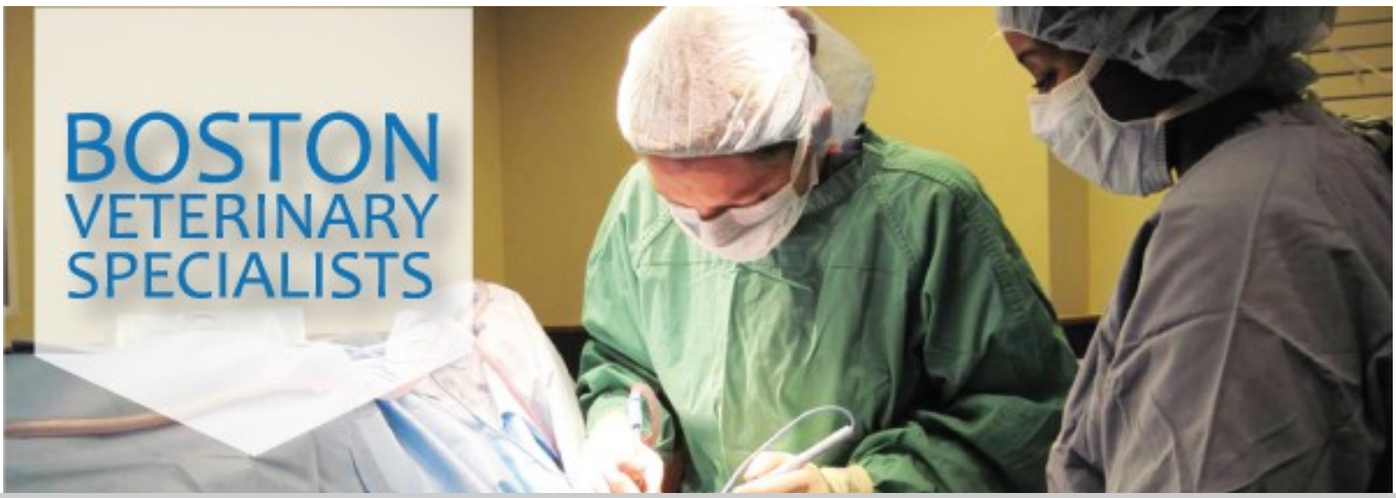


Monthly Update
Issue Contributors: Kimberly Bebar, DVM, Virginia Sinnott, DVM, DACVECC, Louisa Rahilly, DVM DACVECC
Editor: William B. Henry DVM, DACVS

March 2013

Update on CPR: What we can learn from the 2012 RECOVER Initiative

Cardiopulmonary resuscitation (CPR) was first attempted in the 1740s when mouth-to-mouth breathing was first recommended for drowning victims. It wasn't until 1903 that chest compressions were incorporated with CPR.[1] Human medicine has formed a standardized form of CPR training through the American Heart Association and the International Committee on Resuscitation evaluates and routinely updates recommendations on human CPR. Such standardized training and evaluation of CPR technique did not exist in veterinary medicine until the recent formation of the RECOVER Initiative.

What is the RECOVER Initiative?
The Resassessment Campaign on Veterinary Resuscitation (RECOVER) Initiative is the first veterinary effort to assess both veterinary and human studies on CPR. The goals of this large undertaking was to form a consensus on evidence based recommendations for CPR, pinpoint holes in veterinary CPR research, and eventually form standardized training for veterinary CPR.[2] Over 100 specialists in critical care, anesthesia, and cardiology reviewed all human and veterinary literature to answer specific questions on CPR. All papers were assigned level of evidence score with veterinary randomized, controlled clinical trials being assigned the highest scores. The sum of the evidence would then allow recommendations to be formed.[2] In 2012, a special issue of the Journal of Veterinary Emergency and Critical Care was published and contained the updated CPR guidelines recommended by the RECOVER Initiative. This issue has free public access online.

