the hand). Then add 2 ml of freshly drawn blood and invert the sample and start counting. If the clot does not form quickly (should start in 1 minute and be completed by 2 minutes) as indicated by tipping the tube every 15-20 seconds and keeping a watch on the blood in the tube and noting when the blood is first starting to gel or clot. This test was invented to take the place of the gray top diatomaceous earth based Activated Coagulation Test). The tubes now available contain kaolin and are purchased through Haematolic Technologies Inc., and can be ordered by calling 802-878-1777 or going to there website at haemtech.com. Normal Clotting Times for the dog are < 120 seconds when using their Kaolin containing tubes and < 100 seconds in cats.

Blood as the best replacement fluid in significant hemorrhagic shock: Research has now also shown that in significant hemorrhagic shock that the best resuscitation fluid to use, which I have been saying all along and for years now;) is fresh whole blood. Therefore I highly recommend each practice have a "walking donor program". This involves having a few healthy large dogs that can be brought into the clinic on a moments notice and their blood harvested and then used immediately (given as a transfusion before refrigeration is necessary). CPDA1 bags are ideal for the collection but even the old ACD or even just sodium citrate solution can be used as the anticoagulant.

Reassess LOC, CRT, pulse pressure strength, HR, RR, MM color, toe temp, Doppler flow-provide another bolus of Plyte 20 ml/kg (10 ml/kg cats) if not seeing improvements

Assess for cause – AFAST, TFAST, radiographs, labs, repeat exam

Peripheral – Central Venous Pressure Assessment – with IV fluid administration technique:

Consider peripheral cephalic vein catheter to fluid bag and dripping as the leg is held straight and the bag is gradually lowered. When the drip stops dripping in the drip chamber this corresponds to peripheral (and probably central if no flow obstruction in the vascular line from cephalic vein into the major basilica and on into the axillary and brachiocephalic vein that leads to the vena cava

Transfusion triggers – often said to be a PCV of around 20% - still a common number thought of. If there is underlying heart or brain or cord other major organ disease then this number should be higher… 25%. ***Also transfuse when clinically noting that severe bleeding occurring*** – as PCV will not reflect this hemorrhage as this would take hours to manifest. Best for shock if whole blood; but packed cells and plasma or fresh frozen plasma can also be used 1 bag PRBC to 2 bag FFP ; Commonly start with 5 - 20 ml/kg administration.

Autotransfusion - do whenever feasible! – collectable, warm, is patient's own, some clotting factors, but also some debris, microclots, bubbles, microthrombi, even some contamination. In general is safe and effective and very economical – collect with as little agitation as possible. Filter with 170 micron filter and then 40 micron filter but in some cases no filtration feasible. Many patients have been autotransfused without the benefit of filtration without known adverse clinically recognized effects. There is always some systemic DIC stimulation with it however. Technique: cut top of corner of IV P lyte bag off, attach blood admin set with 170 micron filter, poor blood from suction canister (often collected in a non sterile one, but one that has scrubbed out with TechniCare, Care Tech Labs, Saint Louis, MO. Note: TechniCare is the only surgical scrub that is FDA cleared to say that it is non-toxic; and it is OK to put into open wounds; see a great Youtube video) into the P-lyte bag and raise bag and begin transfusion. Give 1 mg/kg diphenhydramine as it decreases the histaminic response from the Hagaman factor/ Krinnen activation.

Rate of delivery: as required according to need**. In rapid hemorrhage *as fast as possible***; even with blood bag under pressure; In severe shock – same – give as rapidly as possible; Consider NOT giving at full bore until the source of the hemorrhage is stopped – or at least significantly slowed.

Continue fluid rapid flow rates until Doppler flows are adequate, BP returning to at least 60-70 and venous pressures are now positive; limit continued flows after that at those rates once endpoints are reached and especially in those with pulmonary, brain, cord injury as over dosing may provide for increases in edema in these structures especially.

Other Shock Drugs: **IV Vitamin C 50 mg/kg as an electron donor antioxidant and this decreases capillary leak (research is burns in sheep model – 1/3 less tissue edema noted -**

Dudrick etal) repeat every 12 hours for 2 days as oxidation from inflammation still ongoing post shock;

IV B-complex vitamins especially thiamin and niacin - these are needed in cellular metabolism in all cells. The enzymes transketolase, pyruvate dehydrogenase (PDH), and 2-oxoglutarate dehydrogenase (OGDH) are all important in carbohydrate metabolism and these are derived from thiamine. The cytosolic enzyme transketolase is a key player in the pentose phosphate pathway, a major route for the biosynthesis of the pentose sugars deoxyribose and ribose. The mitochondrial PDH and OGDH are part of biochemical pathways that result in the generation of adenosine triphosphate (ATP), which is a major form of energy for the cell. PDH links glycolysis to the citric acid cycle, while the reaction catalyzed by OGDH is a rate-limiting step in the citric acid cycle. In the nervous system, PDH is also involved in the production of acetylcholine, a neurotransmitter, and for myelin synthesis. As can be seen the B complex vitamins, thiamine B1, riboflavin B2, are key to cellular metabolism. Riboflavin (vitamin B_2) is part of the vitamin B group. It is the central component of the cofactors FAD and FMN and as such required for a variety of flavoprotein enzyme reactions including activation of other vitamins. Riboflavin is continuously excreted in the urine of healthy individuals,[making deficiency relatively common when dietary intake is insufficient. The vitamin is not stored.. A deficiency of riboflavin can be primary - poor vitamin sources in one's daily diet - or secondary, which may be a result of conditions that affect absorption in the intestine, the body not being able to use the vitamin, or an increase in the excretion of the vitamin from the body such as in fluid diuresis. Subclinical deficiencies in inflammatory bowel disease, diabetes and chronic heart disease in humans are know. Niacin B3 - Niacin is a precursors of the coenzymes nicotinamide adenine dinucleotide (NAD) and nicotinamide adenine dinucleotide phosphate (NADP). NAD converts to NADP by phosphorylation in the presence of the enzyme NAD+ kinase. NADP and NAD are coenzymes for many dehydrogenases, participating in many hydrogen transfer processes in cell metabolism. NAD is important in catabolism of fat, carbohydrate, protein, and alcohol, as well as cell signaling and DNA repair, and NADP mostly in anabolism reactions such as fatty acid and cholesterol synthesis.[7] High energy requirements (brain) or high turnover rate (gut, skin) organs leave these organs at higher risk of metabolism dysfunction when niacin is lacking. Its unsure how fast can occur but stressful conditions such as that occurring with shock are thought to bring subclinical effects soon after.

Steroids - The jury is not yet made a decision –Initially in the 1960's there were some studies that suggested a salutary effect when corticosteroids and routine dosing of hydrocortisone (100-200 mg) was used and published as a recommendation (Leffall, LD: Current concepts in the management of surgical shock. J Natl Med Assoc. 1968 Sep; 60(5): 401–407). . Recommendations were also given to veterinarians to give steroids to dogs in the early post shock period – Then more was a published: One study was published that refuted the claims that steroids were of benefit: Am J Surg. 1975 Sep;130(3):321-7. **Inadequacy of steroids in the treatment of severe hemorrhagic shock.** Raflo GT, Jones RC Jr, Wangensteen SL.
Massive doses of methylprednisolone were given to dogs prior to severe, lethal, hemorrhagic shock. An untreated group of dogs subjected to hemorrhagic shock served as controls. No persistent significant differences were seen in cardiac output, mean arterial blood pressure, superior mesenteric artery flow, and survival. Calculated total peripheral resistance tended to be lower in the treated dogs and was significantly lower after reinfusion of shed blood. Pretreatment with methylprednisolone did not prevent plasma elevations of the lysosomal enzymes, cathepsin D and beta-glucuronidase. Stabilization of hepatic lysosomes in treated dogs subjected to hemorrhagic shock was not evident. The results failed to indicate significant salutary effects of methylprednisolone sodium succinate in this lethal hemorrhagic shock model

J Pediatr Surg. 1980 Dec;15(6):790-6. Corticosteroid therapy in hemorrhagic and septic shock in puppies. Connors RH, Coran AG, Wesley JR, Drongowski RA, Weintraub WH.

The efficacy of corticosteroid therapy in the treatment of shock remains controversial. In order to evaluate this question, the following controlled experimental study was undertaken. There were 44 puppies (2-6 kg) used to examine the effects of methylprednisolone (30 mg/kg) in both hemorrhagic and live Escherichia coli septic shock. In order to isolate the effects of steroid treatment, no volume or antibiotic therapy was given. Arterial, venous, and pulmonary artery catheterization allowed continuous hemodynamic and metabolic monitoring. One control group received steroid treatment and was not subjected to shock. Septic shock was achieved by a rapid bolus infusion of 10(9) live E. coli organisms. Hemorrhagic shock was produced by bleeding the puppy an average of 43% of his blood volume. Four septic and four hemorrhagic shock groups received either no treatment, steroids at the time of shock, or steroids 30 min before or after shock. Cardiac outputs of less than 50% of control values and significant lactic acidosis were documented in all of the shock animals. The septic groups showed more profound alterations in these parameters and a decreased overall survival. No statistically significant differences could be found, however, in the hemodynamic, metabolic or survival figures among the different septic shock groups, or among the various hemorrhagic shock animals. The anticipated preservation of cardiac output and decrease in leakage of lysosomal acid phosphatase were not seen with any treatment schedule. The theoretical benefits of corticosteroid treatment in shock could not be documented in these two models of severe septic and hemorrhagic shock in puppies.

J Trauma. 1987 Jun;27(6):667-70.Influence of steroids on hemorrhagic and traumatic shock.

Hardaway RM, Williams CH. A hemorrhagic-traumatic shock model in 20 domestic pigs (Sus scrofa) was used to evaluate the pharmacologic effect of methylprednisolone in preventing disseminated intravascular coagulation (DIC). Pairs of animals were anesthetized with thiopental and both femoral arteries cannulated. Four ml/kg-1 of blood were withdrawn, frozen, thawed, and returned to the animal. One femoral artery cannula was connected to a blood pressure monitor for arterial systolic, diastolic, and mean pressures along with heart rate and ECG. The other catheter was used to bleed the animal down to and maintain a mean arterial pressure of 50 mm Hg for 2 hours. Blood samples were taken during the control period before bleeding, and at the end of the 2-hour shock period. Blood samples were analyzed for prothrombin time, partial thromboplastin time, fibrinogen level, and platelet count. The combination of hemorrhagic shock and hemolysis produced DIC and a fatal shock. Pharmacologic doses (30 mg/kg-1) of methylprednisolone significantly prevented the DIC. However no resuscitation effects from fatal shock was noted.

New information is surfacing that suggests that patients can become adrenal exhausted and become cortisol deficient as soon as 24 hours post injury so if one sees clinical hypotension, weakness and depression that can not be explained then a 1 mg/kg up to 2.5 mg/kg of prednisone may be given. The higher dose is what I generally use to start. Cortisol levels can be analyzed to provide a better guide to steroid therapy. Septic and chronically ill and older patients seem to be more susceptible and particularly if they have had recent steroid injections for such things as dermatological conditions.

Antibiotics – Most all of the traumatic, hemorrhagic, anaphylactic and septic shock patients benefit from intravenous broad spectrum antibiotics. These are given soon after admission and continued for at least 24 hours – more specific antibiotics may be added as more information is gathered. For example to surgical exploration reveals a ruptured small intestine in a blunt trauma patient then both metronidazole and enrofloxacin will be added to the first generation cephalosporin that was given initially.

Analgesics – Traumatic shock is associated with pain and 1995 study published in the NEJM by Anon revealed that pain unmitigated effectively contributed to a 23% more death rate in infant patients post thoracotomy. In those infants that died they had higher cortisol and catecholamine levels, were more acidotic and had higher oxygen demands. Therefore it is highly recommended to have post trauma patients on continuous rate infusions of such medications as fentanyl, hydromorphone, and others for at least 12-24 hours. LIdocaine and ketamine may also be effective. In anesthesia its been recommended to place 0.65 ml of ketamine (1 ml is 100 mg) in a liter of the fluids being delivered during the surgery and this can be continued without any side effects. Ketamine and powerful MNDA antagonist and it effective in pain control as a CRI.

Hyperbaric oxygen – Hyperbaric oxygen therapy is another drug therapy that can be very effective to help restore oxygen debit deep in such tissues as the liver, gastrointestinal villi, kidney, heart, and nervous system.

Supplemental Oxygen the first 12-24 hours post shock – post surgery – continued as a nasal oxygen catheter or other has been shown to be associated with less wound infections in surgical patients (statistically significant), particularly when involved with GI and neuro surgery. The reason has been investigated and appears to be related to increased oxygen tension levels in tissues, provided by the supplemental oxygen. Therefore it is also recommended to continue to provide supplemental oxygen to at least a level of 35% for up to the first 24 hours post shock and post operatively in surgical patients.

Bioresonance, photonic therapy, and targeted pulsed electromagnetic field therapy – these biophysics based therapies increase blood flow to tissues, decreases pro-inflammatory cytokine production, decreases pain, increases anti-inflammatory cytokine production and increases lymphatic flow. For actual mechanisms of action and specific recommendations please see the section in the manual that discusses these modalities. A new device called a Bemer that is also electromagnetic, and is a mat that the animal is placed on for 8 minutes, increases capillary blood flow, provided additional fluid therapy is provided, and this affect on the microcirculation balances flow and increases tissue oxygenation.

Chapter 7. Gastric Dilation and Volvulus

History and Clinical Signs:

Commonly affecting the large breed deep chested breeds gastric dilatation and volvulus syndrome has the potential to be a life threatening problem. It has been associated with blunt and penetrating trauma. Progressive gastric distension leads to pressure on the vascular system especially the venous system compromising venous return to the heart thus leading to inadequate preload and shock secondary to inadequate stroke volume. Pressure on the diaphragm caused by a progressively dilating stomach may compromise lung expansion and lead to ventilatory compromise. Vascular compromise of the circulation to the stomach itself may lead to tissue ischemia, release of endotoxins into the circulation and ultimately to the release of cytokines and SIRS.

Diagnosis:

Diagnosis is commonly made by observing a dog that is restless, attempting to retch non-productively and perhaps has rapid abdominal distension. Due to the fact that the GDV mainly occurs in the deep chested dog the abdominal distension may not be evident until late in the disease. In early cases the gas distended stomach may be detectable on percussion of the cranial abdomen. On examination the dog may be in hyperdynamic shock or may be in a stage of decompensatory shock. As such findings are variable from tachycardia, tachypnea, bounding pulses and injected mucous membranes to collapse, respiratory distress, weak thready pulses.

Diagnosis moving on to Treatment:

Immediate treatment should consist of oxygen if the dog is showing any signs of shock, and volume replacement with crystalloids and synthetic colloids started. Recent studies point to the value of hypertonic saline mixed with a colloid and given at 5 –7 ml/kg as a bolus and then reassessing. Hetastarch or Oxyglobin should be considered to maintain BP and flow. ECG should be monitored, as these dog are prone to ventricular arrhythmias. The stomach should only be decompressed after volume replacement has been started due to the potential for worsening the hypovolemic shock. **Rapid onset corticosteroids in the past have been given at shock doses (dexamethasone sodium phosphate at 2-8 mg/kg iv or methylprednisolone sodium succinate at 15-30 mg/kg iv) and broad spectrum antibiotics started. However there are NO good controlled randomized blind study of a significant number of patients that has been done to conclude that steroids of any kind make a significant difference in survival. However there are numbers of patients that have developed severe gastrointestinal hemorrhage and pancreatitis associated with these medications so this practice is no longer advocated.**

A right lateral radiograph should be taken in most cases if there is any doubt. On occasion the volvulus will not be evident on the right lateral in which case if there is a high index of suspicion a left lateral radiograph should taken. A characteristic shelf sign with compartmentalization supports a diagnosis of a gastric volvulus. Barium placed by an NG tube may have to be administered to define the location of the stomach. Coagulation should be monitored as these patients are at risk for DIC. Blood pressure should be monitored. A thoracic radiograph on any patient > 5 years is also recommended.

The dog ideally is taken to surgery as rapidly as possible for derotation and a gastropexy. Gastric lavage can be performed prior to, or during surgery; however it should be remembered a stomach tube can be passed on a twisted stomach. It is also possible to pass a stomach tube through the wall of an ischemic stomach and excessive force should not be used. Following gastric repositioning an incisional gastropexy is accomplished. A nasogastric tube is inserted to prevent re-dilation postoperatively. In cases that have much food material in the stomach the stomach is massaged and the food removed via a large orogastric stomach tube in which water is added to dilute the food material. In cases that have very thick or very large amounts of food material including "chuncks" the stomach is opened and all the food material is dumped out and into a basin. The stomach is closed routinely with two continuous closure patterns. An inverting pattern on the second closure can also be used and is recommended if peritonitis is also present or the stomach had previously ruptured. This is a "serosal patch" and helps prevent leakage of the gastric incision line.

When Necrosis is Present:

When the stomach is returned to its normal anatomic position the color of the stomach is observed carefully. If necrosis with a dark blue purple color persists then the area involved, most commonly the greater curvature section, is removed and closure is accomplished. Closure is done with either simple continuous polypropylene in two layers or an automatic stapling system is used (United States Surgical TA 90) which applies two staggered rows of 4.2 mm stainless or titanium b shaped staples along a 90 mm section. The later method is faster but can not be used in very edematous stomachs because the staples pull out. If resection is required a gastrostomy tube is usually recommended to be inserted to provide an access of continued decompression postoperatively. It is also used to medicate the mucosa with Sucralfate and gruel food and water. The tube is placed through a mucosal purse-string in the antrum incision that is used for the incisional gastropexy. A straight plain 12-20 Fr. red rubber feeding tube is placed through the muscoa purse-string and the purse-string is tied. A seromuscular stitch is placed next to the tube exit site in the stomach and encircled around the tube and tied to prevent the tube from migrating. The incisional gastropexy is then completed with 0 to 1 polypropylene as a simple continuous pattern that closes first the dorsal gastric to abdominal wall incision lines. The submucosa of the stomach and the fascia of the abdominal wall must be grasped with each bite. The suture is placed loosely and then drawn tight to ensure good placement and a tight water tight closure respectively.

