Chelonian Emergency and Critical Care

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Abstract

There are numerous chelonian species that arise from a diverse array of habitats. Chelonians are long lived and slow to reach sexual maturity, making them extremely vulnerable to human impacts on their habitat and populations. Unusual anatomic and physiological features, such as the shell and being ectothermic, make chelonians medically challenging for the veterinarian. This article presents information on the medical evaluation and stabilization of critically ill and injured chelonian patients presented to the emergency clinician. History taking, performing a physical examination, recommended diagnostic testing, fluid and transfusion therapy, cardiopulmonary resuscitation principles, nutritional support, hospital environment, and therapeutic agents recommended for the emergency and critical care of chelonians are reviewed. Differential diagnoses are presented for a variety of conditions encountered by the emergency clinician for marine turtles, tortoises, freshwater aquatic turtles, and terrapins. There are significant differences in the disease problems encountered by captive and free-ranging specimens. This review will be useful for the veterinarian working in private practice, zoological or aquarium medicine, and wildlife rehabilitation. Copyright 2005 Elsevier Inc. All rights reserved.

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The order Chelonia[1] or Testudines[2] includes tortoises, turtles, and terrapins and is comprised of approximately 270 species,[1] one quarter of which reside in North America.[2] Chelonians reside in a wide range of ecosystems. Aquatic species occur in marine, brackish, and freshwater habitats, while terrestrial species reside in desert to tropical environments. All reptiles, including Chelonia, are ectothermic and depend on environmental heat and behavior to attain their preferred body temperature (PBT). The preferred optimal temperature zone (POTZ) is a temperature range that allows reptiles to thermoregulate to maintain their PBT. The POTZ varies among the different species of chelonians.

Chelonians have long lifespans, often surpassing humans, and are slow to reach reproductive maturity. For example, the loggerhead sea turtle reaches sexual maturity at approximately 25 to 35 years of age.[3] The slow sexual maturity rates of chelonians tend to make them more susceptible than other vertebrates to human pressure. These pressures include habitat degradation and destruction, collection for commercial traffic such as the pet trade, and exploitation for food and medicinal purposes. Chelonians are extremely hardy animals and can have normal activity despite being critically anemic (hematocrit <5%) and hypoproteinemic (total protein <1 g/dL). They can also survive months without food and tolerate extreme levels of dehydration.

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Triage Principles In Chelonians Presented For Emergency

Ideally, the emergency chelonian patient should be medically evaluated and then stabilized. However, initial emergency treatment may need to take precedence over a diagnostic work-up in a critically ill turtle. When possible, a minimum database should be established before starting emergency therapy. The keys to success in medically managing chelonians are patience, minimizing the stress throughout the course of treatment, minimizing the handling time by being prepared, treating dehydration and maintaining an adequate hydration status, providing appropriate nutritional support, and lastly, maintaining the turtle at its POTZ.

History

The medical history is an important step in assessing the critically ill chelonian.[4,5] Captive specimens have a high incidence of medical problems related to husbandry issues. A questionnaire given to the client or caretaker can save time and request the following essential information:[4]

1. Reference data: date, client and animal identification, common and scientific names, captive or free-ranging specimen, presumed sex and age, duration of ownership, details of previous ownership, time in captivity, reason for presentation.
2. Information on the client's animal collection: animals in direct and indirect contact with the presenting turtle.
3. Free-ranging specimens: GPS coordinates, specific location of where the turtle was found, time and date found, housing and transport conditions since that time, details on any treatment provided.
4. Housing: indoors, outdoors, both; enclosure description.
5. Environment: temperature range, heat source, humidity, lighting, photoperiod, recent changes, filtration and water quality in aquatic specimens.
6. Nutrition: describe diet in detail, seasonal variation in diet, vitamin or mineral supplementation, food preparation and storage, how is water provided and frequency of water changes.
7. Observations: description of activity level, appetite, fecal and urate/urine output and quality and quantity, clinical signs and behavior, and duration of presenting signs.
8. Reproductive data: breeding and egg-laying details.
9. Disease control: methods of disease control, quarantine program details, disinfectants used, information on all humans in contact with the turtle, historical health problems in the collection, recent acquisitions.
10. Hibernation: details of management.

Diagnostic Testing

The initial diagnostic workup may include a physical examination, including body weight and morphometric measurements, clinical pathology, radiography, fecal examination, and possibly other specialized diagnostics. The emergency chelonian patient should be maintained within its POTZ during the diagnostic work-up. When working with these patients, the veterinarian should also minimize the likelihood of transmitting contagious diseases by wearing gloves, hand-washing between patients, and disinfecting equipment during the examination and hospitalization. Chelonians are challenging to evaluate medically and treat due to their highly evolved and effective structural and behavioral defenses. The shell is an anatomical feature unique to chelonians, and the primary reason they are such a medical challenge. The box turtle (*Terrapene* spp.) is the most extreme example of this adaptation and may retreat into its hinged shell so that it is difficult to safely assess without sedation. Depending on the patient's physical condition and the species of chelonian, various levels of restraint will be needed for the initial evaluation. A detailed physical examination may require sedation or anesthesia; however, chemical immobilization should be delayed until the patient has been stabilized.

A systematic approach should be followed when performing a physical examination on a chelonian. An observational examination of the turtle before handling can provide important information. General body condition, including overall musculature and fat, degree of alertness and strength, head and body symmetry, aural swellings, ocular abnormalities (eg, discharge, squinting, and sunken eyes from dehydration), nasal discharge, asymmetric nares, respiratory difficulty, open mouth breathing, cervical swelling, carapacial abnormalities (eg, fractures and other injuries or deformities), lameness or abnormal flipper use, abnormal skin (eg, dry, flaky or ulcerated), an inability to dive or floating asymmetrically

are all abnormalities that can be observed without handling the animal.

A physical examination form that includes a turtle diagram is recommended for recording biological data and external abnormalities such as shell fractures, missing flippers or limbs, and lacerations. Digital images can be used to document specific lesions or injuries for long-term case monitoring. The gender,[6,7] morphometrics, and age should be determined. A rough age estimate may be made by counting scute growth rings; however, these are not necessarily a sensitive method for age determination. Body weight should be recorded before therapy, and then measured serially during treatment. Weight trends can be a good indicator of hydration status.

Deep cloacal temperature may be representative of the chelonian's recent environmental temperature, and is an important parameter to obtain and monitor in hypo- and hyperthermic patients. A digital, distant laser, thermal monitoring device (Raynger St, Raytek Corporation, 1201 Shaffer Road, P.O. Box 1820, Santa Cruz, CA USA) can be used to detect surface body temperature, and when directed at the prefemoral or prescapular areas correlates well with core body temperature.[4] Heart rate and rhythm can be assessed with an esophageal stethoscope, a pulse oximeter cloacal probe, or a doppler probe placed in the region of the thoracic inlet between the distal cervical region and the proximal front leg.[8-10]

Evaluate the limbs for swollen joints and fractures. The plastron and carapace should be evaluated for scute quality, abnormal keratinization, hardness and pliability, pyramiding, fractures, ulceration, malodor, and external parasites or epibionts. Hemorrhage within the scute keratin may be indicative of trauma if localized or septicemia if more generalized. Shell fissures usually occur at the plastron/carapace junction and may indicate septicemia, vasculitis, or hypoproteinemia.[11] Examine the skin for sloughing, abnormal shedding, swellings, edema, abscesses, ulceration, exudate, malodor, and epibiota and external parasites.

Digital palpation of the caudal coelomic cavity through the inguinal fossa can be used to confirm the presence of eggs, cystic calculi, organ enlargement, masses, or fluid. The cloacal region should be examined for swelling, trauma, abnormal discharge, infection, and myiasis. In larger chelonians, digital palpation of the cloaca can be used to assess gravidity, colonic and cloacal tone, cystic calculi or space occupying lesions.[4]

Exteriorizing the head of the chelonian from the shell and performing an oral examination can be difficult for the veterinarian and stressful for the chelonian. This examination may need to be delayed until the turtle is stabilized.[4] Once the head is exteriorized, inspect the oral cavity including the tongue, glottis, choana, and outlets of the eustachian tubes. Particular attention should be given to mucous membrane color, the quantity of mucus, petechiation, plaques, ulceration and caseous material. Be prepared to obtain any diagnostic specimens and administer any medications or nutritional support via a stomach tube if indicated. Perform a complete ophthalmic examination of the cornea, anterior and posterior chambers, and menace and papillary visual reflexes. A periocular examination and evaluation of the beak, mandible, tympanic membranes and nares should also be performed while the head is restrained.

An emergency chelonian minimum database should consist of a hematocrit, total solids, glucose, and subsequently, a complete blood count and plasma biochemical panel. Bacterial blood cultures should be collected before initiating antimicrobial therapy. While the size and patient condition will dictate the amount of blood that can be safely collected, the author generally recommends 0.5 to 0.8 mL/100 g body weight for healthy patients and a reduced sample volume for diseased patients. Lithium or sodium heparin are the anticoagulants of choice, because EDTA can cause red blood cell lysis in chelonians.[12]

A wide range of venipucture sites can be used in chelonians,[4,13-17] and the choice of site should be based on the species, size and condition of patient. Lymph contamination of the blood sample is a common problem in chelonians and will alter many clinical pathology parameters.[13,16,18-20] Collection of blood from the jugular vein is preferred based on the low incidence of lymph dilution from this site,[13] but may be stressful and not always feasible due to the difficulties in accessing the vein. Alternative sites used by the author include the brachial and subcarapacial veins in tortoises, the dorsal tail vein in aquatic species, and the cervical sinus in sea turtles.

Radiography is an important diagnostic tool used to assess chelonian emergencies. Useful reviews of chelonian radiography are available.[21-26] Radiopaque materials such as barnacles should be removed from the shell before performing a radiographic study. Three radiographic views should be routinely performed in chelonians presented for emergency care: anterior-posterior and lateral projections using a horizontal x-ray beam and a dorsoventral view.[22,23] Additional views such as lateral, dorsoventral and oblique, may be needed for specific problems such

as fractures of the limbs or skull. An anterior-posterior horizontal beam radiograph should be taken in chelonians with fractures of the carapace to assess lung involvement.[26] Digestive tract radiographic contrast procedures are often necessary to document intestinal obstruction and foreign bodies.[22]

Determining Hydration Status and Fluid Therapy

On completion of the initial evaluation, the patient should be stabilized. Most chelonians presented for emergency care are dehydrated, thus rehydration is often the first step in treatment. Physical examination findings indicative of dehydration in chelonians include sunken eyes, changes in skin turgor, skin tenting, loss of skin suppleness, dry mouth with ropey, thick oral secretions, depression, a slow and difficult to find heart beat, and minimal to no urination. Venipuncture and tube feeding are more challenging in the dehydrated patient.[1] Weight loss found over 1 to 14 days is likely caused by dehydration, thus serial body weights should be performed during hospitalization.[1] Elevation of the packed cell volume (PCV) and total solids or total protein (TP) can be helpful in determining the extent of dehydration. However, ill chelonians are often anemic and hypoproteinemic, which may mask the extent of dehydration. Serial PCV and plasma TP determinations help assess the status of the patient and target the most appropriate therapeutic regimen. Hypoglycemia or hyperglycemia is often present in sick chelonians. Blood glucose determination is easy, quick, inexpensive and essential in choosing the appropriate fluid therapy in chelonians.

Fluid Types

Selecting the route, rate and type of fluids to administer depends on the species of chelonian and condition of the patient. Fluid choice is frequently dictated by clinician preference, the patient's presenting problem, and clinical pathology and acid-base abnormalities. Many ill tortoises have isotonic or hypotonic dehydration.[27] Lactic acidosis is common in stressed chelonians. Most debilitated chelonians benefit from rehydration therapy and glucose supplementation. Mammalian crystalloid fluid preparations are suitable for chelonians. Fluids commonly used in chelonians include "reptile ringers solution" (one part Lactated Ringers Solution + 2 parts 2.5% dextrose and 0.45% sodium chloride),[27-29] Normasol-R[1], and lactated ringers solution. Use of lactated ringers solution is controversial in chelonians based on the common finding of lactic acidosis.[27,28] It is critical to correct hydration status of the ill chelonian before starting oral nutritional support.

Whole blood transfusions are indicated in cases of acute hemorrhage and life-threatening anemia.[30] Sea turtles with a PCV ≤5% may benefit from a whole blood transfusion from a healthy captive sea turtle donor (Manire, C, pers comm., 2005). Those chelonia with a PCV >5% can often be successfully managed with fluid therapy, iron supplementation, and other supportive measures. The donor and recipient should be the same species, because cross matching has not been perfected in reptiles. Acid-citrate-dextrose solutions are the preferred anticoagulants for storing blood for transfusions.

Hetastarch, diluted 1:2 or 1:3 with 0.9% saline, can be given at a rate of 0.1 mL/kg every 10 to 15 minutes in chelonians with severe shock from massive blood loss.[1] A purified bovine hemoglobin (Oxyglobin, Biopure Corp., Cambridge MA 02141) has had limited clinical use in sea turtles,[29] desert tortoises,[30] and a terrapin[31] without adverse affects. In healthy desert tortoises (*Gopherus agassizi*) this product was administered at dose of 20 mL/kg IV without adverse effect.[30] A Hispaniolan slider, *Trachemys decorata*, was resuscitated after near exsanguinations with the use of Oxyglobin and a single blood transfusion from another individual of the same species. Discolored mucous membranes are normally observed after using this product.[30]

Route of Fluid Therapy

Intravascular. In severely compromised chelonians, intravenous (IV) or intraosseous (IO) routes of fluid administration allow for rapid rehydration and emergency therapy. However, placement and maintenance of catheters in these sites can be technically challenging, especially in aquatic species, and should be reserved for patients that are unconscious or minimally responsive.[1] The jugular vein is the preferred site for IV catheter placement in most chelonians. A small skin incision allows direct visualization of the vessel. After catheter placement, secure the catheter to the skin with tape and or suture.[1,32] Maintaining patency of the jugular catheter may be difficult, especially in active turtles.[33] Intravenous or IO routes are necessary for administration of whole and artificial blood, colloidal fluids, and fluids containing greater than 5% dextrose.[1,30,34-36] Intraosseous catheters may be placed in the distal humerus, distal femur or plastron-carapacial bridge.[33,37] An appropriately sized spinal needle can be inserted into the distal one fourth of the medial aspect of the humerus at an angle of approximately 30 to 45° from

parallel. The needle should be inserted as distally as possible without entering the joint capsule. Confirm the spinal needle position radiographically. The catheterized limb should then be reduced into the fossae and secured with tape to the carapace.[33] The primary disadvantages associated with IO catheters are that the fluid flow rate is limited due to the small bone marrow space, fluid and drug administration may be painful, and the metal of the spinal needle may fatigue and break.[38]

Bolus IV fluid therapy can be used to stabilize some patients before pursuing other routes of administration. The subcarapacial vein is used for most chelonians and the cervical sinus for sea turtles. Advantages to the bolus IV method include easy vessel accessibility, minimal stress to the patient, and repeated vascular access.