Introduction to CPR
The survival rate to discharge of pets that undergo in-hospital cardiopulmonary arrest (CPA) is 4-9% compared to humans that have a 10-20% survival rate.[2] Even though the odds for survival are not good, animals that survive can make a full neurologic recovery. In a 2004 retrospective study, 15 dogs and 3 cats that experienced in hospital CPA and survived to discharge were reviewed and 17/18 of these pets had no neurologic deficits upon discharged from the hospital. One dog had minor ataxia at the time of discharge that resolved within 2 months of hospital discharge.[3] Although CPR may not be a common occurrence in most hospitals, it is important to be prepared for cases of in hospital or anesthetic arrest.The overall incidence of CPA under anesthesia is 0.17% in dogs and 0.24% in cats; however, these patients have a higher rate of return of spontaneous circulation (ROSC) and survival to discharge. Survival to discharge rates for animals experiencing CPA under anesthesia have been reported as 46% in dogs and 36.4% in cats.[4]

CPR has classically been described as consisting of basic life support and advanced life support. The RECOVER Initiative developed a CPR algorithm that breaks CPR into steps in order that they should be started.

Continued next page

CT Corner

CCVS CT Scan Hours:
8:00 AM-6:00PM 7 days a week. 1-800-457-4900

The breakdown of CT charges are as follows:

1. CT Scan, In patient $905.00 (case already hospitalized at CCVS or referred to CCVS for work up and treatment and has a CT scan)

2. CT Scan, Additional image (if you add an additional scan site $300.00)

3. CT Scan, Out patient $985.00 **(case sent to CCVS exclusively for a CT; this includes charges for doctor overseeing case, IV catheter, and fluids post CT).

4. CT "Met Check" $590.00

5. CT STAT fee, $50.00 (on top of whatever you are doing).

These charges cover the CT, the contrast, radiologists read, rapid infuser, sevo anesthesia, and technician fee if we need to call someone in for the CT. It does not cover injectable drugs, if needed for IV anesthesia; estimated additional cost $50.00-$75.00.

Continuing Education Opportunities

All our lectures provide 2 hours of Continuing Education Credits. You can register online through our websites, Boston Veterinary Specialists (www.bostonvetspecialists.com) and Cape Cod Veterinary Specialists (www.capecodvetspecialists.com). A meal is provided during each lecture. Your technicians are welcome as well.

CCVS:
Dr. Louisa Rahilly:
May 21, 2013, *"Steroids in veterinary medicine: Friend or Foe."*

Dr. Daniel Beaver:
June 4, 2013, *"Hip Dysplasia"*

Step 1 - Chest compressions

Chest compressions are essential to generate blood flow to vital organs such as the heart and brain. At best, chest compressions achieve 20-30% of normal cardiac output.[4] As such, it is imperative that they are started quickly and correctly to improve the rate of ROSC. Once started, chest compressions are not stopped for anything during CPR. Several factors, including patient conformation, hand position, compression depth, compression rate, and recoil of the chest can impact the cardiac output achieved by chest compression.

Patient positioning

Lateral recumbancy is considered to be the appropriate positioning for CPR. The one exception is Bulldogs, who with a barrel shaped chest, can be compressed in dorsal recumbency much like humans.[4] The patient should be positioned so that the patient's back is against the person doing compressions. This will prevent the patient from falling off the table. The person doing compressions should stand on a stool so they are above the patient. This positioning will help generate enough force to adequately compress the thorax.

Hand positioning

In order to deliver enough force to generate an appropriate cardiac output, the hands should be clasped together with the elbows locked. The motion for chest compressions comes from your back and shoulders. There are two hand positions for chest compressions that can be used. The cardiac pump theory involves positioning the hands directly over the heart and compresses the cardiac ventricles against the ribs. This method is generally used in small breed or keel chested dogs such as Greyhounds.[5] It can be modified to a one handed technique for cats and toy breeds. This method involves placing your thumb directly over the heart with the hand wrapping around the chest and squeezing the hand together to generate compression.

