# Harold Davis, BA, RVT, VTS

1.1.1. CPR an Update

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## INTRODUCTION

Cardiopulmonary arrest (CPA) can be considered the ultimate emergency. CPA is defined as the sudden cessation of functional ventilation and effective circulation. The veterinary clinic health care team may be involved with the management of a CPA. It is the responsibility of the staff to be prepared to respond to such an emergency. In 2012 RECOVER (Reassessment Campaign on Veterinary Resuscitation) guidelines were established for the management of cardiopulmonary resuscitation. This discussion will review the principles of CPR along with the recommendations from the RECOVER guidelines.

## Preparation

Preparation is key to the management of a cardiac arrest. Clinic staff must be trained in the principles of CPR. Initial training can take place online. For more information go to https://recoverinitiative.org/first-responders-other-pet-professionals/cpr-bls-als/

The ideal number of participants in a resuscitation attempt is three to five. Practice drills should be held at least monthly. A stuffed animal can be used as the patient during these drills. Each person should understand what his or her responsibilities would be during an arrest. After each practice session or actual resuscitation, a team self-evaluation should be performed.

Where will the resuscitation attempt take place? Some people prefer to perform CPR wherever the patient is located and bring the resuscitation equipment and supplies to the patient. Others prefer to designate an area in the clinic. When selecting an area take into consideration the space available; is there enough room for a CPR team (3 plus people) and equipment? An oxygen source should be readily available. Good lighting is a must. If CPR is to be performed on a table, then the height of the table should be adjustable. If the height of the table is not adjustable then a footstool should be made available, or CPR should be performed on the floor

Crash carts/kits help to make the resuscitation endeavor more efficient by having all the supplies readily available. If a cart is used then in addition to the endotracheal tubes, drugs, catheters, syringes etc. equipment may be stored on the cart such as suction machine, ECG, and defibrillator. The crash cart or kit should be checked at the beginning of each shift and restocked immediately after each use.

CPR PROTOCOL

The RECOVER guidelines include an algorithm (flowchart) to guide the CPR endeavor as well as a drug dosage chart. Both can be obtained from the Veterinary Emergency and Critical Care Society (www.VECCS.org).

RECOGNITION OF CPA

The existence of cardiac arrest must be recognized early if we are to effectively resuscitate the patient. The ABCs should be rapidly checked in the apneic unresponsive patient. The absence of a palpable pulse, audible heart sound, or effective ventilation (agonal breaths should not be considered effective breaths) all supports the assessment of cardiopulmonary arrest. Even under the best of circumstances it may be difficult to palpate a pulse therefore, not much time should be spent trying to assess pulses. If there is any question that CPA has taken place the patient should be treated as such until proven otherwise.

BASIC LIFE SUPPORT (BLS)

Circulation

Once it has been recognized that a CPA has taken place chest compression can be instituted without waiting to intubate the patient, in other words intubation and chest compression can be carried out simultaneously. Chest compressions are performed with the patient in lateral recumbency, alternatively if the patient has a barrel chest confirmation it may be placed in dorsal recumbency and the sternum is compressed. With the arms extended and locked, the hands are placed one on top of the other and the fingers interlaced, then the hands are placed over the appropriate area on the chest. The shoulders are squarely over the patient's chest and the compressive force is applied by bending at the waist. The person delivering the chest compressions should not compress the chest by bending the elbows; it will be difficult to generate an appropriate force to affect perfusion. To take advantage of the cardiac pump mechanism in deep or keel chested dogs we should apply pressure laterally, directly over the heart and compress the chest 1/3 – ½ its width, at a rate of 100 to 120 compressions per minute. In the case of medium to giant patients the hands are placed over the widest portion of the chest and compressions are performed; this will take advantage of the thoracic pump mechanism. Alternately in cats and small dogs, a one-handed circumferential chest compression with the hand wrapped around the sternum directly over the heart or the thumb and first two index fingers can be used to compress the chest (taking advantage of the cardiac pump mechanism). Allow the chest to recoil completely between compressions, approximately equal compression and relaxation modes. It is not necessary to try and synchronize breaths between compressions. The person delegated to compress the chest should change every 2 minutes to prevent fatigue; this is considered one BLS cycle. Minimize interruptions to chest compressions; make interruptions no longer than 10 seconds

Airway / Breathing

Following confirmation of a patent airway, an endotracheal tube is inserted. If there is absence of effective ventilation, then positive pressure ventilation should be begun with 100% oxygen. The ventilatory rate is one breath every six seconds (10 breaths / min) with a tidal volume of 10 ml/kg and an inspiratory time of 1 second. Hyperventilation should be avoided. Higher respiratory rates, longer inspiratory times and higher tidal volumes lead to impaired venous return due to increased intrathoracic pressure as well as decreased cerebral and coronary perfusion due to vasoconstriction, all of which has led to poor outcomes in people.

Assessing Effectiveness

The effectiveness of the team's efforts must be monitored frequently. Improvement in mucous membrane color and the presence of a palpable pulse during CPR has been used for assessing effectiveness. However, even in the best of circumstances palpation of a pulse can be difficult. The placement of a Doppler flat probe on the cornea has been used as a tool to assess effectiveness but it should be used with caution. There is potential for motion artifact or retrograde venous blood flow and not arterial flow. If a direct arterial line is in place, arterial pressure waveforms and pressures can be used to assess effectiveness of therapy. In essence you will have a compression-to-compression assessment of your technique. The goal is to achieve a diastolic pressure of 40 mm Hg or greater. There is strong evidence supporting the use of end-tidal CO2 (ETCO2) to non-invasively assess resuscitation efforts. Studies have shown that ETCO2 varies directly with cardiac output during cardiac arrest. Dramatic decreases in ETCO2 occur during cardiac arrest; with effective CPR increase in ETCO2 is seen. Data suggest that ETCO2 values of >15 mmHg in the dog and >20 mmHg in cats may be associated with a higher rate of return of spontaneous circulation.

Internal Cardiac Massage

If external chest compression is not effective, then the doctor may elect to perform internal cardiac massage. Internal cardiac massage is associated with better cardiac outputs, cerebral and coronary perfusion. If external cardiac compressions are not effective (generation of a palpable pulse, improved mucous membrane color, detection of blood flow with Doppler or increase in ETCO2) within 5 minutes or if the heart has not started beating spontaneously in 10 minutes, then internal cardiac massage should be initiated. In some cases, it might be indicated to go with internal massage from the outset.

