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Emergency and Critical Care Procedures in Small Animals

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Introduction

Emergency care for patients is very important. Often, the patient is presented in critical condition and the veterinarian needs to work quickly and efficiently to stabilize the patient. The goal of this paper is to provide a quick reference for setting up an emergency area in a clinic and assistance for getting through emergencies. The primary areas covered include: setting up for an emergency, both before and when the patient initially arrives, cardiopulmonary arrest (CPA), blood transfusions, and fluid therapy.

Setting up for an emergency

Setting up for and dealing with an emergency efficiently can mean the difference between life and death. Being prepared before any emergency arrives is vital. Veterinarians should have a certain area in their clinic that is designated as the emergency treatment area. Often, this area is either the surgery preparation area or the surgery room (if there is no preparation area). The "emergency area" should have certain resources readily available, such as oxygen, suction, a laryngoscope, a major surgery pack that includes a curved Mayo scissors and a Balfour retractor, assorted catheters, sutures, sterile towels, drapes and emergency drugs: epinephrine, atropine, and lidocaine. Other helpful drugs and biologicals would include: dexamethasone, a first-generation cephalosporin, dextran 70 or Hetastarch, plasma, and whole blood.[1] In addition to these items within the emergency care area, the clinic should also be equipped with a micro-hematocrit centrifuge and a spectrophotometer. These items are essential for measuring the packed cell volume and total protein of an animal. The microscope is also an essential piece of equipment. It can be used for several things, including cytology of thoracic or abdominal fluid and a quick blood cell count.

Staff preparation is also important. The technical staff should be trained to get a thorough history when an owner calls with an emergency. They should also be trained to help in an efficient manner when the emergency arrives.

Initial assessment and stabilization of the patient is critical. The four critical organ systems to check are the respiratory, cardiovascular, urinary, and nervous systems. These four organ systems can initially be evaluated by checking the temperature, pulse rate and quality (intensity), and respiratory rate and effort. These boil down to a quick TPR.

If the respiratory and/or cardiovascular systems are compromised, cardiopulmonary resuscitation may be necessary. (Cardiopulmonary resuscitation for cardiac arrest is outlined later in the article.) Fluid therapy may be necessary to stabilize the patient. Animals in shock often require immediate fluid therapy. Shock doses of fluids involve large amounts that must be given over a short period of time. A new protocol involves 5-6 ml/kg of hypertonic saline (7.5%) followed with the same amount of a colloid solution, such as Hetastarch. This is because smaller amounts of hypertonic saline can be given to relieve shock and the colloid is given because a large majority of the electrolytes in the hypertonic saline leak out of the vascular system within an hour. Initial fluid therapy also helps to prevent ischemic renal damage.

Hemorrhage and/or edema of the brain can be life threatening. Initial therapeutics may be necessary to reduce intracranial pressure.[2] Diuretics such as mannitol can be used, but care must be taken not to decrease the pressure too quickly. Rapid reduction could cause even worse trauma to brain cells than either the hemorrhage or edema.

While the patient is being stabilized, the clinician or an assistant can get a thorough history of the problem from the owner. Then, after the patient is stabilized and the history recorded, a good data base should be collected.

A minimum data base of a critical patient should consist of measurements of the packed cell

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volume (PCV), total solids or a total protein, glucose, blood urea nitrogen (BUN), sodium, potassium, and urinalysis. The pH status of the animal should also be determined by performing a blood gas analysis and measuring the pH of the urine.

Next, implement some sort of fluid therapy (as discussed later in the paper) and start further diagnostic procedures to determine the underlying problems.

Cardiopulmonary arrest

Cardiopulmonary arrest (CPA), other than that induced by anesthesia, often carries a guarded to poor prognosis in veterinary medicine. The aim of this brief review of cardiopulmonary resuscitation (CPR) is to make the reader aware of how to perform CPR in a simple manner. Cardiopulmonary resuscitation begins with the ABC's—airway, breathing, and circulation.