For medium, large, and giant breed dogs, the thoracic pump theory should be used as this method can generate better cardiac output in these large dogs where the chest cannot be easily compressed. In this method, the hands are positioned over the widest part of the chest. As the chest is compressed, the increased intrathoracic pressure collapses the aorta and vena cava, driving blood out of the thorax. As the compression ends and the chest is in recoil position, the pressure gradient causes blood to flow back in the thorax.[5]

Figure 1: Cardiac pump method is pictured on the top with the hands positioned directly over the heart. Thoracic pump method is pictured on the bottom with the hands positioned over the widest part of the chest. Note that the fingers are interlocked appropriately in both pictures.

Compression rate and depth

The rule of thumb with chest compressions is to push hard and push fast. The goal is to compress the thorax from 1/3 to 1/2 normal width. The chest should be allowed to completely return to normal width in between compressions.[5] Studies have shown higher rate of ROSC with chest compression rates of 120 per minute.6 A good rule of thumb is to compress the chest to the beat of the Beegee's Stayin Alive. Given the fast rate and depth of compression, chest compressions are very tiring and within two minutes, studies have demonstrated that the person completing chest compressions can no longer perform adequate compressions.[7] Given this, the compressor should be rotated every two minutes or sooner if they are tired.

Step 2 - Ventilation

Recently, human medicine has been advocating "Hands Only CPR" in which compressions without ventilation are used. In veterinary medicine, ventilation is considered essential as most patients arrest due to respiratory failure rather than cardiac disease. Chest compressions should not be stopped for intubation. Patients should be intubated in lateral recumbancy with the cuff inflated and the endotracheal tube secured as soon as possible. A goal of ten breaths per minute should be delivered.[5] If higher or lower ventilation rates are used, decreased cardiac, cerebral perfusion and increased intracranial pressures are seen. If using an anesthesia machine, the bag should be squeezed to a pressure of 10-15 cm H2O.

Step 3 - Monitoring

Monitoring equipment such as EtCO2 and ECG should be applied to the patient. ECG can be used to guide rhythm diagnosis and drug selection. Chest compressions should not be stopped to evaluate the ECG. ECG should be evaluated in the brief time it takes to change compressors. EtCO2 can be used to verify endotracheal intubation. If properly intubated a consistent, very low level reading should be seen.[5] EtCO2 levels of >15 mmHg in dogs or >20 mmHg in cats can predict impending ROSC.[8]

Step 4 - Vascular access

Vascular access should be attempted only after chest compressions and ventilation are started. Most commonly, peripheral IV catheters are attempted. If attempts are not successful, cut-down catheters to the lateral saphenous or jugular veins can be placed. Another option is an intra-osseous (IO) catheter. All drugs and treatments that can be given IV can be given via an IO catheter. If no access is achieved, certain drugs can be given via the endotracheal tube. These include vasopressin, atropine, lidocaine, epinephrine, and naloxone. The general rule is to double the dose, dilute with sterile saline, pass a red rubber tube down the endotracheal tube, deliver the drug, and flush with 10mL of sterile saline or air.

Step 5 - Pharmacologic intervention
If CPA occurs under anesthesia, the gas anesthesia should be turned off and the induction medications reversed.

Common reversal agents:

Reversal	Drug Reversed	Dose
Naloxone	Pure mu opioids (morphine, fentanyl, methadone, hydromorphone)	0.04 mg/kg 1mL/20 lbs
Atipamezole	α_2 agonists (Dexdomitor, yohimbine)	100 µg/kg 0.2mL/20 lbs
Flumazenil	Benzodiazepines (midazolam, diazepam)	0.01 mg/kg 1mL/20 lbs

Vasopressors
Vasopressors are considered the mainstay of the pharmacologic arm of CPR. Given the poor cardiac output during CPR, vasopressors are used to generate a high systemic vascular resistance and increase blood flow to vital organs. Epinephrine and vasopressin are generally used for their vasoconstriction properties via α1 and V1 receptors respectively. Epinepherine or vasopressin can be used every 3-5 minutes IV as studies have not demonstrated a difference in ROSC between these drugs. The recommendation for dosage of epinephrine has been changed to 0.01mg/kg (0.1mL/20 lbs) as this dose has been associated with better survival to discharge rates.5

Atropine
Atropine is a parasympatholytic agent. It is primarily used in asystole or pulseless electrical alternans associated with increased vagal tone; common conditions with increased vagal tone include vomiting, ileus, GDV, administration of opioids, and pediatric patients.