ADVANCED LIFE SUPPORT

Categories of Cardiac Arrest

The type of cardiac arrest dictates which therapy will be utilized in CPA. There are three primary categories of cardiac rhythms seen during a CPA event: perfusing, non-shockable (asystole and pulseless electrical activity [PEA] and shockable (ventricular fibrillation [VF] and pulseless ventricular tachycardia [PVT]).

Asystole (Figure1) is characterized by no electrical or mechanical activity. On the ECG, a flatline represents no electrical activity. There will also be no detectable pulse or heartbeat. Epinephrine (Adrenaline) / vasopressin and atropine are the primary drugs used to treat this rhythm.

Pulseless rhythms (Figure2) may be near normal in appearance or wide and bizarre QRS complexes. There will also be no detectable pulse or heartbeat. RECOVER guidelines state that if the QRS is repeatable and the heart rate is less than 200 and there are no pulses then consider the rhythm to be PEA. Epinephrine or vasopressin is indicated, and fluid bolus and atropine should be considered.

Ventricular fibrillation (Figure 3) is characterized by chaotic electrical activity and no coordinated mechanical activity. The ECG display will show no definable pattern, marked irregularity in rhythm, P waves and QRS complexes are unidentifiable. There will also be no detectable pulse or heartbeat. Defibrillation is the treatment of choice.

RECOVER guidelines characterize pulseless ventricular tachycardia (Figure 4) as a repeatable QRS complexes with a rate greater than 200 beats per minute and absent pulses. This is considered a shockable rhythm.

Table 1 Therapies used during CPR. All drugs are given IV.

Therapy Action Indication Comment

Epinephrine (Adrenaline) Arterial vasoconstrictor; increases diastolic pressure resulting in augmented coronary and cerebral blood flow Asystole

PEA

Prolonged VF/VT Dose every other 2 min BLS cycle

Vasopressin Direct smooth muscle vasoconstrictor Asystole

PEA

Prolonged VF/VT Alternative to epinephrine

Atropine Parasympatholytic CPA associated with intense vagal stimulation

Crystalloid Fluids Increase perfusion hypovolemia If known to have prearrest hypovolemia

Reversal Agents Naloxone → opioid

Flumazenil → benzodiazepines

Atipamezole → Alpha - 2- agonist Administered if drugs given in peri-CPA period.

Sodium Bicarbonate Increases pH to correct metabolic acidosis CPA > 10 – 15 minutes

Defibrillation

Defibrillation is the treatment of choice for ventricular fibrillation (VF) and pulseless ventricular tachycardia (PVT). If the patient has VF or PVT and the duration is less than 4 minutes or if VF is diagnosed during a rhythm check between BLS cycle the heart is defibrillated immediately. However, if the duration of VF or PVT has been suspected to be greater than 4 minutes then a 2-minute cycle of BLS must be performed prior to defibrillation.

The precordial thump is a method of mechanical defibrillation where the patient is struck with the heal of the hand directly over the heart in the hopes of converting the patient. While there is minimal efficacy for this technique it should be considered only if a defibrillator is not available.

## 1.1.2. FLUID THERAPY AN OVERVIEW

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Fluid therapy can be a major component to the management of the emergent or critically ill patient.

### Determining Fluid Requirements

A patient history along with a complete physical examination is the foundation for the development of a fluid therapy plan. It is important to determine the degree of dehydration and the perfusion status of the patient prior to beginning fluid therapy. There are several clinical and laboratory methods which may be used to determine the hydration status of the patient.

### History

The owner should be asked questions about food and water intake. Is the animal eating? If not, when did it last eat? Is the animal drinking water, if so, increased, or decreased amounts? Is the animal suffering any abnormal losses such as vomiting, diarrhea, or polyuria? What is the duration of theses abnormal losses?

### Physical Findings

Skin turgor or skin elasticity is a crude way of determining the interstitial compartment volume (hydration) status. When assessing skin turgor its best to use the same location for consistency in technique. The lateral thorax or between the shoulder blades are good locations to assess skin turgor. With 5% dehydration the skin, when lifted, will return to its normal position quickly but slightly slower than normal. With 8% dehydration the skin returns to its normal position slower than 5% dehydration but faster than 10% dehydration. When the patient is 10% dehydrated the skin will remain tented and not return to its normal position. Elasticity of the skin is affected by cachexia and obesity. It is possible to have a normally hydrated patient that has reduced skin elasticity due to cachexia; or a dehydrated patient that has normal skin elasticity because of being fat. Other signs consistent with dehydration include dry skin and mucus membranes, oliguria, and signs of compensatory peripheral vasoconstriction. Perfusion is assessed by evaluating 6 parameters known as the perfusion parameters. They include mentation, mucous membrane color, capillary refill time, heart rate, pulse quality, and extremity temperature. In poor perfusion states it is not uncommon to see decreased mention, pale mm color, prolonged capillary refill, increased heart rate (in the dog), cool extremities, and poor pulse quality.

Laboratory Analysis:

Packed cell volume (PCV) and total protein (TP) are simple tests that can be used to evaluate hydration. PCV and TP are often elevated with dehydration. In an animal with both anemia and dehydration, the PCV may appear to be normal, but this is due only to hemoconcentration. A urine specific gravity greater than 1.030 usually indicates that the kidneys are responding to the dehydration in an appropriate manner. Electrolyte and acid base status can be a valuable addition to evaluation of the emergency patient. Depending on the disease process, it is not uncommon to find electrolyte abnormalities with sodium and / or potassium. Lactate levels > 2 mmol/L suggest poor perfusion and inadequate tissue oxygenation. Monitoring lactate can help identify patients that may benefit from fluid therapy as well as a monitoring tool to determine if fluid therapy provided was adequate.