A jejunostomy tube is placed for feeding if a portion of the stomach had to be resected. The patient is then fed by this tube postoperatively as a continuous rate infusion. Another alternative is to pass a nasodudenal to nasojejunal catheter at the time of surgery. The abdomen is irrigated and closed IF the contamination is not a concern. With gastric rupture the abdomen is generally left open with only a back and forth suture pattern. These dogs will take three to four days before its generally time for the abdomen to be closed.

Postoperative Treatment:

This involved around the clock monitoring and supportive care. Frequently arrhythmias are a problem after the first 24 hours post GDV rotation back to normal.

Summary of the Protocol:

PROTOCOL FOR ASSESSMENT AND TREATMENT OF GASTRIC VOLVULUS

Blow By Oxygen Administered As ASSESSMENT (Physical Exam) is completed

Gastric Tympani Present and Gastric Distension suspected, Assess Shock

IV Catheters (two) Large Bore (14 gauge) in the cephalic veins

Plasmalyte Bolused (40 ml/kg mini) or 5 ml/kg Hypertonic Saline and Hetastarch begun

Radiograph the Abdomen and Chest (Right Laterals) and see Double Bubble

If Severe Distension perform gastrocentesis with long 14 gauge needles or catheters

If Unsure pass an NG Tube - administer Barium (2-3 ml/kg) and re radiograph

Confirmed cases induce with Ketamine/Diazepam & begin positive pressure ventilation

Clip and Prep for Wide Exploration from Xyphoid to Pubis – explore note stomach

Aspirate Air from stomach with either 14 g cath or with an NG tube passed

Reposition stomach into normal position. Inspect for damage, hemorrhage, etc Pull Pylorus ventrally from the right and push the body dorsally with right hand to the left

Inspect the spleen and short gastric vessels – allow time for stomach flow to return

Explore; Remove Spleen at the least bit of thrombus formation or hemorrhage

Ligate torn short gastric vessels, splenic vessels, perform splenectomy if mottled

Irrigate the stomach with warm water – or in some cases have to open to evacuate

If much to evacuate use a shroud sewn to the stomach before the gastrotomy

Assess the Gastric Wall for evidence of necrosis

Resect any necrotic stomach – close with 2-0 PDS and 3-0 PDS or TA 90 stapler

Perform NG or EG tube placement; G tube and J tube (if resection was needed)

Perform incisional gastropexy - tube gastopexy if did gastric resection

Irrigation and closure of the abdomen continuous.

Chapter 8: Bad Wound and Fracture/Luxation Emergency Management

Practical management of severe wounds and open fractures begins with initial assessment and management. The first priority is the control of severe hemorrhage that may be associated with the injury.

TECHNIQUES TO STOP SEVERE EXTERNAL BLEEDING:

Described in order of preference.

1. **Direct pressure:** Apply direct pressure by hand over a dressing over the entire bleeding area. In the absence of compress, a bare hand or finger is used. A pad of cloth or gauze (compress) held between the hand and the wound helps control the bleeding by absorbing the blood and allowing it to clot. The compress can be bound in place using bandage material which frees the hands of the first-aider for other emergency action. Do not disturb blood clots after they have formed within the compress. If blood soaks throught the entire pad, **do not remove the pad**, but add additional layers of cloth, and continue to direct hand pressure more evenly.

2. **Elevation**: Unless there is evidence of a fracture, a severely bleeding open wound of the paw or leg can be elevated above the level of the heart. This elevation uses the force of gravity which helps reduce blood pressure in the injured area, thus slowing down hemorrhage. Elevation is more effective in larger animals with log limbs where greater distances from wound to heart are possible. Direct pressure with compress must also be continued to maximize the use of elevation.

3. **Binding the wound with a tight dressing** – and reinforce this with another dressing – this can not be left on but only for a several hours – change in 2 is best and place on the surface of the dressing as a "Sharpie Report" that notes the time the dressing needs to be changed. Often this is best done under sedation.

4. **Pressure on the supplying artery**: If external bleeding continues following the use of direct pressure and elevation, application of digital pressure over the main artery supplying the wound can be very successful. Apply pressure to the femoral artery in the groin for severe bleeding of the rear leg and even the external iliac and is some cases the very caudal aorta; the brachial artery in the inside of the upper front leg for wounds of the front leg. Always supply direct pressure in addition to the pressure point when it is used.

5. **Packing of the wound as deep as possible** – use role gauze and push the gauze in as deep as possible and keep packing until its tight and full. Then bind the gauze in place

6. **Pressure above and below the bleeding wound**: This can also be used in conjunction with direct pressure. Pressure above the wound will help control arterial bleeding (bright red, pulsating blood), pressure below the wound will help control venous bleeding (dark, oozing blood).

7. **Tourniquet**: We use to say that a tourniquet is dangerous and should only be reserved for a severe life-threatening hemorrhage in a limb you do not expect to save. But we do not say that any longer BUT if used it should be WIDE**.** A wide (2" or greater) piece of cloth should be used to wrap around the limb twice, and a knot is tied. A short stick or similar object is then tied into the knot as well. Twist the stick to tighten the tourniquet until bleeding stops. Secure the stick in place with another piece of cloth and make a written note of the time that it was applied. After application it should not be loosened until in the OR. The wrapping of vetwrap also can be used because as you wrap the wide band of vetwrap on it acts as a tourniquet. **A pneumatic blood pressure cuff** CAN be used without threat of limb loss for up to 2 hours in some cases this is because of the very wide with and it being full of air.

8. Hemostatic agents – these have now been found to be very effective in major hemorrhage and are used both by the military and in civilian EMS. The main ones used are made of materials that activate platelets and help in the binding of the platelet plug to the added fibrin network that is formed. (a microporous aluminosilicate) are the most commonly used for severe hemorrhaging wounds including those of patients with hemophilia, and other clotting disorders. Other homemade materials that have been used are granulated sugar and starch. In the Vietnam war cyanoacrylics (such as SuperGlue) were used as a deep wound sealant that was pushed into the hole and gauze used to hold it in as it set. Currently the two that I use are the

chitosan and polysaccharide bead types. The zeolite in the past was associated with exothermic burns produced but the newer version (Quick Clot) is free from this problem. It still cannot be buried where the other two can be left in.

NEXT STEP - PROTECT, PREVENT FROM BECOMING DEHYDRATED

After the bleeding is controlled the next step is to protect the wound from getting any further contamination and prevent it from becoming dehydrated. This is most commonly done by applying a water or saline soaked dressing onto the wound and a protective bandage applied. Do not remove or disturb the cloth pad or dressing initially placed on the wound as this will cause further dehydration, pain, blood loss and heat. The wound should be "immobilized" using a compressive dressing. Irrigation and cleaning of the wound should follow.

Application of sugar and honey are very good as initial topical agents that help also prevent dehydration and both have antibacterial properties and are used to help prevent infection and serve to keep the wound moist and stimulates granulation tissue.. Simple granulated sugar and simple honey (Note: Minooka honey has antibacterial properties and can be purchased sterile for wound application)

Irrigating with 2.5 pH electrolyzed oxidized water works very well. Research and studies have shown that the electrolyzed oxidized water will kill almost all organisms in 30 seconds. It is interesting that the water does not injure tissues. This is because of the significant antioxidant characteristics and defenses that most tissues have but bacteria, viruses, yeasts and fungal organisms do not. The use of 9.5 pH electrolyzed reduced water may have the ability to provide antioxidant effects as well to the wound. These ionize waters are available by using ionizing devices. They are fairly simple set up and run; often simply just placing the ionizer on the counter plugging in the water connector to the faucet and then just plugging in the electrical supply to the outlet. There are about 20 different manufacturers of ionizers but I am only familiar with the one that is a medical grade device that comes out of Japan. It is manufactured by the Enagic company based in Osak. I have used my device for the care of wounds for five years. And have been very impressed with its ability to contract infection and also to provide antioxidant icing effects to severely wounded tissue. Often I start with the use of 2.5 pH water if the wound is relatively free of grim and debris. But if it is filled with dirt that I use the 11.5 water first to help loosen up the grime and debris. It only takes contact time of about 30 seconds to have its ability to kill the bacteria. This involves both the higher pH water and a lower pH water. Wounds that are chronically infected have a lot of pus require the use of 11.5 pH water first.

Sedation is often required. In severe wounds the addition of a local or regional anesthetic is recommended prior to the irrigation and debridement. An intravenous broad spectrum antibiotic should be give prior to the commencement of the debridement

Closed Fracture & Dislocation Management Principles and Specific Recommendations

On arrival do the ABCs as is required with all patients. When a fracture/luxation is suspected treat the patient as it does before radiographs are taken and splint! This might mean just keeping the patient on a section of cardboard (small patientst) or a section of Plexiglas or plastic (larger dogs) or some other material that can be radiographed without much beam interference. Shock and pain are most often associated with fractures and luxations and both are treated best with intravenous fluids and analgesics respectively. If spinal involvement is suspected then complete the neurologic exam first (before the analgesics are given) especially checking for pain sensation by pinching toes and noticing the patient's reaction Remember withdraw of the limb to toe pinch is not an indication the pain sensation is being recognized in the brain and the patient must respond with a noticeable cry or at least a head turn and anxiousness. I prefer small incremental doses of hydromorphone given very slowly. A small dose of dexdomitor (0.1 ml per 20 lb) is also helpful in combating pain and the two are often given but only after fluids are provided in the vast majority of cases. If a long bone fracture is suspected that is unstable then a more specific newspaper or cardboard splint is applied. This is temporary and is meant to provide neurovascular protection. Then radiographs are taken. If radiographs are taken it is also recommended to take thoracic and abdominal films that also include the spine. If dollars are not available but the fractured limb is splint-worthy (and most long bone fractures are – with the only exception being very young and very old animals that are at risk with sedation and anesthesia). In these cases a cage-confinement method of "stabilization" may be effective. In some cases (especially the young animal with open physeal regions) splinting may be offered and done as the only therapy provided and with good results seen. In extremely young (1- 6 weeks old) *no splinting* might also be attempted with good results obtained. Case example: a 3-4 week old kitten that was presented after being injured. It sustained a midfemoral closed fracture and owners had rescued the kitten off the street. Radiographs had been taken at specialty referral center and a young surgeon who saw the kitten recommended surgery – The owners had no money for this option and came to me for a second opinion. I suggested care rest as the femur was straight in the radiographic AP projection but it was slightly overlapping and angled in a lateral projection. In approximately 2 weeks the fracture was believed stable enough because the kitten was walking fairly normally on the limb. Cage rest continued another week and then radiographs were taken and revealed healing ☺.

Splints also provide significant stabilization that pain relief is also provided. In midshaft fractures of the humerus and femur the splint should extend above to include the shoulder and hip joints respectively and down to include the humeroradial and femorotibial joint but best also are extended down to the foot as this prevents slipping and edema distally. These shoulder or hip Spica splints also helpful for fractures of the scapula, scapular humeral joint an elbow luxations and femoral neck, proximal shaft injuries. When these are used they ideally should be followed with open fracture reduction and internal fixation BUT there have been occasions where dollars were not available to this type of care and spica stabilization was the definitive method used to manage these injuries. Most go on to heal. It is recommended to switch to fiberglass or plaster if this option must be used… I had one case in a middle-sized mixed breed dog about 2 years old that was treated with a newspaper Spica in which more paper and flower and water were added to the outside to make (literally) a shell of paper Mache. He wore this until the fracture was stable and healing completed (no radiographs were taken however) at approximately 4 months out.

In large dogs with femoral or humeral fractures spica splints will also work best to be used for temporary stabilization as these eliminate movement. However in selected cases these have been used as the definitive means of stabilization.

Salter fractures in young dogs and cats have been effectively treated with anesthesia, closed reduction and then placement in a spica (elbows) or Ehemer slings (distal femur) with success. Ideally most will be treated definitively then with open reduction and internal fixation but in cases were dollars are not available to do this, this might be the method for treating the fracture definitively. However it is VERY important to remove the splint-sling weekly under sedation /anesthesia if possible and the limb bent and range of motion evolutions completed and then the splint-sling replaced. This is generally required for 2-4 more changes and then limited exercise is allowed for another 4 weeks or so.

Hip and Elbow luxations often can be treated successfully without surgery – provided no fracture portions are observed. These do require complete anesthesia to reduce. Use plenty of distraction time and force when it comes to large dogs with luxations that have been out of more than 6-12 hours. Once reduced immobilize in position of at least 2-3 days minimum and 10-14 days most often but no more. If re-luxation occurs another try and closed reduction and stabilization is possible and sometimes successful. Otherwise open reduction will be needed.

Principles of fracture management also include:

1. Always keep strictly confined – only indoors – crated – out only eliminate and on a leash for this. Cover the bottom with a plastic bag (old IV bags work) when its wet out to keep the splint dry.
2. Check the splint weekly (with owner daily checking for spoilage, wetness, toe swelling, odor, patient bothering it, or acting uncomfortable.. If these are seen then the splint needs to be changed.
3. Change as often as needed (weekly in some cases), and when changing inspect all areas of the skin covered for rubbing sores; use Columbia Wound Powder or other astringent powder between splint padding and the skin when the changes are done.
4. Warn owners the risks of splint only treatments. In some cases surgery will still be needed and in some cases a disaster can occur and even limb removal may be needed☺
5. Taken radiographs from every 1-3 weeks - in the older patient especially the use of a magnet attached to the splint will help speed healing. Ideally the use of a LOOP (Assissianimalhealth.com) will greatly speed healing in all fractures and luxations. Research has suggested an average of speed up by 1/3rd.

Open Fracture Management. Splint them where they lie

Use spica splints mad of newspaper if you have any doubt that there could be a fracture associated with the wound. These DO NOT cause a point of stress on the fracture. Most fractures do better and the soft tissues certainly survive better and have less microvascular injury. Sedation is generally required. Truetta even used these splints on open fractures with fair results.

Most fractures can wait for surgery until the patient is stable. However this is not the case with open wounds if at all possible and those involving the skull or spinal cord. Definitive surgery is best done as within hours of the injury.

SPICA SPLINT APPLICATION TECHNIQUE is recommended for patients with fractures of the shoulder, humerus, proximal 1/3 of the radius or shoulder or elbow luxations. It is also recommended for femoral and proximal tibial fractures and is some cases of coxofemoral luxations and stifle lucations (derangements). The limb is encircled with Specialist cast padding and the body as well after placing tape stirrups. Then either newspaper or cardboard or fiberglass tape is used to fashion a firm splint from the toes to the dorsum of the spine. Then the splint is bound to the limb snugly with gauze and flowed by tape (prefer AC tape or Elasticon as it sticks to the body at the edges of the splint/body edges that help prevent the spica from slipping; this is especially important with hip spicas as opposed to shoulder spicas. One of the important aspects of the use of Spica splints is that they must immobilized joint above and the joint below where the fracture or luxation is. Unfortunately the plastic splints that only reach the midsection of the humerus and the proximal portion of the tibia do not then immobilize the humerus or the proximal portion of the tibia very affectively and therefore should not be used to fractures or dislocations involving the tibia or the humerus. These MUST be immobilize using spica splints. These splints have been utilized for both temporary and for general conserve the immobilization of fractures more long term.

Newspaper and cardboard splints can also be utilized for immobilization of the distal extremities as well and are ideal to be placed on prior to radiographing suspected fractures. The same principle of a mobilization early helps prevent injury to nerves and vessels as well as the surrounding soft tissue which is vitally important especially in distal extremities

Chapter 9: Management of Penetrating Injuries from Bites Bullets and Other Objects (and general wound and fracture care)

MANAGEMENT GUIDELINE OVERVIEW

Just like all injuries, the management of penetrating injury follows the same guidelines and priorities as for general trauma care. Treat the most life threatening problems in priority first and then follow up with those that are limb threatening and then those that are non-limb or life threatening. Start by assessing the scene for safety. Make it safe if it is not. Assess for immediate life-threatening conditions and treat them if they are present. Perform a thorough physical exam and obtain a thorough history. Treat the problems found definitively and complete follow-up care. Document all findings, communications, estimates, agreements, actions well.

There are also other important management decisions that must be made that are specific to the penetrating trauma itself. It was stated in the past that every traumatic event that penetrated the skin should undergo operative exploration and repair. However we know today that this old rule (started before the widespread use of broad spectrum antibiotics) is no longer applicable.

Today a "selective management" concept of handling penetrating wounds is recommended and is based on the following criteria:

1. careful assessment (physical exam, radiographs, ultrasound, lab indices, and monitoring),

2. knowledge of the mechanism of injury, forces involved, and physiologic consequences,

3. knowledge of anatomy involved or possibly involved,

4. past clinical experience with the management of the various types of penetrating injuries,

5. owners financial commitment,

6. facility and staff abilities,

7. other concurrent medical conditions the pet has.

INITIAL ASSESSMENT AND TREATMENT

If the animal is now brought to your hospital scan the patient quickly for injury including all surfaces. If external bleeding, a sucking wound in the neck or chest is noted a compressive or triangular occlusive dressing should be applied respectively. Impaled objects should be stabilized with a dressing if applicable. They should not be removed unless 1. they are thought to be interfering with the movement of air in the airway; 2. they are continuing to create lacerating trauma due to continuous movement that can not be controlled; 3. they are endangering the staff (rare).