The epicoelomic fluid administration site is useful in chelonians that are completely retracted into their shell and difficult to coerce out. McArthur (2004) describes this as the preferred site for fluid administration to critically dehydrated chelonians.[27] The needle should be inserted into the potential space located dorsal to the plastron and ventral to the pectoral muscles, coelom, and the scapulohumeral joint, and directed caudally toward the opposite hind leg.[32]

The intracoelomic (IC) route is commonly used for maintenance fluid therapy in sea turtles. Fluids may be injected into the coelomic cavity through the inguinal fossa. An IC catheter has been described for use in sea turtles for up to 5 days.[27,39] This route is technically easy and allows administration of crystalloid fluids with up to 5% dextrose, however, fluids may not be absorbed rapidly when given by this route. Disadvantages of coelomic administration include the potential of compromising the lung space or perforating the lungs, the urinary bladder,[32] or an ovarian follicle in mature females. Hypoproteinemic patients may have fluid in the coelomic cavity (ascites/anasarca), which will further complicate absorption.

Subcutaneous fluid administration is technically easy. Fluids can be given into any accessible fold of skin, but are typically placed into the inguinal fossa, front limb fossa, or ventral neck fold. Administering the fluids in multiple sites may improve absorption and rehydrate the chelonian faster. Disadvantages to this route include poor absorption in severely debilitated chelonians and that only ≤2.5% dextrose solutions can be administered.

The oral route of fluid administration should be reserved for use in patients with functional gastrointestinal tracts that are mildly to moderately dehydrated and for maintenance fluid therapy. Severely dehydrated and weak turtles tend to regurgitate orally administered fluids. Fluids can be administered directly into the stomach using an appropriately sized, well-lubricated red rubber or metal feeding tube. An equine stomach tube may be used for large chelonians. For long-term oral medication, fluid therapy and nutritional support, an esophagostomy tube should be considered. The stomach volume in most chelonian patients is about 2% of the body weight or 20 mL/kg.[1,32] Anatomically, the stomach is located in the anterior one third to midcoelomic cavity. The distance to the anterior portion of the stomach should be marked on the tube selected for feeding. In species prone to regurgitate after tube feeding, such as sea turtles, the patient should be placed at a slight incline on a padded board to avoid regurgitation and to assist in passing the feeding tube into the stomach. The head and neck should be extended to straighten the esophagus for tube passage. The head should be secured by grasping the turtle on either side behind the mandible. Steady downward pressure will cause the lower jaw to fatigue and open. A padded speculum or polyvinyl chloride tube can be used to keep the mouth open. The turtle should be held in a vertical position after the tube is removed and its head and neck extended until it swallows to prevent leakage or regurgitation.

Finally, soaking mildly dehydrated patients in shallow luke warm water (75-80° F), which reaches to just below the chin when the head is retracted, will assist in rehydration.[32] Mildly dehydrated marine and estuarine turtles will benefit from placement in fresh water for 24 hours. Not only will this help to rehydrate these animals, but exposure to fresh water will also reduce the epibota load. Fluids, various drugs, elemental diets, and dewormers may be administered by the intracloacal route.[1,40] Absorption may be improved if the caudal aspect of the turtle is elevated higher than the cranial aspect for 10 to 20 minute after fluid administration.

Volume of Fluids to Administer. The volume of fluids to administer depends on the degree of dehydration and if hypoproteinemia and anemia are present. Fluid volume should not exceed 2 to 3% total body weight (TBW) in chelonians.[41] Generally recommended maintenance fluid rates range from 15 mL/kg/d in species greater than 1 kg to 25 mL/kg/d in species less than one kilogram. A severely dehydrated patient may tolerate up to 40 mL/kg/d. However, over hydration is a concern because of the slow metabolism in chelonians.[32] Infusion or syringe pumps can be used to accurately control the flow rate.

Table 1. Emergency Drugs Used to Treat Chelonians

Drug	Dosage	Comments
Doxapram	5 mg/kg IM, IV[1]	Respiratory stimulant
Prednisolone sodium succinate	5 to 10 mg/kg IV[1]	Short-acting steroid, used in shock therapy
Dexamethosone sodium phosphate	0.1-0.25 mg/kg IV/IM[1]	Same as above
Methylprednisolone	20 mg/kg IV[1]	Short-acting steroid, CNS trauma
Glycopyrrolate	0.01 mg/kg or 0.05 ml/kg IV, IM, SC[1]	Treat bradycardia
Atropine	0.01-0.02 mg/kg IV, IM, SC[1]	Treat bradycardia
Epinephrine (1:1000, 1 mg/ml)	0.1 mg/kg IV, intracardiac[177]	Cardiac stimulant
Midazolam	1.0 to 2 mg/kg IM or IV[67]	Control seizures
Diazepam	0.5 mg/kg IV[79]	Control seizures
Activated charcoal, kaolin	2-8 gm/kg oral via stomach tube[93]	Absorbs and neutralizes some poisons
Calcium EDTA	10-40 mg/kg IM q12 h[79]	Heavy metal chelator, zinc and lead toxicity
Vitamin K_1	0.2-2.5 mg/kg PO or IM[176], as needed	Coagulopathies, hepatic disease
Iron dextran	12 mg/kg IM 1-2 times/wk[176]	Iron-deficiency anemia
Calcium gluconate	100 mg/kg IM or IC q 8 h[176]	Hypocalcemia
Calcium lactate/Calcium glycerophosphate	10 mg/kg SC, IM[176]	Hypocalcemia
Potassium chloride	15-30 mEq/L of fluid[29]	Hypokalemia
50% dextrose	1 mL/kg IV	Recommend administering at 5-10% in fluids slow bolus for hypoglycemia
Mineral oil	6-10 mg/kg PO[79]	
Cisapride	0.5-2.0 mg/kg PO q 24 h[176]	Gastrointestinal stasis

CPR Principles in Chelonians

The following protocol is recommended for chelonians presented in respiratory or cardiovascular arrest. First, determine if the animal has a heartbeat with a Doppler probe, electrocardiogram, and/or ultrasound. Proceed only if cardiac electrical activity is present. Second, extend the head and neck, swab the mouth to remove any materials blocking the glottis, and intubate the patient with an uncuffed endotracheal (ET) tube. Use suction and or gravity to remove any material from the ET. Ventilate the patient with oxygen. An ambubag can be used for field emergencies. Lubricate the eyes if they are open. In the author's experience, resuscitation is futile if there is pungent odor on exhalation or suction, reduced global pressure that gives the eyes a dented appearance, and increased jaw tone. These findings dictate euthanasia even if there is a heart beat.[1] Place an IV or IO catheter, obtain blood for a minimum database, and then bolus fluids and emergency medications. If the heart rate remains below 20 bpm with ventilation and bolus fluids, glycopyrrolate (IV) or atropine (IV) should be administered.[1] Epinephrine can be given IV, IO, IP, intratracheally or intracardiac.[33]

Therapeutic Agents Used in Chelonian Emergency and Critical Care

Although several pharmacokinetic studies have recently been conducted on chelonians,[42-53] limited information is available on accurate dosing for the numerous species presented to the emergency clinician (Refer to Tables 1, 2, and 3 for dosages). Drugs with available pharmacokinetic data should be selected when possible. Although there are limitations to metabolic scaling, it can be a useful tool when no pharmacokinetic data are available.[1] Because sick chelonians do not necessarily absorb drugs well, it is important to correct hypothermia, dehydration, hypoglycemia, acid-base and electrolyte imbalances before or in conjunction with starting other therapeutic agents. This is especially important when using nephrotoxic or hepatotoxic drugs and anesthetics. Drug pharmacokinetics are temperature dependent

Table 2. Antimicrobials Used to Manage Critical Care Chelonian Patients

Drug	Dosage and frequency	Comments
Amikacin	*5 mg/kg IM q 48 h (gopher tortoises)[42], 2.5-3.0 mg/kg IM q 72 h (sea turtles), 50 mg/10 ml saline × 30 min nebulization q 12 h	Targets primarily Gram-negative bacteria, potentially nephrotoxic
Ceftazidime	*20 mg/kg SC, IM, IV q 72 h[44,45]	Targets primarily Gram-negative bacteria, less nephrotoxic than amikacin
Chloramphenicol	30-50 mg/kg IM q24h, 50 mg/kg PO q24h[79]	Bacteriostatic, aerobic, and anaerobic antibacterial spectrum
Clarithromycin	*15 mg/kg PO q 48-72 h[47]	Used to treat *Mycoplasma* URTD
Clindamycin	5 mg/kg PO/IM q 24 h	Good anaerobic spectrum, use in combination with amikacin, ceftazidime, or enrofloxacin
Enrofloxacin	*5 mg/kg SC/IM q 24-48 h,[49,50] *10 mg/kg PO q 24 h[53]	Irritating to tissue, recommend diluting and giving SQ
Metronidazole	*20 mg/kg PO q 48 h (anaerobes) (yellow rat snakes and iguanas)[48]	Excellent efficacy against anaerobic bacteria, very bitter, potential for toxicity
Fluconazole	*21 mg/kg loading dose, then 10 mg/kg q 5 d SQ, IV[51]	
Itraconazole	*5 mg/kg PO SID or 15 mg/kg PO q 72 h (sea turtles)[46]	
Acyclovir	80 mg/kg PO SID[1] to TID[30]; Topical (5% ointment) q 12 h[30]	

**indicates the dose is based on pharmacokinetics, duration of therapy will depend on the clinical problem and response, but most antimicrobial regimens in critically ill chelonians are administered for a minimum of 2-3 weeks.*

in reptiles, and it is best to maintain the chelonian patient at its POTZ during therapy.[32] Many medications are unpalatable when administered orally, but can be followed by something palatable (eg, a/d diet, tuna juice, fruit or sweet vegetable baby food) to lessen the negative effect.[1]

Antimicrobial Therapy in the Critically Ill Chelonian

Sick and injured turtles are usually given broad-spectrum antibiotics as a treatment for established bacterial infections or as a preventive measure (Refer to Table 2 for dosages). Diagnostic samples should be obtained for culture and antimicrobial sensitivity testing before starting antibiotic therapy whenever possible. Although controversial, the front half of body, including the soft tissues of the forelimbs and neck, should be used for injections,[1,54,55] especially when using nephrotoxic drugs. Enrofloxacin is a commonly used antibiotic in chelonians and has good efficacy against aerobic Gram-negative bacteria. Unfortunately, it can cause tissue necrosis when injected multiple times IM or SQ and is painful on administration. The irritating effect of the drug can be reduced significantly by diluting it in fluids or sterile water and using the subcutaneous route for injection. Once the patient is stabilized, it can be administered orally.[53] Anaerobic bacteria can also cause significant morbidity in chelonians and should be considered when deciding on a therapeutic plan.

Analgesic in the Critically Ill Chelonian

Many critically ill chelonians are painful and benefit from analgesics. Chelonians are relatively stoic and challenging to assess for pain (refer to Table 3 for dosages). Pain may be exhibited in chelonians by a decreased appetite, depression, or alteration in normal behavior. The nonsteroidal antiinflammatory drugs (NSAID) are long acting and decrease endotoxin production in septic patients.[1,56,57] Meloxicam, carprofen, ketoprofen, and flunixin megalimine have all been used in chelonians.[1,56,57] Although NSAID efficacy has not been evaluated extensively by controlled studies, anorexic and depressed cheloni-

Table 3. Analgesics and Anesthetics Used to Manage Critically Ill Chelonian

Drug	Dosage	Comments
Butorphanol	0.2-2 mg/kg IM, 0.2-0.5 mg/kg IV, IO[67]	Premedication, analgesia, lower dose if debilitated, 4h duration
Buprenorphine	0.1-1 mg/kg IM[67]	Same as above
Meloxicam	*0.2 mg/kg SC, IM, IV; 0.4 mg/kg PO q24-48 hrs[56]	Rehydrate patient prior to administration
Carprofen	1-4 mg/kg PO, SC, IM, IV q24h[175]	Same as above
Medetomidine/ketamine M/K	Tortoises- M: 0.075 to 0.15 mg/kg K:5 mg/kg[58,59,60,65,66]; Aldabra tortoises- M:0.025 to 0.08 mg/kg, K:5 mg/kg[59], Freshwater aquatic turtles- M:0.3 mg/kg, K:5 mg/kg[67], can add 0.4 mg/kg butorphanol to this regimen[67];	Reverse M with atipamazole at 5 times the Medetomidine dose in mg (same volume)
Propofol	10-15 mg/kg IV[67]; desert tortoises: low dose 2-4 mg/kg IV, moderate dose 5-8 mg/kg IV, high dose 12 mg/kg IV[67]	Administer slowly to effect over 1-2 minutes, dilute 1:2 with saline[67]

ans often develop normal feeding behavior and activity after NSAID administration. Adequate hydration and renal function should be assured before NSAID administration and duration of administration should not exceed 3 to 5 days.[57,10]

The opioids, butorphanol and buprenorphine, are commonly used in chelonians to manage pain. The disadvantages associated with opioid administration are that they are relatively short acting and may cause sedation in debilitated patients. Butorphanol is contraindicated in patients with head trauma.[1]

Anesthesia in the Critically Ill Chelonian

While anesthesia or sedation is necessary in some emergency situations, it should be used with caution in dehydrated or debilitated patients (refer to Table 3 for dosages).[1,32] A thorough diagnostic workup should occur before anesthesia and should be delayed if the heart rate less is <15 bpm when the patient is maintained at its POTZ, if blood work reveals a PCV <10% or a plasma TP <2.0 g/dL, or if there is evidence of sepsis or severe respiratory compromise.[1]