Common CPR Drug dosages:

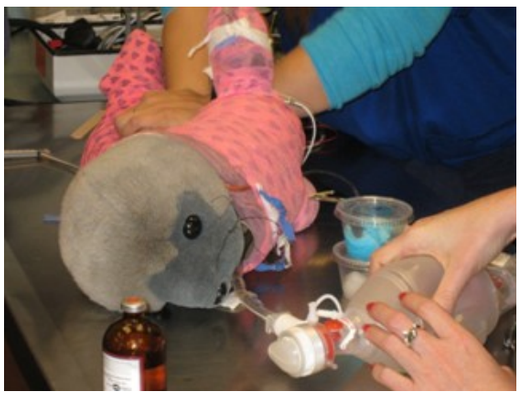
Drug	Activity	Dose
Epinephrine	Vasoconstriction	0.01 mg/kg 0.1 mL/20 lbs
Vasopressin	Vasoconstriction	0.8 U/kg 0.4 mL/20 lbs
Atropine	Parasympatholytic	0.04 mg/kg 0.8 mL/ 20 lbs

Preparedness for CPR
Preparedness for CPR improves performance and ROSC. Part of being prepared involves having a stocked, organized, functional crash cart. In cases where the onset of CPR is delayed, approximately 18% of the time the delay is due to lack of equipment or nonfunctional equipment.9 Given that there is a higher chance of survival for arrests that occur during anesthesia, the crash cart should be placed in an area where anesthesia is performed.9 Crash carts can be easily made in toolboxes or tackleboxes.

Minimal crash cart contents:

- Airway equipment
  - Various sized endotracheal tubes
  - Laryngoscope
  - Endotracheal tube ties
  - Syringes for cuff inflation
- Venous access equipment
  - 18g and 20g IV catheters
  - Injection caps or T-sets for IV catheter
  - Tape to secure IV catheter
  - IO catheters:
    - 18g needles (preferably 1 1/2 inches long)
    - #11 scalpel blades
  - Cut down catheters:
    - #11 scalpel blades
    - 2-0 nylon suture
    - Curved mosquito hemostat
- Drugs
  - Epinephrine
  - Atropine
  - Naloxone
  - 1mL and 3mL syringes (open with 18g needles attached)
  - Predrawn 3mL and 10mL saline flushes
- CPR algorithm
- Drug dosage chart

The other portion of preparedness is practice. Practice will help familiarize staff and doctors to the organization of the crash cart. In addition, teams performing CPR should have a strong leader giving the team directions. Confidence from practice helps develop leadership and a team atmosphere.