The wounds should be assessed closely. Clip the area around the wound and note the wound's location, size, shape, the presence of air or subcutaneous emphysema, the amount of separation of the skin from the underlying tissues, surrounding skin color, the presence of crepitus, pain, and deformity. Cover large open wounds with a water soluble jelly and dress them to keep them clean. Place an antibiotic or antiseptic cream over smaller holes and surrounding areas. Its important to form a protective barrier over the penetrated skin as soon as possible to prevent further contamination with bacteria; particularly with "hospital" entrenched microflora and enteric organisms from the patient. Decisions are then made as to the care options available. Options are based on the animal's overall condition, the wound (mechanism of injury, location, severity), finances available, equipment and help available, and past experience.

SPECIFIC MANAGEMENT RECOMMENDATIONS

General Wound Management - Wounds that do not show signs of deeper tissue disruption, hemorrhage or sucking air are able to be treated conservatively initially as previously mentioned. Simple clipping, gentle cleaning, and dressing are all that is required. All should be treated with broad spectrum antibiotics . It is recommended NOT to use Baytril or other quinolones as a first line broad spectrum antibiotic in most cases. They should be reserved for serious infections and not for prophylaxis except when penetration may involve the brain , sinus, or spinal canal. First generation cephalosporins are otherwise recommended. If the wounds are very severe these are best started intravenously (e.g., cephazolin 40 mg/kg the first dose then 20 mg/kg thereafter Q 6 hr.). Begin the antibiotic coverage BEFORE the would is debrided by at least 30 minutes if possible. If the oral cavity, upper airway, or GI intact is involved then metronidazole at 7 mg/kg IV tid is added. Aminoglycosides are reserved for those cases involving significant gastrointestinal contamination. Gentamycin is given at 5 mg/kg IV or IM Sid and coursed for 3-5 days.

Bite Wound Management - Small skin holes caused by teeth with the muscle intact and no separation of the skin from underlying tissues warrants in some cases only cleaning the area and placing the patient on broad spectrum antibiotics. If tissues under the skin are separated from the skin, fat exits the holes , or subcutaneous tissues feels disrupted then exploration is highly warranted. No cases ever should the wound be simply flushed with saline and sutured closed.

The bite wound minimally is left open to drain. Lacerations and avulsion defects are covered with water soluble jelly, the entire area is clipped and scrubbed and formal exploration of the deeper tissues accomplished. If the skin surrounding the wound is separated from underlying tissue the exploratory incision should encompass this entire area unless special methods are utilized to allow for thorough visual exam without complete exposure (involving high intensity fiberoptic headlight or endoscopic equipment). Upon wide exposure all devitalized fat and muscle should be removed. This needs to be aggressively done. If the thoracic, abdominal or other cavities (calvarium, sinus, joint, spinal canal) are penetrated surgical exploration of those cavities, and debridement, repair, and irrigation are done as needed.

Massive gastrointestinal rupture and contamination cases should not have the abdomen closed. All other cavities, following irrigation and drying are closed. Suction drains are placed where dead space is present if the use of compression dressings can not be used effectively. Sil-Med and other silicone multiholed suction drains and collapsible reservoirs are recommended to be used. But home-made multiholed catheters and continuous evacuation systems made from syringes with plungers held out with a pin can also be used. Gravity assisted passive drains are acceptable where they can be covered and not at great risk for significant contamination which may lead to ascending infection. Wounds are closed with minimal monofilament absorbable subcutaneous sutures used to bring the deeper tissues together. Skin closure may include near far far near or vertical mattress patterns that help close the subdermal and subcutaneous layers.

Gunshot Wound Management - All penetrations should be carefully examined to attempt to determine trajectory and the type of missile, and energy imparted to estimate the possible damage caused. In cases were financial constraints are not a problem most all cases should receive radiographs and a planned exploration based on clinical signs and suspicions for deeper injury. Bullets passing through the chest may be handled conservatively in approximately 50% of the cases. Those involving hemorrhage are begun with diagnosis centesis, chest tube placement, and continuous suction drainage. Counterpressure of 20 mmHg can be helpful for controlling or slowing bleeding of abdominal sources (often initially detected by ultrasound assessment as an AFAST scan). Blood loss may require transfusion, autotransfusion, and exploration if hemorrhage continues (as assessed by serial AFAST scans) and clinical signs worsen. Bullet injuries involving the abdominal cavity usually warrant exploration early in the course but there have been cases where a "watch and wait" course might be taken if the patient is stable, and most often if the wound was caused by a low velocity missile (B-B, pellet, 22 cal short, bird-shot, or shotgun rounds that are deemed to have been from a distance that places the lead shot several centimeters away from each other) and there is no indication of visceral penetration. Abdominal exploration is always preferred in most cases if there is any doubt. Serosal patching of repaired visceral organ injuries is recommended.

Wounds involving other locations are also managed as described for bite wounds. Debridement and irrigation are recommended in most cases except for shallow and low velocity bullets and in cases involving the eye. This includes shot from shotgun injury with wide patterns, provided no clinical signs or radiographic evidence of deeper penetration into abdomen, etc. is observed. Eye penetrations most often lead to enunciation. Radiographs, ultrasound, and CT scanning may be indicated if there is a suggestion that calvarial or sinus penetration has occurred.

Impalement Wound Management - The area and cavity involved are explored before the impaled object is removed. For example an arrow penetrating the chest and abdomen should be left in place until both the chest and abdomen are opened on the midline and removal is done under direct visualization of all the structures involved. If the object is tamponadeing hemorrhage or leakage of gastrointestinal tract contents, occlusion by vascular clamp or Rummel loop should be performed before the object is removed. Management is otherwise similar to bite wounds.

The tenets I subscribe to regarding the emergency management of severe wounds and open fractures can be summarized in 15 statements (Table1). Some of these are old and well proven by their use in many thousands of wounds while others have only come to be realized over the last few years. Some overlap. These are what I believe and are probably not shared by all trauma surgeons but by following them I have had success that I do not think otherwise possible and by teaching them to others I hope others will also realize success in the management of the truly most severe cases in practice.

Table 1-

Tenets of Emergency Management of Wound and Open Fractures

1. The first priority is yourself: Consider all patients with traumatic wounds as having human blood contamination until proven otherwise. Therefore always put on gloves before the patient is touched and use caution. Use Universal Precautions as outlined by OSHA regarding BSI (body substance isolation) precautions (see references).

2. The second priority is providing good assessment of the entire patient and to provide adequate oxygenation, ventilation and circulation and to control major bleeding. The best way to stop bleeding initially is with direct pressure done by hand or with a pneumatic pressure cuff inflated proximal to the wound if possible. Some cases may require immediate surgery to cross-clamp bleeding vessels. Until that time so not let up pressure.

3. Wounds should be kept clean and moist with sterile saline soaked sponges applied from the very beginning of emergency care. Most infections in fresh wounds or surgical wounds come from the hospital environment therefore protect the wound with a temporary sterile towel “bandage” as soon as the patient is seen, even before the patient is placed on an exam table if possible. Wounds covered immediately and kept moist with a saline dressing are associated with significantly less nosicomial infections.

4. Impaled objects should be removed only under controlled surgical conditions with exposure of the deeper tissues involved. The only exceptions are if the object is obstructing the patient’s airway or the object prevents transport and medical care..

5. All wounds involving injury below the skin should be widely clipped, thoroughly explored, debrided as necessary, and lavaged extensively. They should not be closed if they can not be debrided completely clean within 6 hours of the injury or can not be completely removed. Small punctures should be opened and gently irrigated and inspected. They should be left open to ensure drainage Irrigation fluids should not be forced.

6. Debridement of all contaminated and devitalized tissue and copious irrigation are accomplished as soon as possible. If gross contamination is still present following these the wound should never be closed. Rather the wound is packed open with wet saline gauze sponges. This is followed by a dry dressing. Wet-to-dry dressings are changed daily. The wound can generally be closed on day 3-6 when a good granulating tissue bed is present (delayed primary closure) so long as it can be done without much tension.

7. Primary or delayed closure of traumatic wounds following debridement should be completed with non-absorbable monofilament sutures in an interrupted vertical mattress pattern or a near far -far near pattern avoiding the placement of any subcutaneous sutures.

If subcutaneous sutures are used to take the tension off the skin closure layer or ligations are needed to be done use the smallest monofilament absorbable or non absorbable material that is easy to work with such as 3-0 or 4-0 polypropylene.

8. Dead space should be treated with closed suction drains or compression bandages. Sutures placed can not obliterate dead space – only compartmentalize it. Penrose drains should be used in clean wounds only if the exposed end and wound can be covered completely with a sterile compressive dressing.

9. Unstable fractures and luxations should be splinted as soon as possible: “Splint them where they lay”. Bubble wrap works well as a light weight Robert Jones Dressing and newspaper can be used effectively for spica splints. Transporting on a flat rigid object like a board can accomplish “emergency splinting” of the entire patient as well as any obvious fracture and is recommended as a first aid procedure as well as intra-hospital .

10. Wounds and fractures are painful and patients always should be treated with analgesics. Local and regional anesthesia, analgesia and sedation should be not be hesitated to be used as needed. Epidural anesthesia and analgesia is a very effective way to manage pain and catheters provide a very good means of managing wound and fracture pain.

11. Open joints and fractures should be thoroughly debrided and irrigated as soon a comfortably possible. With the use of local, regional or epidural anesthesia this can be accomplished within hours of the injury in most cases in even the more unstable cases.

12. Systemic broad spectrum antibiotics do not take the place of good wound debridement and irrigation but are recommended to be started before the debridement is begun and continued a minimum of 48-72 hours.

13. In severe wounds the importance of enteral nutritional support is a key to the prevention of infection that is just as important as good debridement, irrigation, and broad -spectrum antibiotics. This should be started within hours of the injury.

14. Rest and immobilize the wound, fracture or luxation with compressive dressings to prevent postoperative swelling. In open unstable injuries use external fixation devices (pins and clamps) to allow dressing changes and wound care without loosing immobilization is recommended.

15. Ancillary treatment methods that help assure good oxygenation and blood flow to the injured tissues have a place and should be used: These include the oral administration of pentoxifylline helps improved red cell flexibility; physical therapy (massage, passive range of motion exercises, etc.), hyperbaric oxygen treatments, and even the local application of leeches in distal extremity injuries that have much venous congestion.

A trauma case once presented to our hospital will severe to illustrate many of these tenants:

Louie is a 10 year old Yellow Labrador that was presented to the emergency service after being presumably stuck by a motor vehicle. The owner stated that Louie had been discovered on the side of the road by a passer-by. He was found laying in the snow and had a puddle of blood next to him. He was unable to rise on his real legs. His left rear limb had an easily recognizable severe wound and fracture with much soft tissue injury. The leg was in an abnormal position. The owner placed him on a board and into his truck and immediately brought him to the service. This acted to “splint the entire patient” not only the severely injured limb (Tenet No 9).

Gloves were put on by the emergency team (Tenet No.1) and a sterile towel was applied around the open wound immediately before he was carried on the board into the hospital (Tenet No 3) Assuming significant injury and shock flow – by oxygen was delivered to his face while assessment was being performed. A team member was also preparing to place an intravenous catheter, pull blood for lab analysis, and begin Plasmalyte at a moderate rate. As this was accomplished a thorough assessment protocol was begun to be carried out (Tenet No. 2):

A primary survey or evaluation was done and revealed the following:

LOC (level of consciousness) = alert but quite

Airway = patent

Breathing = normal breathing pattern and rate, breaths sounds heard bilaterally

Cardiovascular = membrane color pink, pulses slightly fast but easily palpable,

Capillary refill time 2 sec, Jugular vein filling time 4 seconds with volume slight,

Heart tones adequate and no murmurs or gallop or arrhythmia, rate same as pulse

Disability = sensation present in all four extremities on toe pinch

Everything else on a quick visual assessment = no obvious external bleeding

Vitals Signs recorded: HR 140, RR 30, BP 120/80, rectal temp 100, weight estimated to be approx. 40-45 Kg. pain score 3-4 / 5

Secondary survey or evaluation revealed normal findings until the caudal one-half of he body was reached. There where numerous superficial abrasions noted on the caudal abdominal skin in the inguinal region. The left rear limb had a large degloving injury and open fracture luxation at the distal end of the tibia and there was much displacement. There was a large area wound involving the medial aspect of the left thigh. The nail bed of the foot was squeezed and sensation of the pinch was acknowledges by the dog. The foot was obviously swollen but some pink color was present in each of the nail beds. There was obvious contamination with road debris throughout the wound. Bowel sounds were not heard on auscultation. There was no pain or distension of the abdomen. There was a small amount of blood at the tip of the prepuce. The urethral meatus was the source of the hemorrhage. Rectal exam was unremarkable. Pain was elicited when the right hip was manipulated. The owner was asked about any possible allergies, when the dog was last fed, any past history of illness or surgery, on any medications and answers recorded.

For the sake of brevity only the most pertinent aspects of care as outlined in the tenants listed above will be described from here on. Following sedation with an initial small bolus of hydromorphone IV Emergency care of the wound-fractures consisted of the following:

The wounds were initially covered with saline soaked sponges (Tenet No.3) while intravenous enrofloxacin (10 mg /kg), metronidazole (7 mg/kg) and cefazolin (40 mg/kg) was administered (Tenet No.12). Further sedation (hydromorphone 0.15 mg/kg and acepromazine 0.001 mg/kg) was provided intravenously following continued fluid support and the wounds were wrapped with more sterile towels and "trauma radiographs" (lateral films of the neck, chest, abdomen, pelvic region) were taken. This revealed a severely displaced fracture luxation of the left tibial-tarsal joint (and a right coxofemoral craniodorsal luxation . The wounds were then initially irrigated and debrided of all gross contamination easily visible (Tenet 6). The wounds were dressed with wet saline dressings and no attempt at closure was done (Tenet 5). Bubble wrap was used over a dry dressing of 4x4 gauze and brown cling to make a light weight Robert Jones dressing that would provide some stability to the fracture luxation (Tenet 9) Analgesia was provided as needed with intravenous hydromorphone and a 100 mcg fentanyl patch was applied to the right distal extremity. (Tenet 10 and 11). A urinary catheter was placed and gross hematuria was noted. Continued monitoring in the ICU was done and 400 mg of pentoxifylline begun orally bid as well as twice a day hyperbaric oxygen treatments. He initially received 100 % oxygen at 15 phi for an hour each treatment in a stainless steel chamber (Companion Animal Hyperbarics, Inc.,) and then 40% oxygen at 4.4 psi for an hour each treatment. This was done using a collapsible and portable hyperbaric chamber (Animal Hyperbarics, Inc.). (Tenet 15). More definitive wound care and surgery was performed the following day.

Under general anesthesia (ketamine, diazepam, isoflurane, hydromorphone, glycopyrolate) and continuous positive pressure ventilatory support with a mechanical ventilator) an epidural catheter was placed to provide epidural anesthesia with lidocaine, bupivicaine, hydromorphone. Louie was taken to surgery after clipping and preparation of the limbs (Tenet 11). The coxofemoral luxation was repaired by open reduction and internal fixation as attempts at closed reduction had failed. The left rear limb was then suspended and surgical preparation completed using chloroxylenol 3% (Technicare). The wound was debrided and irrigated**.** A fiberoptic surgical head-light was used to increase illumination which facilitated the cleaning and debridement process**.** Replacement of the medial collateral ligament was completed with three screws, washers, and No. 5 Ethibond (a braided polyester fiber suture) to simulate the long and short collateral ligaments (Aron, Purinton 1985). A type 2 external fixator was applied for stabilization of the entire joint (Tenet 14).(Clark 1997). Penrose drains were inserted through the posterior aspect of the wound to increase drainage ability where a pocket between skin deep fascia has formed (Tenet 8) and saline dressings applied for wound coverage. Two leeches were applied to the toes to assist with venous congestion and to help prevent microvascular thormbosis and a sterile dressing applied. During the entire 6 hours of surgery for adequate analgesia and anesthesia the isoflurane inhalational concentration required was able to be maintained below 0.5-0.7 % due to the use of the epidural catheter. Postoperative radiographs were completed which revealed the implanted screws and washers and the reduced luxation of the tibial-talar joint and the reduced coxofemoral joint with the two screws used to anchor the supporting Ethibond suture. (Tomlinson 1997) During and immediately after surgery hematocrit, total plasma protein, blood glucose, and venous blood gases were monitored. At the conclusion of the surgery because of the drop of hematocrit below 20 % and a total plasma protein below 4.5 g/dl a unit (500 ml) of stored whole blood was administered.

The patient was admitted back to the intensive care unit with monitoring of ECG, BP, vital signs, urine output and receiving nasal-pharyngeal oxygen. The only new complication noted in the immediate post operative period was the development of paroxsymal unifocal ventricular tachycardia that resolved with 36 hours following surgery. The previously noted hematuria gradually cleared up spontaneously over a period f a few days. Louie remained comfortable and received enteral nutritional support \(Tenet 14) and analgesia via his epidural catheter and fentanyl patch (Tenet 10). Physical therapy (Tenet 15) and tender loving nursing care in the ICU and daily dressing changes (Tenet 6) were performed. Approximately 5 medical grade leeches (LEECHES USA) were applied to his foot daily to decrease edema and help maintain microcirculation in the distal extremity. The injury had essentially caused a 360 degree degloving injury with 270 degrees being an anatomic degloving with loss of all the skin and subcutaneous tissues. The caudal portion of the limb had a complete physiologic degloving as the skin and subcutaneous tissues had pulled away completely from the deeper structures. Because of this the lymphatic draining the toes were literally destroyed and the consequence was significant edema formation. The leeches significantly helped with the reduction of the edema until full thickness grafting was able to be accomplished.