Dehydration vs Hypovolemia

It is important to recognize the difference between dehydration and hypovolemia. Dehydration is a decrease in interstitial fluid volume as evidenced by dry mucous membranes, and decreased skin elasticity. Hypovolemia is a decrease in circulating blood volume and evidenced by poor perfusion parameters. Severe dehydration can lead to hypovolemia; however, a hypovolemic patient does not have to be dehydrated (e.g., a previously healthy dog that has suffered trauma). The fluid deficit occurring with dehydration is corrected over hours (commonly 6 – 12 hours) while hypovolemia should be corrected in less than one hour.

| Fluid Type | Total Shock Dose* | |
|---|---|---|
| | Dogs (mL/kg) | Cats (mL/kg) |
| Isotonic crystalloids | 80 – 90 | 50 – 55 |
| 7.5% Hypertonic saline | 4 – 6 | 3 – 4 |
| Synthetic colloids* | 10 – 20 | 5 – 10 |
| 7.5% Hypertonic saline & synthetic colloid | 1.5 – 3 & 3 - 6 | 1.5 & 3 |

Poor Perfusion/Hypovolemic Patient

Table 1 Fluid doses for various types of fluids and combination. *Note Vetstarch and Voluven may be dosed up to 40 mL/kg

If the initial patient assessment revels that the patient is poorly perfused or hypovolemic then a fluid plan will need to be instituted to address the deficits. The approach to fluid therapy in the hypovolemic patient is approached differently than the simple dehydrated patient. A commonly cited fluid dosage goal of isotonic crystalloids for hypovolemia is 80 - 90 mL/kg/hr for the dog and 50 - 55 mL/kg/hr for the cat (equivalent to one blood volume). Individual animal requirements are variable it may be necessary to administer more or less of this volume to effectively resuscitate the patient. To administer the fluids, a commonly used approach is to administer ¼ dose increments rapidly and then reassess the perfusion parameters looking for improvement or resolution in the signs of poor perfusion. For example, a dog or cat would be given approximately 20 and 10 mL/kg incremental doses of fluids respectively. It is necessary to reassess the patient's condition frequently (i.e., about every 10 - 15 minutes) during large or rapid volume fluid administration. Resuscitation is not limited to crystalloid fluids. Hypertonic saline, synthetic colloids and blood products may be indicated.

Simple Dehydrated Patient

The basic components of a fluid therapy plan (for the simple dehydrated patient) include the determination, calculation, and replacement of the volume deficit (percent dehydration); abnormal on-going losses; and maintenance needs.

To determine the volume deficit replacement, multiply the percent dehydration by the patient's body weight (kg), this will equal the volume of fluids in liters estimated to correct dehydration. Losses through vomiting, diarrhea, excessive urination, burns and transudation into body cavities are abnormal ongoing losses. This volume of these losses should be estimated and calculated into the fluid therapy plan. Typically, abnormal losses should be replaced mL for mL. Normal losses occur through breathing, salivation, urination, and defecation and these are accounted for with the maintenance fluid rate. A rough rule of thumb for the maintenance fluid rate is to give 50 75 mL/kg per day or 2 – 3 mL/kg/hr. Once the volume deficit replacement needs, abnormal ongoing losses and maintenance needs are calculated, the three are totaled. The fluid infusion rate may be determined by totaling up the volume of fluids to be given and dividing that by the total number of hours over which the patient is to be rehydrated. If there aren't enough hours available to safely administer the fluids the patient may be sent to an emergency clinic for continued care or give some of the required fluids subcutaneously. Generally, we like to correct the fluid deficit (volume needed to correct dehydration) over four to eight hours.

Potassium chloride might be added to fluids when serum potassium levels are known to be low (hypokalemia). If potassium levels are not known, hypokalemia may be expected in cases of fluid loss due to gastrointestinal loss, diuresis, and anorexia. Based on the magnitude of these losses the body potassium depletion is thought to be mild, moderate, or severe, the fluids should be supplemented with potassium to 20, 30, or 40 mEq/L respectively. Fluids are not routinely supplemented with potassium if given at faster rates for hypovolemia or rehydration. Potassium should not be administered at a rate faster than 0.5 mmol/kg/hr.

Because the calculation of fluid volume is based on subjective data, potential inaccuracies occur. Therefore, it is necessary to reassess (physical exams [including perfusion parameters], body weight, ins and outs, and pertinent lab test) the patient often. Your patient may require more or less of the original calculated fluid volume; being careful not to cause fluid overload. You are looking for a resolution in the signs that indicated that the patient needed fluids.

## 1.1.3. INITIAL ASSESSMENT OF THE EMERGENCY ROOM PATIENT

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### INITIAL OBSERVATION

An initial 'eye-ball' of the patient provides important information, before any hands-on contact is made. In this time two major issues are addressed. First, how serious does the situation look? Obviously, the animal that can maintain sternal recumbency and is aware of its surroundings is far less concerning than the animal in lateral recumbency with no apparent response to external stimuli.

Second, are there any obvious life-threatening problems that will require attention at or before the time you can evaluate the A-B-Cs? Problems such as arterial hemorrhage or an open chest wound may warrant immediate intervention.

The following patient assessment is then performed within 1-2 minutes. Flow by oxygen should be provided until the assessment is complete and the requirement for ongoing oxygen therapy has been adequately evaluated.

PATIENT HISTORY

The animal's signalment (age, sex, and breed) can provide direction for the diagnostic workup. For example, pediatric or juvenile patients are more likely to contract infectious conditions. Respiratory distress due to heart failure is noted more frequently in male than female cats. Feline asthma is noted more frequently in Siamese cats compared with other breeds. Signalment provides clues to the underlying disorder but never provides a definitive diagnosis.

Does the patient have any pre-existing medical conditions or on medications? Historically, the owner may be able to provide information that supports a reason for hypovolemia such as trauma, excessive urination, diarrhea, or vomiting. What is the travel history of the pet? Pet's environment gives the veterinarian a sense of potential exposure to toxins or infectious diseases.

PHYSICAL ASSESSMENT

A = Airway:

All emergent and critically ill animals should have the patency of their airway evaluated. This involves assessment of the gag reflex and ensuring no airway obstruction is evident. For many patients this is a cursory examination as they show obvious swallowing and resistance to opening of their mouth and there is an absence of signs of obstruction. Recumbent animals that have reduced jaw tone should be closely evaluated for the presence of a gag reflex.