CPR practice session on stuffed animal

References:
[1] http://www.heart.org/HEARTORG/CPRAndECC/WhatisCPR/CPRFactsandStats/History-of-CPR_UCM_307549_Article.jsp
[2] Boller M, Fletcher DJ. RECOVER evidence and knowledge gap analysis on veterinary CPR. Part 1: Evidence analysis and consensus process: collaborative path toward small animal CPR guidelines. J Vet EmergCrit Care 2012 22(sup 1): S4-S12.
[3] Waldrop JE, Rozanski EA, Swanke ED, et al. Causes of cardiopulmonary arrest, resuscitation management, and functional outcome in dogs and cats surviving cardiopulmonary arrest. J Vet EmergCrit Care 2004; 14(1): 22-29.
[4] Hopper K, Epstein SE, Fletcher DJ, et al. RECOVER evidence and knowledge gap analysis on veterinary CPR. Part 3: Basic life support. J Vet EmergCrit Care 2012 22(S1): S26-S43.
[5] Fletcher DJ, Boller M, Brainard BM, et al. RECOVER evidence and knowledge gap analysis on veterinary CPR. Part 7: Clinical guidelines. J Vet EmergCrit Care 2012 22(S1): S102-131.
[6] Feneley MP, Maier GW, Kem KB, et al. Influence of compression rate on initial success of resuscitation and 24 hour survival after prolonged manual cardiopulmonary resuscitation in dogs. Circulation 1988 (77): 240-250.
[7] Sugerman NT, Edelson DP, Leary M, et al. Rescuer fatigue during actual in-hospital cardiopulmonary resuscitation with audiovisual feedback: A prospective multicenter study. Resuscitation 2009 80(9): 981-984.
[8] Brainard BM, Boller M, Fletcher DJ, et al. RECOVER evidence and knowledge gap analysis on veterinary CPR. Part 5: Monitoring. J Vet EmergCrit Care 2012 22(S1): S65-S84.
[9] McMichael M, Herring J, Fletcher DJ, et al. RECOVER evidence and knowledge gap analysis on veterinary CPR. Part 2: Preparedness and prevention. J Vet Emer and Crit Care 2012 22(S1): S13-S25.

POST ARREST CARE: A PERFECT SCENARIO TO APPLY "THE RULE OF TWENTY"

Louisa Rahilly, DVM DACVECC

At the conclusion of cardiopulmonary resuscitation (CPR), there is hopefully a thrilling moment when we have achieved return of spontaneous circulation (ROSC). This joyous moment quickly becomes tempered with the panicked thought...."What Now?". While the survival to discharge rate in human medicine for people who survived the initial arrest episode is only 30-40%, this figure is markedly lower in veterinary medicine with survival rates at 2-10%. While the cause of the arrest and the presence of end stage underlying disease need to be considered in the ultimate outcome, these figures suggest that there is much room for improvement in veterinary post arrest management. "The rule of twenty" is a concept introduced by Dr. Rebecca Kirby in the context of sepsis and the Systemic Inflammatory Response Syndrome (SIRS). It is a list of parameters which have been recognized as essential for critically ill patients in general. It is however, a great rule of thumb for any sick patient, but is an excellent outline in the approach to a post arrest patient.

The first step in managing a post arrest case is to determine and address the underlying cause of the arrest. The following guidelines should be applied to the patient and considered in the context of the underlying disease process. One must always remember, however, that these patients are suffering from both their underlying disease and the effects of having died and undergone CPR. This means they had a period of major organ (including brain, heart, gastrointestinal tract and kidney) ischemia and potentially some trauma sustained from the CPR itself (ie. chest compressions causing pulmonary contusions or rib fractures - good chest compressions can do this!). They will also systemically suffer from reperfusion injury resulting in intracellular organelle and membrane damage which will ultimately result in organ dysfunction and potentially failure. The immediate post arrest period is a critical period in which all of these factors must be considered and addressed concurrently.

Below is Dr. Rahilly borrowing a page from Dr. Kirby's book: an application of the rule of twenty to post arrest cases.

1. **FLUID BALANCE**: Careful administration of fluids including isotonic crystalloids, hypertonic saline, synthetic or natural colloids and blood products is essential to post arrest care. Reperfusion injury may result in endothelial damage and vascular leak into the interstitium. Serial patient assessment to monitor interstitial hydration status as well as close attention to fluid losses (urine quantification in a collection system or weighing of bedding, vomiting/ diarrhea, and panting resulting in increased insensible losses) is necessary. The RECOVER initiative concluded that there is no clear consensus based on the evidence on the type or amount of fluids that are need post arrest, but it is clear that most cases need some fluids. The only exception would include cases which are fluid overloaded or in congestive heart failure as part of the reason for the arrest event. The type of fluids administered should be tailored to each case.