Ten days following the injury Louie underwent a full-thickness mesh grafting with skin taken from his left flank. The graft was applied to the lateral aspect of the hock. Petroleum impregnated gauze was applied following Bacitracin ointment application. This was followed by a sterile layer of 4x4 gauze pads and then cast padding and cling gauze. Seed graphs were applied to the medial side of the wound at various stages following the full-thickness grafting. Dressings were continued to be changed every two to three days as needed. The KE apparatus remained in place for one month after its application to provide support for the skin wound that were healing One week following the removal of the KE apparatus the wounds were almost completely closed with only small areas between the seed grafts were still open. Due to deep crusty snow his owner was using a boot to protect the graft sites. Louie was using his leg quite well and his owner was quite pleased.

This case illustrates many of the multiple tenets I have come to follow that are involved with the emergency care and management of serious wounds and open fractures. It also provides insight to the use of hyperbaric oxygen and leeches for the treatment of microvascular compromised tissues.

Chapter 10: Practical Biophysics Based Technology: Hyperbaric Oxygen Therapy; Photonic Therapy; Targeted Pulsed Electromagnetic Field Therapy; Bioresonance Therapy and the Use of Restructured Water

Other than early and aggressive nutritional support for the seriously ill or injured surgical or medical patient the next important and greatest advance I personally have seen in the daily care of emergency or critical patients in the last 20 years has been what I have been able to accomplish with the use of medical care that is based in biophysics rather than biochemistry. I use biophysics based modalities in the majority of all the patients that I care now, along with standard contemporary care as indicated and continue to be amazed with the improved clinical responses observed.

Basic Biophysics Principles Used in the Surgical and ER/ICU Practice: Sickness or injury are entities that not only are based on anatomy and physiology as we commonly understand it but also on a new area of understanding that involved biophysics. Research is now being able to document this basic biophysics mechanism of action that explains, although superficially and in an oversimplified fashion, how many of the "energy based" forms of treatment work. As further background, Carlo Rubbia won the noble prize in Physics in 1984 that proved that the body more light (EM wave – particle) that solid bio-mater (nucleons) by a factor of almost a billion to one. In biology all chemical reactions and pathways are activated and regulated by biophysical *signals*. It can be in the form or light, sound, heat, mechanical, pieozioelectic as in the case of bone growth and electromagnetic. Paired electron energy transfer is a dominate aspect of energy exchange and regulation in all living cells. Even DNA transcription, protein folding, the making of ATP in the mitochondria, and the generation of electrophysiological propagations such as those involving nerve conduction are associated with paired electron transfer. This is completely different than the properties of conventional electrons moving inside of a copper wire. In this situation the electrons are single. They have random spin which produces noise, friction, heat, and resistance. Whereas electrons in living tissue *always* travel in pairs with zero net spin, which results in very little noise, resistance or heat loss. When in this state these electrons travel both as particles and as waves. The particle aspect of these occurs locally across membranes whereas the wave aspect includes both local and global communications.

Everything that occurs in biochemistry *in vivo* is controlled by a signal in living tissue but when outside a living tissue, such as in a beaker, this signaling is non-existent. The speed of these reactions in living cells is extremely fast (a million per second per metabolically active average cell) (Hanns Brugmann) compared to similar biochemical reactions taking place in the beaker. There has been no artificial laboratory environment that has been able to duplicate this speed. The activation signals of these reactions are transferred through the body's *paired* electrons. Electrons in this paired state can transfer vibration energy and information to coordinate all *in vivo* chemical reactions. Hence, we now are coming to understand the basic mechanisms behind such therapies based on meridian paths, low level lasers, pulse-signal, and shock-wave therapy; modulating repair mechanisms using signal therapy and "electroceuticals" rather than through "pharmaceuticals". Vibrational signals, i.e., sound, heat, light, other forms of electromagnetic phenomena (radio waves, electrical current, including micro-currents , magnetic induction, semiconduction and superconduction) have a controlling influence over biochemical repair mechanisms in the body that have been scientifically proven to exist. It also provides important clues as to the detrimental effects that EM radiation has on living organisms. With this new paradigm: that biophysics is superordinate to biochemistry I began using it in my practice 17 years ago. Three biophysics based treatment modalities are briefly outlined later in the manuscript.

This presentation will center on several "new" therapy modalities unknown to most practicing veterinarians in the US. I was introduced to these through several veterinarians and other health care professionals that I met in my travels providing educational presentations in emergency medicine and surgery at various meetings throughout the United States and several other foreign countries. All have been accepted as proven modalities and much research has been done to verify there effectiveness. We will also look at simple procedures, gizmos and gadgets that the have saved lives in the authors hands and which might literally "make the difference" between living and dying….

Collectively and in summary the new modalities can also save lives as well. Hence I bring them to you as others have introduced them to me. I would hear "you should look into these as they may help your patients" and so, because I always do want to help my patents, I did. One veterinarian who introduced a procedure to me was Dr. Terry Wood, a general practitioner in

Mustang, Oklahoma. He said “I normally do not talk to speakers (at meetings) about such things because they often do not have an open mind about things that are completely different than what is traditional and conventional medicine and surgery. However I was told that you are different. You have proved yourself in providing to us (veterinarians) many practical procedures that have saved lives, and you are already into an area that most all vets no nothing about (hyperbaric oxygen) and so I believe you will at least listen.” I told Terry “yes, I will listen” and that began an adventure into a realm of biophysics based modalities that has literally been a joy. I still find it fascinating why we, as veterinarians, were never introduced to these while we were in veterinary school, but then again it is very understandable, as even though many of these modalities were known of and used by some, for literally the last 50-100 years, they were not felt to be proven and their mechanisms of action were unknown. So at the beginning of this presentation I am going to review practical procedures and some gizmos and gadgets that have saved lives that are simple and easy to accomplish and understand. I have included them in the added handout that accompanies this one that discusses the “new emerging modalities”

When it started: In 1993 I spent a 10 day rotational training session at the world’s famous RA Cowley Shock Trauma Center in Baltimore. It’s a seven story medical center that is devoted to the care of adult trauma patients exclusively and named after a surgeon who helped revolutionize trauma care in the US. RA was all about staying ahead of the “oxygen crisis in every majorly injured patient.” It is there that I was introduced to the first modality I will mention in the list of several…. Hyperbaric Oxygen Therapy (HBOT). I will always thank God that I had an opportunity to visit and learn and be a part of a trauma team there, which also included the use of HBOT for shock, crush injuries, spinal cord and head injuries and even in post-resuscitation patients that had been through a traumatic induced cardiac arrest. I believe that experience was a huge stepping-stone in my career and to this day continues to help me in the care of many of my patients.

In this chapter about new emerging therapies I will be discussing the following modalities:

1.electrolyzed water both the reduced (alkaline) and the oxidized (acid) types;
2.hyperbaric oxygen therapy for any condition that involves ischemia, hypoxia, or edema;
3.targeted pulsed electromagnetic therapy that increases blood flow and oxygenation;
4.photonic therapy that involves the topical use of a 660 nm monochromatic light;

All of these, to be thorough, would require at least several hours of presentation. Therefore I have place more information in this manuscript that I can cover on purpose, so that you will be able to refer back to each modality, should you desire to learn more.

Electrolyzed Water

The electrolysis of water is a process in which electrical current passes through water. Single negatively charged free electrons are added to the water at the positive cathode (reduction) side of a semipermeable membrane and electrons are removed from the water at the negative anode (oxidization). The following reaction summarizes the chemical reactions that occur at the cathode: $4H_2O_2 + 4\ e^- ==> 2H_2$ (gas) + 4OH and at the anode: $2H_2O ==> O_2$ (gas) + $4H^+ + 4e^-$ [1]. Water generated at the cathode is termed electrolyzed reduced water (ERW). This water is alkaline (basic) in pH and has a negative oxidative-reduction potential (-200 to -1200 mv). Water generated at the anode is termed electrolyzed oxidized water (EOW). This water is acidic and has a positive oxidation-reduction potential (+200 to +1200 mv). Water electrolysis units for home and industrial / medical use are commercially made and sold for the generation of both of these types of water. One such unit generates 9 levels of pH in the electrolyzed water (2.5, 4.5, 5.0, 5.5, 7.0, 8.5, 9.0, 9.5, 11.5 pH) and is made with 7 x 5 inch platinum coated titanium electrodes (SD501 Enagic, Inc., Osaka, Japan). The company that manufactures this unit as well as others has made claims that the water produced has health benefits. .

The commercial water electrolizer (also called an ionizer), used at RIVER and which is available to anyone$_a$, first flows water through a high-grade carbon filter to remove trace organic and inorganic water contaminants. This filtered water then flows over a series of 7 platinum coated titanium plates (the platinum acting as a catalyst) in the presence of trace amounts of commonly present calcium, magnesium and sodium that provides ions necessary to allow approximately 230 watts of electrical power to pass through the water and produces structural changes in the water [1]. The unit sits on the counter and the water flows through it via a connection hose to the water supply. The water flowing out of the ionizer is divided into a alkaline water that comes from a hose that extends from the top of the unit and an acid water that flows out of a gray hose that extends from the bottom of the unit.

The electrolysis of the water using the platinum coated electrodes as previously described causes multiple structural changes in the water. These changes have been summarized by others [1, 2, 3] and are listed below:

1. The water's oxygen and hydrogen molecular bonding becomes disrupted with the generation of hydrogen (H^+) ions and hydroxyl (OH^-) ions which are associated with a low pH (acid) water and a high pH (alkaline) water respectively;

2. Free electrons (negative hydrogen ions) are generated at the cathode. These are associated with platinum nano-particles and form "Active Hydrogen" which produces _**reduced wate**_r that has a very low oxidation - reduction potential (ORP) (from -200 to a -1200 mv);

3. The removal of free electrons from the water facilitated by platinum nano-particles with the generation of oxygen gas which literally transfers the water into _oxidized water_ with a very high ORP (from +200 to + 1200 mv);

4. The nano-clustering of the water in which there is a reduction in nuclear magnetic - resonance and the generation of small clusters of water containing 6 molecules in each cluster. This

hexagonal structure is very stable with a resultant hydrogen bond angle of approximately 118 degrees and facilitates water absorption through cell membranes. This is opposed to that seen in standard bulk, tap bottled, reverse osmosis or distilled water that have larger clusters containing 10 to 50 water molecules and a smaller hydrogen bond angle of approximately 108 degrees. The smaller sized clusters enhance the ability to hydrate tissues through its ingestion of the water. The smaller sized clusters (termed micro or nano clusters) also enhances the water's ability to move into the dermis with topical application;

5. A restructuring of the water via the change of the vibrational frequency of the water molecule from approximately 128 Hz to approximately 42 Hz which is also one of the causes of the creation of smaller water clusters;

6. The generation of the fourth phase of water also termed liquid crystalline water or hydrogel those recent investigations by water researcher Dr. Gerald Pollack discovered $_b$. This fourth phase of water is water has also been discovered in living animals by water researcher Dr. Mae-Wan Ho [4];

Various research studies have been published concerning the use of either alkaline electrolyzed reduced water as drinking water or the use of acidic electrolyzed oxidized water topically on wounds or as a disinfectant. This is a brief list of some of the results from such studies:

1. Effective management support of metabolic acidosis associated with renal failure and urinary diversion [5];
2. Support of patients with insulin dependent diabetes that are under additional oxidative stress, as the water is an antioxidant and decreases stress hormones. The feeding of ERW to mice genetically bred to insulin resistant type 2 diabetes significantly reduced blood glucose. [6];
3. Anticancer effects were seen when ERW was fed to rats injected with melanoma cells. This was noted through a decrease in reactive oxygen species (ROS) and the induction of cytokines suggesting a strong immunomodulating effect as well [7];
4. Its effect in decreasing tumor growth through the suppression of tumor vascular growth [8]. In this study laboratory mice were injected with malignant melanoma cells and the mice either drank tap water (control group) or ERW (treated group). There was a significant difference tumor grow rate and in longevity between the groups with the animals drinking the ERW living twice as long as the tap water group with tumor growth and burden being substantially less.
5. Its effects on the prevention of stress inducted impairments in learning tasks [9];
6. Its hepatoprotective effect when toxic materials are ingested [10]; The use of the water (oxidized electrolyzed) for the successful used in the treatment of burn wound infections [11];
7. The effective use of the water (oxidized electrolyzed) in decreasing pathogenic bacterial on tooth brushes and in the mouth as a mouth wash [7];

8. The effective use of the water (electrolyzed oxidized) for the decreasing of pathogenic bacteria in hospital environments [12];
9. Improves ability to effect hydration [13];
10. Decreases insulin requirements in diabetic rats [14];
11. Antineoplstic effect in various types of cancer [15];

In an open study involving pets at several veterinary hospitals including three emergency centers alkaline water (pH 8.5 through 11.5) was given to the pets for drinking. Electrolyzed oxidized water (pH 2.5) was used for topical application on contaminated or infected wounds and burns; in the oral cavity; in ear canals; on table-top surfaces, floors and on various tubes and other surgery equipment. All pets were first introduced to the water either while an inpatient or as an outpatient, with the water being sent home with owners.

There were approximately 100 dogs and 30 cats where the alkaline water for oral consumption in which enough follow-up information was noted to be able comment on the results of placing the pets on the water. It is estimated that there were a total of over 300 pets that received the alkaline water for drinking. It was noted consistently that when the pets were given a choice between the hospitals' tap (municipally supplied) water or freshly made (generated by the ionizer but still using the same water source) alkaline water that they all chose to drink the alkaline water if they did drink. In some cases, documented by video, the dogs would literally "turn their noses away" from the tap water and then seek the alkaline water that had been generated by the water ionizer. Owners commented frequently that their dog or cat appeared to prefer the water compared to the previously offered and consumed tap water. When offered a range of pH, 8.5, 9.0, and 9.5 the pets each appeared to prefer one of the three. 8.5 pH water was generally provided as the initial type that was provided based on previous observations made by another veterinarian [2]. When he was initially giving the dogs alkaline water to his own personal dogs, 8.5 pH was well tolerated. However when 9.0 water was given initially this would result in the production of soft stool. When beginning with 9.5 pH water some developed diarrhea. Therefore 8.5 pH water was generally the pH strength initially used. However there were exceptions: In selected cases 9.5 pH water was initially used and 11.5 pH water was also sent home to be given by the owner in small amounts (15 - 30 ml per Kg body weight per day. These "selected cases" were those that had been diagnosed with a malignant neoplastic condition or had a significant inflammatory skin, bowel, bladder, respiratory or musculoskeletal condition. The reason for this, as recommended by another health care professionals $_d$, was to provide an increased amount of free hydrogen based electrons being absorbed and eventually "donated" to neutralize peroxide radicals known to be in increased amounts in inflammatory and neoplastic conditions.[2]

Regarding the humans in the observational study: These were most often the owners of the pets being treated. Some of these owners had chronic degenerative diseases while other were considered healthy.

When various types of water including the ERW was placed in a bowel and offered to each pet, the pet chose to drink the ERW over all the other types (various bottled types, tap water, well water, water from an osmosis unit, and distilled water). Owners reported that in most cases they saw a *very visible* improvement in the pet's condition when compared to how they were before the electrolyzed water was started. In some the results were so obvious that the owners called or upon their next visit would go out of there way to tell everyone that they saw at the veterinary clinic of hospital about how well there pet was doing after starting in the ERW. Physical examination of the skin, ear and paw of patients with redness and chewing showed significantly less intensity of these signs. There was less diarrhea or multiple bowel movements, less mucus in the stools, less lameness and stiffness. Results were especially apparent in the older animals or those with degenerative joint disease. Most of the changes took several days of water consumption to see. There were no long term side effects in any of the dogs and cats given the water that were noted. Water consumption time ranged from just a few days while the pet was in the hospital to those that continue to be drinking the water.

There were 10 dogs and 1 cat that had topical treatment with the 2.5 pH acidic electrolyzed oxidized water that were able to be assessed well enough to be able comment of the results that were observed. In all cases the topical use of the water was tolerated well. A few seemed to complain slightly following the topical application as if it was causing the sensation of stinging. In one patient with an open fracture and resultant osteomyelitis involving several types of pathogenic bacteria (Pseudomonas sp., Staphylococcus sp., E. coli, etc.). he topical use of the 2.5 pH water was effective in suppressing the bacterial numbers in the affected tissues to the point where no bacterial growth was cultured. The 2.5 pH water was used on 3 burn wound cases, two of which survived and the burn wounds healed well following advancement flap. application and grafting while the third was euthanized due to severe respiratory complications.

All 11 patients that received the topical 2.5 pH water as part of their therapy also received 8.5 to 9.0 pH water for oral consumption. Ten of these 11 cases also were treated with hyperbaric oxygen therapy (HBOT), which can lead to the generation of further reactive oxygen species (ROS) [3]. It was thought that HBOT was another reason for the administration and consumption of the water (author's opinion); the use of the alkaline water would "scavenge" the ROS and help decrease the inflammatory cascade; that the ERW appeared to suppress the inflammatory associated clinical signs . These included redness and swelling of the skin in dermatitis, conjunctivitis, uveitis, and otitis.

The following cases are provided as examples where the use of the electrolyzed water either had a profound - "thought to be associated with the use of the water effect" or just the opposite, where the water's oral ingestion did not prevent the development of neoplasia or the further progression of the cancer:

CASE: A 15-year-old neutered male Border Collie with significant progressive degenerative joint disease and moving with difficulty. Then he had an acute onset of vestibular disease (severe head tilt to the left, falling over to the left, rolling, grimacing, horizontal nytagmus). He stopped eating and would only eat if was fed by hand. The owners were considering for euthanasia. He was stated on 8.5 pH water with the water bowel placed in front of him. He would drink readily. Within one week he improved significantly and has recovered approximately 90%. Following the placement of him on the water his gait and movement improved and this has been continuing. According to his owner he is continuing to play with his ball and enjoying life.

