Clinical Approach to Tortoises and Turtles

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Abstract: Chelonians remain one of the most popular types of reptiles kept in captivity, whether it be as a companion animal or a zoo/wildlife exhibit. Their characteristic shell can be a hindrance to veterinary evaluation and medical/surgical intervention. This masterclass focuses on the veterinary approach to these interesting animals and includes an introduction to the species, relevant anatomy and physiology, physical examination, sedation and anesthesia, diagnostic imaging, diagnostic sample collection and therapeutic routes for drug delivery including central line placement.

Introduction

Tortoises, turtles and terrapins are vertebrates with similar organ systems to mammals. However, they are ectothermic and rely on environmental temperature and behavior to control their core body temperature. They possess both renal and hepatic portal circulations, and predominantly excrete ammonia, urea, or uric acid depending upon their evolutionary adaptations (Table 1). They possess nucleated red blood cells and their metabolic rates are lower than those of mammals. Like all reptiles they exhibit ecdysis – a normal process by which the outer integument is periodically shed throughout life. Most are diurnal but may be crepuscular and secretive in their habits. The species require broad spectrum light for psychological and, in the case of UVB (290-300 nm), vitamin D3 synthesis and calcium homeostasis. Fertilization is internal, and females produce eggs (oviparous). Most species exhibit temperature-dependent sex determination during egg incubation. The longevity of some selected species have been cited but the true life-span of most species have not been determined, largely because deficiencies in captivity invariably lead to premature death while good captive care without predators or exposure to disease can result in extreme geriatric ages of over 100 years. This article focuses on certain veterinary aspects of tortoises, and more complete reviews are listed in the references.1-4 In addition, space restrictions prevent the inclusion of basic anesthesia and surgery details which will be covered in the lecture.

Table 1. Relative nitrogenous waste products excreted by different chelonians.

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<th>Taxa</th>
<th>Relative % excretion</th>
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<tr>
<td></td>
<td>Ammonia</td>
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<tr>
<td>Aquatic turtles</td>
<td>20-50</td>
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<td>Semi-aquatic turtles</td>
<td>5-15</td>
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<td>Rainforest tortoises</td>
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<td>Desert tortoises</td>
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Common Species

Of the over 8000 species of reptiles, there are only around 300 species of chelonians (tortoises, turtles and terrapins). However, almost half of these are threatened or endangered, while several have become popular pet species, or revered exhibit animals. Captive breeding is common and the chelonian pet market is active, therefore, veterinarians are frequently asked to provide professional services to this unique group on vertebrates.

European species (*Testudo* species)

- Hermann’s tortoise (*T. hermanni*) – Southern Europe
- Horsfield’s tortoise (*T. horsfieldii*) – Afghanistan to north-western China, through southern Russia, Iran, and Pakistan.
- Egyptian tortoise (*T. kleinmanni*) – Critically endangered; smallest tortoise in the northern hemisphere.
- Marginated tortoise (*T. marginata*) – Greece, Italy and the Balkans in southern Europe; Largest European tortoise, reaching a weight of up to 5 kg

Box turtles (*Terrapene* species)

- Ornate box turtle (*T. ornata*) – Omnivores with a very varied diet; Midwest US to the Gulf of Mexico, and from Louisiana to Colorado
- Eastern box turtle (*T. carolina*) – Omnivores with a very varied diet; South-Central, Eastern and South Eastern parts of US, and Mexico

Miscellaneous species (*Geochelone* species)

- African spurred tortoise (*Geochelone sulcata*) – Sahara Desert and North Africa; 60-90 cm, 45 - 91 kg
- Red-foot tortoise (*Geochelone carbonaria*) – South American forests; plants, vegetables and fruits
- Galapagos tortoise (*Chelonoidis nigra*) – Galapagos islands; largest living species of tortoise, reaching weights of over 400 kg
- Radiated tortoise (*Astrochelys radiata*) – Native to Madagascar; critically endangered
- Aldabra tortoise (*Aldabrachelys gigantea*) – Islands of the Aldabra Atoll in the Seychelles

