CRITICAL CARE NUTRITION AND FLUID THERAPY IN REPTILES

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Start every reptile case by identifying the species and providing an appropriate hospital environment. It is not sufficient to call the patient a "turtle" or a "lizard" because the needs of each species are unique. For example, the hospital care for an African spurred tortoise differs substantially from that of an ornate wood turtle, Western box turtle, and red-eared slider turtle. Take a few minutes to learn about the particular species' natural history including nutritional and habitat needs. There is no singular reference for species identification, but animal caretakers usually know a common name that can be used to begin an Internet search for information about the species. Bartlett PP, Griswold B, and Bartlett RD, *Reptiles, Amphibians, and Invertebrates: An Identification and Care Guide*[1] is one handy text to keep on the shelf for quick reference. After the species is identified without question, then Internet sources of husbandry information (e.g., www.anapsid.org and www.chelonia.org) may be consulted. The hospital environment must meet temperature, humidity, lighting, substrate, and water requirements. Husbandry methods must be modified for patient status. For example, a water turtle with a fracture of the carapace should not be submerged until after the fracture is sealed, because water could enter the body cavity and lead to coelomitis.

After the species is identified and an appropriate hospital environment has been provided, gradually warm the patient to within its optimal body temperature range before initiating further therapy. As a general guideline for most of the common pet species of reptiles, therapy can begin when the cloacal temperature is between 26°C and 30°C. Raise the body temperature over the course of several hours using radiant heat such as an incandescent lamp or incubator for terrestrial or arboreal species, or a shallow water bath for aquatic species. Support the head to prevent drowning.

Then begin the process of rehydrating patients that are dehydrated and/or volume depleted. Diagnosis and treatment of the primary (i.e., most diagnostic) problem may not need to begin for many hours or days, which may be long after the patient has left the emergency and critical care setting.

Finally, do not feed a dehydrated reptile. Nutritional support is rarely needed in the initial 24 hours of care for reptiles that are presented in serious to critical condition.

Hydration and perfusion status

Assess hydration using eyelid turgor, position of the eyes (sunken/bright), mucous membrane moisture or tackiness, tenaciousness of saliva (does it form durable strands or not), skin turgor/dermal elasticity (thickness and durability of skin tent or folds), abdominal doughiness, PCV, TP (e.g., total protein by refractometer), BUN, plasma sodium, and plasma chloride. Rapid weight loss (in less than a few weeks) can be a sign of fluid loss. Reptile urine is normally hyposthenuric and urine specific gravity does not rise above isosmotic with plasma (~1.008–1.012) during dehydration. Severely dehydrated reptiles (≥10%) may have any combination of the following signs: saliva that forms durable strands, durable skin wrinkles, sunken eyes, doughy abdomen, PCV >40%, refractometer TP >8 g/dL, plasma sodium >165–180 mEq/L (depending upon species), and plasma chloride >120 mEq/L.

Perfusion is generally difficult to estimate. Anuria will occur with decreased glomerular filtration rate, but urination patterns are not easy to recognize and reptile caretakers may not be able to differentiate urination from defecation. Arterial blood flow can sometimes be detected with a Doppler probe in extremities including the limbs and tail, but flow cannot always be detected, even in well perfused reptiles. Non-invasive blood pressure can sometimes be measured in reptile species using a sphygmomanometer and Doppler probe, but readings are not consistent and are confusing. Blood pressure measurements with a non-invasive oscillometric monitor can sometimes be useful in the hands of veterinarians and technicians who are highly experienced with reptiles, but should not be relied upon by novices.[2,3] The Doppler probe can be used to directly measure heart rate, but rate is closely related to body temperature, so the patient should be warmed to the optimal temperature range before interpreting the heart rate. Normal, resting, thermally stable heart rate can be roughly estimated with this formula: heart rate=33.4(weight in kilograms$^{-0.25}$), which calculates out to approximately 25 to 80 beats per minute.