CASE: A 3-year-old male neutered Mixed breed dog with a TPLO postoperatively was found in the hospital run with an open comminuted fracture of the proximal tibia with much soft tissue injury. The fracture was fixed with a long bone plate and the site grafted with cancellous bone. Unfortunately the repaired fracture site became infected. Topical application of the water (2.5 pH) and the ingestion of 8.5, then 9.0 and then 9.5 pH water was provided. The bacterial infection eventually cleared after 2 months of daily applications of the 2.5 pH water and him drinking the 9.5 water. Hyperbaric oxygen had been used on a daily bases to stimulate healing for approximately 4 weeks. His wound was closed surgically as the fracture was appearing to heal radiographically.

CASE: A 1-year-old female spayed Toy Poodle with a large full thickness burn was topically treated with the 2.5 pH water daily until the wound and granulation bed was able to have an advancement of the skin edges and then full thickness grafting (at 7 days post burn). The graft took approximately 5 days to be able to see that it had indeed survived. The dog went on to do well. Hyperbaric oxygen therapy was also used on a daily bases to stimulate healing for approximately 2 weeks.

CASE: A 5-year-old male neutered Welch Corgi that initially seemed to have abdominal pain, but after a few hours was noted to have back pain and began losing the ability to walk in the rear limbs. An intervertebral disc herniation was suspected and confirmed with a myelogram and computerized tomography. Alkaline pH 8.5 water was begun after his hemilaminectomy and discectomy. The owners also started drinking the water when they noticed the dog drinking it readily (more than his regular tap water) and had noted how good it tasted. They also said that when they saw how the dog had now more energy and recovered well, gaining his ability to use both rear legs within a week after the surgery, they became convinced that they too had to be drinking the water.

CASE: A 2-year-old male Weimaraner that arrived after being severely injured by a large dog that attacked him in his own yard. A very significant bite wound with a loss of part of his ear and neck was apparent. The owner had initially taken him to be a primary care veterinarian who attempted to clean the wound, place drains and suture it closed. The veterinarian exclaimed that this was one of the worst bite wound cases you never seen. He sent the patient to us for continued care including further surgery because the wound had now been becoming necrotic. After further debridement, irrigation with 2.5 pH water and commencing with the dog drinking only 8.5 pH water the wound was eventually able to close the wound with a advancement flap. The flap survived and healed well but a small cavern alongside the anchoring of the advanced flat developed. At this time the small cavern is being irrigated with 2.5 pH water and the cavern like sinus is gradually filling in with granulation tissue.

CASE: 11-year-old neutered male Doberman that had been suspected of having Lyme disease and the owner thought the dog was getting "so bad " that he was scheduled to be euthanized at the conclusion of the week as he could no longer walk well and seemed to be in chronic pain. He was only eating and drinking minimally and had lost approximately 8 kg of body weight. The dog was very depressed when I first saw him. The referring veterinarian accompanied me when I saw the patient and remarked that the dog was so much worse. A bowel of 8.5 pH water was placed in front of him and he readily began drinking it. The patient tested positive for Lyme disease with a biotensor[e] and he was treated with the EM frequencies tested and found to be needed using bioresonance unit [f]. The EM signals were also transmitted into the 8.5 pH water specific for patient based on biofeed back from the bioresonace unit [16][f]. He continued to be offered and drinking the alkaline water and within 3 days the owner reversed her decision to have him euthanized. The owner had remarked that the dog was "a different dog" and starting to wall so much better and had begun eating and even playing. Incidental to the dog's treatment the owner also began feeling so much better after she also began drinking the 8.5 pH water.

CASE: An 18-year-old male neutered Domestic Shorthaired cat that was receiving subcutaneous fluids three times a week for chronic renal failure. He also had a house mate that was also similar in age and size and had similar health issues (chronic renal insufficiency). Both cats were receiving subcutaneous fluids 2-3 times each week. Both were started on 8.5 pH water and received biomagnetic resonance therapy and the EM signals were also transmitted into the water[16]. Within a few days both cats were visibly feeling much better and the owner was able to stop giving them subcutaneous fluids. Their appetites had also improved. The subcutaneous fluid support was no longer needed for approximately 4 months and then these were begun again but only needed once every 1-2 weeks. According to the owner the cats were "running around the house as if they were only 5-7 years old". The owner was so impressed with the electrolyzed reduced water therapy that she also stated drinking the water. She bought a water ionizer unit and continues to this day to drink the water. She recently has introduced two younger cats, staring when they were kittens, to the 8.5 pH water and they are thriving better than any other cats she has ever had she said.

One of the most outstanding areas noted was the health of the teeth and oral cavity. We've also seen many animals (both dogs and cats) with chronic joint disease, inflammatory bowel disease, chronic vomiting without a definitive cause, asthma, obesity, wound infections, external ear inflammation and infection, diabetes, hepatitis, cholecystitis, intervertebral disc disease, orthopedic and soft tissue injuries, eye infections, and pancreatitis most have which benefited from being given the electrolyzed reduced water to drink, and electrolyzed oxidized water for wound irrigation. In many case the owners would see how well their dogs and cats did on the water, that they then to begin using the water to drink. Most owners said that not only did their pets appear to feel better but they also felt better. On occasion, diarrhea was note. In those in those cases of diarrhea most often was associated with to rapid an increase in the pH of the water. The diarrhea was felt to be due to a detoxification process that was occurring more rapidly than expected. When this was seen, a lower pH was selected (8.5) in the diarrhea would generally clear in one to three days and then pH would be gradually increased more slowly. Patience with gastric or gastro-esophageal reflux were noted to improve within hours the beginning the electrolyzed reduced water.

For those with severe wound infections and burns, use of the water appeared to be effective. It is presumed that many of the patients in the study were chronically dehydrated, and that this was linked to various disease processes. This was suspected especially in pets that were on municipal water were especially prone to dehydration. It is suspected they can smell the chlorine in the water, and possibly other contaminants.

When the electrolyzed reduced water was started some owners felt that the dog or cat was acting like he or she was years younger. In the case of Sampson's owner he was very impressed with Sampson's ability to walk much more rapidly than he thought he would. Owners with animals that were pregnant explained that the animal's delivery was easier, the pets made more milk, and the puppies and kittens appeared stronger when they were drinking the electrolyzed reduced water as compared to other litters where regular tap water had been provided to the dam and puppies. Patients that had cancer where noted by the owners to feel and eat better and had more normal stools where previously, before the introduction of the ERW there was more constipation.

Patients with specific diseases that particularly benefited from the ingestion of the alkaline water were those in the following disease states: Chronic renal disease; Chronic liver disease; Mammary gland cancer; Dental disease (treatment and recovery, disease prevention; Prostatic disease; Degenerative joint disease; Asthma; Chronic lung disease; Pneumonia; Heart disease; Autoimmune hemolytic anemia; thrombocytopenia; Degenerative disc disease; Post-trauma, post-surgical; HBC (hit-by-car) injuries; Fractures; Snake bite; Bite wounds (minor to severe); Burn wounds; Post Joint Surgery (knees); Post foreign body removal; Post dental surgery; Post use of the hyperbaric oxygen chamber; chronic wound infections; sinus infections; skin diseases; otitis externa; conjunctivitis;

The following conditions were found to have positive effects from the topical use of oxidized reduced water: acute wounds (to help prevent infections); infected wounds (both acute and chronic; sinus infections; skin diseases; otitis externa; conjunctivitis; dental disease (gingivitis).

Regarding the results in the humans drinking the water or using it topically: The humans that were owners either voluntarily stated that they were drinking the water too and noticed considerable improvement in their own chronic degenerative condition (such as osteoarthritis with more mobility and less pain) or did not report any changes in their health if they were of those that felt they were already healthy. Observations of the electrolyzed oxidized water (EOW) used topically in wounds revealed not adverse effects. Both fresh wounds and those over several hours old that were treated with the EOW showed a positive response with none that provided a positive wound culture after treatment. All healed, even those that were major. Systemic side-effects were observed in some people drinking the ERW if they had significant disease conditions. These side-effects observed were the following: diarrhea, malaise, nausea, a tingling in the mouth or “bad taste” in the mouth as they were drinking the water. Lowering the alkaline pH level or changing briefly to clean water resolved the reported problems is all those making and reporting these observations.

This small investigation into the effects of electrolyzed water in pets has been previously reported (see post-notes at the end of this paper). The following conclusion are made: Use of the water clinically both systemically and topically was associated with positive results. The few adverse responses (diarrhea, not wanting to drink) responded completely by decreasing the alkaline pH

Hyperbaric Oxygen Therapy (HBOT)

What HBOT involves is the placing of the patient into a chamber and the delivery of 100% oxygen under pressure (5-15 psi) for 45 – 90 minutes 1-2 times per day depending on the indication.

Indications include any disease or injury process that has in its pathophysiology tissue ischemia, tissue hypoxia or edema. If one thinks seriously about it that includes most of what we see in all our seriously injured and many of our seriously ill patients. Recent published papers and presentations have also indicated that HBOT is one of the best immune system modulators as it increases stem cells within the patient’s circulation by 50% (humans and rats) and is a significant anti-inflammatory “agent” and generator of the antioxidant superoxide dismutase. It decreases edema by literally squeezing on the water out of the interstitial and cellular compartments. This decreases what I will call the “oxygen jumping distance” and promotes cellular and tissue oxygenation. We use our chamber at RIVER commonly for the following types of cases: post “big-dog, little-dog” bite injuries and crush injuries; spinal cord compression from disc herniation and trauma; pancreatitis; post any ischemic episode such as choking, near drowning, near death – arrest; snake bite; pancreatitis; post GI foreign body surgery; post GDV; post head injury; and in any cases where significant edema, ischemia, inflammation or hypoxia is believed to be playing a role in the patient’s condition.

Why use hyperbaric oxygen therapy Hyperbaric oxygen therapy is an important therapy in any patient in which the following conditions are present or expected to develop, which have also been shown effective in numerous published investigations. A few are provided in the reference list [1-4] :

1. Edema that will compromise tissue blood flow and oxygenation;
2. Hypoxia to the tissues (this includes any major wounds but especially severe bite wounds); hypoxia is reduced globally and as well as locally

3. Ischemia to tissues (especially those involved with the nervous, gastrointestinal, cardiovascular and musculoskeletal systems and wounds);
4. It is the only therapy we have available that has been clinically proven to release active stem cells from the patient's bone marrow, significantly enhancing recovery.[4']

The primary mechanisms of action in HBOT are:
1. The immediate hyperoxygenation of plasma, interstitial space, and cells; [1-4]
2. The compression of all body structures containing fluids and gases, causing decreases in edema and decreases in gas volume or bubble size;[1-4]
3. The stimulation of stem cells from the bone marrow and transference of the activated stem cells into the circulation and into tissues. [4']
4. Inhibition of the 3D structure of the circulating leukocyte from spherical to discoid via the prevention leukocyte synthesis of membrane associated cGMP which is needed to "activate" the leukocyte. This decreases oxidative stress as it stabilizes the leukocyte.

Oxidative stress typically is associated with a LOW oxygen (ischemic) environment, causing biochemical reactions to occur that produce reactive molecules that causes oxidation of other structural molecules that cause . Since oxygen is used preferentially as an electron acceptor in many biochemical reactions, the lack of oxygen inhibits electron transfer (known as "redox reactions" or oxidization - reduction" where oxidation is the removal of electrons from a substance verses addition of electrons when reduction occurs. In an oxygen poor environment hypoxanthine is produced from the activation of xanthine oxidase, rather than the production of ATP. The hypoxanthine accumulation causes the production of superoxide radicals which eventually produce highly reactive hydroxyl radical (OH^-). This radical seeks any free electron to electro neutralize it and it commonly interacts with ANY cell protein causing denaturization of that protein, destroys it. This destroys the cellular organelle associated with that protein. It also triggers a destructive biochemical cascade that involves the expression of leukocyte cell wall adhesion receptor and "leukocyte activation" with its adherence. The outcome is a triggering of a destructive biochemical cascade that literally causes a killing of cells, tissues, and ultimately the entire patient. Hyperbaric oxygen then, because of its suppression of leukocyte associated oxidation and reactive molecule formation it is, in effect.

While HBOT is emerging in veterinary medicine as an effective treatment or co-therapy for a wide variety of medical and surgical conditions in small animal veterinary medicine. HBOT may be underutilized, in part because practitioners may not be sufficiently familiar with how HBOT works, why it works, what it does (especially as it related to its initiation and propagation of progenitor stem cells from the patient's own bone marrow and how efficacious it is for the delivery of oxygen to ischemic tissues and the significant effect it has on decreasing edem, especially in organs where edema is especially detrimental such as in brain and spinal cord injuries and medical conditions (such as that occurring after a cardiac or near -cardiac arrect where hypoxia was prolonged and neurologic sequela have ensued. At the very time of this writing I have a severe head trauma patient that has made significant recovery from six hyperbaric oxygen treatments of 1.5ATA (surrounding the patient with 100% oxygen and increasing the pressure within the chamber to 7.2 psi for 2 hours). He is not fully recovered yet but from where he was (in a semicoma state with inappropriate whining - vocalization to now 4 days later able to walk, having no further vocalization and appears to see and recognize individual "family" members). There is no question that hyperbaric oxygen therapy (HBOT) is emerging in veterinary medicine with profound effects; profound effects in wounds where you can see the progression of healing day by day to that just mentioned with a dog that was severely head injured just days ago and now is oriented and walking. Hyperbaric oxygen therapy is effective ancillary and supportive co-therapy for a heterogeneous group of disorders seen in both small animal, equine, and exotic/pet bird and zoo medicine and surgery .

Mechanism of HBOT

When the patient is placed into the hyperbaric chamber and pressurization begins, the fraction of inspired oxygen (FiO_2) is increased in conjunction with the gradual increase in atmospheric pressure (**FIGURE A**). This results in an increased concentration of oxygen molecules within the chamber (Dalton's Law), so as the patient breathes, there is an increased concentration of oxygen molecules delivered to each alveolus (increased alveolar partial pressure of oxygen, PAO_2). Concentrated oxygen molecules in the alveolus (Boyle's Law) results in increased O_2 available for diffusion into pulmonary capillaries.

Because gases move from areas of higher pressure to areas of lower pressure, increased concentration of oxygen in the alveoli results in an increase in oxygen molecules diffusing across the alveolar epithelium into the blood (Graham's Law). The solubility of a gas in a liquid is directly proportional to the partial pressure of that gas in contact with the liquid (Henry's Law). This explains why high concentrations of oxygen in the alveolus will result in high concentrations of dissolved oxygen in the blood and a significant increase in PaO_2

The high concentration of oxygen molecules dissolved in the blood (high PaO_2) forms a pressure gradient for the movement of oxygen from the blood through the capillary endothelium and into the tissues. The amount of oxygen entering and the rate of diffusion into the interstitium are determined by the partial pressure(s) of oxygen across the capillary wall (Graham's Law)

The gradient of oxygen partial pressure between the interstitial space and the intracellular compartment determines the amount of oxygen that enters the cells and the rate at which it enters. Therefore, significantly increased PaO_2 in blood ultimately results in an increased rate of oxygen delivery into the interstitial space and then into the cells (increased PtO_2).

Human hyperbaric oxygen chambers are either monoplace (accommodates one person) or multiplace (several people at one time).[12] Many veterinary practices have acquired previously owned monoplace equipment from human facilities to treat their patients. Veterinary-specific hyperbaric chambers also are available, with some being large enough for ambulatory equine patients.[12]

Most veterinary high-pressure hyperbaric oxygen treatments use 100% oxygen at 2.0 to 3.0 ATA,[12] while low-pressure therapy may be conducted at 1.5 to 2.0 ATA. When lower pressure is used, treatment times may be longer. The average treatment time at 2 ATA is 45 – 60 min.[7,13] The average treatment time at 1.5 ATA (commonally used for head and spinal cord injury) is 2 hours when attained at that common pressure. Patients have been treated up to six times in a 24-hour period, depending on the severity of the condition.[13]

Benefits of HBOT Primary effects of hyperbaric oxygen are 1) hyperoxygenation and 2) decreased gas bubble size. Hyperoxyenation results in greater oxygen-carrying capacity of the blood due to increased dissolved O2 in plasma, which subsequently increases the diffusion of oxygen into the tissues (Graham's Law). [14] This delivery of oxygen is independent of red blood cells (hemoglobin), so that in areas where capillary flow is compromised, tissues have a greater opportunity to receive much-needed oxygen. Tissue PO_2 may remain elevated by more than 10% above normal for up to 3 hours after a single hyperbaric dive.[15] It has been documented that an increased oxygen gradient between a wound and its surrounding environment will stimulate angiogenesis and, subsequently, increased proliferation of fibroblasts.[12] It has also been well documented that HBOT results in that the population of CD34+ cells in the peripheral blood of humans doubling. This was after just one treatment at 2.0 atmospheres absolute (14.7 psi) of 100% oxygen for 2 hours. Over the course of 20 treatments, circulating CD34+cells increased eightfold. The number of colony-forming cells (CFCs) increased from 16+-2 to 26 +- 3 per 100,000 monocytes plated. Elevations in the CFSs were entirely due to the CD34+ subpopulation, A high proportion of progeny cells expressed receptors for vascular endothelial growth factor -2 and for stromal - derived growth factor. Bone marrow concentrations of nitric oxide (-NO) in mice increased by 1000 in association with the HBOT. It has been determined that the HBOT mobilized the stem/progenitor cells by stimulating -NO synthesis.[4']

Decreased gas bubble size is paramount in the treatment of mechanical vascular obstruction from decompression sickness[16] or air embolism[17]; smaller bubbles pass through the vasculature more easily, thereby clearing the obstruction. Additionally, the smaller surface area of smaller bubbles reduces the activation of platelets, complement, and Hageman factor (factor XII).[16]