First make sure the airway is patent. This is done by clearing the mouth of anything foreign, such as vomitus. The trachea should then be checked for any foreign bodies. If there are any foreign objects in the trachea, subdiaphragmatic thrusts can be performed in a manner similar to the Heimlich maneuver in humans to remove them.[3] Now the animal can be intubated.

After intubation, breathing is initiated. Ventilations can be given via an ambu bag that is attached to 100% oxygen.[3] Ventilation should be given after each fifth chest compression and the chest should be compressed at least 80 times/minute.[4] Chest compressions complete the third step of circulation. Fluids may also be given at this time to improve circulation.

After the ABC's have been completed, the EKG should be evaluated if a heartbeat has not returned. There are three main electrocardiographic findings that represent common syndromes in patients with CPA. They are ventricular asystole, ventricular fibrillation, and electromechanical disassociation.[3] Ventricular asystole is characterized by a flatline, which means the heart is at a standstill. The treatment for this is epinephrine. Table 1 gives some dosages of drugs and counter shock that are useful in CPR. Ventricular fibrillation can be defined as the disorderly depolarization of the ventricular myocardium.[3] Electrical defibrillation is the treatment of choice. Electromechanical dissociation (EMD) is a term used to describe the generation of organized electrical depolarizations of the heart without concurrent mechanical (pumping) activity.[5] The QRS wave can usually be recognized, but is often wide and bizarre. The treatment for EMD is epinephrine.

Post-CPR treatment includes appropriate fluid therapy, monitoring for post-CPR seizures, and appropriate diagnosis and treatment of the underlying problem.

Blood transfusions

Critically ill patients often need some type of fluid replacement. The type of fluid replacement can vary from whole blood to lactated Ringers Solution. Whole blood can even be administered as various components—packed red cells, platelets, and plasma derivatives. This section will focus on only whole blood transfusions.

It is not advisable to give whole blood transfusions to every critically ill patient that comes into a clinic. Patients should be evaluated for the type of fluid that needs to be replaced. The condition of the patient and type of fluid loss will dictate this.

Indications

A major guideline in blood transfusions is anemia. Anemia is usually the result of red blood cell destruction (hemolysis) or hemorrhage. Therefore, the hematocrit is often used as a guideline for transfusions. This should not, however, be the only criterion. The clinical status of the patient is the best guideline for determining when to transfuse.[6,7] Indications for red blood cell transfusion in anemic patients include: prolonged capillary refill time, tachycardia and tachypnea at rest, and exercise intolerance.[8] Animals with these signs have most likely experienced a sudden drop in hematocrit. An example would be a trauma that has caused an acute episode of blood loss. An animal not showing these signs, but with a decreased hematocrit, is most likely suffering from an ongoing blood loss or some type of in vivo hemolysis (e.g. blood sucking parasites and auto-immune hemolytic anemia, respectively).

Dogs and cats suffering from acute blood loss and showing clinical signs should be transfused at hematocrits of <20% and <15%, respectively.[9] In situations that are chronic in nature with no clinical signs, dogs and cats should be transfused with hematocrits of <15% and <10% respectively.[9]

After a blood transfusion has been deemed necessary, there are some logistics to be worked out, relating to blood type, cross matching, blood sources, collection and storage of the blood, administration of the blood, and reactions

that could occur with the transfusion.

Cross-matching

Dogs have 13 blood types known as Dog Erythrocyte Antigens (DEA) 1.1(A_1), DEA 1.2 (A_2), and DEA 3 through 13. The most important blood types clinically are DEA 1.1(A_1) and 1.2 (A_2), but DEA 7 (Tr) is also considered important.[9] Therefore, animals negative for DEA 1.1, DEA 1.2, and DEA 7 are considered universal donors. Dogs that have never been pregnant or undergone a previous transfusion can usually be given incompatible red blood cells. The reason for this is that most dogs do not have preformed antibodies against canine blood group antigens.[10,11,12]

Cats have 3 blood types. They are types A, B, and AB.[13] Cats are not routinely typed since 90% of the American domestic shorthairs in the United States are Type A.[8] It is advisable to blood type exotic purebred cats, though, because they have a higher incidence of blood type B. Also, blood type B cats generally have naturally occurring antibodies against the A antigen. Acute transfusion reactions can occur when type A blood is transfused into type B recipients.[8] Type A cats generally do not have antibodies against the B antigen and can be given type B blood without acute reactions. The survival of these transfused cells is reduced, however.[14] There is no universal donor in cats.