Anatomy and Physiology

Tortoises are characterized by a hard shell, formed dorsally by the carapace and ventrally by the plastron. The shell is composed of bony plates overlaid by offset keratin scutes, and each area has a specific name. Tortoises possess a common cloaca which receives the lower gastro-intestinal, reproductive, and urinary tracts. In addition,
lungs are simpler and composed of vascular pockets, more like a cavitated sponge than alveoli. The internal organs are not dissimilar in distribution but separated by two thin membranes. The heart is located within a cardiac membrane, while the lungs are dorsal and separated from the remaining viscera by a post-pulmonary membrane (or septum horizontale). Chelonians have complete tracheal rings, and males possess a single copulatory phallus.

Tortoises rely on environmental temperature and behavior to maintain their body temperature within their preferred optimum temperature zone (POTZ). Within, this species-specific POTZ, a tortoise is able to achieve the preferred body temperature (PBT) for specific metabolic activities, which may vary diurnally and seasonally, and by age and gender. The metabolic rate of reptiles is lower than for mammals and birds, and consequently the k constant in determining energy expenditure, nutritional requirements and even calculating allometric drug doses are related to the equation; Basal Metabolic Rate (BMR) = 10 x W kg^{0.75} kcal/day.

The chelonian heart is composed of 3 anatomical chambers but arguably 5 functional divisions; left and right atria, and a single ventricle formed by the cavae venosum, arteriosum, and pulmonale. Despite the single ventricle, oxygenated and deoxygenated blood are kept functionally separate and there are both pulmonary and systemic circulations (similar to mammals). Peripheral blood cell types include thrombocytes, erythrocytes, heterophils, eosinophils, basophils, lymphocytes, and monocytes (including azurophils). Renal and hepatic portal circulations exist.

The skin varies by location from thin and keratinized to think and heavily armored by large scales. The chelonian shell composed of both dermal bone plates and epithelium. Reptiles do not have extensive skin glands and their skin is essentially dry. All reptiles shed their skin. The frequency of ecdysis is dependent upon species, age, nutritional status, environmental temperature and humidity, reproductive status, parasite load, hormonal balance, bacterial/fungal skin disease, and skin damage.

Most species require some form of conditioning prior to breeding (eg, hibernation or seasonal cooling of temperate species). Sexual dimorphism in chelonians is usually obvious in adults with males often having a concave plastron and a longer tail. Overzealous and unrelenting males may ardently pursue females causing repeated harassment. Fertilization is internal, and reproduction is oviparous (hard shelled eggs). Gender determination is related to incubation temperature, often with elevated temperatures producing males and lower temperatures females.

**Physical Examination**

Small to medium tortoises (eg, Testudo species) are not difficult to handle, although their strength and uncooperative nature can hinder the examination and cause frustration. A little patience with the tortoise head held down often persuades a shy individual to protrude the head from the shell, at which time the thumb and middle finger can be placed behind the occipital condyles to prevent retraction of the head back into the shell. However, in the larger species (eg, leopard tortoise, Geochelone pardalis), keeping a strong individual from pulling free may be physically impossible. In such cases, sedation or the use of a neuromuscular blocking agent may be necessary.