Several excellent reviews and controlled studies on injectable and inhalant anesthestic regimens have been recently conducted in chelonians.[57-67] It is important for the emergency clinician to be comfortable with a few anesthetic regimens that can be applied to a wide range of chelonian species under a variety of circumstances. The author's preference for injectable anesthetics include the combination of medetomidine and ketamine[58,59,66] or propofol IV[67] for short, relatively noninvasive procedures or for induction of general anesthesia. The advantages of the medetamidine and ketamine combination are that it may be given IM or IV, the medetomidine is reversible with atipamezole, and very low doses of ketamine may be used because of the synergism with medetomidine. The low ketamine dose does make a significant difference in the level of sedation and muscle relaxation. Butorphanol may be added to the medetomidine and ketamine cocktail for additional analgesia and sedation.[67] Disadvantages of the medetomidine and ketamine anesthetic regimen include significant species variations in anesthesia and sedation in response to the drug combination and induction of significant bradycardia, hypotension, hypercapnia, and hypoxemia. Furthermore, these drugs may be contraindicated in debilitated or dehydrated chelonians, especially those with hepatic or renal dysfunction. The lower end of the dose range should be used in debilitated chelonians. Propofol is a hypnotic sedative that provides rapid induction. While intravenous injection is preferred, the drug does not cause irritation if it is administered extravascularly.[57] If propofol is given by rapid infusion, it can cause a marked respiratory depression.[67] Propofol dosages for chelonians range from 2 to 15 mg/kg, and recovery rates are dose dependent. Use the lower end of the dose range in debilitated chelonians to allow intubation. Local anesthesics, such as lidocaine, may be used alone or in combination with injectable or inhalation anesthesia.[68]

Inhalant anesthetics should be used for invasive or prolonged procedures. In critical chelonian pa-

tients, it may be advisable to use inhalation anesthetics without an injectable induction agent. Ventilation and thermoregulatory support should be maintained during the procedure and throughout the recovery period. Monitor heart rate via a Doppler, pulse oximeter, or ECG. Intraoperative fluid therapy and vascular access for emergency support should be maintained. Although isoflurane is useful in reptiles, sevoflurane provides significant reduction in recovery times and may be more appropriate for critically ill patients.[64] Sea turtles are notorious for prolonged recoveries with a variety of anesthetic regimens and have much faster recoveries when using the reversible combination of medetomidine and ketamine for induction and sevoflurane for maintenance anesthesia.[69]

Nutrition Needs of this Species in the Emergency Setting

Nutritional support is an important component of chelonian critical care.[1] Patients respond more quickly to therapy if their nutritional status is positive.[1] The critically ill chelonian is often immunosuppressed secondary to starvation.[1] Regurgitation and aspiration may occur in dehydrated and debilitated chelonians. These turtles may not be able to digest solid food and the material may remain in the stomach as a result of decreased gastrointestinal (GI) motility. Thus GI nutritional support should not be instituted until the patient has been rehydrated and attains normal blood glucose and GI motility. The volume of formula fed by stomach tube is approximately 7% of the turtle's body weight in grams daily. Begin with smaller volumes and more dilute solutions and steadily increase the volume and concentration to meet the turtle's nutritional requirements. The turtle should be weighed daily during the convalescent period, and the measurement of weight gain or loss can be used as a guide for dietary management.

Esophagostomy tubes (E-tubes) are integral in managing the critically ill chelonian. The stress associated with tube placement is short, and usually far outweighs the stress associated with daily head restraint to administer oral medications, fluid therapy, and nutritional support. An E-tube may be left in place for months, is usually well tolerated by the turtle, and most clients can manage the turtle with an E-tube at home. The tube should be left in until the animal is eating normally. An E-tube may be stressful to patients where the tube prevents them from withdrawing into the shell, and therefore may be contraindicated in such patients. Possible complications of E-tube placement include cellulitis or abscess formation at the stoma site and ulceration or erosion with or without perforation of the gastric wall at the point where the tube contacts the stomach. Smaller patients are at greater risk of developing problems from the E-tube. Smaller tube size and the propensity to clog with thick solutions may limit the ability to meet the patient's nutritional needs. The technique for placing an E-tube has been described.[1,27] Sedation is recommended for tube placement. Test the formula to be used before tube placement to assure it will pass through the tube without clogging. The tube should enter at the mid to lower esophagus rather that the upper esophagus or pharyngeal region. Premeasure the tube and obtain radiographs after E-tube placement to confirm tube positioning. A purse string suture and Chinese finger lock suture will secure the tube. Flexible tubing should be used that allows for flexion and extension of the neck. After feeding, the tube should be flushed with water or saline to remove any gruel. Enteral tube feeding formulas that have been used in various species of chelonians can be found in Table 4.

Hospitalization

A dedicated room or facility designed to accommodate the various levels of medical care required for chelonians is ideal, however, this is usually not practical. The veterinarian and hospital care staff should have access to literature on the natural history and husbandry needs of the various chelonian species presented to the facility for medical care[2,70-75] (www.chelonia.org, world chelonian trust web site). Hospital personnel should be trained in chelonian husbandry and medicine. The importance of infectious disease control during the physical examination, diagnostic work up, and hospitalization cannot be overemphasized. Chelonians with suspected infectious disease should be hospitalized in isolation. In aquatic settings, separate filtration systems should be used for turtles with suspected infectious diseases. Captive specimens should not be exposed to wild specimens and visa versa. The clinician should avoid mixing species and separate animals from different sources. Enclosures should be simple in design and made out of easy to disinfect, nonporous, nonabrasive materials such as plastic, glass, painted or sealed wood, stainless steel, or fiberglass. Plastic storage tubs, plastic swimming pools, and modified plastic dog kennels can be used to house hospitalized chelonians. Intensive care units used for avian species can be used for smaller critically ill chelonians. The best substrate for use in a critical care setting should pose minimal fire risk, if ingested should not cause

Table 4. Enteral Feeding Formulas and Diets for Anorexic and Critically Ill Chelonians

	Enteral diet information	Comments
Herbivores	Critical Care diet (Oxbow Pet Products, 29012 Mill Road, Murdock, NE 68407, 800-249-0366)	Alfalfa based product, may clog smaller tubes, www.oxbowhay.com
	1 part alfalfa pellets blended for several minutes with 2-4 parts water	Very thick and may clog tube
	Alfalfa Powder[78] (NOW foods, Glendale Heights, IL 60108), comprised of alfalfa that has been harvested, dried and powdered, can mix with fruit baby foods for frugivorous species	Health or natural food stores, 1 part volume powder to 5 parts of water, only short term by itself, add extra calcium, Vit D, psyllium (methylcellulose)-motility disorders
	Green Powder[78] (NOW foods, Glendale Heights, IL 60108), comprised of barley grass that has been harvested, dried and powdered.	Same as above, more crude fiber, lower crude protein, lower levels of Ca and Ph so better for gout and renal failure
	Emeraid II (Lafeber Co., Cornell, IL 61319)	
	Walkabout Farms enteral feeding diets	http:www.herpnutrition.com
Omnivores/ Carnivores	Canine/feline a/d diet® (Hill's Pet Nutrition, Inc., Topeka, KS 66601) (mixed with 4 jars of vegetable baby food)	
	Critical Care diet (Oxbow Pet Products)	
	Ensure ®(Abbott Laboratories, Abbott Park, IL 60064) alone or mixed with fish blenderized (sea turtles), add mixed green vegetables for green sea turtles (*Chelonia mydas*)	Add vitamin/mineral supplementation
	Walkabout Farms enteral feeding diets	http:www.herpnutrition.com
Elemental diets easily absorbable	1) Peptamen (elemental diet for children) (Nestle USA Inc., Deerfield, IL 60015)	
	2) Vivonex Novartis, (Novartis, Minneapolis, MN 55416)	

an impaction, and should allow for proper wound and waste management.[76,77] Compressed, baled hemp chippings, shredded paper, newspaper, and rabbit pellets may be used.[76,77] Hide areas within the enclosure should be used to make the patient more comfortable and assist in thermoregulation. Hides can be made out of disposable materials such as cardboard boxes and margarine containers with holes cut in them. Appropriate containers for food and water should also be provided.

Hospital personnel should become familiar with the POTZ for the species presented for emergency evaluation and potential hospitalization. In general, reptiles are hospitalized at the mid- to high end of their POTZ, but should still be provided with a thermogradient. Basking lights, infrared ceramic heat bulbs, or thermostatically controlled radiant heating panels can be mounted to walls of the enclosure or the cage front. The heat source should always be placed outside of the enclosure. Under tank/enclosure heating elements are not recommended. Diurnal heat cycles (lowering the temperature at night) are beneficial to recovering chelonians.[76] Infrared or ceramic heat emitters can be used as nighttime heat sources without affecting photoperiod. Timers can be set for light and heat source activation. The environmental temperature for a hospitalized patient should be monitored daily with maximum and minimum thermometers or digital thermometers. Sick chelonians that are too weak to move from a heat source should be monitored closely.

Basking chelonians require exposure to full spectrum lighting.[78] Several weaker UVA and UVB-emitting fluorescent tubes are commercially available.[78] However, artificial lights cannot replace the benefits of natural sunlight, thus moving the patient out-

doors when weather permits is probably best. Containers that facilitate moving the patient inside and outside are helpful and efficient.[76]

Humidity should be measured and monitored in all enclosures. As a general rule, desert chelonians need to be kept at humidity levels <40%, while tropical species need humidity levels of > 60%.[77] The humidity can be increased if necessary by providing heated water in bathing areas, regular misting and dampening of substrate, using damp soil or peat/sand base substrate, and keeping lids on holding areas. Open top enclosures will provide better ventilation and are preferred for most chelonians.[76]

Initially, debilitated aquatic and semiaquatic species should be dry docked on a padded surface, such as a shower box or plastic draining board mats.[79] These turtles can be kept moist by regular misting and placing Vaseline or another water soluble (K-Y) jelly on the skin and shell. Once stabilized, these animals require specialized facilities. Marine turtles should be provided specially designed circular fiberglass tanks with a filtration system and continuous flow, temperature controlled salt water. You must adjust water levels to accommodate turtles with varying degrees of debilitation. Water quality issues need to be addressed for all aquatic species. Semiaquatic species need haul out areas with a basking heat source. Turtles should not have direct access to electrical outlets, cords or filtration systems.

Differential Diagnosis and Medical Principles of Emergency Care in Chelonians

The general medical, surgical, and emergency care principles used in various chelonian species are similar. Medical problems differ significantly between chelonians coming from a captive or free-ranging environment. The majority of problems encountered in captive chelonians can be traced back to improper husbandry. It is not uncommon for a captive chelonian with a chronic medical problem to present as an emergency. The environment (marine, freshwater, estuarine, terrestrial) of free-ranging chelonians will dictate the types of problems that are encountered.

Traumatic Injuries

Trauma is a common reason for chelonians to be presented for emergency care. Chelonians that experience a traumatic injury may present with uncontrolled hemorrhage, lacerations, head trauma, and fracture of the limbs, skull, mandible, or shell. Problems encountered in free-ranging marine turtles may include boat related injuries secondary to propeller or direct impact, encounters with predators such as sharks, entrapment in dredging equipment, dropping on a boat deck after incidental capture, and wounds created from fishing gear entanglement such as nets, fishing line, crab and fish traps and plastic rings from beverage containers. Captive marine turtles are predisposed to traumatic bite wounds from interspecific (eg, shark in same aquarium) or intraspecific aggression. Sea turtles should not be housed together if space is limited. Freshwater and estuarine species, such as the diamond back terrapin *(Malaclemys terrapin)*, encounter similar traumatic injuries as marine specimens. Aquatic and terrestrial chelonians are commonly hit by automobiles or trucks when crossing roads. Predators, primarily carnivores, commonly cause severe damage to freshwater and terrestrial chelonians by gnawing on the limbs and shell.[32]

Traumatic injuries in chelonians often involve the central nervous system (CNS) and require immediate attention. Short-acting corticosteroids such as methylprednisolone, dexamethasone sodium phosphate, or prednisolone sodium succinate should be administered IV and then repeated in 12 to 24 hours.[1] Supportive care, wound care, broad-spectrum antibiotics, and analgesics are indicated depending on the type of injury. Warm the patient to ambient indoor temperatures (68 - 75 F; 20 - 30° C) only after hemostasis is achieved, antibiotics are on board, and vital signs are stable.[1] Warmed animals have higher O_2 demands, increased potential for hemorrhage, and increased bacterial growth in contaminated wounds. Once the turtle is stabilized, radiographs can be taken to determine the extent of the injuries, prognosis and plan for further therapy. In cases of hind limb paresis, it is important to rule out a spinal or pelvic fracture. Pelvic fractures may predispose female turtles to dystocia; therefore, these animals should not be released into the wild.

Uncontrolled hemorrhage should be addressed immediately. This can be accomplished by digital pressure, a pressure bandage, vessel ligation with suture, or by surgical electrocautery. Carapace and plastron fractures are common in chelonians. After radiographic evaluation, the fracture site and surrounding tissue should be cleaned with dilute chlorhexidine, betadine, or saline. A wet-to-dry bandage may be placed over the injury to further decontaminate the wound. Foreign debris should be carefully removed from the fracture site. If the coelomic cavity is open, minimize contamination. Fractures of the carapace over the lungs or of the bridge may put the

patient at risk for bacterial and fungal pneumonia. After cleansing, the shell fracture should be reduced. If realignment is difficult or a spinal injury is suspected, then fracture alignment should be approached with caution or delayed. After cleansing and drying the fracture, the wound should be dressed. Silver sulfadiazine (SSD) cream or triple antibiotic ointment are applied to open shell fractures and wounds. The author recommends covering open wounds and shell fractures with a silver-coated mesh (Acticoat with silcryst nanocrystals, Smith & Nephew, Inc., Largo, FL USA). This product provides 72 hours of antibacterial and antifungal activity; however, it must be kept moist with sterile water while being used. DuoDerm or tegaderm can be used to cover various dressing materials and keep the wound clean and dry. For a more waterproof bandage, tissue glue can be applied to the edges of the adherent bandages. Vet wrap (3-M Corp., St. Paul, MN USA) can be used to keep the dressing in place and stabilize the fracture. Aquatic species should be kept in shallow water or may need to be dry docked until a waterproof bandage is placed over the wound or fracture or until final repair. Shell fracture repair methods have been described previously.[1,26]

All skin wounds should be cleaned and debrided as described for shell injuries. Primary closure should be reserved for noncontaminated wounds. Contaminated wounds should be left open to heal by second intention or closed using a delayed technique once the wound has been decontaminated. Reptiles produce thick caseous abscesses. Because these abscesses do not drain well, penrose drains are generally not used for wound care. In areas that are difficult to bandage, suture loops can be placed around the wound, the preferred topical treatment and dressing applied, and umbilical tape placed through the suture loops and tied together like a shoelace to hold the dressing in place. This method allows for regular wound cleaning and bandaging.