Cross-matching is not the same as blood typing. A blood cross-match test detects the serologic compatibility (or incompatibility) between the anemic recipient and the potential donor.[9] A major cross-match tests for antibodies in the recipient's plasma/serum against the donors cells. A minor cross-match does the opposite. Cross-matching is done to decrease the risk of hemolytic (immediate or delayed) transfusion reactions in previously sensitized patients, patients with naturally occurring isoantibody (especially cats, since some purebreds have a high incidence of type B), and neonatal isoerythrolysis.[15]

Reactions still can occur even if a cross-match test is done. The reason for this is that the cross-match does not check for white blood cell or platelet antigens. These two items are often the main source of many immediate transfusion reactions. [15]

The source of blood varies among clinics. This depends on the size of the clinic and how many transfusions they do on a regular basis. A practice may elect to have a clinic dog or cat that is a donor. Other clinics may either use their own pets or have a standing agreement with a client to use their dog or cat. In any situation, there are some guidelines and suggestions that should be followed.[15]

Dogs can safely donate 20 mL/kg of blood every two weeks. Cats that weigh 6-7 kg can give 50 mL every two weeks safely.[13] Some donor cats may show signs of hypovolemia and require fluid replacement. These cats should be given 100 mL of lactated Ringer's solution intravenously.[13]

Blood is most often collected from the jugular vein due to ease of accessibility. The femoral artery can be used in dogs, but requires heavy sedation. Dogs and cats are generally sedated to facilitate the ease of harvesting the blood. A combination of xylazine, butorphanol, and glycopyrrolate is used in dogs at Iowa State University. Cats can be tranquilized with ketamine and diazepam. After the dog or cat is sedated, the area over the jugular is clipped and a surgical scrub performed. The blood is then drawn via venipuncture. In dogs, 450 mL of blood is usually collected by gravity into a bag that contains 63 mL of citrate-phosphate-dextrose-adenine(CPD-A). The CPD-A is the anti-coagulant and nutrient solution.[8] Blood is usually drawn from cats via a 19 gauge-butterfly catheter into a syringe. The syringe is preloaded with CPD-A at a ratio of 1 mL CPD-A per 7 mL of blood.[16] Two small syringes are preferred over one large syringe since they are less likely to collapse the vein.

Whole blood mixed with CPD-A may be stored for up to 4 weeks if it is refrigerated at 1 to 6°C. It must be remembered, though, that if a whole blood transfusion is to supply platelets or clotting factors, it must be administered within six hours of collection and that platelets are inactivated with refrigeration. Prior to administration, the blood should be filtered to remove clots and debris and warmed if it is not already warm.

Administration Rate

The rate of transfusion depends on two factors: hydration status and cardiac function of the patient. If an animal is normovolemic with a normal heart, the rate is 5 mL/kg/hr. Animals that are dehydrated can be transfused at higher rates (15 mL/kg/hr), while animals with cardiac failure should not exceed 1 mL/kg/hr. Cats that do not have heart failure tolerate rapid and intermittent transfusions from a syringe over 30 minutes to one hour.[16] A rough estimate of the transfusion's effect can be made based on the knowledge that 22 mL/kg of whole blood will increase the PCV by 10%.[13] A formula [11] used to calculate the posttransfusion

increase in PCV can be found in Figure 1. The best and most accurate thing to do is measure the PCV and TP after the transfusion has been completed.

Common transfusion reactions are fever, vomiting, and hemolysis. Often if the only reaction is a fever, the transfusion can be continued and antipyretics can be given. If vomiting occurs, the transfusions can be slowed down. If this does not stop the vomiting, the transfusion should be stopped. If hemolysis occurs, the transfusion should be stopped immediately.