B = Breathing:

Following evaluation of the airway it is necessary to confirm that the animal is making breathing efforts. Is the effort normal, decreased or increased? Are breath sounds normal, diminished, or increased? Can the breath sounds be characterized (crackles, wheezes)? By observing the patient breathing and listening to breath sounds one may be able to localize the breathing difficulty to the pulmonary parenchyma, pleural space or thoracic wall.

C = Circulation:

Assessment

There are 6 physical examination parameters that allow a rapid evaluation of the circulatory status. Keep in mind that circulatory shock is a clinical diagnosis.

1. Mentation
2. Mucous membrane colour
3. Capillary refill time
4. Heart rate
5. Pulse quality
6. Extremity temperature

These clinical findings should be evaluated in combination; an abnormality in a single parameter does not have the clinical significance of multiple abnormalities.

Common clinical findings of circulatory shock:

- Reduced mentation
- Pale or white mucous membranes
- Slow capillary refill time
- Tachycardia
- Reduced pulse quality
- Cool extremities in comparison with core body temperature

Patients with vasodilatory shock can have red mucous membranes, rapid CRT, bounding pulses and warm extremities. As these animals are likely to present with concurrent hypovolemia these signs of vasodilation may not be evident until after adequate fluid resuscitation.

Tachycardia is the appropriate and expected response to circulatory shock. The presence of normocardia or bradycardia in canine shock patients (ie. Patients with abnormalities of the other 5 parameters) is of concern as it suggests decompensated shock and is associated with greater severity of illness and a poorer prognosis. Feline shock patients will often present without a tachycardia and this is not considered to have prognostic relevance as it does in dogs.

D = Dysfunction (neurologic):

Assessment:

1. Mentation
2. Pupils
3. Posture

Descending from a higher level of consciousness to a lower level, suggest worsening neurologic involvement. ocular trauma. Pupils that are poor to non-responsive with unilateral or bilateral mydriasis, bilateral miosis, or pupils that are miotic and become mydriatic suggest neurologic involvement. Three types of abnormal postures are: Schiff-Sherrington, decerebellate and decerebrate rigidity; these postures suggest spinal cord, cerebellar, or brain stem injury respectively.

E = Exposure & Environmental Control:

In human medicine exposure is an essential aspect of patient evaluation as clothing can hide serious injuries or abnormalities. Once an animal is considered safe for movement the removal of blankets, turning the patient etc is important for the same reasons. Environmental control in the veterinary context is the removal of any source of ongoing harm. For example, washing off caustic liquids or inducing emesis of a recently ingested toxin.

Body Temperature:

Body temperature is not addressed in the standard ABCs and may not be required for the assessment of every patient. But extremes of body temperature are an indication for urgent medical attention and as a result the temperature of at-risk patients should be measured during assessment. Any recumbent, poorly responsive patient should have their temperature measured, especially in small patients who are extremely prone to hypothermia. Animals that are rapidly panting or have obvious signs of exertion such as tremors or seizures should also have their temperature evaluated.

Summary

Following initial stabilization and management a definitive care plan is developed for further diagnostics, therapy, monitoring, and supportive / nursing care.

## 1.1.4. Gaining and Maintaining Venous Access

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Gaining venous access is an important life saving measure in the management of the emergent or critically ill patient. Once venous access has been obtained it may be used to administer fluids and/or medications; provide nutritional support facilitate cardiovascular monitoring; or collect blood samples.

### Catheter Insertion Site

Peripheral insertion sites include the cephalic, lateral, and medial saphenous, and the auricular vein.

Central vein insertion sites include the jugular, lateral and medial saphenous veins. To achieve central vein catheterization via the saphenous vein, long catheters must be used; they are threaded so that they lie in the caudal vena cava.

### Vein Selection

Selection of a vein depends on several factors such as the skill of the person placing the catheter, available veins, therapeutic goals, and the animal's problem or disease. Any vessel that is visible should be considered a candidate for percutaneous catheterization.

Catheter Insertion Methods

Percutaneous

This percutaneous insertion technique is simple. With this technique, the needle (butterfly or the through-the-needle catheter or the over-the-needle catheter is inserted through the skin, subcutaneous tissues, and ultimately into the vein. A potential problem with this technique is the possibility of the catheter tip flaring or tearing because of the drag on the catheter as it goes through the skin.

Seldinger (Guide wire Technique)

The Seldinger or guide wire technique is used most to place multi-lumen central catheters or long single lumen catheters. A long flexible guidewire is inserted into the vein and ultimately a catheter is threaded over the guidewire and into the vessel. This is described in more detail under multi-lumen catheter.

Central Venous Access via a Peripheral Vein

At times it is desirable to place a peripheral catheter for the purpose of serial blood sample collections. Short peripheral catheters often do not aspirate well and so a long catheter, advanced to a large central vein is used. Long catheters are through-the-needle, and such needles are commonly too large for small patients. In this situation, a common approach is to first place a short over-the-needle catheter into the medial or lateral saphenous vein. A long through-the-needle catheter (the needle has been removed) is advanced into the pre-placed short catheter. The two catheter hubs are joined tightly together, and the catheter is secured to the patient.

Jugular Catheterization

There are times when using a central line is preferred to a peripheral vein. Most veterinary patients better tolerate the jugular catheter. It allows for uninterrupted flow of the IV infusion. Jugular catheters also facilitate the collection of blood samples and make possible the administration of hyperosmotic fluids and CVP measurements. Single or multi-lumen catheters may be placed.

## Procedure

A wide area of hair over the catheterization site should be clipped. The insertion site is surgically prepped, and aseptic techniques is employed (gloving and draping).

Patient positioning is key to a successful outcome. Placement of the jugular catheter is best done with the patient in lateral recumbency. It is important that the patient be positioned properly, and the vein immobilized. If the vein is not immobilized properly, it may roll laterally or wrinkle longitudinally.

## Through-the-Needle Catheter Insertion

The catheter needle should be introduced subcutaneously. The needle tip is positioned over the vein and aligned as close as possible to the longitudinal axis of the vein. Insert the needle tip into the vein; it may require that you apply a little angle to the needle to pick up the vein wall. Once it is estimated that the entire needle tip is within the lumen of the vein, the catheter is threaded into the vein. Once the catheter is threaded apply pressure over the catheter puncture site and back the needle out. A needle guard is placed, the catheter is aspirated and flushed confirming the placement. The catheter is secured and a lite bandaged is placed.