Steady distractive pressure to the maxilla and mandible can open the mouth, and once the mouth is open, the index finger (in small gentle specimens) or a mouth gag (in larger specimens) can be inserted into the mouth to prevent closure. This method enables the handler to keep the mouth open with one hand, leaving the other free to examine the head and take samples for laboratory investigation. Examination of the head should include the nostrils for any discharges and the beak for damage and overgrowth. The eyelids should be open and not obviously distended or inflamed, and the eyes should be clear and bright.
Conjunctivitis, corneal ulceration, and opacities are frequent presentations. The retina can often have degeneration as a consequence of freezing during hibernation, and ophthalmic examination is warranted in any anorectic animal. The tympanic scales should be examined for signs of swelling associated with aural abscessation. Verification of a tympanic abscess can often be made with observation of exudate emanating from the eustachian tube openings within the lateral walls of the pharynx. The integument should be free of damage that is often caused by aggressively courting males and subcutaneous swellings that are usually abscesses. The buccal cavity must always be examined, particularly for evidence of inflammation, infection, gout, and foreign bodies. Stomatitis can quickly lead to a generalized esophagitis, and examination down the pharynx and into the esophagus with a rigid endoscope is advisable. Note should also be made of the mucous membrane coloration, which is normally pale pink. Hyperemic membranes may be associated with septicemia or toxemia. Icterus is rare but may occur with biliverdinemia from severe liver disease. Pale membranes are often observed in cases of true anemia. Pale deposits within the oral membranes may represent infection or urate tophi associated with visceral gout. The glottis may be difficult to visualize, being positioned at the back of the fleshy tongue; however, one must check for any inflammation and glottal discharges that may be consistent with respiratory disease.

The withdrawn limbs can also be extended from the shell of small to medium chelonians with steady traction. The coelomic space within the shell is restricted, and therefore, gently forcing the hindlimbs into the shell often leads to partial protrusion of the forelimbs and head, and vice versa. The more aggressive species, especially the terrapins and turtles, should be held at the rear of the carapace. Larger species can deliver an extremely powerful bite, and so great care is necessary at all times. Certain species also possess functional hinges at the front or back (or both) of the plastron or carapace, and care should be exercised not to trap a finger when the hinge closes. A wedge or mouth gag can be used to prevent complete closure of a hinge, and no chelonian will close a hinge on its own extended limb. The integument should be examined for parasites, particularly ticks and flies; dysecdysis; trauma; and infection that may arise from rodent, dog, or wildlife attacks. Aggressive conflicts and courting trauma must also be considered in the communal environment. Limb fractures are less commonly reported in chelonia but are often caused by rough handling, with a greater incidence reported in those individuals with secondary nutritional hyperparathyroidism. Focal subcutaneous swellings are usually abscesses, but grossly swollen joints or limbs are more often cases of fracture, osteomyelitis, or septic arthritis.

The prefemoral fossae should be palpated with the chelonian held head-up. Gentle rocking of the animal may then enable the clinician to palpate eggs, cystic calculi, or other coelomic masses. The shell should be examined for hardness, poor conformation, trauma, and infection. Soft poorly mineralized shells are usually a result of secondary nutritional hyperparathyroidism from dietary deficiencies of calcium, excess phosphorus, or a lack of full spectrum lighting. Pyramiding of the shell, historically, has been linked to dietary excesses of protein, although the cause may be multifactorial it appears to be primarily linked to environmental humidity. Shell infection may present as loosening and softening of the scutes with erythema, petechiae, purulent or caseous discharges, and a foul odor. Deep infections usually involve the bones of the shell and cause osteomyelitis.

Prolapses through the vent are obvious, but determination of the structure involved is necessary. Prolapses may include cloacal tissue, shell gland, colon, bladder, or phallus. Internal examination with digital palpation and an endoscope is recommended. Male chelonians can be differentiated from females by their longer tails and the position of their cloaca caudal to the edge of the carapace. Other sexually dimorphism characteristics may also be obvious, including the concavity of the male plastron in many species.
Anesthesia and Sedation

Regional anesthesia and local block

Inadequate knowledge of precise nerve positions is probably responsible for the current lack of regional nerve blocks in reptiles; however, nerve locators may help alleviate this problem. Certainly the judicious use of local anaesthetics or spinal blocks have been used, and although inadequate for major surgery, they may be useful for decreasing general anaesthetic requirements. Recently, an epidural technique was developed that was effective for permitting field-based phallectomy of hybrid Galapagos tortoises (*Geochelone*), and has subsequently been investigated in red eared sliders (*Trachemys*). The author used 1ml lidocaine per 25 kg injected into the dorsal tail into the coccygeal spinal cord to induce complete relaxation of the cloaca and phallus. Mild hindlimb paresis was noted in some animals but resolved within 2-3 hours.