Other beneficial effects of HBOT include: increases in leukocyte oxidative killing capacity[18,19]; modulation of nitric oxide production[20-22]; and modification of growth factors and cytokine effects through regulation of their levels and/or receptors.[23-25] HBOT also decreases production of clostridial alpha toxins,[26] and is synergistic with some antibiotics such as fluoroquinolones, amphotericin B, and aminoglycosides, all of which use oxygen to transport across the cell membrane.[27-30] An additional benefit is decreased edema due to vasoconstriction in normoxic tissues decreasing flow of blood into those tissues.[14,31]

Indications for HBOT In veterinary medicine, there is a paucity of scientific evaluation of hyperbaric oxygen; therefore, HBOT applications and protocols are largely adopted from human studies. Literature searches on HBOT in veterinary medicine yield primarily anecdotal case reports and conference proceedings.[8,12,13,32-35] Crowe discussed more than 1,400 hyperbaric oxygen treatments given to dogs and cats over a 2-year period.[33] In that report, a wide variety of conditions were treated, with the results assessed as "extremely favorable" in the majority of cases. In veterinary patients with severe pancreatitis, the administration of 1 hour of hyperbaric oxygen at 2 ATA increased the survival rate by as much as 70%.[32] A retrospective study on the use of HBOT that demonstrated benefits in veterinary patients with spinal cord injuries/compressions, head injuries, or stroke-like conditions has been reported,[34] as have the results of a retrospective study involving HBOT and wound healing.[35]

Hyperoxygenation is indicated in conditions characterized by ischemic insult(s)[36,37] such as aortic thromboembolism, gastric dilatation volvulus, traumatic brain injury, stroke, and post CPCR (post cardiopulmonary cerebral resuscitation), as well as non-healing wounds, skin flaps or grafts,[38,39] radiation injuries,[40,41] and crush injuries.[42,43] Hyperoxygenation in patients with sepsis, osteomyelitis, diskospondylitis, gangrene, fungal infections, and necrotizing fasciitis increases leukocyte killing capacity, provides antibiotic synergy, and decreases clostridial toxin production.[44,45] Additionally, the modification of growth factors and cytokine effects provided by hyperoxygenation are helpful in inflammatory conditions such as pancreatitis,[46] heat stroke,[47] and envenomation.[12]

A series of neurologic cases treated with HBOT was presented during the 2007 American College of Veterinary Internal Medicine Forum and the 2008 International Veterinary Emergency & Critical Care Society Symposium. Conditions discussed included global ischemia, head trauma, fibrocartilaginous emboli, intervertebral disc extrusion, and inflammatory central nervous system disease. The speaker felt that the adjunct use of hyperbaric oxygen was instrumental in the improvement and recovery of these patients.[16,31]

At the Pet Emergency Clinic and Specialty Hospital in Thousand Oaks, California more than 1,700 HBOT sessions have been administered, treating conditions ranging from wounds to envenomation, from central vestibular disease to osteomyelitis, and from traumatic brain injury to pancreatitis, among others.[8,32-35] We recently retrospectively evaluated HBOT as an adjunct therapy in the management of emergent central nervous system conditions. The favorable results obtained prompted an international, multicenter, prospective study that is currently ongoing. In our experience, veterinary small animal practitioners often do not recognize situations in which their patients could benefit from this treatment modality. At the Institute of Veterinary Emergencies and Referrals in Chattanooga, Tennessee, the chamber has been gradually become a major treatment adjunct for the same diseases and injuries as those mentioned with the Pet Emergency Clinic and Specialty Hospital in Thousand Oaks, CA. Now I believe we are averaging approximately 7 treatments per day at the RIVER.

Contraindications Awareness of HBOT contraindications[33] is important to providing safe, optimal care. In veterinary medicine, HBOT contraindications and complications often are inferred from human studies.

Absolute contraindications to HBOT include:

1. untreated pneumothorax or pneumomediastinum... well actually this is now not completely true. In my experience this last year I had an opportunity of "diving" two patients with low levels of hyperbaric oxygen with only moderate or minimal pneumothorax.
2. high risk of aspiration, such as with coma, unconsciousness, or semiconscious states.... these are not IF the patient can be accompanied by a professional in the camber OR the ports in the head closing door of the chamber allowing an IV line and Airway management device such as an endotrachael tube that is maintained in place by the use of medications that are able to be delivered intravenously.
3. respiratory failure requiring mechanical ventilatory assistance (if using a monoplace chamber) Actually not so now as there are ventilators that are able to be set up outside the chamber.
4. implantation of older types of pacemakers
5. uncontrolled seizure activity
6. non-mammalian species, due to differences in respiratory physiology and/or anatomy
7. certain cancer chemotherapy agents which will cause severe oxidation associatedcell injury. These include bleomycin, doxorubicin, and cisplatin
8. Anyone getting disulfiram (Antabuse) or sulfamylon cream should not receive HBOTx; Silvadine cream is OK, .

Relative contraindications to HBOT include: upper respiratory infections, asthma, pregnancy, history of spontaneous pneumothorax, severe congestive heart failure; yet in do some the HBOT has helped survive several patients with pneumonia and congestive heart failure.. but they were watched throughout the therapy and did well.

Complications Oxygen toxicity from the formation of reactive oxygen species (ROS) is a potentially serious complication of HBOT.[33] ROS originate from the reduction of molecular oxygen by the addition of an electron. Because this electron is unpaired in its valence shell, the resultant molecule is highly reactive and can cause significant cellular damage.[48] Cellular oxidant stress (and subsequent damage) is determined by the relationship between ROS formation and ROS elimination by antioxidant defenses.[48] Natural antioxidant defenses within the central nervous system can become overwhelmed if overexposed to oxygen, and when this occurs, oxygen-induced seizures may result.[48,49] Careful decompression is recommended[48,49]; anticonvulsant therapy is not required.[48,49] Seizures typically do not reoccur if future hyperbaric treatments are conducted at a lower pressure or shorter length of exposure.[48] While ROS are implicated in pulmonary toxicity in human studies,[48] presently there are no published veterinary reports citing this relationship. NOTE: some of the recent evidence suggests that one of the best antioxidants to employ electrolyzed reduced water (pH 9.5) that contains hydrogen based "free electrons" that has a oxidative reduction potential (ORP) of -500 to - 800 mv (as opposed to regular water that has an ORP of a positive 300-500 mv. (go to Enagic, Inc).

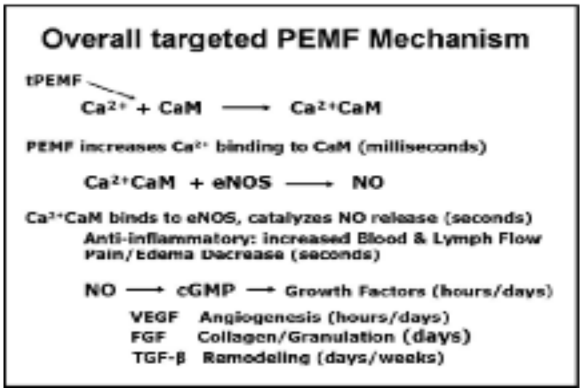
Confinement anxiety and aural barotrauma are less-serious complications of HBOT.[7] If ear discomfort (aural barotrauma) is noted during compression or decompression, the rate of the process is slowed. For containment anxiety, anxiolytic medication is recommended.

Targeted Pulsed Electromagnetic Field Therapy

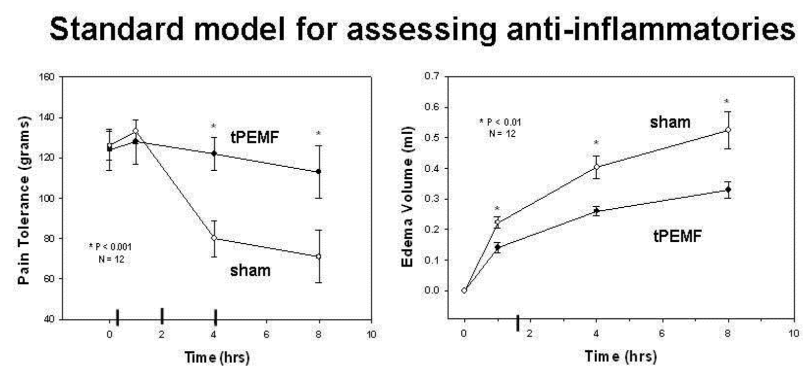
Biophysics based technology in the form or subtle targeted pulsed electromagnetic field (PEMF) therapy with a portable electromagnetic coil that was developed initially as a bone induction coil more than 30 years ago by a biophysicist Arthur Pilla, PhD at Columbia University, NY. He then, through the efforts of a personal friend of mine David Soloff, went on to develop a less cumbersome portable coil that has FDA clearance for soft tissue injuries, pain and edema. David had witnessed the pain his father went through as he suffered from severe burns in a burn unit at UCLA Medical Center, saying to himself “there must be more that can be done for the pain my Dad is going through” and he started a diligent search. In that search David found articles written by Pilla suggesting that the bone induction coil Pilla had developed and used to induce bone healing in delayed unions and nonunions was also found to decrease the discomfort human patients were noticing when they were treating their fractures. He convinced Pilla to continue his research and develop a coil that could decrease pain and increase healing via the same mechanisms the bone induction coil was based on. The following pages outlines much of what is known now about this new technology we now have available as veterinarians for our patients. NOTE: There is hardly a day that goes by that I do not use the coin on at least one of my patients and I trust that after you read this information you will be convinced in its effectiveness and will begin using this technology. It is available through Assisi Animal Health at

either www.assisianimalhealth.com or www.assisivetrx.com. The commercial units available are either portable, running on two lithium batteries, or as a plug-in model that can operate 3 coils at the same time. They all deliver a targeted PEMF signal with each signal being a 2 msec burst of 27.12 MHz with 2 bursts being delivered per second They are single turn copper coil systems mounted in a plastic cover. The treatment consists of laying the coil on the external surface of the animal or human intended for the treatment area. The coil then uniformly exposes the area with an electric field of 6±1V/m.

The graphic below *illustrates one known PEMF effect, the acceleration of the natural anti-inflammatory cascade.* This pathway accounts for the preponderance of existing experimental and clinical data. Even if not the definitive or sole mechanism, the evidence of effectiveness in clinical conditions that benefit from enhanced anti- inflammatory and regenerative activity is substantial.



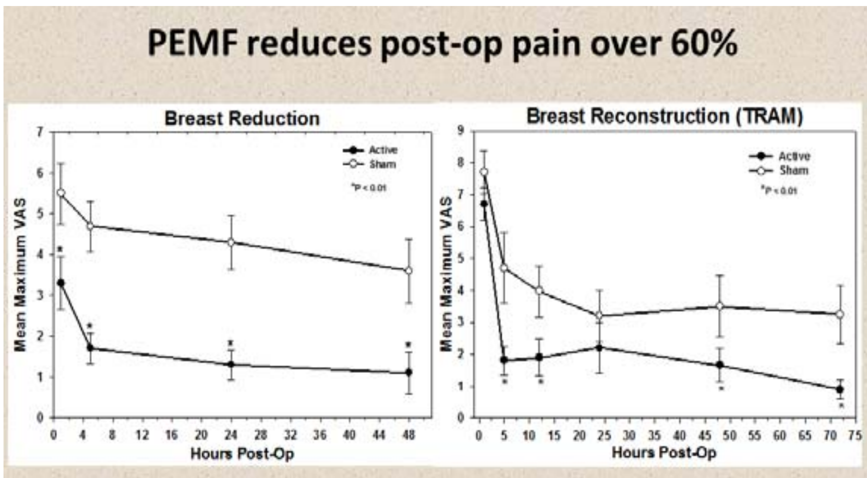
Other research proposes slightly different pathways to generate similar effects (Brighton 2001) and ongoing research at Los Alamos National Labs is evaluating more general mechanism, such as network effects (i.e. lowering electromechanical thresholds in general). The effects of PEMF have been evaluated in multiple animal models. Here using the standard model to evaluate the effectiveness of treatments (device and drug) on inflammation: injection of carrageenan into a rat paw and evaluate pain and swelling. This graphic illustrates the significant level of effectiveness PEMF (three 15 minute treatments, two hours apart) has in that model, essentially mitigating pain and significantly reducing swelling, as would be predicted by the cascade described above (Johnson 2008). As noted above, similar findings have been demonstrated in clinical trials.

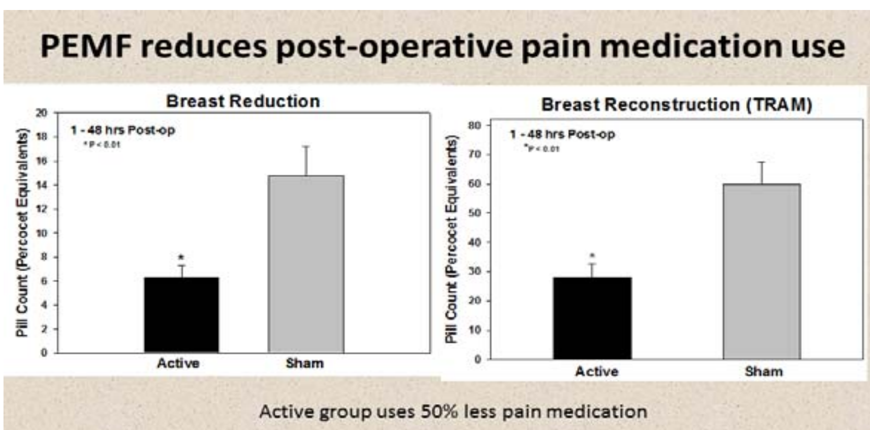


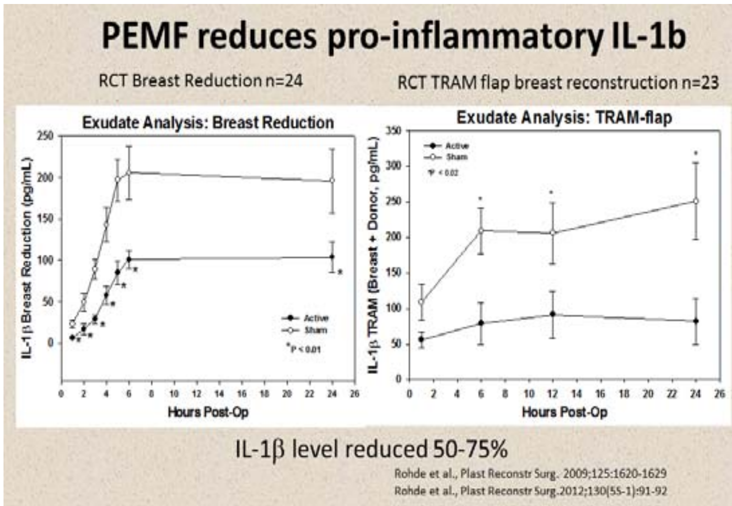
Pain tolerance remains the same in active group; decreased by 59% (P < 0.001) at 8 hours in sham group

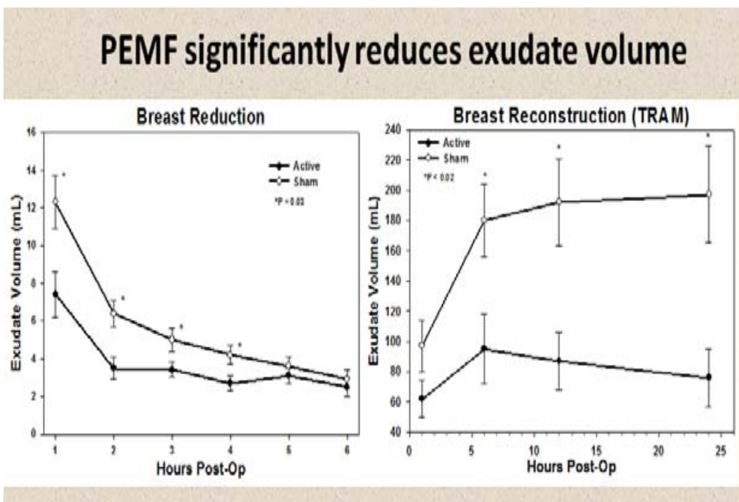
Significantly greater edema in sham group 61% (P = 0.003) vs active group at 8 hours

The next 4 graphics illustrate the effects of PEMF in two post-surgical clinical studies, one in a primary breast reduction cohort (n=24) and the second in a TRAM flap breast reconstruction study (n=27). IL-1b following PEMF treatment for 30 minutes every 4 hours (Rohde 2009) in the breast reduction study and 15 minutes of treatment every two hours (Rohde 2012), in the TRAM flap study (both breast and donor site treated concurrently). Treatment was delivered automatically through lightweight, disposable devices that were either active or sham. In general, the patients in the active group had 50% less pain visual analog scale), used 50% less pain medication, had reduced levels of exudate and had significantly less IL-1b that the sham treatment group. The IL-1b data is of special significance, as it is a key driver of inflammation and found in most tissues. Reductions in this key biomarker point to a reduction in the inflammatory response.









There is a substantial body of research on electromagnetic fields in general and then work on specific areas of clinical medicine. Systematic reviews (Guo 2012, Pilla 2011, 2006) provide useful resources for understanding the scope of PEMF work. Specialty areas, such as plastic surgery (Strauch 2009), cartilage repair (Massari 2007) and bone (Aaron 2006) provide more specifics within those specialties.

Cardiovascular and neurological evidence

PEMF has been shown to have effects in cardiovascular and neurological systems, in in vitro cell culture systems, animal models and human clinical trials (see following). One clear advantage of PEMF treatments for these systems is the long safety record, as treating a breast reconstruction or facial procedure necessarily entails treating the underlying tissue, such as the heart or brain. The technology is easy to use, is of relatively low-cost, and has already been approved by regulatory bodies world-wide for other indications. Secondarily, current management of a variety of cardiovascular and neurological conditions is often only palliative, i.e. treating symptoms without affecting the underlying pathology. In contrast, PEMF treatment offers a direct and effective treatment of the underlying pathologies in several models.