## Multi-Lumen Catheter

Multi-lumen catheters are available in both the over-the-needle and through-the-needle style. Multi-lumen catheters have two to three separate lumens in one catheter. Multi-lumen catheters allow simultaneous infusions at one catheter site. Though one catheter is placed, the multi-lumen catheter provides the same functions as two to three separately introduced single-lumen catheters. The catheter site is prepared as previously described. Catheter placement is usually completed percutaneously with a guide wire technique. Once inserted the catheter is sutured in place and an occlusive bandage is applied.

## Catheter Maintenance

Catheter maintenance entails catheter site inspection (looking for signs of phlebitis, thrombosis, infection) and / or fluid infiltration), assessing patency, cleansing of the site and re-bandaging. Peripheral venous catheters should only be replaced when clinically indicated and routine replacement every 72 to 96 hours is not necessary. If routine catheter care is performed, and the catheter removed when problems are first noticed, one can often exceed the 72- 96-hour rule. A study looking at peripheral and jugular venous catheter contamination in dogs and cats supports this.

Human literature suggests that normal saline (without heparin) may be as effective as heparinized saline in the maintenance of catheter patency. , . Heparinized flushes may be warranted in peripheral catheters placed with the intention of performing serial blood draws.

## Complications

Catheter related complications include phlebitis, infection, thrombosis, extravasation of fluids, and catheter emboli.

## Vascular Access Options in Difficult Placements

At time vascular access can be difficult for several reasons. It may be due to peripheral edema, tough skin, non-visible, palpable, or “flat” veins which may be secondary to hypovolemia. There are options to consider which may facilitate vascular access.

### Tough Skin - Facilitative Incision or Relief Hole

A facilitative incision or relief hole reduces the skin tension and friction against the catheter. It is indicated in severely dehydrated patients or patients with tough skin. A facilitative incision may be made with a number eleven blade or a 20-gauge needle. A 0.5 – 1 millimeter incision is made directly over the vessel extending through the dermis. Care should be taken to avoid the vessel when making the relief incision. Local anesthetic blocks are rarely needed.

### Inability to “Raise a Vein” - Application of a Warm Towel

Application of lukewarm towel around the limb for two – three minutes may make the vessel prominent. While the towel is in place the vessel is held off or a tourniquet is applied, and the paw is repeatedly squeezed. Placement of the warm towel should increase local blood flow resulting in venous distension making the vein prominent.

Inability to See or Feel a Vein – Ultrasound Guided Insertion

Ultrasound guided catheter insertion has been utilized in human medicine. Given the fact that ultrasound units are more prevalent in veterinary practice, ultrasound guidance for difficult catheter placement is becoming more common. There have been a few papers written about the use of Ultrasound Guided catheter insertions; one paper concluded that the ultrasound guided technique was feasible and comparable to the landmark-based technique for placement of central venous catheters in dogs.

Venous Cutdown

A full cutdown is indicated when the patent is severely hypovolemic and hypotensive or if the patient is obese or has subcutaneous edema. This procedure should be done under full aseptic conditions. The risks of cutdown, procedures include bleeding and infection.

Intraosseous (IO) Catheter Placement

In the event vascular access cannot be obtained the establishment of an intraosseous (IO) line is a reasonable alternative. Fluid or drugs administered by this route are rapidly taken up into the circulatory system.

Access Sites

The most common sites for access include the trochanteric fossa of the femur, the greater tubercle of the humerus, the anterior aspect of the proximal humerus and tibial crest.

Insertion

The necessary supplies are obtained (IO catheter / needle, lidocaine, scalpel blade, and syringe). Clip and aseptically prepare the insertion site. Inject lidocaine into the skin and periosteum. A stab incision may be made with the scalpel blade over the site of penetration. The bone marrow needle is placed on the site of penetration; pressure is applied to the needle while making firm 30◦ rotations. Apply steady pressure as the rotation maneuver is made and the needle passes through the cortex.

As an alternative, the EZ IO drill and specially made bone marrow needles (EZ IO, Mila International, Erlanger KY) can be used. The EZ IO drill is a battery powered drill made for the rapid insertion of bone marrow needles. Once the needle is firmly seated placement is confirmed. Once the placement of the needle is confirmed, attach the IV set, and begin the fluid infusion. Fluids may be administered with gravity flow or under pressure.

In human's osteomyelitis is the complication of greatest concern. The complication rate reported in one paper was approximately 0.6% in 4000 cases. Osteomyelitis is possible related to the use of hypertonic solutions, faulty technique or prolonged infusion.

## 1.1.5. OXYGEN THERAPY – CHASING THE BLUES AWAY

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### OVERVIEW

Hypoxemia is defined as inadequate oxygenation of arterial blood (PaO2 < 80 mm Hg or SPO2 <~ 95%). Hypoxemia is a result of either low fractional inspired oxygen (FIO2), hypoventilation, or venous admixture (ventilation/ perfusion mismatch (most types of lung disease), right to left anatomic shunts, and diffusion defects). Oxygen therapy may be beneficial to those patients with impaired gas exchange. The goal of oxygen therapy is to provide adequate oxygen to the tissues, using the lowest possible inspired oxygen concentrations. In the absences of arterial blood gases or pulse oximetry one will need to rely on clinical signs. Clinical signs of hypoxemia include cyanosis, increased respiratory rate and effort, tachycardia, orthopnea, use of accessory respiratory muscles, and anxiety. Individually, the clinical signs do not prove hypoxemia, but together they are suggestive of hypoxemia and indicate the need for more definitive testing.

## METHODS OF OXYGEN ADMINISTRATION

There are a variety of methods of oxygen delivery. The method selected depends on the expected duration of therapy, patient size, demeanor, and equipment availability. Available methods include flow-by, face mask, oxygen bag (hood), oxygen collar / tent, oxygen cage, transtracheal, nasal insufflation and high flow nasal canula.

### Face Mask

Masks are readily available and easy to use. Masks are only good for short-term use. High-inspired oxygen concentrations can be obtained if a properly fitted facemask is used. Unfortunately, patients often fight the face mask (unless obtunded) thereby increasing oxygen consumption and canceling the effects of the oxygen therapy. The patients face and nose should fill the mask as much as possible to reduce the amount of dead space in the mask. Increased dead space will increase the work of breathing. Sometimes it is helpful to remove the rubber dam from the face mask to achieve a better fit.

