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FLUID THERAPY IN SMALL MAMMALS

Connie J. Orcutt, DVM, Dipl. ABVP
Angell Animal Medical Center
Boston, MA

Owners of small exotic mammals are increasingly requesting sophisticated diagnostic and treatment protocols for their pets, and our challenge as clinicians is to extrapolate applicable protocols for larger animals to these much smaller individuals. The area of emergency medicine and intensive care is of particular interest, because small mammals can decompensate very rapidly. By the time many of these animals are brought to the clinic, they are suffering from dehydration and hypovolemic shock. Aggressive fluid therapy is often indicated but is complicated by difficult venous access, physiologic diversity among many species of small mammals, and a lack of research data regarding their response to therapy. In some cases, the clinician must weight the advantage of delivering fluids intravenously against the risk of life-threatening stress that may result from aggressive therapy (e.g., catheter placement). Some of the same monitoring protocols used to measure response to fluid therapy in traditional pets, such as arterial blood pressure measurement, can be applied to small exotic mammals with some modifications. While attempting to rehydrate small mammals and provide maintenance fluids, the clinician must also monitor clinical signs to avoid iatrogenic overhydration.

GOALS OF FLUID THERAPY

In cases of hypovolemic shock, which is common in small exotic mammals presenting in a debilitated state, perfusion and oxygen delivery to the tissues must be addressed prior to hydration. Adequate perfusion relies on sufficient intravascular fluid volume and a normally functioning cardiovascular system, and hydration involves adequate fluid stores in the interstitial spaces. When dehydration is estimated at >8%, osmotic forces in the interstitium will begin to pull fluid from the intravascular space and impact perfusion.

One can look at the goal of fluid resuscitation as being to give the least amount of fluid possible to reach the desired endpoints. This is especially important in small patients in which fluid volume overload can occur rapidly without appropriate monitoring. How does the clinician determine the “endpoints” of fluid resuscitation? This employs the use of clinical parameters that can be continually assessed: mentation, capillary refill time, pulse character, blood pressure, heart rate, respiratory rate, body temperature, strength, urinary output, and mucous membrane color. Success is more likely if treatment is instituted in the early stages of hypovolemia.

Fluid therapy is imprecise, in large part because the volumes of the various body compartments are constantly in flux. Fluid therapy usually consists of a plan entailing 3 stages: resuscitation (restoration of tissue perfusion and oxygenation), hydration (restoration of interstitial fluid), and maintenance. The first stage requires replacement of intravascular volume, which may depend on a variety of fluids. If the patient has a stable cardiovascular status, the interstitial volume deficit can be replaced over 12-24 hours. If interstitial fluid volume loss has been more acute, the fluid deficit may need to be replaced rapidly, i.e., within 1-4 hours.

Maintenance requires assessment of anticipated ongoing losses of both fluids and electrolytes.

FLUID SELECTION

The 3 basic categories of fluids used for therapy included crystalloids, synthetic colloids, and oxygen-carrying solutions. Crystalloids and colloids can be used together for the resuscitation phase, and crystalloids used alone form the basis of the rehydration and maintenance phases.

Crystalloids

Crystalloids may be replacement or maintenance fluids. The former have electrolyte concentrations resembling the extracellular fluid composition, and the latter contain relatively less sodium and more potassium. Common replacement fluids include lactated Ringer’s solution (LRS), 0.9% saline, Normosol-R (Ceva Laboratories, Overland Park, KS), and Plasmalyte-A (Baxter, Deerfield, IL). Crystalloids rapidly distribute to the interstitial space; only ~20% of the administered volume remains in the circulation 1 hour after treatment. This redistribution of fluid can lead to interstitial edema, which can further impede oxygen delivery to the tissues in the acute phase. In some individuals, pulmonary or cerebral edema can result.

Hypertonic saline (usually given as a 7.5% solution, which is 2600 mOsm/L) is a crystalloid fluid used specifically for resuscitation in cases of hypovolemia. The dosage is usually 5 ml/kg administered over 5-10 minutes. The advantage of this fluid is that it can expand intravascular volume to a degree equivalent to colloids but at ¼ the volume of fluid administered. However, the effect is transient (< 30 minutes), so a colloid should be administered concurrently. Hypertonic saline is contraindicated in dehydrated patients.

Colloids

Colloids are fluids containing substances of large molecular weights that generally cannot pass through capillary membranes. These fluids are true intravascular volume expanders. A colloid can be used in conjunction with a synthetic colloid to reduce fluid depletion in the interstitial space; crystalloid volume is 40%-60% of that if a crystalloid is used alone. Synthetic colloids include hetastarch and Oxyglobin (Biopure, Cambridge, MA), and biological colloids include plasma, blood, and albumin. These fluids are usually isosmolar. Particular blood components should be administered depending on the specific need, but the availability of these products for small exotic mammal patients is often a limiting factor in successful treatment. Hetastarch is used most often in the author's practice in ferrets with diarreah and subsequent hypoalbuminemia. Relatively slow infusion of hetastarch in ferrets, rabbits, and other small mammals is recommended to prevent hypertension, which can result from bolus infusion. The author uses a dose of 5 ml/kg delivered over 20 minutes; that can be repeated up to a daily dose of 20 ml/kg.