Fractured limbs in chelonians may result as a consequence to a variety of traumatic insults, such as being hit by a car or boat, being dropped, or having excessive force applied to the limbs when extricating them for tube feeding. Chelonians suspected to have metabolic bone disease should be handled with caution, as they are predisposed to pathological fractures. Patient stabilization takes priority over permanent fracture repair. Various methods or combinations of methods may be used to repair a long bone fracture in a chelonian. Several excellent reviews are available on chelonian and reptile orthopedic procedures.[26]

Vomiting, Ileus, Obstruction

Vomiting or regurgitation in chelonians is usually indicative of a poor prognosis.[32] A thorough diagnostic work up should be performed to make a definitive diagnosis. Some causes of vomiting include foreign body or other gastrointestinal obstruction, noxious tasting materials, dehydration and debilitation, gastric stasis, gastrointestinal yeast, and parasitism. Vomiting is more common in anorectic and debilitated turtles than tortoises.[1] Turtles should be rehydrated and stabilized first, and then tube fed with an easily digestible elemental diet such as Peptamen (Nestle USA, Inc., Deerfield, IL USA). The neck should be extended and the turtle held in a vertical position after the tube is removed to prevent regurgitation. Higher caloric diets should be introduced gradually.

Heavily parasitized turtles and tortoises may become partially or completely obstructed with nematodes after being dewormed with relatively low doses of fenbendazole (30 mg/kg PO once).[11] These patients should be rehydrated and stabilized to ensure that they regain their normal gastrointestinal motility. To prevent this complication, always start debilitated chelonians with lower doses of anthelminthics (fenbendazole) and gradually increase the dose to the recommended levels of 50 mg/kg over several weeks. The gradual increase in dosage reduces the chance of obstruction by reducing the number of parasites affected per treatment. Fenbendazole, although effective in chelonian species, should be used with caution based on recently described bone marrow suppression effects avian species.[80] Pyrantel pamoate may be a safer alternative anthelminthic to use in debilitated chelonians.

Gastrointestinal stasis or ileus is a common cause of morbidity in debilitated chelonians and must be differentiated from obstruction. Gastrointestinal stasis is precipitated by dehydration, systemic disease, dietary indiscretion, decreased dietary fiber, malnutrition, suboptimal management practices, and seasonal motility changes.[81] Diagnosis is challenging because of difficulties in palpating the chelonian coelomic cavity and the normally slow GI transit time of these animals. Without appropriate treatment, the condition may progress to impaction and obstruction require intensive medical or surgical therapy.[82] Debilitated marine turtles often develop a secondary gastrointestinal stasis and become obstructed with nondigestible prey materials. Radiopaque material and gas in the gastrointestinal tract are visible radiographically. This condition can be resolved with fluid therapy, mineral oil, enemas, and gastrointestinal motility modifiers. The obstruction should be resolved

before offering the animal food. In other chelonians, elucidating the cause of the ileus, correcting the medical problem, and providing supportive care will usually resolve the ileus. Motility modifying drugs, such as metoclopramide and cisapride, are clinically effective in chelonians.[82,83]

Foreign body ingestion is a common emergency presentation in chelonians.[83-87] Occasionally foreign bodies are found incidentally on whole body radiographs. In aquatic species, fishhooks with attached fishing line may become anchored in the oral cavity, esophagus, or other parts of the gastrointestinal tract. These foreign bodies frequently lead to intestinal plication or coelomitis secondary to penetration of the serosal surface of the gastrointestinal tract. A variety of foreign materials, such as plastic bags, metal, and glass, have been found in marine turtle gastrointestinal tracts and may be an incidental finding or lead to an enteritis or obstruction. Ingestion of substrates such as corncob, wood chips, gravel, sand, kitty litter, or walnut shell by captive terrestrial chelonians may cause GI obstruction.[32] The radiographic hallmark sign for intestinal obstruction is the accumulation of radiopaque material in a dilated segment of intestine. A prominent obstructive gas pattern is not always observed. Conservative medical treatment consisting of enemas, parenteral fluids, petroleum laxatives and water given via a stomach tube (15 mL/kg) may be all that is necessary for clinical resolution.[88] However, surgical removal of the foreign body or material may be required in some cases.[83,89,90]

Hypothermia

Hypothermia, or cold stunning, in sea turtles is a wintertime phenomenon where the water temperature suddenly drops below 50°F (10°C).[29] The turtles lose their ability to swim and dive, become buoyant and float to the surface. It is most common in juvenile sea turtles, and has been documented to occur from the Gulf of Mexico to New England and Western Europe. Hypothermia is also a common problem in other chelonian species. Common causes of hypothermia may include escape from a heated enclosure, airline transport, power or heating element failure, and an unexpected drop in nighttime temperatures.[32] Hypothermia has been investigated more thoroughly in sea turtles; however, similar medical management can be applied to other chelonians. Secondary infections, especially bacterial pneumonias, are not uncommon and may not be apparent until several weeks after the initial hypothermic event.[32]

A classification system has been developed for hypothermic sea turtles based on a series of reflex responses, including head lift, cloacal or tail touch reflex, eye touch reflex, and nose touch reflex.[91] The degree of responsiveness can be used to dictate the best approach to be taken and approximate a prognosis. The severity of secondary problems often depends on the length of time the animal has been debilitated and the temperature extremes the turtle was exposed to. Traumatic wounds, dehydration, corneal ulcerations, dermal, carapacial and plastron lesions, flipper tip necrosis consistent with frostbite, and buoyancy disorders are frequent findings in severe cases.[29] Other chelonian species often present with similar clinical signs, including lethargy, poor response to external stimuli, and in extreme cases evidence of frostbite of digits and tail tips.[29]

Common abnormal clinical pathology findings in cases of hypothermia include an initial heterophilic leukocytosis with subsequent development of leukopenia and monocytosis, both regenerative and nonregenerative anemias, hypoglycemia or hyperglycemia, increased creatine phosphokinase (CPK), decreased blood urea nitrogen (BUN), hypocalcemia, hypoproteinemia, hypokalemia, hypernatremia, hyperchloremia, and metabolic acidosis.[29] Electrolyte disturbances may be secondary to malfunctioning salt glands. Cultures of blood and other fluids often reveal localized and systemic bacterial and fungal infections. Radiographs often reveal changes consistent with pneumonia. Coelomic fluid evaluation may reveal evidence of inflammation or infection.[29]

The therapeutic plan for hypothermic sea turtles should include a slow increase in body temperature, gradual reintroduction to sea water from fresh and brackish water over a 2 week period, prophylactic antibiotic and antifungal therapy, nutritional support, and close monitoring of clinical pathology and acid-base abnormalities.[29] Many turtles can have positive clinical outcomes with proper medical attention. Body temperature and heart rate are important parameters to obtain at the time of presentation, and to monitor until the rewarming process is complete. Less severe cases are placed in shallow water, while more severe cases are dry-docked and placed on foam pads. The water or room temperature should initially be only 4-6°F (2-4°C) warmer than the ambient water temperature where the turtle was found. Body temperature should be increased by 5°F (3°C) per day until reaching 75°F (24°C). Broad-spectrum systemic antibacterial and antifungal therapy should be initiated when the turtle reaches 60 to 65°F (16-19°C). The skin and shell should be kept moist with bacteriostatic water and soluble lubricating jelly.

Hyperthermia

Reptiles are less able to compensate for elevated temperatures than mammals or birds. Temperatures over 100°F (38°C) are usually lethal for most chelonians.[32] Hyperthermia in chelonians can occur as a result of placing a turtle in a glass or plastic tank outdoors in the sun, a closed car during the day, or accidental overheating in an enclosure. Ill or injured chelonians stranded on a beach or road also may become overheated. Early clinical signs of hyperthermia include increased activity, retreating to the water, seeking cool areas, and hyperemic skin. Eventually, the turtle develops open mouth breathing, rapid respirations, and may become comatose.[32] Treatment should include cooling the animal, administering fluids and possibly, in severe cases, a short acting steroid to reduce brain swelling.[32] The chelonian should be placed into a shallow pan of cool water (not cold) for a brief period to reduce the core body temperature. Body temperature should be monitored carefully. Subsequently, the turtle should be placed in a small enclosure at the lower end of its POTZ.[32]

Drowning

Despite the chelonian's ability to survive extended periods without breathing and having significant anaerobic respiration adaptations,[32] drowning is a common problem in the aquatic and terrestrial chelonian. A common cause of drowning in marine turtles occurs when the animals are incidentally captured or entangled in shrimp nets or various fishing gear and subsequently trapped underwater for extended periods of time. Diamondback terrapins (*M. terrapin*) are attracted to crab traps and often are unable free themselves once trapped. Terrestrial chelonians may be found at the bottom swimming pools.

Live turtles that have been submerged under water for extended periods of time may present in a comatose state without corneal or deep pain reflexes. The cardiopulmonary resuscitation protocol described previously should be used in cases where there is cardiac and respiratory arrest. Trawl-captured loggerhead sea turtles exhibit a marked acidemia and lactic acidosis when first brought on board.[92] Blood gas and lactate levels should be monitored during the recovery process. Once intubated, the turtle should be placed with its head down to drain fluid from the lungs. Suctioning fluid from the endotracheal tube may be of some benefit. Limb and head pumping, intermittent positive-pressure ventilation (2-6 times per min), and doxapram administration (5-10 mg/kg IV) may assist in reviving the turtle. Aggressive therapy to correct acidosis, electrolyte imbalances, dehydration, and hypothermia may be necessary. Broad-spectrum antimicrobial therapy is usually indicated.

Toxicosis

Chelonians can be exposed to a variety of toxins and contaminants in captivity and the wild. Unfortunately, many of the toxicities that have been documented in captive chelonians are iatrogenic and induced by the veterinary clinician.[93] Ivermectin has been used successfully and safely in a variety of reptiles; however, it is toxic to many species of chelonians.[94] Although there are species differences in susceptibility to the toxic effects of ivermectin, the drug should be avoided in all chelonians. Clinical signs associated with ivermectin intoxication are primarily related to general neuromuscular weakness, and death usually occurs because of respiratory paralysis.[94]

Metronidazole is used to treat anaerobic bacterial infections and amoebiasis in reptiles.[1,48] Tortoises are prone to developing side effects from this drug, and may not tolerate the relatively high doses or duration of therapy necessary to treat amoebiasis effectively.[1] Metronidazole treatment regimens in chelonians need to be tailored to the individual with close monitoring for clinical signs of toxicity. Clinical signs of metronidazole toxicity include anorexia, head tilt, circling, dysequilibrium and signs of hepatotoxicity.[95] Metronidazole toxicity can be fatal in chelonians.

Two red-belled short-necked turtles (*Emydura subglobosa*) with shell lesions were soaked for 45 minutes in a dilute (0.024%) chlorhexidine solution and subsequently developed partial flaccid paralysis and died.[96] Cholecalciferol toxicity has been reported in a leopard tortoise (*Geochelone pardalis*)secondary to ingesting rodent bait.[97] While numerous plant species are suspected to be potentially toxic in chelonians, few published reports have been made on actual toxicosis.[98] Oak toxicity was recently reported as the suspected cause of death in an African spurred tortoise, *Geochelone sulcata*.[99] Lead poisoning has been documented in a wild common snapping turtle (*Chelydra serpentina*) after swallowing a fishing sinker[100] and a tortoise after ingesting lead paint chips.[101] Central nervous system disease predominated in these cases. Sea turtles may encounter waters that contain chemical pollutants, such as petroleum products from oil spills, and present with oil or tar on their skin and shell or systemic signs of toxicity due to ingestion.[79] An increased stranding rate of sea turtles in Florida has been associated with red tide blooms of the dinoflagellate *Karenia brevis*. Affected

animals often present with central nervous system deficits.[102]

A diagnosis of toxicity in a chelonian is usually based on a thorough history, clinical signs, physical examination, and various diagnostic tests. The diagnostic tests generally used to confirm a toxic exposure include contaminant analysis of blood, plasma, stomach contents or tissue, and radiographs. Fluid therapy, wound care, and other supportive measures described previously may be used to treat intoxication. In addition, activated charcoal or psyllium may be used to bind and decrease the absorption of orally ingested toxins,[79] calcium EDTA to treat lead toxicity,[103] midazolam or diazepam[93] to control seizures, and atropine to treat organophosphate toxicity.

Nutritional Diseases and the Critically Ill Chelonian

Some of the more common nutritional diseases that occur in captive chelonians include generalized cachexia/starvation, metabolic bone disease or secondary nutritional hyperparathyroidism, vitamin A deficiency, and iodine deficiency/goiter.[104-106] These patients are often immunnocompromised and predisposed to secondary infections. Nutritional hyperparathyroidism or metabolic bone disease is most common in young growing chelonians and is caused by deficiencies in calcium, vitamin D, an improper calcium/phosphorous ratio, lack of exposure to UV light, or a combination of these factors. Clinical signs may include a soft deformed shell, limb fractures, and a malformed overgrown rhampthotheca.[106] Radiographs can aid in the diagnosis of advanced cases.

Starvation or cachectic myopathy may occur in captive and free-ranging chelonians.[107,108] In captive specimens, primary malnutrition and poor husbandry (eg, suboptimal environmental temperatures) are often responsible. Confiscated Southeast Asian turtles are routinely presented with severe emaciation after being maintained at suboptimal conditions for extended periods of time.[1] Emaciated free-ranging chelonians usually have an underlying problem.[108] The underlying cause of the emaciation may be masked by numerous secondary medical problems such as bacterial or fungal pneumonia, septicemia, and severe endoparasitism.[108] These turtles may be critically anemic, hypoproteinemic, and hypoglycemic. They often have severe ascites, serous atrophy of fat, lymphoid depletion, and bone marrow suppression.

Severely malnourished chelonians may present in a moribund state and require emergency care. Treatment for energy deficiency in chelonians should involve fluid and electrolyte replacement initially and then small but increasing levels of calories. In addition, iron dextran, whole blood or artificial hemoglobin, broad- spectrum antimicrobial drugs, and antiparasitics may be necessary. Specific nutritional problems such as vitamin A deficiency, metabolic bone disease and hypothyroidism should be treated once the turtle has been stabilized.