Anesthesia with injectable drugs

Intravenous or intraosseous propofol (3-10 mg/kg) or alphaxalone (5-10 mg/kg) provides a rapid, controlled mode of induction. They are relatively non-toxic and there is reduced risk of thrombophlebitis if injected perivascularly - this is of particular concern since intravenous access may be relatively difficult, especially in active animals undergoing elective procedures. Alphaxalone also has the added advantage of being effective when administered intramuscularly (10-20 mg/kg).

If intravenous access is impractical or dangerous to attempt, intramuscular agents can be used to induce sufficient chemical restraint for intubation. For intramuscular injections in lizards and chelonia the forelimb musculature is preferable, whilst for snakes, the epaxial muscles are used. Recently, an intramuscular combination of ketamine (10-30 mg/kg), medetomidine (0.1-0.2 mg/kg) or dexmedetomidine (0.05-0.1 mg/kg), and morphine (1.5 mg/kg) or hydromorphone (0.5 mg/kg) has proven effective for a variety of chelonians, and can be readily reversed using atipamezole (0.5-1 mg/kg), and, if necessary, naloxone (0.2 mg/kg).

Anesthesia with volatile agents

Isoflurane or sevoflurane are the agents of choice for maintenance of anesthesia. These volatile agents have faster modes of action, are more controllable, and facilitate faster recoveries than most alternatives. Furthermore, their lack of reliance on hepatic metabolism or renal excretion further reduces the anaesthetic risk to debilitated reptiles or those with questionable renal or hepatic function. Prolonged breath holding is common with chelonians and crocodilians, and gas induction is not recommended. Intubation of conscious patients has been suggested following local lidocaine spray, but cannot be recommended given the stress and risks of trauma to reptile and staff.

Many chelonians have a powerful bite and a strong mouth gag is required for protection during intubation and throughout anesthesia. For most pet reptiles, small gauge endotracheal tubes or catheters are inserted through the glottis immediately caudal to the tongue; this may be aided by forcing the tongue up and forward by pressing a finger into the intermandibular space from under the jaw. The reptilian glottis is actively dilated, and therefore its movement will often be abolished once anesthetized. A guiding stylet can therefore be useful in facilitating endotracheal tube placement. The bifurcation of the trachea may be sited far cranial in some chelonia and therefore a short uncuffed endotracheal tube should be used and securely taped into position.
Ventilation

Chelonians lack a functional diaphragm, instead relying on limb movements for ventilation. The action of these muscles is abolished at surgical anesthetic planes, and intermittent positive pressure ventilation is essential for all reptiles that are anesthetized for prolonged periods. Ventilation rates should initially mirror pre-anesthesia evaluations, and then adjusted to maintain end-tidal capnography readings of above 10 mmHg, and ideally 15-25 mmHg. The use of electrical ventilators enables precise and consistent ventilation rates and pressures to be maintained which has removed some of the variables associated with manual ventilation and unstable anesthetic depths. Large reptiles are prone to ventilation-perfusion mismatch if placed into lateral or dorsal position, and therefore it is wise to achieve a surgical plane of anesthesia before surgical positioning.

Monitoring

Monitoring anesthesia can be very different compared to that of mammals. Palpebral and corneal reflexes are generally reliable. Corneal reflexes are abolished at excessive depth, while pupillary diameter may bear little relation to the depth of anesthesia (unless fixed and dilated which indicates excessive anesthetic depth or brain anoxia and death). Jaw tone and withdrawal reflexes (tongue, limb or tail) are useful, becoming abolished only at a surgical plane. This also correlates with full loss of righting reflex, loss of spontaneous movement, and complete muscle relaxation. Cloacal tone is lost at excessively deep levels. Temperature should be monitored as metabolism of drugs is directly related to core temperature with decreases commonly associated with protracted recoveries. Pulse oximetry, using either an oesophageal or cloacal reflectance probe is useful for monitoring pulse rate, and strength. In addition, although the spO₂ readings are often low and have not been conclusively validated for reptiles, monitoring the trend in spO₂ is often helpful. Doppler is often more reliable than pulse oximetry when placed over the carotid or aimed towards the heart. End-tidal capnography has proven useful, and should be maintained above 10 mmHg and ideally between 15-25 mmHg. Excessive ventilation and low ETCO₂ readings tend to correlate with a delayed return to spontaneous respiration and slower recoveries.⁹