Nutritional status and body condition score

Body condition can be scored on a scale of 1 to 9 (1=emaciation; 5=excellent condition; 9=morbid obesity). Estimate condition in lizards and snakes by palpating the muscling over pelvis and tail; characterizing abdominal distension; and palpating abdominal fat bodies. Cachexia, like severe dehydration, can lead to sunken eyes and loss of skin elasticity. Estimate condition of chelonians by subjective assessment of density: they should have reasonable heft for the size. Formulae to calculate chelonian body condition based on weight and size have been reported, but the information resulting from these calculations has not proven to be clinically useful.[4] Obese turtles and tortoises may have fat bodies visible beneath bulging, unpigmented skin, whereas markedly underweight individuals may have obvious tendons on the limbs with muscle wasting. Larger reptiles generally eat less frequently than smaller reptiles. Carnivores generally eat less frequently than omnivores and herbivores. In general, most reptiles can withstand weeks to months of anorexia, so body condition score is more useful than history of appetite to judge nutritional status. Keep in mind that blood glucose concentration less than 20 mg/dl can be normal for some reptiles, so it is important to check a reference for normal values.[5]

Methods of fluid administration

Fluids may be administered 1) per os, 2) via oro-gastric intubation, 2) subcutaneously, 3) intracoelomically, 4) intravenously, or 5) intraosseously. If a patient will not drink voluntarily when offered water, then the author prefers subcutaneous fluid administration over intracoelomic for several reasons. First, fluids are absorbed rapidly from the subcutaneous space in individuals with normal oncotic pressure and appropriate body temperature. Secondly, when fluids are placed into the subcutaneous space, it is possible to visually identify when they have not been absorbed because pitting edema will occur, whereas ultrasound or other imaging technique is required to monitor the absorption of fluids placed into the coelomic cavity. Third, the subcutaneous location avoids the risk of accidental placement into internal organs because the exact location and size of the organs is not predictable among species, between the sexes, and even in the same individual at different times. Accidental fluid administration into lungs, gastrointestinal tract, reproductive tract, urinary bladder, or other organ is common with intracoelomic administration and the person who administered the fluids is not aware of the mistake unless exploratory surgery or necropsy is performed. Some authors recommend avoiding subcutaneous fluids in snakes because in some animals the subcutaneous space does not readily accept large volumes; this is, however, species specific and small volumes can be administered in multiple subcutaneous locations if necessary.

Many reptiles voluntarily drink when placed into a shallow, tepid (27–30°C) water bath for 10 min. Ensure the patient is strong enough to avoid drowning and monitor the water bath temperature with a thermometer. There is no evidence to support the hypothesis that reptiles might “drink” via the cloaca, though some authors have misreported the results of studies on the hypothesis.[6-8] Orogastric intubation is used commonly in patients that require feeding, but is usually not attempted for fluid therapy alone because it is more stressful than other methods. Administer subcutaneous fluids under the skin that overlies the scapula in lizards or the epaxial muscles of the body in snakes and lizards. Administer subcutaneous fluids under the skin overlying the humerus or femur in turtles and tortoises. Catheterize the jugular vein in chelonians; a cut-down may be necessary to identify and secure the vein. Use heavy sedation if necessary and local anesthesia; secure the catheter in place with skin sutures. Catheterize the ventral caudal vein in large lizards. Jugular catheterization is possible in some lizards, though it requires surgical dissection in species with a short, muscular neck. Use local and/or general anesthesia and sterile technique to place intraosseous catheters distoproximally into the femur or proximodistally into the tibia of lizards or chelonians. In snakes, perform a ventrolateral surgical approach to expose the jugular vein within the cranial $1/5^{th}$ of the coelomic cavity under general anesthesia. A catheter can be placed into the cardiac ventricle of snakes without surgery. Other vascular access sites are available, but they are generally not as useful as those recommended here.

Methods of nutritional support

Feed only well-hydrated reptiles with reasonably good mentation; never feed a dehydrated reptile. Start by offering an array of species-appropriate food items presented in a manner that is appropriate for the species. Then try assisted feeding either by holding food items in front of the reptile’s nose (with tongs or forceps) or by placing small volumes of feed paste into the mouth with a rubber-tipped syringe. If the patient refuses to eat for several days after it is well hydrated, then consider orogastric tube feeding. No clinical trial of total parenteral nutrition has been reported, though glucose can safely be added to parenteral fluids for short-term support.