Cardiovascular evidence

Although not identical to neurological tissue, many of the disorders in the cardiovascular arena are driven by the same mechanisms as those in neurology. Previous results in the treatment of ischemic injury (infarcts in heart or brain), inflammation (traumatic brain injury, atherosclerosis) and chronic disease (congestive heart failure, neurodegenerative diseases) suggest the utilization of PEMF in neurology.

In general, PEMF effects reported in the cardiovascular literature include protective (reducing damage from an ischemic event like a heart attack by pretreatment) or restorative (improving outcomes after such an event) mechanisms. The protective effects were first described in the early 1990s (Goodman 1994). Early research into the basic effects of PEMF in intact tissue showed a marked response from 'chaperone' molecules, specifically heat shock proteins, that were associated with improved outcomes in subsequent ischemia (a manifestation of a more generalized protective mechanism, ischemic preconditioning (Yellon 2003, Hausenloy 2008). Additional efforts demonstrated improved outcomes in cell systems (Goodman 1998), in ischemic injuries in animals (Dicarlo 1990, George 2008) and in other systems (Goodman 2002, Robertson 2007). The restorative effects of PEMF include evidence of increased cGMP production (Wu 2009; Januszyck 2010), angiogenesis (Colonna 2008, Delle Monache 2008) and tubule formation (George 2008). In vivo work has demonstrated that PEMF treatment can increase neovascularization (Roland 2000) and improve transferred tissue survival via neovascularization (Weber 2004) and in post-myocardial infarct models can reduce infarct size (Albertini 1999), increase neovascularization in the peri-infact area (Patel 2006), improve cardiac function post-MI (Yuan 2010) and reduce infarct size, enhance ejection fraction and alter gene expression (Lee 2012). The graphic illustrates the effects of PEMF in on infarct size following treatment in a standard mouse model of myocardial infarct (Lee 2012)

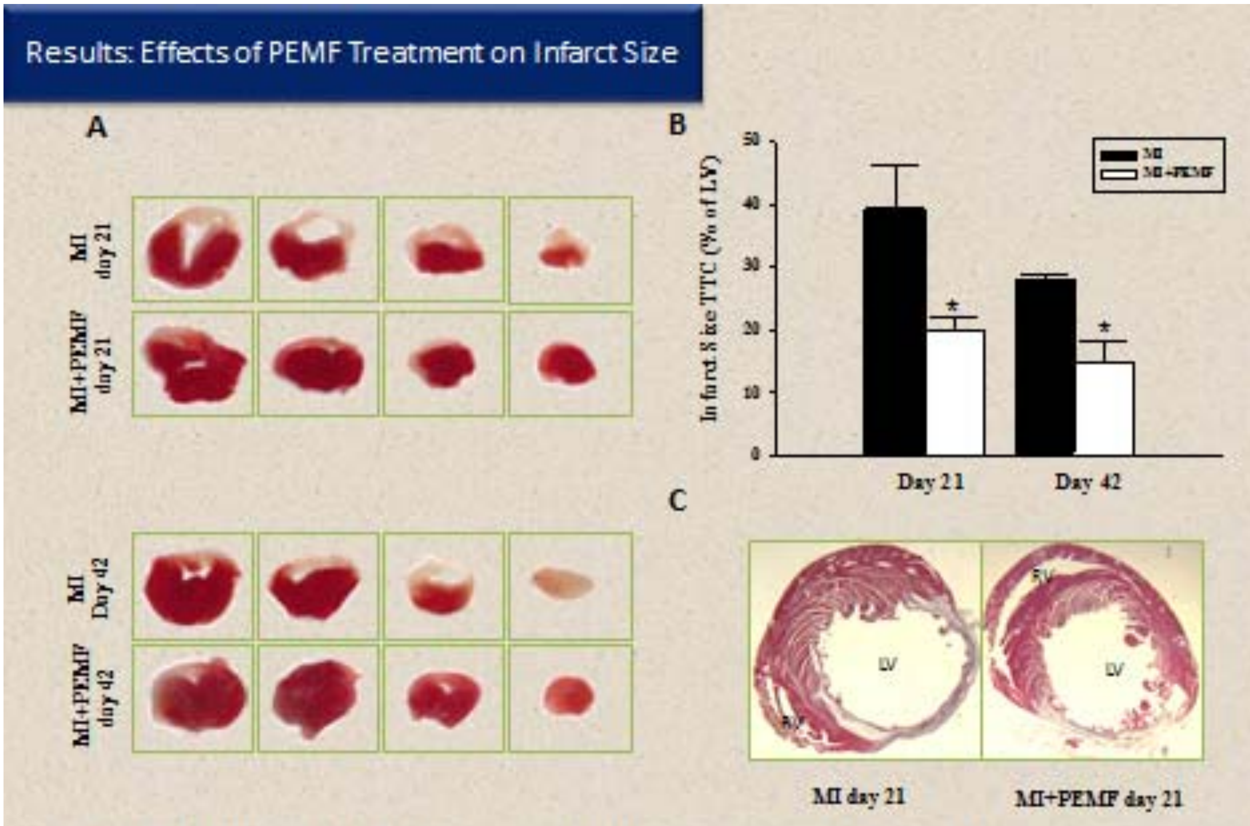


Figure 1. A. Representative examples and B. quantitative measurement of infarct size by triphenyl tetrazolium chloride (TTC) staining at 21 and 42 days after LAD occlusion. Results are expressed as means ± S.E.M of 4 hearts/group (N=4). * $p < 0.05$ compared to MI. C. Exemplary Masson's trichrome stainings of infarcted hearts at 21 days after LAD occlusion. Infarct size was significantly smaller in PEMF-treated animals as compared with sham animals (MI) 21 and 42 days after MI.

The first human trial of PEMF for cardiovascular disease (Shen 2008) was a randomized, controlled trial of patients with chronic stable angina (n=30) who could not be revascularized otherwise. The study provided significant safety data, and showed a significant improvement in physical activity and severity of angina in the active cohort. Imaging was not statistically, significant, but three patients had notable improvements in perfusion. This trial supports the potential for PEMF to treat longer standing, chronic ischemic disorders, including, potentially, those found in the neural tissues.

The study was out of the Cleveland Clinic and examined the use of the targeted Pulsed Electromagnetic Field coils, when applied to the external thoracic cavity in humans with end stage ischemic heart disease (with no options given for further care). Patients= were significantly improved compared to the placebo controlled patients. There were 30 patients randomly enrolled with 15 in the active coil group and 15 in the placebo nonactive coil group. They were all self treated at home where the coil used for 30 minutes twice each day. An angina score was determined as well as SPEC imaging and an echocardiogram at 0, 1,3, and 5 months from the beginning of the coils application. At the conclusion of the study it was determined statistically that was significantly less angina in the treated group, as well as improved perfusion (comparable to patients that get a successful surgical angioplasty). The patients with the active loops also had less angina frequency, and more physical activity without the onset of angina. In conclusion, there was a significant improvement in myocardial pain and an increase in myocardial contractility. (Michael Shen MD, Craig Asher MD, Mary Chandy MD, Tudor Scridon MD, Eric Dandes BS, Eduardo Vargas BS, Adrian Hernandez, MD, PhD, Howard Bush, MD, Kenneth Fromkin MD, Louis Ignarro PhD, Arthur Pilla PhD, Gian Novaro MD. Use of Pulsed Electromagnetic Fields For Ischemic Cardiomyopathy Therapy (EFFECT Trial): A Randomized, Double-Blind, Parallel, Placebo-Controlled, Prospective Trial; Abstract: Proceedings, American Collage of Cardiology Annual Meeting, New Orleans, 2008).

Here is also another poster that was presented at the American College of Cardiology Annual Meeting: Non-Thermal Pulsed Radio Frequency Electromagnetic Fields Attenuate Myocardial Ischemic Injury by Preventing Mitochondrial Dysfunction. Won Hee Lee[1,2*], Sang-Ging Ong[1*], Yongquan Gong[1], Arthur A Pilla[4], Patricia Nguyen[1,2,3#], and Joseph C Wu[1,2#] [1]Department of Medicine, Division of Cardiology, [2]Stanford Cardiovascular Institute, Stanford University School of Medicine, Stanford, CA, 94305, USA, [3]Department of Veterans Affairs Palo Alto Health Care System, Palo Alto, CA, 94304, USA, [4]Departments of Biomedical Engineering, Columbia University, and Orthopedics, Mount Sinai School of Medicine, New York, NY 10029, USA.

The use of PEMF therapy has been shown to improve myocardial function, In this study the authors set out to study the underlying mechanism of this noted improvement. They investigated the effects of PEMF on attenuating myocardial ischemic injury. They ligated the left anterior descending artery of rats and then treated the rats with the IVIVI coil (15 minutes twice each day for 3 days) or a sham (unactive) coil and noted the following:

1. PEMF protected against tissue damage following myocardial ischemic injury

2. PEMF reduced oxidative stress (ROS) in HL-1 atrial cardiomyocytes following the ischemic injury This was noted via evaluation of level of oxidative stress with quantification of MitoSOX signals in HL-1 cardiomyocytes in the presence or absence of PEMF treatment (15 min) after I/R. Data were grouped from 20-30 cells studied over four separate experiments (n=4), expressed as means ± SE. *p<0.05 vs. normoxia, #p<0.05 vs. I/R, and !p<0.05 vs. I/R+MPG. MPG: 2-mercaptopropionyl glycine.

3. PEMF reduced cell death in HL-1 atrial cardiomyocytes following the ischemic injury. This was note via quantification of PI staining (B) in HL-1 cardiomyocytes in the presence or absence of PEMF treatment. Data were expressed as means ± SE (n=4). *p<0.05 vs. I/R + PEMF.

They found, in conclusion that PEMF treatment protected against ischemia/reperfusion (I/R) injury through reduction of oxidative stress and prevention of mitochondrial permeability transition pore (MPTP) opening via transmission electron microscopy (TEM) images from hearts treated. Mitochondria injury score was also statistically less in the treatment group verses the sham (control) group They saw that PEMF prevents loss of mitochondrial transmembrane potential as well. PEMF protects against cardiac mitochondrial damage following I/R and prevents mitochondrial fragmentation following I/R. It reduces oxidative stress following I/R and prevents MPTP opening following I/R leading to decreases cell death. Taken together, these results demonstrate that PEMF treatment significantly protects against myocardial ischemic injury.

Neurological Evidence

The understanding that the functional behaviors of neuronal tissue are fundamentally electrical had created a clinical and scientific environment in which electrically-based therapeutics commonly within the average clinician's experience. A very active research community is currently developing a wide variety of therapeutic electrical interventions, such as implanted electrical stimulators, where power generators are implanted in the trunk and electrodes lead to the specific areas of the brain targeted for stimulation (Goodman 2012, Eller 2011, Moyer 2011). While potentially effective, these require neurosurgery with the attendant risks as well as future maintenance and revision. Non- invasive brain stimulation, NIBS, entails the use of external stimulators to produce biological effects in the brain. This area is actively being researched, with over 200 open clinical trials. The most well-known treatment is transcranial magnetic stimulation, currently used for treating major depression, testing nerve responses and is being research for a number of other indications (Ridding 2007, Kobayashi 2003) . TMS employs large magnetic fields which are pulsed over targeted areas of the brain to directly produce neuronal activation. However, TMS operates at high power levels, is not effectively portable, the mechanism of action not well elucidated and, in the case of depression, the effectiveness is limited (Berlim 2013) and there are potential adverse effects. Other types of neurological stimulation include transcranial direct current stimulation (Brasil-Neto 2012) and cranial electrical stimulation (Smith 2006), both of which use external electrodes to generate currents on the skull. Although there is some evidence that these technologies can alleviate neuropsychological symptoms in some users and enhance cognition in others, the technology requires electrode placement, can produce local adverse events, and the mechanism of action is not well understood. Even the simple physics are problematic, in that electrical current will not flow through the skull with any reliability, so the actual dose is hard to ascertain. PEMF, by contrast, is low power, readily portable, has no known adverse effects, can easily be self-administered and has a long clinical safety record. It is supported by a large body of clinical and basic science work which supports its anti-inflammatory and regenerative effects. In addition, the human body is virtually transparent to magnetic fields, so penetrating the skull has none of the challenges seen with direct electrical stimulation.

PEMF has been evaluated in neuronal models; the following figures demonstrate part of the mechanism described above, in a neuronal context. On the left the increase in nitric oxide production in neuronal cell cultures after one PEMF exposure and on the right, similar effects further along the targeted cascade, where cAMP production is increased. Note in both slides, the right hand bar shows how the effects of PEMF can be reduced by using selective inhibitors of the cascade (W7 and LNAME, respectively; Casper 2008).

There is substantial evidence the tPEMF can accelerate the anti-inflammatory responses in general and have effects on peripheral neuropathies, including improving diabetic neuropathies in both animal (Mert 2006, Gunay 2011) and clinical populations (Graak 2009, Bosi 2005, Musaev 2003). In other peripheral nerve conditons, PEMF has been shown to enhance neurite outgrowth in cultures (Lekhraj 2011, Macias 2000) and nerve repair (Longo 1999, Crowe 2003). In other work, PEMF has been demonstrated to enhance certain adenosine receptors in the whole brain, but not in brain slices, suggesting that there may be some network effects that are driven by PEMF (Varani 2011)

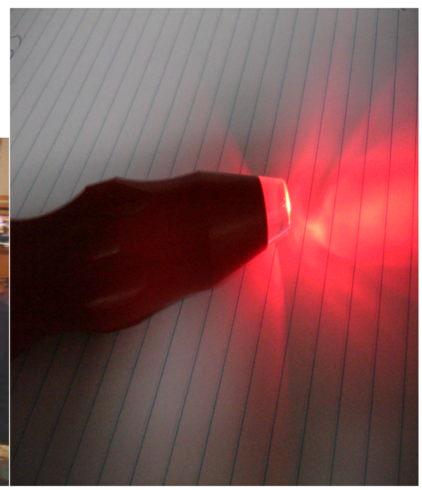
In work from University of New Mexico, PEMF treatment in an allodynia (chronic pain model) demonstrated that PEMF had significant effects in reversing the chronic pain. This model, a ligation of the sciatic nerve unilaterally, produces reliable bilateral allodynia. As seen here, overnight treatment (15 min treatments every 2 hours) significantly reduces allodynia in both paws, suggesting effects at the spinal cord, where bilateral allodynia is mediated. Testing after a single 15 minute treatment produces an immediate and pronounced effect (Milligan, 2012 unpublished).

In cognition, PEMF has been shown to enhance neuronal activity, which is the first indictor that it may have enhancing effects on cognition. The immediate need there is military, for training purposes, but the long-term need is in pathological neurodegenerative conditions. As seen above, PEMF has been shown to enhance neuronal activity, which is suggestive of the development of treatment regimens for cognitive enhancement. Others have demonstrated that PEMF exposure can reduce morbidity via neuroprotection and improve cognitive activity in neurodegenerative and normal models (Arendash 2010, 2012, Dragicevic 2011) and that the effects may translate into reduced morbidity in human cohorts (Schuz 2009).

In summary, PEMF technologies have been in clinical use for treating inflammatory conditions for almost 100 years. Advances in the understanding of basic cellular and physiological mechanisms, rapid advances in digital signal generation technologies and the development of more advanced materials have resulted in simple, easy to use devices with an outstanding safety profile. Basic scientific and clinical evidence supports current clinical use in treating post-operative pain and edema, as well as in wound healing, and has resulted in worldwide approval of PEMF for these applications. Research in a variety of areas points to significant potential for PEMF to provide effective treatments where few, if any, currently exist. In particular, the neurosciences, with their long-standing use of electrotherapies, coupled with the dearth of interventions for the most common and costly conditions, such as stroke, traumatic brain injury and cognitive decline, are especially suitable for development of PEMF therapies. Initial findings across scale (cells, tissues, animals and humans) suggest the need for rapid and vigorous research in the appropriate indications. A non-invasive, non-pharmacological intervention with ease of use and an outstanding safety record is potentially available today. With only a moderate amount of resources, rapid and definitive answers around the potential for PEMF in the neurosciences will be found.

Photonic Therapy:

This involves the use of a specific torch-like instrument. It produces 185mW of energy in the 660nm wavelength; it is then turned on and placed on the skin. This allows a horse, dog, cat, human to be treated using only 5 to 10 seconds per point. Normally it takes only 4 to 6 treatments to fix all but the most serious problem. Treatments are given every second day. You may give a daily treatment and, even though you can do no harm, it will not make the patient heal any faster, though, in the case of a fresh injury, it will assist in removing pain. How it works: Light energy (photons) is transformed into electrical energy by the connective tissue under our skin. This electrical energy is transmitted to the brain by the nerves. Stimulating specific combinations of points on the skin will cause the brain to release particular hormones and other chemicals which relieve pain, increase the immune response and promote healing. The McLaren Method of diagnosis and therapy uses broad band 660nm red light to provide the photons required to painlessly and safely stimulate tissue. Visible light is a small part of the electro-magnetic spectrum and ranges between 400-700nm. Wavelengths below 400nm (ultra violet) have high energy and do not penetrate deeply into tissue. Above 700nm, in the infrared range, there is less energy per photon and longer treatment times would be required.