Arterial lines are difficult to place in reptiles and require a surgical cut-down procedure. A recent study in green iguanas has demonstrated poor correlation between indirect and direct blood pressure measurements in reptiles.¹¹ The same researchers also concluded that only norepinephrine (0.3-0.5 mcg/kg/min) resulted in a significant increase in blood pressure when used in hypotensive iguanas (unpublished data). Blood gas estimations are often affected by intracardiac or pulmonary shunts, especially in aquatic species.

Recovery and post-operative care

Towards the end of surgery, the anesthetic gas should be discontinued while maintaining ventilation for a further 5-10 minutes to facilitate drug excretion. At this point, oxygen should be discontinued in favor of ventilation using room air delivered by an ambu(lance) bag as this will help stimulate spontaneous respiration. Once breathing spontaneously, the reptile can be extubated, and returned to an incubator to fully recover. Continued monitoring remains essential until righting reflexes return and the animal is ambulatory. It is not unusual for a recovering reptile to revert back to unconsciousness and apnea. Additional analgesia and fluid support should be provided as indicated.
Diagnostic Imaging

Radiography

Anesthesia facilitates accurate positioning and better diagnostic films. For vertical beam dorsoventral radiographs, most conscious individuals will remain motionless long enough to permit exposure. Ideally, the head and limbs should be extended from the shell in order to reduce superimposition of the limb musculature on the coelomic viscera. For lateral horizontal beam radiographs the chelonian is best placed on a central plastron stand. By lifting the animal clear of the ground the limbs and head will be encouraged to extend but the tortoise will remain immobile. Both left and right lateral projections should be taken with the lateral edge of the shell touching (or as close as possible to) the cassette. The third basic coelomic view is the horizontal cranio-caudal (or anterior-posterior) view. Again the chelonian is positioned on a central plastron stand, with the caudal edge of the carapace touching (or as close as possible to) the cassette, with the head facing the x-ray tube and the beam centered on the midline of the cranial rim of the carapace.

Radiology of the head and limbs will require their exteriorization from the shell and this will require general anesthesia. The use of sandbags, foam, and tape will aid positioning. Standard interpretation requires that orthogonal views should always be taken. Even slight rotation makes interpretation difficult.

Ultrasonography

Ultrasound has gained popularity, particularly with regard to examining tissue parenchyma, guiding biopsy needles and, with color flow doppler, investigation of cardiac disease. The giant species will require a 5MHz probe while a 7-14 MHz probe will suffice for most pet animals. When dealing with very small specimens (or for the ultrasound examination of eyes) a 20+MHz probe is more appropriate, but increasingly expensive. Good contact and imaging generally require copious quantities of gel or a water bath. It is helpful to try and maintain the animal in a normal position or, failing that, at least appreciate the complications associated with organ displacement. When using a water bath, variable stand-off distance is easily achieved but, without a bath, a suitable stand-off and copious gel may be required. There is no doubt that the interpretation of a two-dimensional grey scale image takes time and experience to master, but with practice ultrasound can be a useful adjunct to radiography. The authors find the use of ultrasound most rewarding for the assessment of (i) reproductive function and disease, especially ovarian activity and distinguishing between pre-ovulatory ova stasis and post-ovulatory egg stasis; (ii) liver and gall bladder, (iii) kidneys and (when present) bladder; (iv) any soft tissue mass; (v) ocular and retrobulbar disease; and (vi) cardiac disease (using color flow doppler).