Dystocia

Most dystocias in chelonians do not present as a medical emergency unless there is an obstructive process involved. It may be difficult to determine when a gravid patient is overdue or when one should intervene. Common causes of dystocia in chelonians include inadequate nesting sites, inadequate thermal environment, malnutrition, dehydration, poor muscle tone, endocrine abnormalities, and metabolic abnormalities such as hypocalcemia. A dystocia is more likely to be a medical emergency when it occurs secondary to reproductive tract or cloaca prolapses, systemic infections, abnormal egg shape and size, stricture or torsion of the oviducts, impingement of the pelvic canal from misaligned healed fractures, uroliths, soft tissue masses, or broken eggs.[109] The dystocia patient may be asymptomatic or may have one or more of the following clinical signs: decreased appetite or anorexia, decreased activity level, excessive basking, restlessness, constant digging behavior, raising the hindquarters accompanied by cloacal aversion, and eventual weakness and lethargy.[109] The diagnostic workup should include a thorough history, physical examination, and radiographs. Radiographs should be evaluated for the presence of eggs, the size, shape, and position of eggs, eggs in the bladder,[110] any broken eggs, bone density, pathological fractures and pelvic fractures, evidence of constipation, and cystic calculi. Ultrasound, hematology, and a serum chemistry profile may provide additional important information in some cases.

Debilitated chelonians suffering from dystocia should be stabilized before oxytocin therapy or surgery. Dehydration, hypothermia, and hypocalcemia should be corrected. Antibiotic therapy and nutritional support may be indicated in some cases. It is important to provide adequate nesting areas, water, and an appropriate thermogradient during the treatment period.[109] In nonobstructive dystocias, the patient may be pretreated with calcium followed by oxytocin. Eggs should pass within 30 to 60 minute.[109] Obstructive dystocias will require surgery in most cases. If the egg can be visualized through the cloaca, ovicentesis and collapsing the egg may be attempted.

If surgery is deemed necessary, an inguinal approach is less invasive and preferred over entering the coelom via a plastron osteotomy. A salpingotomy, salpingectomy, or gonadectomy may be performed depending on the cause of the dystocia and condition of the oviductal tissue.[109] The ovary should always be removed with the oviduct to prevent ovulation into the coelomic cavity during the next reproductive season. A unilateral salpingectomy can be performed to maintain future reproduction.[111]

Urolithiasis

Cystic calculi have been documented in a variety of captive and wild turtle species.[112] The condition is relatively common in California desert tortoises. Most cases result from water deprivation or excess amounts or inappropriate types of dietary protein.[113,114] Emergency care should be sought if the chelonian is straining excessively or develops a prolapse of the uterus or bladder. Treatment should include rehydrating and stabilizing the patient for a surgical cystotomy.[113]

Cloacal and Phallus Prolapses

A cloacal prolapse should be attended to quickly so that the prolapsed organ remains viable. Cloacal prolapses usually occur from excessive straining secondary to an inciting cause, which may include constipation, bacterial enteritis, parasitic enteritis, cystic calculi, egg binding, and other conditions causing straining.[115] In addition to determining the cause of the prolapse, it is important to determine what structure is protruding and its viability.[115] The colon has a lumen with feces inside and a smooth surface. The urinary bladder is thin walled, translucent, and urine may be aspirated from it. The uterus and oviduct have a lumen, no feces, and longitudinal striations on the surface.

Treatment for a cloacal prolapse should include cleaning, lubricating, and replacing the viable tissue back through the vent. Soaking the prolapse in 50% dextrose will reduce the edema to facilitate replacement. A purse string or transverse suture should be used to maintain the reduction. The vent can be surgically enlarged to assist in replacing the prolapsed tissue. In cases of chronic prolapse when the tissue is edematous and friable, it may be difficult to impossible to reduce the tissue and instead require a coeliotomy or amputation. If the colon is prolapsed, a colopexy can be used to prevent recurrence.[115]

Chelonians have a large phallus, which is solid tissue and has no lumen. Phallus prolapses are not uncommon in chelonians, and may occur secondary to an infection, forced separation during copulation, irritation or desiccation from substrates while attempting to breed, constipation, or neurologic defects.[32] The phallus can be reduced using the same techniques described for the cloaca. If the phallus is necrotic, the base of the penis can be double ligated with two vertical mattress sutures and then amputated.[32] Penile amputation will not affect urination but the turtle will not be able to copulate or reproduce.[32]

Parasites

Ectoparasites, such as maggots,[116] ticks,[116] sarcophagid fly larvae,[117,118] leeches,[119] and various epibiota found on sea turtles,[108,119] may contribute to the overall poor condition of a critically ill chelonian and should be manually removed or treated appropriately. Placing marine turtles in freshwater for 24 hours will significantly reduce the parasite load and aid in rehydration.

Endoparasites may be a contributing factor to disease in an already compromised chelonian, and in some cases they may be the primary cause of debilitation.[11,120-129] Stress, overcrowding, poor husbandry, infectious diseases, and immunocompromising conditions may lead to heavy endoparasite infestations. Clinical disease associated with *Entamoeba* spp. is much more prevalent in chelonians than previously recognized.[1,120,121] It is a difficult parasite to identify and treatment may need to be started before a specific diagnosis is made.[1] There are multiple species of amoeba with varying degrees of pathogenicity.[1] The most common clinical signs are diarrhea, often with intermittent blood and mucous, anorexia, depression, and severe dehydration. Treatment consists of aggressive fluid therapy and supportive care. Bonner recommends a prolonged course and high doses of metronidazole (100 to 150 mg/kg sid PO for 5 days, skip 7 days, and then repeat another 5 day course) due to the difficulties in eradicating this parasite.[1] This regimen may be toxic to tortoises. Recent pharmacokinetic studies in the yellow rat snake and green iguana suggest that a dose of 20 mg/kg every 48 hours reaches therapeutic levels for treating anaerobic bacterial infections.[48,130] Metronidazole eliminates the trophozoites stages, while iodoquinol can be used to treat the amoebic cyst stages. Broad-spectrum antimicrobial therapy is often indicated.[1]

Digenetic trematodes of the family Spirorchidae are commonly found in the cardiovascular system of freshwater and marine turtles, and have been implicated as a cause of significant morbidity and mortality in some cases.[18,126,127,129] The eggs are released into the circulatory system, and eventually become trapped within the terminal arterioles of the visceral

organs, extremities and shell. A granulomatous response is produced by the eggs in various tissues, including the gastrointestinal tract, liver, spleen, lungs and CNS.[18,126,127] Clinical signs are related to the pathology caused by the eggs and may include generalized debilitation, severe ulcerative colitis, pitted ulcerations (due to ischemic necrosis) of the carapace and plastron, edematous limbs due to vascular obstruction, and buoyancy problems secondary to pneumonia. A major loggerhead sea turtle stranding event occurred in south Florida in 2001.[129] Most turtles presented with partial paralysis and many had secondary problems. Postmortem results revealed adult trematodes in the brain and spinal cord. No other primary agent has been identified in these turtles. These turtles often respond to supportive care and treatment for the trematodes. Treatment with high dose of praziquantel may be effective in decreasing the severity of clinical signs but will not affect the eggs already in the tissues.[131,132]

Infectious Disease

Several excellent reviews of infectious diseases in chelonians have been published.[128,133,134] Clinical signs associated with infectious disease agents may be severe, present acutely, and warrant emergency care. Upper respiratory tract disease (URTDS) complex is a relatively common reason for chelonians to be presented and provides a good example of dealing with an infectious disease in an emergency setting.[134-141] Herpesvirus, iridovirus and *Mycoplasma agassizii* are important infectious diseases of terrestrial chelonians.[134-141] Infected chelonians often present with an acute onset of clinical signs, including anorexia, depression, and nasal and ocular discharge.[134-142] Herpesvirus and iridovirus infected chelonians frequently present with stomatitis and glossitis,[137,143] whereas this is never observed with *M. agassizii* alone.[138,140,141] Mixed infections of Herpesvirus and *M. agassizii* have been reported, further complicating the diagnosis.[144]

Herpesviruses have been documented to affect many chelonian taxa, and all chelonians should be considered susceptible.[134,135,142-148] These infections are believed to lie dormant in various tissues following the primary infection, and during times of stress, such as hibernation and illegal importation, recrudesce.[134] Herpesvirus infections have been implicated as the causative agent in several diseases of captive and free-ranging sea turtles.[145,147-149] Fibropapilloma disease syndrome (FP) is the most well studied disease affecting sea turtle populations. A herpesvirus has been implicated as the causative agent of the disease syndrome,[147-152] however, environmental pollutants or other unknown immunosuppressive factors are most likely a contributing factor in the disease process.[153] Turtles may have multiple cutaneous FPs found on all soft integumentary tissue, but especially in the axillary and inguinal regions.[147] The FPs can develop on the eyelids, conjunctiva, and cornea and may be so extensive as to impair the turtle's vision.[147] This visual impairment hinders feeding and leads to emaciation. Furthermore, FPs may be found internally in various organs.[152,153] A diagnosis is made by observing typical skin lesions and histopathology.[150] Radiography and laparascopy are used to identify internal FP. Euthanasia is recommended in turtles with internal lesions. Initial treatment consists of correcting dehydration, hypoglycemia, and malnutrition. Antimicrobial therapy is usually indicated before and after surgery. Laser surgery can be used to remove the FPs in stages. In these cases, the skin is often left open to heal by second intention (Pers. comm. Mader D, 2003).

Iridovirus is an important emerging disease in chelonians[137,154] Until recently, it had only been recognized sporadically.[136,155] Frogs are implicated as a reservoir host capable of infecting captive and free-ranging chelonian populations.[137] Viral infections in chelonians are often complicated by secondary bacterial, fungal, and parasitic infections, and should be considered in the diagnostic and therapeutic approach. Diagnostic samples (eg, serology, cytology, histopathology, electron microscopy, culture and PCR) should be collected before initiating treatment.[133,137,156]

Initial emergency therapy should focus on stabilizing the patient with emergency drugs and rehydration. Critical care may consist of broad-spectrum antimicrobial therapy for aerobic and anaerobic bacteria, antifungals, antiviral drugs, fluid therapy, and nutritional support. Acyclovir administered orally and topically has been shown to be clinically effective against both chelonian herpesvirus and iridovirus infections.[137,157]

Bacterial and Fungal Infections

Debilitated and injured chelonians often present with bacterial or fungal infections. These may include infected traumatic injuries, abscesses, stomatitis, shell infections, osteomyelitis, and respiratory disease. Poor husbandry, malnutrition, and a lack of sanitary procedures are predisposing factors for infection in captive specimens. Bacterial abscesses are the most common inflammatory condition in reptiles, and can occur anywhere on the body. Reptile abscesses are most often well encapsulated by fibrous

connective tissue. Gram-negative bacteria cause the highest morbidity in chelonians, however, anaerobic bacteria (eg. *Bacteroides* spp., *Fusobacterium* spp., *Clostridium* spp., and *Peptostreptococcus* spp.) can cause serious disease and should be considered in the therapeutic plan.[158] *Bacteroides* spp. and *Fusobacterium* spp. produce potent tissue toxins, which can cause tissue necrosis and increase the severity of mixed aerobic and anaerobic bacterial infections.[158] *Clostridium* spp. have systemically active toxins that cause hemolysis and renal tubular necrosis.[158] *Salmonella* spp. can cause disease in chelonians and are a potential zoonosis.[159] Atypical mycobacterial infections can cause abscesses, cutaneous and subcutaneous nodules, osteomyelitis, osteoarthritis, and other problems in chelonians.[160] Predisposing factors include debilitation, injury, malnutrition, and other disease processes. This is also a potentially zoonotic disease. *Dermatophilus chelonae* is a newly discovered species of bacteria that grows at lower temperatures than *D. congolensis*.[161,162] Several tortoise and turtle species have been reported to develop skin abscess, dermal nodules, ulcerative stomatitis, septic arthritis, and a granulomatous coelomitis. Middle and inner ear abscesses are commonly seen in captive and wild box turtles and other chelonians.[163,164] Lesions may be unilateral or bilateral. A variety of Gram-negative bacteria have been isolated from most cases, however, anaerobic bacteria, fungal organisms and parasites may be involved.[163,164,165] The route of infection may be via the eustachian tube. Organochlorine toxicity and vitamin A deficiency are predisposing factors.[163]

Shell infections can involve the superficial keratin or may extend into the osteoderms of the carapace and plastron. Aerobic and anaerobic bacteria and mycotic agents are commonly isolated. Mucormycosis has been associated with ulcerative epidermitis in soft-shelled turtles (*Trionyx ferox*). This is a very serious condition in this group of chelonians because of the importance of the integument and shell as a site of oxygen transport and osmotic balance.[166] Culture, cytology, histopathology, and molecular diagnostics are routinely used to diagnose bacterial and fungal infections. Special stains, such as acid-fast stains for *Mycobacteria* spp., also may be needed to make a diagnosis.

Treatment for bacterial infections should include antibiotic therapy based on culture and antimicrobial sensitivity. Anaerobic bacteria should be treated with metronidazole, penicillin, chloramphenicol, or clindamycin.[158] Because of the caseous nature of reptile abscesses, complete surgical excision of the abscess and removal of the accumulated caseous material are required for effective treatment. Antibiotic-impregnated polymethylmethacrylate beads have been used to treat osteomyelitis in reptiles.[167] The silver mesh described previously can be used to pack wounds and provides 72 hrs of antibacterial and antifungal activity. Pharmacokinetic studies involving fluconazole and itraconazole in sea turtles have advanced the treatment capabilities for fungal infections.[46,51]

Pneumonia

Pneumonia is a common problem in critically ill chelonians.[1,168] Suboptimal temperatures, increased humidity, malnutrition, and overcrowding are predisposing factors for pneumonia.[1,168] Because reptiles tolerate an anaerobic environment, they can conceal clinical signs of pneumonia until the condition is severe.[168] Pneumonia can be caused by a wide array of infectious diseases. Gram-negative bacteria are recovered from a large percentage of the cases. These are often opportunistic infections with the same bacteria being considered normal flora in the healthy chelonian.[168] Anaerobic bacteria are more difficult to culture, but do represent an important cause of pneumonia.[158] Although less commonly isolated, atypical bacteria such as *Mycoplasma* spp., *Chlamydiophila* spp., and *Mycobacterium* spp. are also important pathogens to consider.[168,169] Herpesviruses have been implicated as a cause of respiratory disease in several chelonian species,[134,145] and may predispose the patient to secondary bacterial and fungal infections.