Long-term nutritional support can be provided via esophagostomy tube in anorectic chelonians, and may be attempted in lizards and snakes with oral or facial lesions that preclude use of the mouth. Use chemical restraint in all but the most obtunded patients, and always use local anesthesia. Pre-measure the tube to the midpoint of the body in lizards and chelonians or ⅓ to ½ the distance from the snout to the vent in snakes. Perform percutaneous esophagotomy with a scalpel blade over the tips of hemostats placed from the mouth approximately ½ the way between the head and the thoracic inlet (about twice the length of the head in snakes). Avoid incising the jugular vein; use ultrasound to identify the major vessels if needed. Ensure the tube is within the lumen of the esophagus by passing it orally before redirecting it aborally back into the distal esophagus. Secure the tube to the skin with sutures using tape butterfly or “finger trap” pattern on tube.

Fluid therapy: when, what, and how much

Many of the reptiles that are presented for emergency care are chronically dehydrated and volume depleted. These patients require fluid therapy and parenteral routes should be used in those with signs of moderate to severe signs. Intravenous or intraosseous routes are reserved for cases of acute volume depletion or those that need colloids or glucose. Calculate maintenance (10 to 20 ml/kg/day) plus deficit (relative acute body weight loss); replace losses over 72 to 96 hours because rapid expansion of the intravascular space and hydration of the interstitial space are not necessarily followed by rapid rehydration of the intracellular space.[9,10] Warm fluids to the optimal body temperature and provide approximately 25 to 30 ml/kg/day; avoid rates in excess of 40 ml/kg/day. Some authors recommend directed free water replacement in reptiles with plasma sodium >160 mEq/L,[9] but this hypothesis has not been tested, and clinical success with mixed electrolyte solutions indicates this is probably unnecessary. Use a metered pump to deliver intra-osseous or intravenous fluids; use a burette to prevent accidental delivery of excess fluids.

Select the type of fluids using data from the minimum objective database (e.g., blood albumin, electrolytes, glucose) and standard pathophysiological rationale. Parenteral crystalloid options include Plasma-Lyte A (294 mOsmol/L; Baxter Healthcare, Deerfield, IL), Normosol-R (294 mOsmol/L; Abbott Laboratories, North Chicago, IL), lactated Ringer's solution (273 mOsmol/L; LRS; Abbott Laboratories), 5% dextrose (253 mOsmol/L; D_5W), 0.9% NaCl (308 mOsmol/L), and combinations. Some authors recommend diluting crystalloids with dextrose in water to more closely approximate "normal" reptile blood osmolality because it has been postulated that commercially available crystalloids might be hypertonic and therefore detrimental.[6] This hypothesis is not clinically useful because reptiles are adapted to tolerate severe dehydration and widely ranging plasma osmolality (e.g., 250–400 mOsm/L) and electrolyte concentrations.[7,11] Dilution of crystalloids is not encouraged by the author, though half-strength LRS/$D_{2.5}W$ (263 mOsmol/L) or 0.45% NaCl/$D_{2.5}W$ (280 mOsmol/L) would be reasonable during the initial stages of therapy for moderately hyperkalemic (K^+=8.0-10.0), severely dehydrated reptile patients. Some authors also postulae that lactated crystalloids may be detrimental, but reptiles tolerate high blood lactate levels (e.g., 20 mmol/L)[12] so the amount of lactate in commercially available crystalloids is not clinically relevant.