It has been stated that ultrasound can be used to guide biopsy collection, and although this is theoretically true, when dealing with small exotic patients the use of endoscopy offers superior, direct visualization with less collateral damage, and has proved more valuable for accurate and safe biopsy collection.

Computed topography

Computed topography (CT), offers excellent high-resolution, detailed images. Potentially, it would be the diagnostic imaging technique of choice for tissue-air interfaces (eg, respiratory tract) and skeletal structures. Magnetic Resonance Imaging (MRI) is preferred for most soft tissue evaluations especially the CNS.
A definitive diagnosis relies upon the demonstration of a host pathological response (eg, paired rising titers, cytology, histopathology) and the causative agent (eg, cultures, parasitology, PCR, toxicology). Consequently, the ability to collect diagnostic material is of paramount importance.

**Blood collection**

The most clinically useful vessels appear to be the jugulars, subcarapacial sinus, and dorsal coccygeal veins. The left and right jugular veins are preferred because of the reduced risk of lymphatic contamination. The regional anatomy varies with species but the vessel is generally located laterally and may even be visible if temporarily occluded by digital pressure at the base of the neck. The needle is positioned caudal to the tympanum, and directed in a caudodorsal direction. A subcarapacial site is also available and formed by the venous communication between the most cranial intercostal vessels arising from the paired azygous veins and the caudal cervical anastomosis of the left and right jugular veins. This sinus can be accessed with the chelonian’s head either extended or retracted, making it useful for uncooperative or aggressive individuals. Depending upon the species and conformation of the carapace, the needle may be bent up to 60° and positioned in the mid-line just caudal to the skin insertion on the ventral aspect of the cranial rim of the carapace. The needle is advanced in a caudodorsal direction maintaining slight negative pressure. If a vertebra is encountered the needle is withdrawn slightly and redirected further cranial or caudal. Lymph contamination is certainly possible, but uncommon. To access the dorsal coccygeal vein the needle is angled at 45-90° and placed, as cranial as possible, in the dorsal mid line of the tail. The needle is advanced in a cranioventral direction while maintaining slight negative pressure. If the needle encounters a vertebra it is withdrawn slightly and redirected more cranial or caudal. The exact position, size and even presence of this vessel may vary between species and there appears to be a greater risk of lymphatic contamination.

**Shell and skin biopsies**

A combination of local, regional, or general anesthesia and sharp excision or a skin punch biopsy instrument is effective. A single suture closes the deficit. Biopsy of the chelonian shell requires general anesthesia and cortical biopsy devices.

**Lung lavage**

The simplest method of obtaining a representative sample from the lower respiratory tract is by lavage performed in the sedated or anesthetized patient. A sterile catheter of appropriate size is placed through the glottis (ideally through a sterile endotracheal tube) taking great care not to touch the oral membranes. The catheter is advanced down the trachea and into the lung. The catheter is advanced to a mid-coelomic position. Once in place, 5 ml of sterile saline per 1 kg bodyweight can be infused. Sample recovery is often aided by rotating the animal and repeatedly aspirating. The submission of fresh and fixed lavage material, multiple air-dried smears, and a microbiologic swab permits detailed investigation.

**Cloacocolonic lavage**

This can be performed on most conscious reptiles and provides the clinician with a diagnostic sample where defeation is infrequent. A sterile lubricated round-tipped catheter is inserted into the cloaca and cranial into the colon. A relatively large catheter should be used as this helps prevent kinking of the tube and perforation of the thin intestinal wall. On no account should the catheter be forced. Once in place, 10ml per kg bodyweight should
be gently infused through the catheter and repeatedly aspirated until a sample is obtained. The direct collection of fecal material from the distal colon using a lubricated gloved hand offers another practical option in large reptiles.