Chelonians appear to be more susceptible to fungal pneumonia than other reptile orders.[1,128,170,171] Over exposure to fungal spores, immunosuppression, or overuse of antibiotics are predisposing factors. *Aspergillosis* spp., *Candida* spp., *Mucor* spp., *Geotrichum* spp., *Penicillium* spp., *Cladosporium* spp., *Rhizopus* spp., *Beauveria* spp., *Sporotrichum* spp., *Basidiobolus ranarum* and *Paecilomyces* spp. have all been isolated from chelonians with pneumonia.[128,170-172] Migrating nematode parasites and digenetic spirorchid trematodes may predispose the chelonian to bacterial or fungal pneumonia.[127,129] Aspiration pneumonia may occur in debilitated chelonians.[168] Clinical signs may include anorexia, lethargy, increased or abnormal respiratory sounds, increased respiratory rate (especially at rest), and asymmetric floating in aquatic species.[168] Abnormal posture may also be noted in cases of inspiratory and/or expiratory dyspnea, which may manifest itself as labored breathing with the neck extended and mouth open.[168]

Diagnosis of pneumonia is based on history, physical examination, and horizontal beam anterior-posterior and lateral radiographic views.[168] A tracheal wash should be performed before starting therapy if the patient can tolerate the procedure.[168] Sedation may be necessary. A sterile red rubber catheter or bronchoscope is placed through the glottis, down the trachea, through a bronchus and into the lung. If the pneumonia is determined to be unilateral based on the radiographic findings, then treatment can be targeted to that lung. Sterile saline solution should be flushed through the catheter and then aspirated back. Bronchoscopy is limited to larger patients, but will allow visualization of the respiratory tract and collection of appropriate samples. Cytology and culture should be performed on samples obtained from the pulmonic lavage. Fungal pneumonias often produce localized or diffuse granulomatous nodules, which makes recovery of the organism difficult without a biopsy. Nodules noted on radiographs may be suggestive of fungal involvement.[168,172,173]

Treatment for a fungal pneumonia should include minimizing stress, providing a positive nutritional balance, and maintaining hydration.[1] Patients in extreme respiratory distress from pneumonia should be positioned on a slight incline with their head and forelimbs extended.[1] The animal can be intubated to facilitate suction of debris from the lower respiratory tract. Coupage may be helpful in bringing up debris to be suctioned. Supplemental oxygen may inhibit respiration and compromise the chelonian's limited ability to eliminate inflammatory debris.[1] Oxygen supplementation should be humidified to avoid irritation of the respiratory system.[168] Bacterial pneumonia should be managed with broad-spectrum antibiotics. Nebulization therapy can be used to increase the humidity of the respiratory epithelial microenvironment, improve pulmonary hydration, and increase the mucociliary transport mechanism.[1,168] Furthermore, it assists in breaking up necrotic and inflammatory debris and delivers antimicrobials directly to the site.

Treatment of fungal pneumonia in chelonia is difficult and often unsuccessful. Some authors advocate prophylactic antifungal therapy in susceptible species.[1] Medical management generally consists of oral or subcutaneous fluconazole[51] or itraconazole.[46] Amphotercin B may also be used, and can be delivered directly into an affected lung via a catheter placed through a carapacial osteotomy.[171,174] Granulomatous nodules may require surgical excision.[168] Acyclovir therapy is indicated when herpesvirus is diagnosed or suspected.

Buoyancy Disorders

Aquatic turtles, especially sea turtles, are often presented with buoyancy disorders, where they are unable to float normally at the surface or submerge.[79] Any condition leading to gas or air accumulation in a body organ or in the coelomic cavity may cause abnormal buoyancy. Common causes of this condition include 1) pneumonia, 2) gastrointestinal disease (eg, motility disorders, spinal cord injury, foreign body and other obstructive processes leading to gas accumulation), and 3) free air in the coelomic cavity (respiratory or intestinal leakage or microbial fermentation). Efforts should be directed toward diagnosing the primary problem, which may include blood work, radiology, endoscopy and laparoscopy. Initially the turtle should be stabilized and then attempts should be made to treat the primary disease. Laparoscopic surgery has been used to repair a lung tear in a sea turtle (Pers comm, Dover S, 2004). Intracoelomic administration of large volumes of sterile fluids has been used as an ancillary treatment for this condition in loggerhead sea turtles (Pers comm, Sheridan, T, 2005). Some turtles, especially those with spinal injuries, may remain abnormally buoyant for life.

Septicemia

Bacterial septicemia is a relatively common sequellae to more localized infections. Multiple Gram-negative bacteria are commonly cultured; however, anaerobic bacteria and fungal organisms may also be isolated.[1,175] Clinical signs may include anorexia, lethargy, weakness, red-purple oral mucous membranes, and general malodor of the turtle.[1] Petechial hemorrhages occur initially along marginal scutes and then develop into larger areas of hemorrhage.[1] Hemorrhage across the bridge is a serious clinical sign and can progress to a disseminated intravascular coagulation (DIC)-like syndrome.[1] Successful treatment of sepsis is more likely if clinical signs are recognized early and treatment is begun before diagnosis on predisposed turtles. Leaving these patients at the temperature at which they were received for 72 hrs should be considered as a therapeutic option because warming the patient will facilitate bacterial proliferation.[1] Administer room-temperature fluids and IV broad-spectrum antibiotics while the patient is still cool, and then gradually warm the

patient over a 48 hour span while continuing therapy.[1]

References

1. Bonner BB: Chelonian therapeutics. Vet Clin of North Am Exotic Animal Practice 3:257-332, 2000
2. Ernst CH, Lovich JE, Barbour RW: Introduction, in Ernst CH, Lovich JE, Barbour BW (eds): Turtles of the United States and Canada. Washington, DC, Smithsonian Institution Press, 1994, p xviii
3. Crouse DT, Crowder LB, Caswell HA: A stage-based population model for loggerhead sea turtles and implications for conservation. Ecology 68:1412, 1987
4. Barrows M, McArthur S, Wilkinson: Diagnosis, in McArthur S, Wilkinson R, & Meyer J (eds): Medicine and Surgery of Tortoises and Turtles. Ames, IA, Blackwell Publishing, 2004, pp 109-140
5. Divers SJ: Basic reptile husbandry, history taking and clinical examination. In Practice 18:51-58, 1996
6. McArthur S, Meyer J, Innis C: Anatomy and Physiology, in McArthur S, Wilkinson R, Meyer J (eds): Medicine and Surgery of Tortoises and Turtles. Ames, IA, Blackwell Publishing, 2004, pp 35-72
7. McArthur S: Veterinary Management of Tortoises and Terrapins, Oxford, Blackwell Science, 1996
8. Bennet RA: Anesthesia and analgesia. Sem Avian Exotic Pet Med 7:30-40, 1998
9. Bailey JE, Pablo LS: Anesthetic monitoring and monitoring equipment in small exotic pet practice, in Fudge AM (ed): Sem Avian and Exotic Pet Med Philadelphia, PA, Saunders, 1998, pp 53-60
10. Malley AD: Reptile anesthesia and the practicing veterinary surgeon, In Practice 19:351-370, 1997
11. Norton TM, Lung N, Tabaka C, et al. Medical management of *Manouria emys emys* confiscated from Hong Kong, in: 2003 Scientific Proceedings, Annual Conference of the IUCN Turtle Survival Alliance. Orlando Florida, IUCN Turtle Survival Alliance, 2003
12. Muro J, Cuenca R, Pastor J, et al: Effects of lithium heparin and tripotassium EDTA on hematologic values of Herman's tortoises (*Testudo hermanni*). J Zool Wildl Med 29:40-44, 1998
13. Redrobe S, MacDonald J: Sample collection and clinical pathology of reptiles. Vet Clin North Am (Exotic An Pract) 2:709-730, 1999
14. Martinez-Silvestre A, Perpinan D, Marco I, et al: Venipuncture technique of the occipital venous sinus in freshwater aquatic turtles. J Herpetol Med Surg 12(4):31-32, 2002
15. Lloyd M, Morris P: Chelonian venipuncture techniques. Bull Assoc Reptil Amphib Vet 9:26-29, 1999
16. Jacobson ER: Blood collection techniques in reptiles: laboratory investigations, in Fowler ME, Miller RE (eds): Zoo & Wild Animal Medicine: Current Therapy 3. Philadelphia, PA, WB Saunders Co, 1993, pp 144-152
17. Hernandez-Divers SM, Hernandez-Divers SJ, Wyneken J: Angiographic, anatomic and clinical technique descriptions of a subcarapacial venipuncture site for chelonians. J Herpetol Med Surg 12(2): 32-37, 2002
18. Innis CJ, Kincaid AL: Bilateral calcium phosphate ureteroliths and spirorchid trematode infection in a red-eared slider turtle, *Trachemys scripta elegans*, with a review of the pathology of spirorchiasis. Bull Assoc Reptil Amphib Vet 9:32-35, 1999
19. Lopez-Olivera JR, Montane J, Marco I, et al: Effect of venipuncture site on hematologic and serum biochemical parameters in marginated tortoises (*Testudo margtinata*). J Wildl Dis 39:830-836, 2003
20. Crawshaw GJ, Holz P: Comparison of plasma biochemical values in blood and blood lymph mixtures from red-eared sliders, *Trachemys scripta elegans*. Bull Assoc Reptil Amphib Vet 9:13-15, 1996
21. Taylor SK, Citino SB, Zdziarski JM, et al: Radiographic anatomy and barium sulfate transit time of the gastrointestinal tract of the leopard tortoise. J Zool Wildl Med 27:180-186, 1996
22. Silverman S, Janssen DL: Diagnostic Imaging, in Mader DR (ed): Reptile Medicine and Surgery. Philadelphia, PA, WB Saunders, 1996, pp 258-263
23. Wilkinson R, Hernandez-Divers S, Lafortune M, et al: Diagnostic imaging techniques, in McArthur S, Wilkinson R, & Meyer J (eds): Medicine and Surgery of Tortoises and Turtles. Ames, IA, Blackwell Publishing, 2004, pp 187-208
24. Meyer J: Gastrographin as a gastrointestinal contrast agent in the Greek tortoise (*Testudo hermanni*). J Zoo Wildl Med 29:183-189, 1998
25. De Shaw B, Schoenfeld A, Cook RA, et al: Imaging of reptiles: A comparison study of various radiographic techniques. J Zoo Wildl Med 27:364-370, 1996
26. Mitchell, MA: Diagnosis and management of reptile orthopedic injuries, Vet Clin North Am (Exotic An Pract) 5:97-114, 2000
27. McArthur S: Feeding techniques and fluids: in McArthur S, Wilkinson R, Meyer J (eds): Medicine and Surgery of Tortoises and Turtles. Ames, IA, Blackwell Publishing, 2004, pp 257-272
28. Prezant RM, Jarchow JL: Lactated fluid use in reptiles: Is there a better solution? in 1997 Scientific Proceedings, annual Conference of the Association of Reptile and Amphibian Veterinarians. Houston, Texas, Association of Reptile and Amphibian Veterinarians, 1997, pp 83-87
29. Turnbull BS, Smith CR, Stamper MA: Medical implications of hypothermia in threatened Loggerhead (*Caretta caretta*) and endangered Kemp's Ridley (*Lepidochelys kempi*) and Green (*Chelonia mydas*) sea turtles, in: 2000 Scientific Proceedings, Annual Conference of the American Association of Zoo Veterinarians Conference. New Orleans, LA, 2000, pp 31-35
30. Wilkinson R: Therapeutics, in McArthur S, Wilkinson R, Meyer J (eds): Medicine and Surgery of Tortoises and Turtles. Ames, IA, Blackwell Publishing, 2004, pp 465-503
31. Wack RF, Anderson NL: Resuscitation of a Hispaniolan slider, *Trachemys decorata*, using Oxyglobin® and a blood transfusion J Herpetol Med Surg 14:4, 2004
32. Boyer TH: Emergency care of reptiles, Vet Clin of North Am (Exotic Anim Prac) 1:191-206, 1998
33. Whitaker BR, Krum H: Medical management of sea turtles in aquaria, in Fowler ME, Miller RE (eds):