Natural colloids include whole blood, plasma, concentrated albumin, and polymerized bovine hemoglobin (Oxyglobin, Biopure, Cambridge, MA, USA); synthetic colloids include hydroxyethyl starches (hetastarch), and dextrans. Colloids (3 to 5 ml/kg bolus) should be used in addition to crystalloids in reptiles with hypoalbuminemia, increased capillary permeability, hypovolemic perfusion deficits, or conditions with less tolerance for large volume infusion (e.g., brain and pulmonary disease and cardiac insufficiency).[9] Homologous (same species) whole blood or plasma transfusion is reasonable in cases of severe acute blood loss anemia or hypoalbuminemia. The safety and efficacy of heterologous (different species) transfusions have not been reported. Although a transfusion may not approximate a return to normal levels of plasma constituents such as coagulation proteins and albumin, even a small amount may be sufficient to rescue a critical patient or provide sufficient protection for a surgical procedure.

The goal of fluid therapy is to restore normal tissue perfusion and cellular fluid/electrolyte balance. Monitor for improvement in mucus membrane moisture and color, eyelid and skin turgidity, eye position, and behavior (e.g., activity & appetite). Heart rate at a stable body temperature is a useful parameter (rate will slow with improving pressure), but non-invasive, indirect blood pressure measurements should not be relied upon to make decisions about fluid therapy. Measure PCV, total protein by refractometer, BUN, and electrolytes over time; adjust therapy accordingly. Body weight is very useful because it can be used to determine whether estimated deficits have been replaced (i.e., 10% dehydrated patient should gain 10% of body weight with fluid therapy). Urination is an indirect measure of hydration and renal perfusion. Monitor urine output, but consider behavioral influences on urination patterns. Adequately hydrated chelonians should void urine approximately every other day and the volume is reported to be approximately 0.5 to 3.0% of body weight per day.[13] Urinating less than once every five days can occur with hyperuricemic or hyperkalemic renal failure in chelonians, even when bathed and treated with appropriate fluids.[13] Urine specific gravity is not useful for monitoring hydration.

Nutritional support: when and what

Anorexia is one of the most common presenting complaints from reptile owners, and nutritional support is frequently included in the long-term medical management of reptile diseases. Proper hydration and body temperature must pave the way for nutritional supplementation to avoid potentially fatal "refeeding syndrome" characterized by hypokalemia and hypophosphatemia. DO NOT RUSH TO FEED. It is often better to wait several days before providing nutritional support beyond diluted simple carbohydrates and electrolytes. Ensure normal muscle strength before attempting to assist feeding a reptile, or risk regurgitation and aspiration pneumonia. Nutritional needs vary among herbivores, omnivores, insectivores, and carnivores, and feeds must be chosen to meet nutritional needs. Several commercially available products are available for assisted enteral feeding of reptiles. The following list includes the products that the author uses and recommends. Nutritional support begins by feeding the enterocytes with either half-strength Pedialyte (Abbott Laboratories) or Gatorade (Stokely-VanCamp, Inc., Oakland, CA). Herbivores may then be fed a variety of species-appropriate vegetables that have been processed in a blender or Critical Care for Herbivores (Oxbow Animal Health, Murdock, NE). Carnivores may be fed insects or whole, skinned rodents that have been processed in a blender, or Carnivore Care (Oxbow Animal Health, Murdock, NE). Omnivores may be fed a combination of vegetables and appropriate prey items that have been processed in a blender or Emeraid Psittacine Omnivore (Lafeber Co., Cornell, IL). Refer to Donoghue[14] for detailed nutrition information.

Estimate nutritional needs based on feeding history, body condition, energy requirements for maintenance, and additional energy requirements for reproduction, growth, recovery from illness, or wound healing. The energy required for maintenance in kcal/day can be designated "standard metabolic rate," or SMR. The energy required for maintenance in kcal/day can be designated "standard metabolic rate," or SMR. In reptiles this is calculated according to body weight (BW) in kilograms by this formula: $SMR=10(BW^{0.75})$. This equals 2.4 kcal/day for a 150 g lizard. Estimate additional energy needs and multiply SMR by a factor between 0.2 and 4.0 to calculate requirements. Begin by feeding most sick reptiles about 1 kcal/100 grams body weight/day. It is reasonable to estimate that the ultimate goal of nutritional supplementation will be about 5 kcal/100 grams body weight/day during the recovery period, though this will probably not be achieved during the hospital stay.