2. **ANALGESIA:** Many patients are comatose or severely neurologically depressed following an arrest episode due to a period of cerebral ischemia. One should consider the degree of reaction/awareness to painful stimuli as well as the presence of injury (existing pre arrest or potentially incurred during CPR) and treat accordingly. The RECOVER initiative did not specifically look at analgesic medications used in the post arrest period, but analgesia at this point is similar to that of many critically ill patients. Reversible agents such as pure mu agonists (Fentanyl, Remifentanyl, Hydromorphone, Oxymorphone, Methadone) should be considered so that they can be completely reversed if arrest recurs or the degree of sedation is deemed inappropriate (ie. hypoventilation). One should keep the respiratory depression of opioids in mind and titrate medications to effect so as not to contribute to hypoventilation and hypercapnea. Non-steroidal anti-inflammatory agents which may contribute to gastrointestinal or renal injury should be avoided. Other agents to consider are Ketamine or Lidocaine infusions. Ketamine increases metabolic demand and therefore is not an ideal choice when one considers the need to maximize adequate cellular oxygenation. There is also controversy surrounding Ketamine use in cases with brain injury (and post arrest cases suffered some brain injury in the form of ischemia!). Lidocaine (initially as a bolus of 1-2mg/kg followed by a CRI of 50mcg/kg/min) is a good choice in dogs as it provides analgesia with minimal respiratory or cardiac compromise and can serve as an anti-oxidant.

3. **ONCOTIC PRESSURE:** Adequate Colloid Oncotic Pressure (COP ~17mmHg) is necessary to help maintain intravascular volume and minimize fluid leakage into the interstitium, which can decrease organ function. Oncotic pressure can be augmented through the administration of synthetic colloids, plasma and albumin infusions (canine or human). Careful consideration of protein losses and patient COP relative to colloid administration is necessary as endogenous albumin production is triggered by low COP; over-zealous augmentation of oncotic pressure with synthetic colloids can therefore stifle the production of albumin. Patients with high protein losses (severe peritonitis/ diarrhea) may need 1-2mL/kg/hr of a synthetic colloid while those with minimal to no on-going protein losses but a low total protein due to underlying disease or historic protein losses often only require 0.5-1mL/kg/hr.

4. **ALBUMIN CONCENTRATION:** Albumin contributes the bulk of colloid oncotic pressure (COP), but also has important functions in wound healing, systemic buffering and drug transportation. Hypoalbuminemia has been shown to be a risk factor for mortality in multiple disease states. Endogenous albumin production can be maximized clinically through careful titration of colloids (see above) and providing nutrition. Anorexia causes albumin production to stop within 24 hours and no further production will occur until nutrition is instituted.

5. **BLOOD PRESSURE (CARDIOVASCULAR SYSTEM):** Ensuring adequate tissue perfusion is absolutely necessary for the recovering brain and other major organ systems in the post arrest patient. Analysis of the evidence in the RECOVER initiative found that normal, or perhaps even mild to moderate hypertension (MAP >150mmHg) results in better neurologically intact survival. Vasopressor and/or cardioactive drugs may be required to achieve this outcome. Which drugs and the optimal goal blood pressure are still unknown. It is clear, however that hypotension is unacceptable. Monitoring tissue perfusion through such parameters such as lactate, base excess and central venous oxygenation improve the sensitivity of detecting cellular hypoxia and on-going occult shock.

6. **BODY TEMPERATURE:** The RECOVER initiative found that there is evidence to suggest that post arrest hypothermia initiated as soon as possible in comatose post arrest patients and maintained for >12 hours is beneficial for survival. The recommendation is to cool to approximately 32-34 degree C: 89-93 degree F. Veterinarians should note, however, that these numbers are in human patients and experimental cases and not in clinical small animal patients who are warmer than humans in health. Details of how to achieve the hypothermia and the duration of which are not known. Practically for small animals in a clinical setting, achieving hypothermia is often not a challenge as many cases post arrest are cold. My approach is to not actively rewarm them unless they become <92 degree F. If re-warming is necessary, it should be done slowly (<1 degree C per hour).