Fluid therapy

Blood transfusions are an important part of fluid therapy, but often they are not indicated and there are cheaper and easier ways to provide fluid therapy. Examples of this would be to buy commercially available fluid solutions. The choice of solutions is varied and leads to several questions.[17]

1. Is fluid therapy indicated?
2. What type of fluid should be given?
3. By what route should the fluid be given?
4. How rapidly should the fluid be given?
5. How much fluid should be given?
6. When should fluid therapy be discontinued?

These questions will be reviewed individually.

Indications

Indications for fluid therapy vary. Emergency patients are often in shock and fluid therapy is very critical in these patients. Animals may also present with vomiting or diarrhea and be dehydrated.

Fluid Choice

Once it has been decided that the animal needs fluids, the next step is to decide on what fluid to give. Fluids can be put into three general categories. The first category includes the fluids that deliver free water. An example of this is 5% dextrose. The second category is the crystalloids. Crystalloids are solutions that contain electrolytes and non-electrolyte solutes that are capable of entering all body fluid compartments. Examples of these fluids are 0.9% saline and lactated Ringer's solution. The third category is the colloids. These are solutions of large molecular weight substances that are restricted to the plasma compartment of the blood. Examples of these solutions are plasma itself, dextran, and hydroxyethyl starch (hetastarch). The choice of the fluid is generally guided by the condition of the animal and what type of fluid is being lost. Table 2 describes some types of fluid loss and also some possible fluid replacements. Electrolyte panels are also helpful in determining what fluid replacement to use. It is best to try and match the electrolytes lost with the abnormality of the animal. Not all fluid replacements will exactly meet the needs of the patient.

A common electrolyte pair added to fluids is KCl. Potassium can be added to fluids to achieve a normal serum level. It is important to remember that K^+ should not be given IV at rates higher than 0.5 mEq/kg/hr. Rates greater than this can cause adverse cardiac effects.

Another major electrolyte that often needs to be adjusted is sodium. In situations where there is hyponatremia, it is best to use solutions rich in Na^+, such as 0.9% sodium chloride. Hypernatremia may also be a problem and require fluids that are low in Na^+ such as 5% dextrose in water or 0.45% sodium chloride with 2.5% dextrose.

Metabolic acidosis and respiratory acidosis are probably the most common acid-base disturbances in small animals.[18] Metabolic or respiratory alkalosis situations do not occur very often. Performing blood gases is an important step in determining these situations. Urine pH measurements can also be very helpful.

Anions such as lactate, acetate, and gluconate, are added to crystalloid solutions as a source of base because their oxidative metabolism in the body yields bicarbonate.[17] Bicarbonate can also be added to fluid solutions to act as a basic buffer and may be preferred in some instances because it does not require any metabolism in the body to be effective. Bicarbonate deficiency can be calculated as follows:

Bicarbonate deficit (mEq) =
Body weight (kg) x .3 x Base deficit (mEq/Liter)

Often animals will correct their own acid-base imbalance if the underlying problem is corrected.

Route

After the type of fluid has been chosen, the route of administration must be decided. Some of the choices are intravenous, subcutaneous, oral, intraperitoneal, and intraosseous (intramedullary). The choice of the route may sometimes be dictated by the physical status of the animal, the clinical disorder, and the duration and severity of the disorder.

The intravenous route is usually the best choice because this route delivers 100% of the fluid to the cardiovascular system. This allows for both the correct dosage to be administered and for rapid dispersion of water and electrolytes throughout the body. Another advantage to the IV route is that large volumes can be given rapidly in larger veins. This is often very important in animals that are in shock or have lost a lot of blood rapidly. The jugular vein is the largest and allows for large volumes to be given rapidly. The cephalic is also commonly used, as well as, the lateral saphenous and femoral veins. The choice of the vein may be dictated by the clinical problem. For example, the lateral saphenous would probably not be a good choice in a dog with a gastric dilatation volvulus. The posterior vena cava could be occluded by the enlarged stomach and reduce blood flow from the caudal half of the body, thereby limiting the amounts of fluids that could be given via the lateral saphenous.