Zoo & Wild Animal Medicine 4th ed. Philadelphia, PA, WB Saunders, 1999, pp 217-231
34. Rosskopf WJ: Disorders of reptilian leukocytes and erythrocytes, in Laboratory Medicine: Avian and Exotic Pets Fudge AM (ed), Philadelphia, PA, WB Saunders Co, 2000, pp 198-204
35. Divers SJ: Emergency care of the critically ill reptile, in 1997 Scientific Proceedings, Annual Conference of the Association of Reptilian and Amphibian Veterinarians. Houston, Texas, Association of Reptile and Amphibian Veterinarians, 1997, pp 153-162
36. McCracken H, Hyatt AD, Slocombe RF: Two cases of anemia in reptiles treated with blood transfusion (1) hemolytic anemia in a diamond python caused by an erythrocytic virus, (2) nutritional anemia in a bearded dragon, in 1994 Scientific Proceedings, Annual Conference of the American Association of Zoo Veterinarians. Pittsburgh, PA, American Association of Zoo Veterinarians, 1994, pp 47-51
37. Mader DR: Trauma management in reptiles and amphibians. Proc NA Vet Conf 10:742-743, 1997
38. Wellehan JFX, Lafortune M, Gunkel C, et al: Coccygeal vascular catheterization in lizards and crocodilians. J Herpetol Med Surg 14:26-28, 2004
39. Mader, DR, Schaff S, Moretti R, et al: Intracoelomic catheters in sea turtles, in 2002 Scientific Proceedings, Annual Conference of the Association of Reptilian and Amphibian Veterinarians. Reno, NV, Association of Reptilian and Amphibian Veterinarians 2002, pp 31-32
40. Innis C: IME-Per-cloacal worming of tortoises. Bull Assoc Rept Amph Vet 5:4, 1995
41. Jarchow JL: Hospital care of the reptile patient, in Jacobson E, Kollias G Jr (eds): Contemporary Issues in Small Animal Practice 9: Exotic Animals. New York, Churchill Livingstone, 1988, p 59
42. Caligiuri R, Kollias GV, Jacobson E, et al: The effects of ambient temperature on amikacin pharmacokinetics in gopher tortoises. J Vet Pharmacol Ther 13:287-291, 1990
43. Jacobson ER, Harman G, Laille E, et al: Plasma concentrations of praziquantel in loggerhead sea turtles *Caretta caretta* following oral administration of single & multiple doses. Am J Vet Res 64:304-309, 2003
44. Lawrence K, Muggleton PW, Needham JR: Preliminary study on the use of ceftazidime, a broad spectrum cephalosporin antibiotic, in snakes. Res Vet Sci 36:16-20, 1984
45. Stamper MA, Papich MG, Lewbart GA, et al: Pharmacokinetics of ceftazidime in loggerhead sea turtles (*Caretta caretta*) after single intravenous and intramuscular injections. J Zoo Wildl Med 30:32-35, 1999
46. Manire CA, Rhinehart HL, Pennick GJ, et al: Plasma concentrations of itraconazole after oral administration in Kemp's Ridley sea turtles, *Lepidochelys kempi*. J Zool and Wildl Med 34:171-178, 2003
47. Wimsatt J, Johnson J, Mangone BA, et al: Clarithromycin pharmacokinetics in the desert tortoise. J Zoo Wildl Med, 30:36-43, 1999
48. Kolmstetter CM, Frazier D, Cox S, et al: Pharmacokinetics of metronidazole in yellow rat snakes, *Elaphe obsolete quadrivittata*. J Herpetol Med Surg 11:4-8, 2001
49. Prezant RM, Isaza R, Jacobson ER: Plasma concentrations with disposition kinetics of enrofloxacin in gopher tortoises (*Gopherus polyphemus*). J Zoo Wildl Med 25:82-87, 1994
50. Raphael BL, Papich M: Cook RA. Pharmacokinetics of enrofloxacin after a single intramuscular injection in Indian star tortoises (*Geochelone elegans*). J Zoo Wildl Med 25:88-94, 1994
51. Mallo K, Harms CA, Lewbart GA, et al: Pharmacokinetics of fluconazole in loggerhead sea turtles (*Caretta caretta*) after single intravenous and subcutaneous injections, and multiple subcutaneous injections. J Zoo Wildl Med 33:29-35, 2002
52. Holz P, Barker IK, Crawshaw GJ, et al: The anatomy and perfusion of the renal portal system in the red-eared slider (*Trachemys scripta elegans*). J Zoo Wildl Med 28:386-393, 1997
53. James SB, Calle PP, Raphael BL, et al: Comparison of injection versus oral enrofloxacin pharmacokinetics in red-eared slider turtles, *Trachemys scripta elegans*. J Herpetol Med Surg, 13:5-10, 2003
54. Holtz P, Barker IK, Burger JP, et al: The effect of the renal portal system on pharmacokinetic parameters in the red-eared slider (*Trachemys scripta elegans*). J Zoo Wildl Med 28:386-393, 1997
55. Beck K, Loomis M, Lewbart G, et al: Preliminary comparisons of plasma concentrations of gentamicin injected into the cranial and caudal limb musculature of the Eastern box turtle, (*Terrapene carolina carolina*). J Zool Wildl Med 26:265-268, 1995
56. Hernadez-Divers SJ: Single-dose oral and intravenous pharmacokinetics of meloxicam in the green iguana, in 2004 Scientific Proceedings, Annual Conference of the Association of Reptilian and Amphibian Veterinarians, Naples, FL, 2004, pp 106-107
57. McArthur S: Anaesthesia, analgesia, and euthanasia, in McArthur S, Wilkinson R, & Meyer J (eds): Medicine and Surgery of Tortoises and Turtles. Ames, IA, Blackwell Publishing, 2004, pp 379-401
58. Norton TM, Spratt J, Behler J, et al: Medetomidine and ketamine anesthesia with atipamezole reversal in private free ranging tortoises *Gopherus polyphemus*, in 1998 Scientific Proceedings, Annual Conference of the Association of Reptilian and Amphibian Veterinarians. Kansas City, MO, Association of Reptile and Amphibian Veterinarians, 1998, pp 25-27
59. Lock BA, Heard DJ, Dennis P: Preliminary evaluation of medetomidine/ketamine combinations for immobilization and reversal with atipamezole in three tortoise species. Bull Assoc Reptil AmphibVet 8:6-9, 1998
60. Bennett, RA: Review article: A review of anesthesia and chemical restraint in reptiles. J Zoo Wildl Med 22(3):282-303, 1991
61. Page, CD: Current reptilian anesthesia procedures, in Fowler ME, Miller RE (eds): Zoo & Wild Animal Medicine: Current Therapy 3. Philadelphia, PA, WB Saunders Co, 1993, pp 140-143
62. Holz P, Holtz RM: Evaluation of ketamine, ketamine/xylazine, and ketamine/midazolam anesthesia in red-eared sliders. J Zoo Wildl Med 25:531-537, 1994
63. Oppenheim YC, Moon PF: Sedative effects of midazolam in red-eared slider turtles. J Zoo Wildl Med 26:409-413, 1995

64. Rooney MB, Levine G, Gaynor J, et al: Sevoflurane anesthesia in desert tortoises (*Gopherus agassizii*). J Zool and Wildl Med 30:64-69, 1999
65. Sleeman JM, Gaynor J: Sedative and cardiopulmonary effects of medetomidine and reversal with atipamezole in desert tortoises. J Zoo Wildl Med 31: 28-35, 2000
66. Dennis PM, Heard DJ, et al: Cardiopulmonary effects of a medetomidine-ketamine combination administered intravenously in gopher tortoises. J Am Vet Med Assoc, 220:1516-1519, 2002
67. Bennet RA, Divers SJ, Schumacher J, et al: Roundtable-Anesthesia. Bull Assoc Reptil Amphib Vet 9:20-27, 1999
68. Mader DR: Understanding local analgesics: Practical use in the green iguana (Iguana iguana), in 1998 Scientific Proceedings, Annual Conference of the Association of Reptilian and Amphibian Veterinarians. Kansas City, MO, Association of Reptile and Amphibian Veterinarians, 1998, pp 7-10
69. Chittick EJ, Stamper MA, Lewbart GA, et al: Medetomidine, ketamine, and sevoflurane for anesthesia of injured loggerhead sea turtles: 13 cases (1996-2000). J Amer Vet Med Assoc 221:1019-1025
70. Smith C: Desert tortoise care. Bull Assoc Reptil Amphib Vet 4:13-15, 1994
71. Boyer DM, Boyer TH: Tortoise care. Bull Assoc Reptil Amphib Vet 4:16-27, 1994
72. Boyer TH, Boyer DM: Aquatic turtle care. Bull Assoc Reptil Amphib Vet 2:13-17, 1992
73. Boyer TH: Box turtle care. Bull Assoc Reptil Amphib Vet 2:9-14, 1992
74. Higgins BM: Sea Turtle Husbandry, in Lutz PL, Musick JA, Wyneken J (eds): The Biology of Sea Turtles Volume II, Boca Raton, FL, CRC Press, 2003, pp 411-440
75. Gurley R: Keeping and Breeding Freshwater Turtles. Ada, OK, Living Art Publishing, 2003, pp 1-297
76. McArthur S: Hospitalization: in McArthur S, Wilkinson R, & Meyer J (eds): Medicine and Surgery of Tortoises and Turtles. Ames, IA, Blackwell Publishing, 2004, pp 239-255
77. Abrahams R: Housing reptiles in the veterinary hospital. Bull Associ Reptil Amphib Vet 3:6, 1993
78. Wright K: IME-Two Products Useful for Tube-feeding Herbivorous Reptiles. Bull Assoc Rept Amph Vet 7:5-6,1997
79. Adkins E, Driggers T, Ferguson G, et al: Ultraviolet light and reptiles, amphibians, Roundtable. Bull Assoc Reptil Amphib Vet 13:27-37
80. Campbell T: Sea turtle rehabilitation, in Mader DR (ed): Reptile Medicine and Surgery. Philadelphia, PA, WB Saunders, 1996, pp 427-436
81. Howard LL, Papendick R, Stalis IH, et al: Benzimidazole toxicity in birds, in 1999 Scientific Proceedings, Annual Conference of the American Association of Zoo Veterinarians. Columbus, Ohio, American Association of Zoo Veterinarians 1999, p 36
82. Boyer TH: Turtles, Tortoises, and Terrapins, in Mader DR (ed): Reptile Medicine and Surgery. Philadelphia, PA, WB Sauders, 1996, pp 332-335
83. Tothill A, Johnson JD, Wimsatt J, et al: Effect of cisapride, metoclopramide, and erythromycin on gastrointestinal transit time in the desert tortoise. J Herpetol Med and Surg 10:16-20, 2000
84. Helmick KE, Bennett RA, Ginn P, et al: Intestinal volvulus and stricture associated with a leiomyoma in a green turtle (*Chelonia mydas*), J Zoo Wildl Med 31:221-227, 2000
85. McArthur S: Problem-solving approach to conditions of marine turtles: in McArthur S, Wilkinson R, Meyer J (eds): Medicine and Surgery of Tortoises and Turtles. Ames, IA, Blackwell Publishing, 2004, pp 301-307
86. Jaeger GH, Wosar MA, Harms CA, et al: Use of a supraplastron approach to the coelomic cavity for repair of an esophageal tear in a loggerhead turtle. J Am Vet Med Assoc 223:353-355, 2003
87. Schumacher J, Papendick R, Herbst L, et al: Volvulus of the proximal colon in a hawksbill turtle (*Eretmochelys imbricata*). J Zoo Wildl Med: 27:386-391, 1996
88. Reidarson TH, Jantsch CA, Gendron SM: Medical treatment for multiple foreign objects in a hawksbill turtle (*Eretmochelys imbricata*). J Zoo Wildl Med 25: 158-160, 1994
89. Boyer TH: Emergency care of reptiles. Sem Avian Exotic Pet Med 3:210-216, 1994
90. Gould WJ, Yaegar AE, Glennon JC: Surgical correction of an intestinal obstruction in a turtle. J Amer Vet Med Assoc 200:705-706, 1992
91. Lloyd CG: Surgical management of colon prolapse and subsequent stricture in a Mediterranean spurthighed tortoise, *Testudo graeca*. J Herpetol Med Surg 13:10-13, 2003
92. Sandove SS, Pisciotta R, DiGiovanni R: Assessment and initial treatment of cold-stunned sea turtles. Chelon Conserv Biol 3:84-87, 1998
93. Harms CA, Mallo KM, Ross PM, et al: Venous blood gases and lactates of wild loggerhead sea turtles (*Caretta caretta*) following two capture techniques. J Wildl Dis 39:366-374, 2003
94. Wellehan JFX, Gunkel CI: Emergent diseases in reptiles. Sem Avian Exotic Pet Med, 13:160-174, 2004
95. Teare JA, Bush M: Toxicity and efficacy of ivermectin in chelonians. J Am Vet Med Assoc 183:1195-1197, 1983
96. Wilkinson R: Formulary, in McArthur S, Wilkinson R, Meyer J (eds): Medicine and Surgery of Tortoises and Turtles. Ames, IA, Blackwell Publishing, 2004, p 497
97. Lloyd M: Chlorhexidine toxicosis from soaking redbellied short-necked turtles, *Emydura subglobosa*. Bull Assoc Reptil Amphib Vet 6:6-7, 1996
98. Duhr D: Poisoning due to an intake of mice bait with cholecalciferol in combination with acute egg binding in a tortoise. Praktische Tierarzt 79:210-212, 1998
99. McArthur S: Appendices, Plants said to be poisonous to chelonians: in McArthur S, Wilkinson R, Meyer J (eds): Medicine and Surgery of Tortoises and Turtles. Ames, IA, Blackwell Publishing, 2004, pp 511-513
100. Rotstein DS, Lewbart GA, Hobbie K, et al: Suspected oak *Quercus* toxicity in an African spurred tortoise, *Geochelone sulcata*. J Herpetol Med Surg 13:20-21, 2003
101. Borkowski R: Lead poisoning and intestinal perfo-