### Oxygen bag (hood)

An alternative to the face mask is the oxygen bag. A clear plastic bag is placed over the head of a patient and a hose from an oxygen source is placed near the animal's nose. The bag remains open along the animal's neck to allow the gas to escape. A flow rate of five to eight liters per minute is used. It has been reported that animals tolerate this bag/hood method when they resist the oxygen mask . Care should be taken to ensure that the bag does not collapse around the nose and mouth. It is very easy for animals (especially large dogs) to overheat with this technique and should be avoided if dogs become hot.

Oxygen Collar (tent)

Another alternative to the mask and hood is the oxygen tent. Take an Elizabethan collar (e-collar) placing plastic wrap over the front, leaving a one – two-inch (5.1 Cm) opening at the top. The opening allows expired carbon dioxide and heat to escape. An oxygen hose is inserted into the e-collar.

Oxygen Cage

A good oxygen cage should have the following features: it must have a system for eliminating carbon dioxide; deliver a known amount of oxygen in a concentration beneficial to the patient (40 - 50%); and a mechanism for controlling temperature (70ºF) and humidity (50%). The disadvantages to this system are, it's expensive to operate, the nursing staff have minimal access to the patient, and it is difficult to accommodate large patients.

Transtracheal

The placement of a "through-the-needle" catheter into the trachea can facilitate the administration of oxygen. The transtracheal route may be indicated when the nasal route is contraindicated. The procedure is carried out much like a transtracheal wash. An area over the trachea is clipped and prepared. Using aseptic technique, the catheter is inserted two - three tracheal rings below the cricoid cartilage or through the cricothyroid membrane. The tip of the catheter should lie in the region of the carina. A light bandage is placed around the patient's neck. The catheter is attached to a humidified oxygen source. Humidified oxygen is used to prevent irritation of the mucosal lining of the airway. Excessive oxygen flow rates are avoided, to prevent trauma from catheter “whip” to the tracheal wall. In one study it was determined that transtracheal oxygen administration permitted lower oxygen flow rates than nasal oxygen administration. The flow rates used for transtracheal O2 administration produced significantly higher inspired O2 concentrations and PaO2 than corresponding nasal O2 flow rates . The flow rates evaluated in this study ranged from 10 ml/kg/min - 250 ml/kg/min.

NASAL INSUFFLATION

Nasal insufflation is an excellent method for administering oxygen. The technique is inexpensive; minimal restraint is required, the nursing staff has good access to the patient, and most of the supplies needed may be found in most practices. A nasal oxygen catheter is easily placed and well tolerated by most patients. Nasal insufflation is contraindicated in patients with significant nasal masses, rhinitis, nasal fractures and nasal hemorrhage.

After treatment with a topical anesthetic and the premeasurement of the nasal catheter (3.5 – 10 Fr patient size dependent) from the tip of the nose to the medial canthus of the eye, the catheter is inserted. A lubricated catheter can be placed in the ventral nasal meatus (angling ventromedially) to the predetermined distance. Multiple catheter fenestrations minimize the risk of jet lesions of the mucous membranes. The catheter is sutured or stapled as it exits the alar notch and along side the face or brought up and over the forehead between the eyes and is secured again. The catheter is attached to a humidified oxygen source. A flow rate of 50 - 200 ml/kg/min should be effective in increasing tracheal O2 concentration in most patients to 40% or greater2, . Human nasal prongs are an alternative that can be effective and less invasive but may deliver a lower fraction of inspired oxygen than a nasal catheter. The ability to use nasal prongs will depend on patient anatomy and behavior.

Several complications may be observed: gastric distension, epistaxis, sneezing and serous nasal discharge. High flow rates can cause catheter "whip" trauma to the nasopharyngeal mucosa. To prevent mucosal drying humidify the oxygen through an in-line bubble humidifier.

High Flow Nasal Oxygen (HFNO)

HFNO has more recently been utilized in dogs. This method is advantageous because it can achieve flow rates up to 40-60 L/min and can more reliably deliver high FiO2. HFNO systems can deliver an FiO2 of 21-100%. The air is heated and humidified, then delivered to the patient through a heated breathing circuit and specialized nasal prongs sized to occlude about 50% of the nares. The system allows 100% humidification and control of temperature, thereby enhancing patient comfort and tolerance of these high flow rates

SUMMARY

A variety of options for oxygen therapy have been discussed. The lowest flow rate that improves the patient’s condition is the desired flow rate. The patient's response to oxygen therapy should be evaluated at periodic intervals. The goal is to see an improvement in mucous membrane color, decreased anxiety, decreased breathing and or heart rate, decrease in the magnitude of respiratory distress, and an improvement in PaO2 or SPO2 to an acceptable level.

## 1.1.6. POST-OPERATIVE / ANESTHETIC COMPLICATIONS

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As veterinary personnel responsible for post-operative / anesthesia nursing care, we must be prepared to respond to rapid changes in the patient's condition. Knowledge of anesthetic protocols and operative procedures will help us to anticipate potential complications associated with them. We must be able to recognize life-threatening situations and respond to them immediately. Post-operative/ anesthetic or recovery nursing care requires knowledge in monitoring techniques, potential complications, therapeutic interventions, nursing considerations for specific types of surgical cases, and pain management. In addition, veterinary personnel should be skilled and knowledgeable in initiating cardiopulmonary resuscitation. The goal of this discussion is to provide the veterinary personnel with the tools necessary to function effectively in the recovery room / ICU.

### ADMISSION TO THE RECOVERY ROOM / ICU

The post-operative / anesthetic recovery period begins at the cessation of the operative procedure(s) and / or anesthetic. The recovery period will continue until the patient's physiologic parameters have normalized. When the patient arrives in the recovery area recovery personnel must attend to the ABCs (airway, breathing and circulation), obtain a baseline physical examination, and communicate with the surgeon and anesthetist.