Disadvantages of the intravenous route are that the animal needs to have 24 hour supervision, the catheters need to be placed as sterily as possible, and the catheters need to be replaced every 72 hours.[17]

The subcutaneous route can be used when animals only need maintenance levels of fluids. Large amounts of fluid can be spread over a large area of the back. There is a very low risk of volume overload with this route. The problems with this route are that it cannot be used in animals with severe hypovolemia, animals that are vasoconstricted peripherally, and only isotonic solutions can be given.

Fluids given orally are the easiest to give. Fluids of different tonicities can be given this way and fluids can be administered rapidly without any major problems. It is ideal to get animals to switch from IV to oral fluids. One problem with oral fluids is that animals with extensive losses cannot get enough orally to make up the difference. Oral fluids also do not help animals that are vomiting or have diarrhea.

Intraperitoneal administration has the advantage of giving large amounts at once. Problems with this method include use of only isotonic fluid and increased risk of peritonitis.

The last choice is the intraosseous or intramedullary route, in which fluids are administered into the medullary cavity of a large bone. This route is ideal in young animals with veins that are very small and in animals that are very dehydrated and have veins that have collapsed. Sites that can be used are the tibial tuberosity, the trochanteric fossa of the femur, the wing of the ileum, and the greater tubercle of the humerus. The major disadvantage of this route is osteomyelitis.

Fluid Rate

The fluid rate is the next step. The rate is usually dependent on the status of the animal. If animals are severely dehydrated and have ongoing losses such as vomiting or diarrhea, fluids need to be given rapidly. If animals are only slightly dehydrated and have minor ongoing losses, slower fluid rates are appropriate.

The first step in determining the rate is to calculate the existing deficit. This can be done by estimating how dehydrated the animal is. The percent dehydration is then multiplied by the weight in kilograms and 1000 mL/kg. This gives the amount of fluid lost due to dehydration. The next step is to calculate the maintenance requirement of the animal. A rule of thumb is that animals require 40-60 mL/kg/day for maintenance. Smaller animals require 60 mL/kg/day and larger animals require 40 mL/kg/day. The last thing to figure is any contemporary loss the animal is undergoing. Examples of this would be 200 mL of fluid lost in one day due to diarrhea. The total of these three categories gives you the 24 hour fluid requirement of this animal. This can then be divided up over 24 hours or the dehydration deficit can be made up in the first 4 to 8 hours of treatment followed by maintenance and ongoing loss replacement.[17]

The final considerations: the amount of fluid to give and for how long, are interrelated. The goal of fluid therapy is to rehydrate the animal, allow the animal to remain hydrated, and get the animal over the cause of dehydration. An example would be to rehydrate an animal, treat, and resolve the diarrhea. The animal would then be able to take fluids orally and maintain a normal hydration status. Therefore, the amount of fluid given is dictated by how dehydrated the animal is and how long the animal has had the underlying problem. The time to stop fluids is determined when the animal overcomes the underlying problem and is able to maintain hydration on its own. This is often a judgement call on the clinician's part.

There are some things to keep in mind during fluid replacement. The main one is overhydration of the animal. It is advisable to weigh animals daily that are on fluids to monitor any large gains or losses in weight. Urine output is another good parameter to watch. Normal urine output is 1 to 2 mL/kg/day. Packed cell volumes and total protein levels should be checked at least once

daily. Some clinical signs that might indicate overhydration are serous nasal discharge, chemosis, restlessness, shivering, tachycardia, cough, tachypnea, dyspnea, pulmonary crackles and edema, ascites, polyuria, exophthalmus, diarrhea, and vomiting.[19] If it looks like overhydration is occurring, fluid rates should be adjusted accordingly or stopped.

Conclusion

Management of emergencies and critically ill patients can be difficult and frustrating. However, if certain routines and protocols are followed, clinicians can successfully work their way through these difficult situations. In the end, owners will be much happier and clinicians less stressed.

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Figure 1

$$\text{Mls of donor blood in anticoagulant} = \left[\begin{matrix}\text{2.2 x recipient weight in kgs} \\ \text{x 40 (dog) or 30 (cat)}\end{matrix}\right] \times \frac{\text{hematocrit desired - hematocrit of recipient}}{\text{hematocrit of donor blood in anticoagulant}}$$

Table 1. Example of a drug dosage chart that may facilitate administration of treatment during CPR.