Begin feeding warmed, hydrated, anorectic patients with a small volume of diluted electrolyte and simple carbohydrate solution. After several days of this, move up to water-diluted meals containing 25–50% of SMR. Keep initial volume less than 1% of body weight (w:v). Increase calories, concentration, and volume gradually over the course of several days. In these early stages it is appropriate to divide total daily needs into several small meals spaced evenly over 24 hours. If regurgitation occurs, try further dilution with water and smaller meal volumes. Over time the volume can increase to as much as 3% of the body weight, and meals should be given less often. In fact, most lizards and chelonians only need to eat about 3 times a week. Begin to encourage voluntary feeding as soon as mentation is appropriate and activity levels rise. Discontinue assisted feeding when the patient feeds voluntarily.

References

1. Bartlett PP, Griswold B, Bartlett RD. *Reptiles, Amphibians, and Invertebrates: An Identification and Care Guide*. Hauppage, NY: Barron's Educational Series, Inc.; 2001.
2. Chinnadurai SK, Wrenn A, Devoe RS. Evaluation of noninvasive oscillometric blood pressure monitoring in anesthetized boid snakes. *J Am Vet Med Assoc* 2009; 234:625-630.
3. Chinnadurai S, Devoe R, Koenig A, Gadsen N, Hernandez-Divers S. Comparison of an implantable telemetry device and an oscillometric monitor for measurement of blood pressure in anesthetized and unrestrained green iguanas (*Iguana iguana*). *Proceedings of the Association of Reptilian and Amphibian Veterinarians, 15th Annual Conference* 2008; 94-95.
4. Barrows M, McArthur S, Wilkinson R. Diagnosis. In: McArthur S, Wilkinson R, Meyer J, editors. *Medicine and Surgery of Tortoises and Turtles.* Oxford, England: Blackwell Publishing, Ltd.; 2004. pp. 109-140.
5. Diethelm G. Reptiles. In: Carpenter J, editor. *Exotic Animal Formulary*, 3rd edition. St. Louis, Missouri: Elsevier Saunders; 2005. pp. 53-132.
6. Martinez-Jimenez D, Hernandez-Divers SJ. Emergency care of reptiles. *Vet Clin North Am Exot Anim Pract* 2007; 10:557-585.
7. Minnich JE. The use of water. In: Gans C, Pough FH, editors. *Biology of the Reptilia: Volume12, Physiology C*. New York: Academic Press; 1982. pp. 325-395.
8. Peterson CC, Greenshields D. Negative test for cloacal drinking in a semi-aquatic turtle (*Trachemys scripta*), with comments on the functions of cloacal bursae. *J Exp Zool* 2001; 290:247-254.
9. Mader DR, Rudloff E. Emergency and critical care. In: Mader, DR, editor. *Reptile Medicine and Surgery,* 2nd edition. St. Louis, Missouri: Saunders Elsevier; 2006. pp. 533-548.
10. Mitchell MA. Therapeutics. In: Mader DR, editor. *Reptile Medicine and Surgery*, 2nd edition. St. Louis, Missouri: Saunders Elsevier; 2006. pp. 631-664.
11. Munsey LD. Water loss in five species of lizards. *Comp Biochem Physiol A Physiol* 1972; 43:781-794.
12. Jackson DC. Surviving extreme lactic acidosis: the role of calcium lactate formation in the anoxic turtle. *Respir Physiol Neurobiol* 2004; 144:173-178.
13. McArthur S. Problem solving approach to common diseases of terrestrial and semi-aquatic chelonians. In: McArthur S, Wilkinson R, Meyer J, editors. *Medicine and Surgery of Tortoises and Turtles*. Oxford, UK: Blackwell Publishing Ltd; 2004. pp. 309-377.
14. Donoghue S. Nutrition. In: Mader, DR, editor. *Reptile Medicine and Surgery*, 2nd edition. St. Louis, Missouri: Saunders Elsevier; 2006. pp. 251-298.