### ABCs

The priority is to assess the ABCs, airway, breathing, and circulation. Typically, the patient arrives in the recovery area with an endotracheal tube in place. The endotracheal tube should not be kinked or crimped. A tube must be kept clear of secretions such as blood, mucous, and saliva. If the patient is breathing spontaneously, several questions are asked when assessing the patient's ability to breath. Is the rate and tidal volume adequate; is the breathing effort smooth and easy or labored; is the breathing pattern regular? Are you able to auscultate normal breath sounds? Intubation is usually continued until the patient has regained its swallowing reflex and begins to cough or “buck” the tube. In brachycephalic breeds, extubation is delayed as long as possible and maintenance of airway patency is continuously observed during and immediately following extubation.

Perfusion parameters (Pulse rate, pulse quality, mucous membrane color, capillary refill time (CRT), mentation and extremity temperature) are all used to assess the circulatory status. Pulse rate is a non-specific parameter and may be increased (Hypovolemia, hypotension, hypoxemia, pain, fever, and drugs,) or decreased (Drugs, hyperkalemia, severe hypothermia, increased vagal tone, and heart block) for several reasons. Mucus membrane color and CRT are used to assess vasoconstriction and vasodilation. Vasoconstriction decreases peripheral perfusion and can easily be recognized by pale mucous membranes (when not due to anemia) and prolonged CRT. Many of the same reasons that cause tachycardia can also cause vasoconstriction. "Brick Red mucous membranes with a rapid CRT suggest vasodilation. Cyanotic (blue) membranes are a late indicator of hypoxemia. In the anesthetic recovery period mentation will be altered by the sedatives/anesthetics. Cool extremities are indicative of vasoconstriction which would be consistent with poor perfusion or significant hypothermia.

Physical Examination

Once the ABCs have been addressed a baseline physical examination (PE) should be performed. The initial PE establishes the baseline for further comparisons during the recovery period. In addition to physical examination the temperature is obtained, surgical wounds, dressings, tubes, and catheter sites are inspected.

## 1.1.7. ADVANCED MONITORING TECHNIQUES

The level of recovery care may be as simple as obtaining and recording a temperature, pulse, and respiration or it may be complex as invasive physiologic monitoring. Many of the advanced post-operative monitoring techniques are dictated by the intraoperative / anesthetic period, and the current condition of the patient. Some of these monitoring techniques include, electrocardiogram, blood pressure (non-invasive or direct), pulse oximetry, end-tidal CO2, and arterial pH and blood gases.

## 1.1.8. GENERAL POST-OPERATIVE / ANESTHETIC COMPLICATIONS AND TREATMENTS

### Agitation / Rough Recovery

Upon recovery, some patients experience an excitatory phase, which is like the excitement phase of induction. These patients can often be observed paddling uncontrollably and vocalizing. The excitation is likely to occur in those patients that recover quickly from anesthetics that are eliminated rapidly from the CNS, such as volatile anesthetics. The goal is to restrain the patient to prevent self-induced trauma. An anxiolytic and or an analgesic drug can be given to smooth out the recovery.

### Prolonged Anesthetic Recovery

Ideally the patient should be able to maintain sternal recumbency and lift its head within several minutes of extubation. In some instances, patients will take an unexpectedly long time to recover. There are two general causes for prolonged recovery: either patient or anesthetic related causes. Patient related causes may be due to poor perfusion, hepatic, renal or intracranial disease, and hypothermia. Anesthetic related causes include excessive anesthetic depth and breed predisposition. In the case of prolonged recovery steps can be taken as needed to speed up the patient’s recovery. Fluids may be given to enhance perfusion; manual ventilation with 100% oxygen to enhance the elimination of anesthetic gases; or anesthetic drugs may be reversed. Caution should be used with regards to physical stimulation. It is possible to stimulate an animal to the point of extubation and once extubated it returns to sleep. If physical stimulation is used the veterinary personnel needs to be sure that the patient can protect its airway, remain sternal and lift its head.

### Airway Obstruction

This is most likely to occur in the patient with an unprotected airway. However, a mechanical obstruction can occur in a patient with an endotracheal tube (kinked, mucous plug). There are a variety of causes for airway obstruction they included soft tissue entrapment such as in brachycephalics, laryngeal paralysis, edema, and spasm.

Extension of the neck and gentle withdrawal of the tongue often opens the airway; this position is maintained until the patient is recovered. A roll of tape can be placed in the mouth to keep the tongue pulled out and to maintain a patent airway. Oxygen is administered if the patient is in respiratory distress.

Aspiration

The initial problem caused by aspiration is airway obstruction with foreign material being inhaled into the airway. Aspiration can occur following vomiting or regurgitation of stomach or esophageal contents. Saliva, blood or mucous can also be aspirated. Patients at risk for aspiration are those that have esophageal (megaesophagus) or gastric fluid accumulation, increased abdominal pressure (pregnancy, ascites, abdominal effusion). When this problem is anticipated, the esophagus and stomach should be suctioned to prevent aspiration. Some drugs may predispose the patient to aspiration. These include volatile anesthetics, anticholinergics, and opioids.

If the animal is in lateral recumbency and begins to vomit, lower the head and neck, and hold the mouth open (take care not to get bitten). Once the vomiting has passed, assess the mucous membrane color, respiratory rate, and breath sounds. In the anesthetized intubated patient, the oral cavity may need to be lavaged and suctioned. If the patient is unconscious but not intubated the patient should be placed in a head down position and the oral cavity suctioned or swabbed.

Aspiration of material into the airway may lead to aspiration pneumonia although the signs of pneumonia may not be present immediately, depending on the severity of the aspiration.

Hypoxemia

Reasons for hypoxemia include low inspired oxygen concentration, hypoventilation, right to left shunts, ventilation perfusion mismatch, and diffusion impairment. The most common reasons that may be encountered in the recovery period include hypoventilation (drug related or airway obstruction), aspiration pneumonia leading to ventilation perfusion mismatch. Low ventilation perfusion mismatch occurs when there is blood flow past poorly functional or non-functional alveoli. Significant pulmonary collapse (atelectasis) may be present in the "down lung" after prolonged lateral recumbency. In most instances the removal of the airway obstruction, administration of oxygen, positive pressure ventilation with or without positive end expiratory pressure may be used to treat hypoxemia.

Hypoventilation

Hypoventilation is a result of a reduced minute volume due to a reduction in tidal volume and/or respiratory rate. This will result in an increased arterial PCO2. Causes of hypoventilation include depression of the respiratory center by anesthetic agents, pain such that chest expansion is limited, pleural space disease (pneumothorax, pleural effusion), pulmonary disease (pulmonary edema, pneumonia), and restrictive chest bandages.