Oxyglobin is a hemoglobin-based oxygen-carrying solution (HBOC) approved for use in dogs, which contains purified polymerized hemoglobin of bovine origin in a modified lactated Ringer’s solution. It is isoosmotic with an average molecular weight of 200,000, so it is an effective colloid. Oxyglobin’s pH of 7.8 so will not contribute to the metabolic acidosis present in most cases of hypovolemia. The hemoglobin in an HBOC is free in solution where it binds.
oxygen and carries it to peripheral tissues. This cell-free solution can reach tissues that may be inaccessible to erythrocytes. In addition, bovine hemoglobin is dependent on chloride ions rather than 2,3-diphosphoglycerate and has a low oxygen affinity, so oxygen is readily offloaded in the tissues. Other features of Oxyglobin make it particularly attractive for use in small exotic mammals. It can be delivered via a small gauge peripheral catheter without a filter, and it provides oxygen support without the need for a blood donor. The author has used Oxyglobin in a number of small exotic mammal species but most commonly in ferrets at a dosage of 11-15 mg/kg infused over a 4-hour period using a syringe pump. This dosage has been repeated once in a 24-hour period. Oxyglobin must be used with caution in normovolemic animals or when volume loss is undetermined, in order to avoid fluid overload. It should be used with extreme caution in patients predisposed to the development of pulmonary edema, animals with severely impaired cardiac function, or individuals with renal impairment and oliguria or anuria. Side effects of Oxyglobin include yellow-orange discoloration of the skin, mucous membranes, and sclera as well as red-brown discoloration of the urine. These effects are dose dependent and resolve in 3-5 days. Lipstick measurements of the urine are inaccurate while the urine is discolored. Serum chemistry measurements should be evaluated prior to Oxyglobin administration due to post infusion artifactual increases or decreases in certain serum chemistry tests (depending on the type of analyzer and reagents used). Hemoglobin levels need to be measured directly after Oxyglobin administration.

FERRETS

Intravenous (IV) or intraosseous (IO) fluid administration is the route of choice in most critically ill ferrets. A peripheral catheter may be placed without sedation if the ferret is debilitated or depressed, but isoflurane anesthesia may be required with an active ferret. The lateral saphenous or cephalic vein is catheterized with a 22- or 24-gauge catheter. To avoid the catheter crimping as it penetrates the ferret’s tough skin, the skin adjacent to the vein is first punctured with a 20- or 22-gauge needle. Jugular catheterization may be required if other veins are not accessible or if a catheter larger than 24-gauge is required (e.g., for whole blood transfusions), but a cut-down procedure is often required. The author uses a 22-gauge, 8-inch through-the-needle catheter on a 19-gauge needle (Becton Dickinson Vascular Access, Sandy, UT). In an emergency, a peripheral catheter can be placed in the jugular vein instead. Any catheter should be sutured to the skin prior to bandaging. The clinician should be aware that ferrets often act depressed with neck bandaging in place. Intraosseous (IO) catheterization is an option if veins are not accessible. General anesthesia is recommended for this procedure unless the ferret is extremely debilitated.

A 20- or 22-gauge, 1.5-inch spinal needle placed in the femur, medial to the greater trochanter, is least likely to impede the ferret’s movement. Some medications will cause discomfort when delivered intraosseously. With fluid administration using a indwelling catheter, tubing and ports should be covered with bandage material to prevent chewing. Continuous delivery of fluids by an infusion pump is recommended. In any small mammal, heparinized saline should be used judiciously to flush the catheter in order to avoid heparin overdosage. Vascular access ports (Access Technologies, Skokie, IL) can be used to facilitate repeated blood sampling as well as the IV administration of chemotherapeutic drugs, fluids, blood products, and parenteral nutrition. Catheters as small as 1-Fr. are available for use in small exotic animals. Subcutaneous (SC) fluid administration is adequate in ferrets that are only mildly dehydrated or drinking less than usual, and the daily maintenance fluid dose is usually divided into 3 complements. Alert ferrets may resist SC fluid administration.

Precise fluid requirements for ferrets have not been determined, but volumes of 70-90 mL/kg q24h are often used. Traditional recommendations for treatment of hypovolemic shock have included rapid infusion of a volume of crystalloids equivalent to the ferret’s blood volume. However, this may result in significant pulmonary edema in some cases. One must be particularly cautious to avoid fluid overload in ferrets with clinical cardiac disease or in geriatric ferrets that may have occult heart disease.