**Gastric lavage**

A relatively large, round-tipped catheter can be inserted into the stomach of most conscious reptiles. It is wise to use a mouth gag to prevent damage to the tube. The catheter should pass to the mid-coelomic region before instilling 5 - 10 ml sterile saline per kg bodyweight.

**Urinalysis**

Urinalysis is less helpful in reptiles than mammals. The reptilian kidney cannot concentrate urine and so urine specific gravity is of limited use in the assessment of renal function. Furthermore, renal urine passes through the urodeum of the cloaca before entering the bladder (or posterior colon in those species that lack a bladder). Bladder urine is therefore not necessarily sterile. The clinical picture is further complicated by the fact that electrolyte and water changes can occur across the bladder. Despite these biochemical drawbacks, urine samples are useful for cytological assessments of inflammation, infection, and for the identification of renal casts.

**Visceral biopsy**

Diagnostic imaging and clinicopathology can often indicate visceral disease, which can only be definitively diagnosed by tissue biopsy. Samples may be collected via standard (transplastron or prefemoral) coeliotomy, percutaneously (with or without ultrasound guidance), or endoscopically. Biopsies can be collected using ligation or wedge techniques, biopsy needles, and endoscopic instruments. Endoscopic techniques are typically less invasive, permit closer examination of more of the organ and enable the collection of multiple biopsies. Correlation between biochemical tests and histopathology are generally lacking but serial blood sampling and biopsy currently offers the best diagnostic and monitoring approach to hepatic disease.

**Necropsy**

A detailed necropsy should be undertaken whenever possible as they often provide definitive answers. When dealing with a disease outbreak in a population, elective euthanasia and necropsy of one or more individuals is often the most efficient and cost-effective means to a diagnosis. A thorough and systematic approach is essential as, unlike a physical examination of a live animal, it can never be repeated. Fresh necropsies can provide organ biopsies, blood and other bodily fluids for laboratory examination. Microbiology, histopathology and electron microscopy all take time, but cytology can provide an almost immediate working diagnosis until complete results are obtained. The submission of microbiology samples, especially bacteriology, from reptiles that have died and remained within a heated enclosure must be interpreted with caution. Following the necropsy and the submission of tissues/fluids, samples of major organs should also be frozen in case there is a future need to assess potential toxic or viral involvement.

**Therapeutics**

There are few drug preparations approved for use in reptiles. Drugs authorized for use in other species or for humans may be administered at the recommendation of the veterinarian. All reptiles should be accurately weighed before being medicated to avoid overdosage, and during treatment to monitor response.
As ectotherms, temperatures outside their POTZ can have profound influences on drug distribution, metabolism, excretion, and hence elimination half-life. Some therapeutic regimens state a fixed temperature at which the reptile should be held during treatment. The advantage of this approach is that where pharmacokinetic evidence exists the elimination of the drug will be known and constant. However, if this stated temperature is below or above the POTZ for the species being treated then stress and debilitation may ensue. In addition, where the stated therapeutic temperature is within the POTZ for the species being treated, constant exposure to a fixed temperature is likely to cause stress and maladaptation over a period of time.

Reptiles have a well-developed renal portal system where blood from the caudal half of the body passes through the kidneys before reaching the systemic venous circulation. Therefore drugs that are injected into the caudal half of the body may have a significantly reduced half-life if excreted via tubular secretion; however, studies have demonstrated that these effects are unlikely to be clinically significant. Of potential concern is the injection of nephrotoxic drugs into the caudal limb or tail which may reach renal tissue in high concentration.

Medications can be given by a variety of routes including by mouth or stomach tube (PO), subcutaneous (SC), intramuscular (IM), intravenous (IV), intracardiac (IC), intracoelomic (ICe), intrasosseous (IO), intrasynovial (IS) or intratracheal (IT) injection. Certain drugs can be applied topically, given per cloaca, by inhalation (nebulisation) or by direct intralesional administration. Central line catheters can be placed early on and are useful for facilitating repeated sedation and continued intravenous administration. They are particularly useful for large animals that are less tractable.

References