7. **VENTILATION, OXYGENATION:** Evidence as presented in the RECOVER initiative demonstrates that profound hyperventilation (to a low CO_2) and hypoventilation (with a high CO_2) result in decreased neurologic recovery. The current recommendations are to aim to achieve mild to moderate hyperventilation (mildly low CO_2) if an animal is mechanically ventilated or normocapnea. Similarly, the precise goal for oxygenation is unclear. What studies have demonstrated, however, is that hyperoxia and hypoxia are detrimental. Hyperoxia may result in exacerbation of reperfusion injury with the generation of more reactive oxygen species. Hypoxia may result in decreased oxygen delivery to the tissues. Careful pulse oximetry and/or arterial blood gas monitoring to evaluate oxygenation is imperative in post arrest cases.

8. **ELECTROLYTES, ACID-BASE BALANCE:** There are currently no guidelines for goal electrolyte levels or acid-base parameters in post arrest patients. As critically ill patients, careful attention to sodium levels as a marker of free water status is a necessity. Potassium, calcium, phosphorus and magnesium should also be monitored as these electrolytes all function in important physiologic activities including smooth muscle contraction and vascular tone, cellular energy production, and skeletal muscle strength necessary for adequate ventilation. Acidosis may occur due to hypoventilation or decreased perfusion in these patients and should be treated accordingly as it can result in cardiovascular depression.

9. **CARDIAC RATE, RHYTHM, FUNCTION:** Myocardial ischemia during the arrest may result in arrhythmias and/or decreased systolic function following ROSC. Continuous ECG monitoring for arrhythmias and treatment as indicated is necessary. Inotropic medications such as Dobutamine infusions may also be necessary if there is depressed cardiac contractility post ischemia.

10. **COAGULATION**: Endothelial and cellular damage through ischemia and reperfusion injury may result in coagulation disorders and disseminated intravascular coagulopathy (DIC) in post arrest patients. Monitoring of platelet levels and coagulation parameters is important to attempt to "catch" DIC in its earlier phases and treat accordingly. Plasma administration in cases which show clotting factor consumption through elevation of clotting times should be considered. Theoretically, clinicians should also consider anticoagulant therapy as the inflammation associated with reperfusion injury may trigger a hypercoagulable state.

11. **RENAL FUNCTION:** Renal function can be monitored directly through quantification of urine output and regular assessment of BUN and creatinine. It is important to monitor these values daily as urine function may decrease in the days following a renal ischemic event, such as cardiopulmonary arrest. Renal function is also indirectly evaluated in the assessment of electrolytes and acid-base status as tubular injury may result in diuresis or metabolic acidosis in the absence of a rising BUN or creatinine.

12. **GASTROINTESTINAL INTEGRITY:** The gastrointestinal tract of the dog is very susceptible to ischemia and is considered to be the source of systemic toxins/inflammatory cytokines and activated white blood cells following an ischemic incident and subsequent reperfusion. Antibiotic coverage to "protect" from bacterial translocation from the gastrointestinal is somewhat of a controversial topic in critical care as the development of resistance is a concern, and the question of prophylactic antibiotic use was not specifically addressed in the RECOVER initiative. Measures to improve intestinal integrity, such as enteric nutrition and ensuring adequate gastrointestinal perfusion through cardiovascular optimization, however, make sense as supportive measures which are unlikely to cause harm.

13. **NUTRITION:** Although nutritional status of the post arrest patient was not specifically addressed in the RECOVER initiative, adequate nutrition in critically ill patients is known to maximize immune function and is necessary for endogenous albumin production. Enteric feeding is the optimal route of nutrient administration as it helps to maintain intestinal motility, function and integrity. Calculation of the patients' resting energy requirements (RER) with the goal of feeding 50-100% of RER is recommended, as over-feeding can result in increased CO2 production in an animal with potentially compromised ventilatory reserves to maintain normocapnea. Over-feeding in a neurologically or respiratory compromised animal may result in a respiratory acidosis.

14. **GLUCOSE:** Blood glucose levels should be monitored frequently to ensure normoglycemia as hypoglycemia can be detrimental to neurologic function and recovery and hyperglycemia has been shown to be detrimental to patient outcomes. Dextrose supplementation and conversely short-acting insulin should be utilized as needed to maintain normal blood glucose.