Treatment is dependent on the cause and may include reduction in anaesthetic depth, thoracentesis, placement of the patient in sternal recumbency to minimize the effects of atelectasis, loosening or removal of chest bandages. In some cases, intermittent positive pressure ventilation will need to be initiated.

Hypothermia

Anesthetic drugs can affect the normal thermoregulatory process. Heat loss through an open chest or abdomen contributes to hypothermia. Smaller patients have a greater surface to volume ratio and are more susceptible to hypothermia. Every effort should be made to return and or maintain a patient in a euthermic state. Warm water circulating or forced hot air blankets and drapes, or towels are effective tools for correcting hypothermia or maintaining euthermia.

Hyperthermia

Hyperthermia may be a result of rough recovery / excessive muscle activity, ketamine administration in dogs or myelography. Placing the patient on a cage floor, wetting with tepid water, or directing a fan at the patient are all options for correcting hyperthermia. An anxiolytic may be helpful in patients that are agitated. Because severe hyperthermia can result in increased oxygen consumption oxygen should be administered. Crystalloids help to improve circulating blood volume and cool the patient.

Hemorrhage

The surgical incision should be monitored during recovery. Excessive bleeding at the surgical site; increase in abdominal girth along with clinical signs suggestive of hypovolemia (pale mucous membranes, prolonged refill time, tachycardia, and poor pulse quality) could be indicative of internal bleeding. The causes for bleeding could be due to a slipped ligature, bleeding from small arteries that were not bleeding during closure or a coagulation disorder. Direct pressure should be applied. The clinician may elect to perform an ultrasound and or perform an abdominocentesis or thoracentesis. Therapy may consist of continued direct pressure, fluid resuscitation and/or surgical reexploration.

Hypotension

Anesthetic drugs can have direct negative effects on the cardiovascular system. However, the most common cause of hypotension is hypovolemia. Induction of general anesthesia can unmask pre-existing fluid deficits. Therapy is indicated if the patient is exhibiting poor perfusion parameters (tachycardia, poor pule quality, poor mm color, prolonged CRT, cool extremities, and decreased mentation) and / or when the systolic and mean blood pressure approach 80 and 60 mmHg respectively. Therapy is directed at correcting fluid deficits either through the administration of crystalloids (10 mL/kg and 20 mL/kg boluses in the cat and dog respectively). Synthetic colloids (10 - 20 mL/kg in dogs and 5 – 10 mL/kg in cats) if hypoproteinemic or if it is difficult to maintain intravascular volume with isotonic crystalloids alone. Consider the potential risk of bleeding with the use of synthetic colloids. 7.5 % hypertonic saline (4 - 6 mL/kg in dogs and 3 – 4 mL/kg in cats) can be given in addition to or as an alternative to isotonic crystalloids. Blood products are given to maintain a packed cell volume greater than 25% and / or the total protein greater than 3.5 g/dl (35 g/L). The patient's perfusion parameters should be reassessed frequently (every 10 – 15 minutes) during rapid fluid administration. In those situations where fluid support is not sufficient sympathomimetics such as dopamine or dobutamine should be considered.

Cardiac Arrhythmias

Perhaps the most common arrhythmias observed in the recovery area are ventricular in origin. Treating the underlying cause and in some instances oxygen supplementation and improved ventilation may help correct ventricular arrhythmias. If ventricular tachycardia is the problem, drug therapy may be indicated. Anti-arrhythmic therapy is indicated if the heart rate exceeds 160-180 bpm, the patient is cardiovascularly compromised, or the patient has multiform premature ventricular contractions (PVC's). Lidocaine is generally considered the drug of choice for treating ventricular tachycardia. It is initially given as a bolus at a dose rate of 1 – 4 mg/kg over 1 – 3 minutes in the dog. If the patient is responsive to the bolus, it is then followed by a constant rate infusion of 40 – 80 micrograms/kg/minute IV. The bolus dose in a cat is 0.5 mg/kg slowly. cats are very sensitive to lidocaine and the drug should be used with great caution in this species. Response to therapy can be the total abolishment of the PVC's, a reduction in the number of PVC's, a slowing of the rate, or improvement in the overall cardiovascular status.

Cardiopulmonary Arrest (CPA)

CPA is defined as the sudden cessation of functional ventilation and effective circulation. CPA may be a result of any disease process, which disrupts cardiac and / or pulmonary homeostasis. Potential causes of cardiopulmonary arrest include hypoxia, shock, metabolic disorders, trauma, vagal stimulation, anesthetic or other drugs and environmental influences (hypo or hyperthermia).

The existence of cardiac arrest must be recognized early if we are to effectively resuscitate the patient. In the anesthetized patient a declining blood pressure will be one of the first signs you will see. Other signs include the absence of a palpable pulse or audible heart sound, the absence of breathing effort (agonal breaths should not be considered effective breaths) and fixed and dilated pupils. If there is any question that CPA has taken place the patient should be treated as such until proven otherwise.

The goal of cardiopulmonary resuscitation is to provide adequate ventilatory and circulatory support until spontaneous functions return. Once it is determined that CPA has taken place chest compression is begun at a rate of 80 - 120 compressions per minute. An airway is established, and the patient is ventilated once every six seconds. IV access is obtained either peripherally or centrally and, in some cases, intraosseous. Epinephrine (Adrenalin), vasopressin and atropine are used in the treatment of asystole and pulseless electrical activity. Defibrillation is indicated when the patient has ventricular fibrillation or pulseless ventricular tachycardia.

Summary

One prospective multi-center study determined that the postoperative period was the most common time for dogs and cats to die. Further, it showed that the most frequent time of death occurred within three hours of the termination of the operative procedure . Cardiorespiratory was the most common cause of death in dogs and cats. This reinforces the idea that vigilance is important in the immediate postoperative/anesthesia period. While not ignoring the other body systems the cardiorespiratory system is of great importance.

The goal of postoperative / anesthesia care is to insure a safe and normal recovery of the patient. As discussed, there are several aspects of postoperative / anesthesia care that veterinary personnel must be prepared to manage. It is hoped that this discussion has provided you with the tools necessary to meet that goal.