RABBITS

Daily fluid maintenance in the rabbit is 100-120 mL/kg, and as with ferrets, the volume is decreased in animals with cardiac disease. As discussed above with ferrets, the traditional recommendation of bolusing relatively large volumes of fluids may result in pulmonary edema in these small mammals. The author has also seen geriatric rabbits develop pleural effusion secondary to aggressive crystalloid therapy that has exacerbated occult dilated cardiomyopathy. Rabbits in mid to advanced stages of hypovolemic shock often present in a hypothermic state (<100°F). This may contribute to the difficulty in providing adequate fluid resuscitation without inducing pulmonary edema in rabbits and ferrets. When the rectal temperature falls, adrenergic receptors may become refractory to the catecholamines released in the early compensatory phase of hypovolemic shock. This results in a normal to slow heart rate instead of the tachycardia seen in other animals during effective compensation. In addition, compensatory vasoconstriction is likely to be impaired despite the presence of catecholamines. Thus, thermal support to rewarm hypothermic animals should be an integral part of the fluid therapy plan but should be administered with caution in order to prevent further decompensation. Animals should be placed in incubators, and fluids should be warmed prior to administration.

Catheter placement in rabbits is similar to that described above for ferrets. A 22-gauge catheter can usually be placed in a peripheral vein. Jugular catheter placement may require a cut-down procedure, and rabbits may not tolerate these catheters well. An IO catheter can be placed in the femur through the greater trochanter. For rabbits that require only maintenance fluids and are not in critical condition, SC fluid administration is adequate and well tolerated by most patients.
RODENTS

The usual route for maintenance fluid administration in rodents is subcutaneous. Daily maintenance fluid doses for guinea pigs, chinchillas, rats, and hamsters are 100 ml/kg, and the dose for mice is 150 ml/kg. Gerbils, desert dwellers in nature, are very efficient at conserving fluid so require only 40-70 ml/kg. In critically ill animals, IV, IO, or intraperitoneal (IP) routes are preferable. Fluids often need to be heated prior to administration. In chinchillas and guinea pigs, a 24-gauge catheter can often be placed in the cephalic or saphenous vein. Chinchillas have medial and lateral saphenous veins. A tourniquet may facilitate venous access, and local circulation is enhanced if a warm compress is applied to the skin over the vein prior to attempted catheterization. In emergency situations, the jugular vein may be accessed with a peripheral catheter. A small spinal needle (20- to 22-gauge, 1.5 in.) or a hypodermic needle with a KE wire used as a stylet can be used for IO catheterization. In emergency situations, the jugular vein may be accessed with a peripheral catheter. A small spinal needle (20- to 22-gauge, 1.5 in.) or a hypodermic needle with a KE wire used as a stylet can be used for IO catheterization.

The IP route is also useful for certain medications that otherwise would be administered intravenously. Solutions should be diluted prior to administration. The animal is positioned with the head down. The needle used should be 25-gauge or smaller. In gerbils, hamsters, and mice, the right caudal abdominal quadrant is accessed, and in rats, the left caudal quadrant is used. Always aspirate prior to injection to be certain a viscus has not been entered.

ONE PROTOCOL FOR ACUTE TREATMENT OF THE HYPOVOLEMIC SMALL MAMMAL

This recently published protocol designed by Dr. Marla Lichtenberger demonstrates to what extent fluid therapy for small exotic mammals can be applied. An important part of the protocol is continual measurement of the patient’s systolic blood pressure using an ultrasonic Doppler flow detector (Parks Medical Electronics, Inc., Aloha, OR). The patient is placed in lateral recumbency, and a pneumatic cuff is placed above the carpus/tarsus and foot, and the Doppler transducer probe is placed in a bed of conducting gel over a local artery. The cuff is inflated until the Doppler signal is cut off then is deflated until a sound is evident; this first sound is the systolic pressure. Diastolic pressure, and thus the mean arterial pressure, cannot be measured using this method. The normal systolic blood pressure for ferrets, rabbits, and other small mammals can be applied. An important part of the protocol is continual measurement of the patient’s systolic blood pressure using an ultrasonic Doppler flow detector.

Blood pressures are recorded until the systolic pressure is >40 mm Hg, and hetastarch is discontinued, and the patient, if hypothermic (core temperature <95°F), is warmed over 30 minutes using hot water bottles or a convective heater and warmed IV fluids. When the rectal temperature reaches 99°F, the blood pressure is reevaluated. Hetastarch administration can be repeated at 5 ml/kg increments over 15 minutes until the systolic blood pressure is >90 mm Hg. The author of this protocol has found that after this point, further resuscitation fluids are not usually required. The patient’s body temperature must be maintained using an incubator and warm fluids. If the blood pressure falls again, hetastarch is administered at 5 ml/kg followed by a constant rate infusion of 3-5 ml/kg/hr. Cardiac function should be assessed, and electrolyte, acid-base, and glucose derangements must be corrected. If these parameters are normalized and the hypovolemic shock is not responding, treatment is continued. In rabbits and ferrets, Oxyglobin is bolused at 2 ml/kg over 10-15 minutes until a normal heart rate and a systolic blood pressure of >90 mm Hg is reached. Oxyglobin is then infused at a constant rate of 0.2-0.4 ml/kg/h.

REFERENCES