Cardiopulonary Resuscitation: ACLS Tx*
Dose in Ml/Lb Body Weight by IV Route, Double Dose if Tracheal

Emergency Drugs	Dose	5 lb	10 lb	20 lb	30 lb	40 lb	50 lb	60 lb	80 lb	100 lb
Epinephrine 1:1000 1mg/ml	0.1mg/lb 0.2 mg/kg	0.5	1	2	3	4	5	6	8	10 ml
Atropine 0.5 mg/ml	0.025mg/lb 0.05mg/kg	0.25	0.5	1	1.5	2	2.5	3	4	5 ml
Lidocaine 20 mg/ml	1.0 mg/lb 2.0mg/kg	0.25	0.5	1	1.5	2	2.5	3	4	5 ml
Na Bicarb 1mEq/ml	0.5mEq/lb 1.0mEq/kg	2.5	5	10	15	20	25	30	40	50 ml
Dexameth. sp 4 mg/ml	2 mg/lb 4 mg/kg	2.5	5	10	15	20	25	30	40	50 ml
Ca Gluconate 100 mg/ml	5 mg/lb 10 mg/kg	0.25	0.5	1	1.5	2	2.5	3	4	5 ml
Counter-shock										
External	1-10 ws/lb	25	50	100	150	200	250	300	400	500 ws
Internal	1-1 ws/lb	2.5	5	10	15	20	25	30	40	50 ws

*Advanced cardiac life support treatment

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Table 2. Potential fluid, electrolyte, and acid-base disturbances in various diseases and suggested crystalloid solutions.

Abnormality	Type of Dehydration	Electrolyte Balance	Acid-base Status	Fluid Therapy
Simple dehydration, stress, exercise	Hypertonic	—	—	Half strength or balanced electrolyte solution; 5% dextrose solution
Heat stroke	Hypertonic	K^+ variable Na^+ variable	Metabolic acidosis	Half strength electrolyte solution followed by balanced electrolyte solution
Anorexia	Isotonic	K^+ loss	Mild metabolic acidosis	Balanced electrolyte solution; KCl
Starvation	Isotonic	K^+ loss	Mild metabolic acidosis	Half strength or balanced electrolyte solution; KCl; calories
Vomiting	Isotonic or hypertonic	Na^+, K^+, and Cl^- loss	Metabolic alkalosis; metabolic acidosis chronically	Ringer's solution; 0.9% saline with KCl supplementation
Diarrhea	Isotonic or hypertonic	Na^+ loss K^+ loss chronically	Metabolic acidosis	Balanced electrolyte solution; HCO_3; KCl(if chronic)
Diabetes Mellitus	Hypertonic	K^+ loss	Metabolic acidosis	Balanced electrolyte solutions; KCl
Hyperadreno-corticism	Isotonic	K^+ loss	Occasionally mild metabolic alkalosis	Balanced electrolyte solutions; KCl
Hypoadreno-corticism	Isotonic or hypertonic	Na^+ loss K^+ retention	Metabolic acidosis	0.9% saline followed by balanced electrolyte solutions
Urethral obstruction	Isotonic or hypertonic	K^+ retention Na^+, Cl^- variable	Metabolic acidosis	0.9% saline followed by balanced electrolyte solutions; KCl postobstruction
Acute renal Failure	Isotonic or hypertonic (with vomiting)	K^+ retention Na^+, Cl^- variable	Metabolic acidosis	Balanced electrolyte solutions
Chronic renal Failure	Isotonic or hypertonic (with vomiting)	Na^+, K^+, Cl^- variable	Metabolic acidosis	Balanced electrolyte solutions
Congestive heart failure	Plethoric (Na^+, H_2O retention early); hypo-tonic chronically	Na^+ retention (but diltutional hyponatremia)	Metabolic acidosis (chronically)	5% dextrose solution
Hemorrhage shock	Isotonic		Metabolic acidosis	Balanced electrolyte solutions; blood
Endotoxic shock	Isotonic		Metabolic acidosis	Balanced electrolyte solutions; 0.9%saline

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