Dr. Brian McLaren examining a patient The photonic therapy "torch"

Photonic acupuncture is the application of monochromatic light to classical acupuncture points, and is the correct name for what has been described as laser acupuncture, or low-level laser therapy. One may describe electro-magnetic radiation (EMR) in space in terms of wavelengths, and in tissue in terms of photons or packets of energy. A more accurate scientific concept describes EMR as variations in the electrical field strength, where the frequency and amplitude are the features of importance. Understanding the biological effects of light's action in tissue clearly demonstrates there are disadvantages, but no clinical or biological advantages, in using a low level laser light compared to using a non-coherent light. A unifying electro-physiology theory is advanced, postulating how the various forms of stimulation of acupuncture points result in similar changes in physiological parameters. An understanding of the phylogenetic evolution of the body's electro-magnetic field sensory systems, allows a rational explanation for the origin of acupuncture points and channel

That low level laser light could stimulate acupuncture points has been known since 1968 (Mester 1985). Simple light emitting diodes (LEDs) became available in the early 1970s, with the first Gallium-Arsenide diode laser developed in 1979, but only in the last five years have superbright or super-luminous diodes (SLDs) been commercially available. A recent survey amongst physiotherapists showed 94% of respondents were dissatisfied with the amount and quality of information available on laser therapy (Baxter 1994). Due to a lack of basic understanding, controversies surround the stimulation of tissue with light, and whether or not coherent, collimated, and narrowly mono-chromatic, laser generated light, produces different effects from non-coherent broad band light (Pontinen 1992, Baxter 1994).

Both laser diodes and modern SLDs are now made from a Gallium-Aluminium-Arsenide (Ga-Al-As) alloy formed into a double hetero-junction chip. This means that there are two junctions of dissimilar crystalline alloys, not just one junction as in the older style LEDs. The SLD has the same chip structure as a solid state laser, but it lacks the thin films of reflective aluminium to form a resonant cavity, which would technically make it a laser.

In the biological literature, it is common to find comments relating the wavelength of light to specific effects, such as absorption, penetration depth, and even mode of function, however, as the velocity of light changes with each change in the density of the tissue, so does the wavelength (Kane and Sternheim 1988). The past ten years have seen an explosion in knowledge regarding the molecular basis for membrane transport, which permits an understanding of the physiological basis for clinical acupuncture at a level not previously possible.

THE BIOLOGICAL EFFECTS OF LIGHT

The efficacy of phototherapy has long been known, even though its' mechanism of action was not understood. From 1500 BC Indian Sanskrit documents, through the histories of the ancient Egyptians, Greeks and Romans, one finds references to the healing powers of light. Henri de Mondeville (1260-1320 AD) used red light to treat smallpox. John of Goddesden, physician to Edward II of England, in 1510 treated a prince with smallpox, using red dyes, red bedclothes and red curtains (diffuse red light), and cured him without a vestige of pock marks. In 1903 a Danish doctor, was awarded a Nobel prize for treating tuberculosis and smallpox with red light to abolish suppuration and lessen scarring (Kleinkort and Foley 1984).

With the advent of modern antibiotics and improved hygiene much of this old information was forgotten or ignored (Karu 1989). Not surprisingly, suggesting that light could be used to treat disease risked accusations of pseudo-science, as quackery flourishes in the twilight zone of knowledge.

When lasers were discovered in the late 1950s, the observed biological effects were attributed to the uniquely high coherence of the radiation (Mester et al 1985), however, Karu (1987), conclusively demonstrated that there was no scientific or physical basis for such a belief.

While low powered laser light was used to stimulate acupuncture points from 1963, it was not until 1989 that sufficient, detailed, scientific information was available to understand the interaction of light with tissue. In 1990 with the advent of SLD technology, and then in 1991 with the publication of Bioenergetics texts, it was possible to introduce a rational, scientific, advanced method of non-invasive acupuncture treatment, which Pontinen (1992) described as pain-free, sterile, safe, and effective.

It must be clearly stated that biological specimens only absorb non-coherent light, and the coherence of laser light is lost after the first millimetre of epidermis.

In discussing the biostimulatory effects of low intensity light on tissue, a number of erroneous points are commonly encountered:

(a) Basford (1989) states that red light penetrates 0.8-15mm into tissue whereas infrared light reaches 10-50mm, (penetration increases with wavelength). This statement is incorrect.

There is little penetration up to 600nm, due to absorption by the various peptide bonds, chromophores, porphyrins, haemoglobin, oxyhaemoglobin, and photo-inducible components such as urocanic acid and melanin (Wilson and Jaques 1990). From 600nm to 700nm there is a steep rise in penetration (about 2.5 times the distance), due to decreasing haemoglobin absorption, and then penetration is roughly constant above this region to about 1300nm, with a small dip at 960nm due the high absorption at this level by water (Smith 1991).

(b) Light beams of lasers and non-lasers show a variety of different intensity profiles, divergent beam widths, and wavelengths. In an attempt to rationalise different forms of treatment, a common suggestion is to quote all treatments in Joules per square centimetre, regardless of the spot size (Pontinen 1992, Baxter 1994). As time is involved in the measurement of Joules/square cm, this has led to various high intensity treatments over short times being quoted as equivalent to low intensity long time treatments (Bliddal et al 1987), whereas the irradiation in the first case can introduce bio-inhibition (Harris 1988). This is equivalent to a driver speeding at 200 km/hr, with three passengers, telling a traffic policeman he was only travelling at 50km/hr/person.

(c) A common fallacy is that pulsing makes for deeper penetration. When lasers were first utilised, to get sufficient electrical strength, one had to pulse the current to get a solid material to lase. In modern lasers, pulsing is merely switching on and off and reduces the effectiveness, by a factor equal to the on/off period relationship, thus increasing the time per treatment required (Baxter 1994). This is analogous to suggesting that if the room light was to be switched on and off it would make the room brighter. Manufacturers may provide pulsing because their competition do so, but to purport any benefits from pulsing is wrong.

All electro-magnetic radiation (EMR) has its own frequency with visible light falling between 4x10*14 to 7x10*14 cycles per second (Hz). Gas lasers tend to produce continuous energy, while laser or otherwise semiconductor light is in bursts of 5000Hz. The claim of clinical benefit is based on confusion with the known fact, that slowly pulsing a strong electric field will affect the cyclic adenosine-mono-phosphate (cAMP) and de-oxyribose-nucleic-acid (DNA) synthesis in tissue, while different pulse frequencies of strong electrical fields effect the production of encephalin, dynorphins, endorphins and monoamines (Stux and Pomeranz 1989).

(d) Another fallacy is that pressing the light into the tissue makes the light penetrate further. Proponents of such suggestions (Pontinen 1992, Baxter 1994), do not consider that compression changes the tissue's density, the refractive index, the light's subsequent scatter and therefore may reduce penetration but not increase it.

(e) Many articles describe laser coherence, and the various types of lasers available from gas to diodes, without explaining that most diodes are technically not true lasers, a fact made clear by Baxter (1994). A common error is to describe He-Ne lasers as producing 632.8nm wavelength and Ga-As as producing 904nm (Flemming 1994) as if this were the only wave length produced.

Using a ruby rod, Maiman (1960) produced the first visible laser light at 694.3nm. Within a year, numerous lasers were available, among them being invisible infra-red He-Ne lasers of 1118, 1153, 1160, 1199 and 1207nm, while the first visible He-Ne laser of 633nm did not appear until 1962. In diode systems (laser or otherwise), the radiated wavelength depends on the percentage of aluminium in the diode, which can be manufactured to produce virtually any wavelength required (Baxter 1994).

It is necessary to counter much misinformation and erroneous conceptions if progress is to be made in the use of light to stimulate acupuncture points.

All living cells require energy for growth and metabolism, usually supplied by ATP phosphate bond hydrolysis, which is the common energy transfer in all living organisms (Herbert et al. 1989). The chemiosmotic theory, is based on the principle that concentration gradients across a cell membrane and the phosphodiester bonds in ATP are inter-convertible forms of storing energy.

There is a great similarity between photosynthesis in plant chlorophyll and mitochondrial oxidation utilising cytochromes. Both chlorophyll and mitochondrial cytochromes have a metalated, conjugated porphyrin ring, which is an efficient light absorber. Singlet oxygen is highly reactive, rapidly oxidises a large variety of biological molecules, damages DNA and is responsible for cell destruction. Singlet oxygen is photo-produced by porphyrins, the efficiency of which depends on the side chains, and the radiation energy frequency. Incorporation of metal ions into the porphyrin molecule depresses or even inhibits formation of singlet oxygen (Lubart et al. 1990, 1991).

The absorption of specific wavelengths of light by specific receptors such as rhodopsin, phytochrome, or chlorophyll is easily demonstrated, but can not be as easily demonstrated for porphyrins. All photoreceptor pigments (porphyrins and their derivatives) when irradiated, change colour, and their absorption peak shifts due to cis-trans isomerization.

An even more complex matter is to demonstrate the absorption by non-specialised chromophores such as flavins. Reactions with various components of light produces a photobiological response in the terminal oxidases of the mitochondrial respiratory chain, which has a complex structure as well as a complicated absorption spectrum near 400, 450, 605, 680, 760, and 830nm. Flavoproteins and their semiquinone forms have absorption bands in the red region, which in the case of the respiratory chains are represented by dehydrogenases (Brunori and Wilson 1982).

This is affected by whether the receptor is in the reduced or oxidised form. As the cellular redox potential is lowered or moved more in the reduced direction, the effect of light on tissue is greater. The cellular response is not an all or nothing response, but a graded reaction.

If DNA synthesis is taken as an indicator of cellular stimulation by light, then with as many factors controlled for as possible, DNA synthesis can be observed in wave-length range of about 320nm to 450nm and 600nm to 840nm with maxima peaks at 400, 630, 680, 760, and 820nm (Karu 1989). Light in the wavelengths mentioned is not absorbed directly by the DNA, therefore there has to be intervening photo-acceptors producing photo-products which influence the metabolic processes in the cells. This is why spectral bands of 50-150nm are advantageous (Karu 1989), and why laser's single wave length, used as a stimulatory mechanism is disadvantaged by comparison.

Quoting numerous studies, Karu (1987) states that at the level of a whole organism, the skin possesses light sensitivity, and the presence of the eyes only modifies the skin's photo-sensitivity effect. When light is applied to acupuncture points it stimulates mitochondrial membrane cytochromes, which are normally engaged in electron transfer. This may be seen as the local activation of a universal, primitive, photo-synthetic mechanism, to low intensity near mono-chromatic light, suggesting a similar molecular mechanism with the same primary photoreceptor.

The cells normal function is to pump hydrogen ion (H+) out of the cell against high electrical and chemical gradients. The electro-chemiosmotic pressure so generated, when released by the influx of hydrogen ions into the cell drives the ADP + P -> ATP (Nicholls and Ferguson 1992). Ions have a relatively high surface charge, a high attraction to water, which accounts for the relative lack of ion permeability through membranes.

In the context of cell to cell signalling, if one accepts the term first messenger as a generic term to cover all types of extracellular signal molecules, the term second messenger represents the intracellular signal molecules that are produced in response (Hardie 1993). Almost all mammalian cells, except red blood cells, produce prostaglandin and eicosanoids, which like hormones, have profound physiological effects at extremely low concentrations. Mechanical deformation of cells produces prostaglandin (first messenger) which provokes the metabolic activity as revealed by increased cAMP (second messenger), leading to DNA synthesis and the activation of protein kinases which is involved in the stimulation of phosphorylation (Bereiter-Hahn 1986).

Stimulation with electrical fields serves the same role as the prostaglandin effect. In the neuromuscular systems, electrical potentials which are the product of intercellular chemical reactions, serve as messengers, provoke specific responses, and cyclic series of potentials can be used to automatically control a target organ (Martin and Burr 1988).

In the creation of single cell organisms, the two major branches formed are the eukaryotes (plants, animals and fungi), which have a membrane-enclosed nucleus, and the prokaryotes (bacteria), which lack this organelle. According to the endosymbiotic hypothesis, a purple photosynthetic bacteria formed an evolutionary successful, symbiotic relationship with a primitive form of nucleated cells giving rise to chloroplasts in plants and mitochondria in animal cells. The only known eukaryotes which do not have chloroplasts, mitochondria etc., have symbiotic cyanobacteria within them (Voet and Voet 1995).

Every unicellular organism has to be capable of the full panoply of biochemical processes required, with growth and metabolism controlled only by nutrient availability, with each cell competing for these nutrients with the same and other species. In multicellular organisms, cells are differentiated for a particular purpose, and close cooperation is required between them for efficient function, particularly in the co-ordination of movement, metabolism, and growth (Hardie 1991).

Anatomical and cytological studies have shown that all living things have an underlying regularity that derives from their being constructed in a hierarchal manner. One striking feature that all living organisms have in common is the presence of an ADP-ATP system. Understanding photo-receptor evolution and function, shows that different organisms use different photoreceptors for essentially the same function, while in other cases, essentially the same photoreceptor has been used to achieve different objectives Holmes (1991).

Bacteria and other single cell organisms do not have a nervous system, but they have both a form of memory and a sense of direction, due to electrical potential differences across their cell membranes. Sharks and fish use the electric fields around their body for prey detection, and communication (Kane and Sternheim 1988, Kramer 1990, Moller 1995) as do echidnas and platypus (Manger 1994). Snakes have infrared sensors on their lips (Bereiter-Hahn et al 1986).

Having originated from a common phylogenetic base, all creatures develop characteristics best suited to the environment they inhabit, and as all species share common features to a greater or lesser degree, this may be exemplified by cellular response to electro-magnetic radiation.

Each electrical charge produces an electric field in its vicinity, with the total electric field of multiple charges being the sum of their individual electric fields.

In the case of fish and sharks using the electric fields around their body for prey detection, and communication, this may be exemplified by a school of fish being attacked by a shark. The shark is sensitive to, and attracted by the minute electric fields produced by each fish, which in a school may be considered as an aggregated field. As soon as the shark breaches the outer limits of the school's associated field, a force is transmitted to the entire school and all fish turn as one. In the case of fish living in a conductive medium, these sensors in their skins are particularly well developed.

All living tissue produces electromagnetic fields, and have EMF sensors developed to a greater or lesser extent. Monotremes, which are of a higher phylogenetic development than fish, also utilise electromagnetic radiation sensing, especially under water. Birds, higher mammals, and humans have well developed eyes to receive electromagnetic radiation in the form of visible light. These terrestrial beings also have areas on the skin of increased electrical conductivity, the stimulation of which can alter physiological function. This strongly suggests that acupuncture points are phylogenetically, simply the skin's electric field sensory system, which is common in all things.).

Under the skin is connective tissue, which is largely comprised of collagen. Of the 32 crystalline shapes known to science, 20 of these are so arranged that pressure causes an electrical charge within the crystal. This is known as the Piezo-electric crystal effect. Of these 20 crystals, 10 are also Pyro-electric, that is heat causes an electric charge separation. Collagen is comprised of crystals which are both Piezo and Pyro electric. Thus when the skin is touched the body recognises both pressure and warmth. This information is conveyed to the brain electrically via the nerves.

When an acupuncture point is stimulated with a needle it produces pressure, and via the Piezo-electric effect stimulates the brain, via the nerves. The inflammatory reaction and immune response occasioned by needle insertion is highly localised, incidental and not of importance, where as the induced electrical current known as the discharge of injury, is important.

The electrical stimulation of the brain is not just a momentary effect, as the change in electrical potential of the cells at the acupuncture point, changes the energy level of the surrounding tissue for some 32 to 48 hours.

If cells are grown on an agar plate in an incubator in the dark, on exposure to light (and return to the incubator), it will be noticed they grow at a greater rate for anything up to 3 or 4 generations. If the cells are examined immediately after exposure to light, little change would be noticed. However after 32 to 48 hours improvements in growth rate etc, can be demonstrated.

When a light is shone on an acupuncture point it changes the electrical potential of the cell's walls and the energy level of the cells, in exactly the same way as an acupuncture needle would do, without the problems associated with skin penetration.

Altering skin potentials via irradiation alters the electrical activity in the brain and causal relationships have been shown to exist between the variations in concentrations of the neurohormones, (noradrenaline, dopamine, 5HT, cAMP, and Ca++), the concentration of DNA and RNA synthesis (Martelly and Franquinet 1984). Laakso (1995) showed transcutaneous stimulation of human skin increased blood endorphin levels.

Acupuncture may be shown to be a therapeutic modality which is as effective as, or in some cases more effective than Western medicine (Bensoussan 1991), yet the number of people seeking acupuncture as a method of first choice tend to suggest that it has remained relatively unpopular as a treatment. This may be due to a number of factors including the fact that acupuncture, like chiropractic or physiotherapy, requires a series of treatments for best results. The unpopularity may also be partly due to the strong dislike a large number of people have of needle insertion (Mann 1977, Le Bars et al. 1987), or the risks associated with skin penetration (Waylonis 1988). Also it may be due in no small measure, to the difficulty of TCM theory, not being easily equated by qualified medical personnel, with their own scientific, knowledge base.

The problems related to understanding photonic acupuncture are significant to a more complete scientific understanding of acupuncture. A unifying theory to explain a common mode of action for all of acupuncture's various methodologies, invasive and otherwise, will help explain acupuncture to the medical scientists, open for debate some of the firmly held dogmas now perceived as truths, and reduce the requirement for teaching needle techniques to that associated with other ancient, invasive and potentially dangerous methodologies.

Acupuncture is not a static method, but has changed as it has been developed over thousands of years. A theory to explain acupuncture in a scientific manner may allow it to develop further, and with photonic techniques eliminating the need for skin penetration acupuncture's popularity may be enhanced.

I have been using photonic therapy for the last 10 years, having received my training from Dr. Terry Wood directly and Dr. McLaren by phone call and through is teaching DVDs. At first I was very skeptical but juts did what I was instructed to do. The light was applied directly to the area of concern such as painful back or neck. Then I learned the 14 major acupuncture points and I treat these as well. Now to help me locate the points and the amount of time the light needs to be applied I use the biotensor in my right hand and the photonic light in my left. The light is angled as it is placed on the skin's surface and when the tensor is "resonant" I continue the light application until the tensor becomes disresonant. I continue to do each acupuncture point that same way until all are treated. I also currently have very seasoned chiropractor that has found that the application of the photonic light is as effective as his Activator when he is doing successive Dearfield testing. He exclaims "wow – I can not believe I get these results with just this simple red light".

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