rations in a snapping turtle due to fishing gear ingestion. J Zoo Wildl Med 28:109-113, 1997
102. Lawton MPC: Neurological disease, in Benyon PH (ed): Manual of Reptiles. British Small Animal Veterinary Association. Ames, IA, Iowa State University Press, 1992, pp 128-137
103. Redlow T, Foley A, Singel K: Sea turtle mortality associated with red tide events in Florida, in Seminoff (compiler): 2002 Scientific Proceedings, 22nd Annual Symposium on Sea Turtle Biology and Conservation, US Dept Commerce NOAA Tech Memo, NMFS-SEFSC, Miami, FL 2002
104. Bennett RA: Neurology, in Mader DR (ed): Reptile Medicine and Surgery. Philadelphia, PA, WB Saunders, 1996, pp 141-148
105. Norton TM, Jacobson ER, Caliguiri R, et al: Medical management of a Galapagos tortoise (*Geochelone elephantopus*) with hypothyroidism. J Zool and Wildl Med 20:212-216, 1989
106. Boyer TH: Hypovitaminosis A and hypervitaminosis A, in Mader DR (ed): Reptile Medicine and Surgery. Philadelphia, PA, WB Saunders, 1996, pp 382-384
107. Boyer TH: Metabolic bone disease, in Mader DR (ed): Reptile Medicine and Surgery. Philadelphia, PA, WB Saunders, 1996, pp 385-391
108. Glazebrook JS, Campbell RSF: A survey of the diseases of marine turtles in northern Australia. II. Oceanarium-reared and wild turtles Dis Aquat Org 9:97-104, 1990
109. Norton TM, Keller JM, Peden-Adams M, et al: Debilitated loggerhead turtle (*Caretta caretta*) syndrome along the southeastern US coast: Incidence, pathogenesis, and monitoring, in: 2005 Scientific Proceedings, 25th Annual Symposium on Sea Turtle Biology and Conservation, Savannah, GA, 2005
110. DeNardo D, Barten SL, Rosenthal KL, et al: Dystocia Roundtable. J Herp Med and Surg, 10:8-17, 2003
111. Thomas HL, Willer CJ, Wasar MA, et al: Egg-retention in the urinary bladder of a Florida cooter turtle, *Pseudemys floridana floridana*. J Herpetol Med Surg 12:4-6, 2002
112. Nutter FB, Lee DD, Stamper MA, et al: Hemiovariosalpingectomy in a loggerhead sea turtle (*Caretta caretta*). Vet Record 146:78-80, 2000
113. McKown RD: A cystic calculus from a wild western spiny soft-shell turtle *Apalone (Trionyx) spiniferus hartwegi*. J Zoo Wildl Med 29:347, 1998
114. Bennett RA, Mader, DR: Soft tissue surgery, in Mader DR (ed): Reptile Medicine and Surgery. Philadelphia, PA, WB Saunders, 1996, pp 295-296
115. McArthur S: Problem-solving approach to common diseases of terrestrial and semi-aquatic chelonians, in McArthur S, Wilkinson R, Meyer J (eds): Medicine and Surgery of Tortoises and Turtles. Ames, IA, Blackwell Publishing, 2004, p 315
116. Bennett RA: Cloacal prolapse, in Mader DR (ed): Reptile Medicine and Surgery, Philadelphia, PA, WB Sauders, 1996, pp 355-359
117. McArthur S: Problem-solving approach to common diseases of terrestrial and semi-aquatic chelonians, in McArthur S, Wilkinson R, Meyer J (eds): Medicine and Surgery of Tortoises and Turtles. Ames, IA, Blackwell Publishing, 2004, p 323
118. Stover J, Norton T, Jacobson E, et al: *Cistudinomyia cistudinis* infestation in Aldabra tortoises. Int Colloq Pathol Reptiles Amphib 3:109-110, 1989
119. Sales MJ, Ferrer D, Castella J, et al: Myiasis in two Hermann's tortoises (*Testudo hermanni*). Vet Rec 153:600-601, 2003
120. George RH: Health problems and diseases of sea turtles, in Lutz PL, Musick JA (eds), The Biology of Sea Turtles, Boca Raton, FL, CRC Press 1997, pp. 363-386
121. Jacobson ER, Clubb S, Gaskin JM, et al: Amoebiasis in red-footed tortoises. J Amer Vet Med Assoc 183: 1192-1194, 1983
122. Bonner B, Denver M, Garner M, et al: Roundtable: *Entamoeba invadens*. J Herpetol Med Surg 11:17-22, 2001
123. Jacobson ER, Schumacher J, Telford SR, et al: Intranuclear coccidiosis in radiated tortoises (*Geochelone radiata*) J Zoo Wildl Med 25:95-122, 1994
124. Garner MM, Gardiner C, Linn M, et al: Seven new cases of intranuclear coccidiosis in tortoises, an emerging disease? in 1998 Scientific Proceedings, Annual Conference of the American Association of Zoo Veterinarians. Omaha, NE, American Association of Wildlife Veterinarians, 1998, pp 71-73
125. Gordon AN, Kelly WR, Lester JG: Epizootic mortality of free-living green turtles (*Chelonia mydas*), due to coccidiosis. J Wildl Dis 29:490-494, 1993
126. Rideout BA, Montali RJ, Phillips LJ, et al: Mortality of captive tortoises due to viviparous nematodes of the genus *Proatractis* (family Atractidae). J Wildl Dis 23:103-108, 1987
127. Glazebrook JS, Campbell RSF, Blair D: Studies on cardiovascular fluke (Digenea: Spirorchiidae) infections in sea turtles from the Great Barrier Reef, Queensland, Australia. J Comp Path 101:231, 1989
128. Reavill DR, Schmidt RE, Stevenson R: Review of spirorchid flukes (Digenea: Spirorchidae) and 3 cases in freshwater turtles, in 2004 Scientific Proceedings, Annual Conference of the Association of Reptilian and Amphibian Veterinarians. Naples, FL, Association of reptile and Amphibian Veterinarians, 2004, pp 139-142
129. Zwart P, Truyens HA: Hexamitiasis in tortoises. Vet. Parasitol 1:175-183, 1975
130. Jacobson E, Chrisman C, Homer B, et al: Pathologic findings in loggerhead, *Caretta caretta*, with polyneuropathy in coastal waters off south Florida, in 2001 Scientific Proceedings, Annual Conference of the Association of Reptilian and Amphibian Veterinarians. Orlando, FL, Association of Reptile and Amphibian Veterinarians, 2001, pp 57-58
131. Kolmstetter CM, Frazier D, Cox S, et al: Pharmacokinetics of metronidazole in the green iguana, *Iguana iguana*. Bull Assoc Reptile and Amphibian Vet, 8:4-7, 1998
132. Adnyana W, Ladds PW, Blair D: Efficacy of praziquantel in the treatment of green sea turtles with spontaneous infection of cardiovascular flukes. Aust Vet J 75:405-407, 1997
133. Jacobson ER: Reptilian virus diagnosis, in Fudge (ed) Laboratory Medicine-Avian and Exotic Pets, WB Saunders, Philadelphia, PA, pp 229-235, 1999
134. McArthur S, Blahak S, Koelle P, et al: Roundtable: Chelonian herpesvirus. J Herpetol Med Surg 12:14-31, 2002

135. Petttan-Brewer KCB, Drew ML, Ramsay E, et al: Herpesvirus particles associated with oral and respiratory lesions in a California desert tortoise (*Gopherus agassizii*), J Wildl Dis, 32:521-526, 1996
136. Westhouse RA, Jacobson ER, Harris RK, et al: Respiratory and pharyngo-esophogeal iridovirus infection in a gopher tortoise (*Gopherus polyphemus*). J Wildl Dis 32:682-686, 1996
137. Johnson AJ, Norton TM, Wellehan JFX, et al: Irirodvirus outbreak in captive Burmese star tortoises (*Geochelone platynota*). 2004 Scientific Proceedings, Annual Conference of the Association of Reptilian and Amphibian Veterinarians. Naples, FL, Association of Reptilian and Amphibian Veterinarians, 2004, pp 143-144
138. Schumacher IM, Bradford-Haddenbrook D, Brown MB, et al: Relationship between clinical signs of URTD and antibodies to *Mycoplasma agassizii* in Desert torts from Nevada. J Wildl Dis 33:261-266, 1997
139. Jacobson ER, Maclaughlin GS: Chelonian mycoplasmosis. 1997 Scientific Proceedings, Annual Conference of the Association of Reptilian and Amphibian Veterinarians. Houston, TX, Association of Reptilian and Amphibian Veterinarians, 1997, pp 99-103
140. McLaughlin GS, Jacobson ER, Brown DR, et al: Upper respiratory disease in gopher tortoises: pathologic investigation of naturally occurring disease in Florida J Wildl Dis 36:272-283, 2000
141. Jacobson ER, Gaskin JM, Brown MB, et al: Chronic upper respiratory disease of free-ranging desert tortoises (*Xerobates agassizii*). J Wildl Dis 27:296-316, 1991
142. Muro J, Ramis A, Pastor J, et al: Chronic rhinitis associated with herpesviral infection in captive spurthighed tortoises from Spain. J Wildl Dis 34:487-495, 1998
143. Une Y, Uemura K, Kamile J, et al: Herpesvirus infection in tortoises (*Malacochersus tornieri* and *Testudo horsfieldi*). Vet Pathol 36:624-627, 1999
144. Soares JF, Chalker VJ, Erles K, et al: Prevalence of *Mycoplasma agassizi* and chelonian herpesvirus in captive tortoises (*Testudo* spp) in the United Kingdom. 2003 Scientific Proceedings, Annual Conference of the Association of Reptilian and Amphibian Veterinarians. Minneapolis, MN, Association of Reptilian and Amphibian Veterinarians, 2003, p 91
145. Jacobson ER, Gaskin JM, Roelke, et al: Conjunctivitis, tracheitis and pneumonia associated with herpesvirus infection in green sea turtles. J Amer Vet Med Assoc 189:1220-1223, 1986
146. Jacobson ER, Gaskin JM, Walkquist H: Herpesvirus-like infection in map turtles. J Amer Vet Med Assoc 181:1322-1324
147. Jacobson ER, Burgelt C, Williams B, et al: Herpesvirus in cutaneous fibropapillomatosis of the green sea turtle. Dis Aquatic Org 12:1, 1991
148. Herbst LH, Greiner EC, Ehrhart LM, et al: Serological association between spirorchidiasis, herpesvirus infections, and fibropapillomatosis in Green turtles from Florida. J Wildl Dis 34:497-507, 1998
149. Curry SS, Brown DR, Gaskin JM, et al: Persistent infectivity of a disease associated herpesvirus in green turtles after exposure to seawater. J Wildl Dis 36:792-797, 2000
150. Jacobson ER, Mansell, Sundberg JP et al: Cutaneous fibropapillomas in green turtles (*Chelonia mydas*). J Comp Path 101:3952, 1989
151. Herbst LH, Jacobson ER, Klein PA: Green turtle fibropapillomatosis. Evidence for a viral etiology. 1995 Scientific Proceedings, Annual Conference of the American Association of Zoo Veterinarians. East Lansing, MI, American Association of Zoo Veterinarians, 1995, p 224
152. Aguirre AA, Spraker TR, Balazs GH, et al: Spirorchidiasis and fibropapillomas in green turtles from the Hawaiian Islands. J Wildl Dis 34:91-98, 1998
153. Norton TM, Jacobson ER, Sunburg J: Cutaneous and renal fibropapilloma in a green turtle, *Chelonia mydas*. J Wildl Dis 26:212-216, 1990
154. De Voe R, Geissler K, Elmore S, et al: Ranavirus-associated morbidity and mortality in a group of captive eastern box turtles (*Terrapene carolina carolina*). J Zoo Wildl Med 35:534-543, 2004
155. Chen ZX, Zheng JC, Jiang YL: A new iridovirus isolated from soft-shelled turtles. Virus Res 63:147-151, 1999
156. Origgi FC, Klein PA, Mathes K, et al: Enzyme-linked immunosorbent assay for detecting herpesvirus exposure in Mediterranean tortoises. J Clin Microbiol 39:3156-3163, 2001
157. McArthur S: Problem-solving approach to common diseases of terrestrial and semi-aquatic chelonians, in McArthur S, Wilkinson R, Meyer J (eds): Medicine and Surgery of Tortoises and Turtles. Ames, IA, Blackwell Publishing, 2004, p 374
158. Stewart JS: Anaerobic bacterial infections in reptiles. J Zoo Wildl Med 21:180, 1990
159. McArthur S: Infectious agents, in McArthur S, Wilkinson R, & Meyer J (eds): Medicine and Surgery of Tortoises and Turtles. Ames, IA, Blackwell Publishing, 2004, pp 31-34
160. Greer LL, Strandberg JD, Whitaker BR: Mycobacterium chelonae osteoarthritis in a Kemp's Ridley sea turtle (*Lepidochelys kempii*). J Wild Dis 39:736-41, 2003
161. Bemis DA, Patton CS, Ramsey EC: Dermatophilosis in captive tortoises. J Vet Diagn Invest 11:553-557, 1999
162. Masters AM, Ellis TM, Carson JM, et al: Dermatophilus chelonae sp. nov. isolated from chelonids in Australia. Int J Syst Bact, 45:50-56, 1995
163. Brown JD, Sleeman JM, Elvinger F: Epidemiological determinants of aural abscessation in free-living Eastern box turtles (*Terrapene carolina*) in Virginia. J Wild Dis 39:918-921, 2003
164. Willer CJ, Lewbart GA, Lemons C: Aural abscesses in wild Eastern box turtles, Terrapene carolina carolina, from North Carolina: aerobic bacterial isolates and distribution of lesions J Herpetol Med Surg 13(2):4-9, 2003
165. Cutler SL: Nematode-associated aural abscess in a Mediterranean tortoise, *Testudo graeca*. J Herpetol Med Surg 14:4-5, 2004
166. Jacobson ER, Calderwood MB, Clubb SL: Mucormycosis in hatchling Florida soft-shelled turtles. J Amer Vet Assoc 177:835-837, 1980
167. Divers SJ, Lawton MPC: Antibiotic-impregnated polymethylmethacrylate beads as a treatment for

osteomyelitis in reptiles, in 1999 Scientific Proceedings, Annual Conference of the Association of Reptilian and Amphibian Veterinarians. Columbus, Ohio, Association of Reptile and Amphibian Veterinarians, pp 145-147
168. Murray MJ. Pneumonia and normal respiratory function, in Mader DR (ed): Reptile Medicine and Surgery. WB Saunders Co, Philadelphia, 1996, pp 396-405
169. Vanrompay D, De Meurichy W, Ducatelle R, et al: Pneumonia in Moorish tortoises (*Testudo graeca*) associated with avian serovar A *Chlamydia psittaci*. Vet Rec 17:284-285, 1994
170. Jacobson ER, Gaskin JM, Shields RP: Mycotic pneumonia in mariculture reared green turtles. J Amer Vet Med Assoc 175:929-933, 1979
171. Hernandez-Divers SJ: Pulmonary candidiasis caused by *Candida albicans* in a Greek tortoise (*Testudo graeca*) and treatment with intrapulmonary amphotericin B. J Zoo Wild Med 32:352-359, 2001
172. Hernandez-Divers SJ, Norton T, Hernandez-Divers S: Endoscopic diagnosis of pulmonary granulomas due to *Paecilomyces* in a juvenile loggerhead sea turtle, *Caretta caretta*, in 2002 Scientific Proceedings, Annual Conference of the Association of Reptilian and Amphibian Veterinarians. Reno, Nevada, Association of Reptilian and Amphibian Veterinarians, 2002, pp 3-4
173. Divers SJ: Two techniques for endoscopic evaluation of the chelonian lung, in 2002 Scientific Proceedings, Annual Conference of the Proceedings Association of Reptilian and Amphibian Veterinarians. Reno, Nevada, Association of Reptilian and Amphibian Veterinarians, 2002, pp 123-125
174. Divers SJ: The diagnosis and treatment of lower respiratory tract disease in tortoises with particular regard to intrapneumonic therapy, in 1998 Scientific Proceedings, Annual Conference of the Association of Reptilian and Amphibian Veterinarians. Kansas City, MO, Association of Reptilian and Amphibian Veterinarians, 1998, pp 95-98
175. Garner MM, Herrington R, Howerth EW, et al: Shell disease in river cooters (*Pseudemys concinna*) and yellow-bellied turtles (*Trachemys scripta*) in a Georgia lake. J Wild Dis 33:78-86, 1997
176. Carpenter JW, Mashima TY, Rupiper DJ: Exotic Animal Formulary, Second Edition. Philadelphia, PA, WB Saunders, 2001, pp 41-105
177. Costello MF: Principles of cardiopulmonary cerebral resuscitation in special species, in Fudge AM (ed), Sem Avian Exotic Pet Med 13:132-141, 2004