15. **ANTIBIOTICS/WBC COUNT:** Complete blood counts should be performed every 2-3 days during the critical period (more often if indicated) and peripheral blood smears should be evaluated daily for a manual white blood cell count and evidence of toxic change and/or left shifting. Judicious antibiotic use as indicated for the underlying disease state or developing nosocomial infections is prudent.

16. **RED BLOOD CELLS:** A packed cell volume should be monitored at least twice a day to watch for anemia and as an indicator (along with total solids) of hydration status. Clinicians should have a quick trigger for red blood cell transfusions in post arrest cases as ensuring adequate oxygen delivery is a top priority.

17. **DRUG DOSAGE, METABOLISM, INTERACTIONS:** As with all critically ill patients, one must consider the entire physiologic picture of post arrest cases. Drug dosages or frequency may need to be adjusted based on liver or renal dysfunction and associated increased half-life of hepatically metabolized and/or renally excreted medications. The albumin level should also be considered for drugs which are highly protein bound.

18. **MENTATION:** Many post arrest cases will have decreased mentation and potentially even be in a coma. The clinician must monitor these cases closely to ensure adequate ventilation and gag reflex and consider mechanical ventilation or intubation with close monitoring if either of these parameters are sub-optimal. The RECOVER initiative evaluated the prophylactic use of anti-seizure medications post arrest as seizures are known to be relatively common in humans following ROSC. There is currently no evidence indicating a benefit to seizure prophylaxis post arrest. However, there are some bundled therapy studies that evaluated seizure prophylactic medications (Thiopental and Phenytoin) which used these medications among other interventions and found potential benefit. It is not clear, however, if it was the seizure prophylaxis specifically, another component of the bundle or the entire package which allowed for the benefit. Cerebral function and signs of elevated intracranial pressure should be monitored closely. Signs of elevated intracranial pressure include pupillary changes (miosis followed by anisocoria and mydriasis with progressive intracranial pressure elevations), limb and/or jaw rigidity, decreasing mentation and hypertension with concurrent bradycardia. Suspected elevations in intracranial pressure should be treated with hypertonic saline (3-4mL/kg) if the patient is hemodynamically unstable or mannitol (1g/kg) and/or hypertonic saline if the patient is stable. Brain protective measures such as keeping the head elevated 15-30° and making sure there are no bends of the neck should be taken to ensure adequate cerebral venous drainage in order to minimize intracranial pressure.

19. **NURSING ORDERS:** Detailed nursing orders ensuring constant attention to mental and hemodynamic status are essential. For comatose patients, measures including applying eye lubrication and anti-bacterial oral rinses to avoid ulcers and bacterial colonization should be taken. Regular turning of the patient allows for improved pulmonary function and passive range of motion exercises keeps interstitial fluid moving and lymphatics flowing.

20. **TENDER LOVING CARE:** The most important, but hard to directly institute on our treatment sheets, aspect of critical care is tender loving care. Clean bedding and ensuring that the patient is comfortable, free from anxiety, and clean and dry at all times decreases the risk of nosocomial infection and will ultimately contribute to patient well-being and hopefully survival.
As is evidence by the extensive list of parameters to concurrently monitor and consider in post arrest patients, these cases are intensive. There are no studies in veterinary medicine evaluating the survival effect of these patients being treated by a criticalist specifically, but at this point the recommendation is to hospitalize these patients at a 24 hour facility with the ability to closely monitor and treat critically ill patients on a minute-by-minute basis.

REFERENCES:

Smarick SD, Haskins SC et al. RECOVER evidence and knowledge gap analysis on veterinary CPR. Part 6: post-cardiac arrest care. J Vet Emerg Crit Care 2012; 22(S1): S85-S101.

Kirby, R. "Golden Rule of Emergency Medicine - and More!" Conference proceedings: International Veterinary Emergency and Critical Care Symposium 2009.