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REVIEW OF CURRENT REPTILE ANESTHETIC TECHNIQUES: THE DO’S AND DON'TS

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PATIENT PRESENTATION/ASSESSMENT

A preanesthetic assessment should be performed on all patients. Patient assessment should consist of a complete history, species identification, and a full physical examination including baseline parameters and any additional supporting diagnostic tests, such as blood work and imaging. Ideally all patients should be stable prior to the induction and administration of anesthesia, as most anesthetics are associated with some cardiopulmonary depression. Unfortunately due to the size, disposition, or anatomy of some reptiles, a routine physical examination may not be possible. In these patients, assessment of body weight and general appearance may assist in determining health status of the patient. All animals should be kept at their preferred body temperature (PBT) during the anesthetic period and recovery. An excellent practical suggestion is to perform anesthesia early in the day as this allows animals predisposed to prolonged recoveries to recover during regular working hours rather than late into the night.

ROUTE OF DRUG ADMINISTRATION

Most drugs used for premedication in mammalian veterinary species are administered intramuscularly or subcutaneously. In reptiles this route sometimes leads to delayed time to onset of action, protracted clinical effects, and occasionally no appreciable clinical effect. These may be the result of impaired uptake of drugs from the muscle and or impaired drug metabolism and elimination. It is probably preferable to administer drugs intravenously to reptiles whenever possible to increase the predictability of drug action and minimize the possibility of prolonged recoveries associated with impaired or incomplete uptake from the site of injection. Unfortunately, administering drugs intravenously to reptiles can be difficult. However, with practice, good technique, appropriate patient selection, and skilled physical restraint, it is possible to reliably approach the ventral coccygeal vein in most snakes and lizards and the dorsal coccygeal vein in tortoise and freshwater turtles. In sea turtles the dorsal cervical sinus has also been used for intravenous administration of drugs. Regardless of the route of administration, anesthetic drugs can have variable effects and prolonged recoveries are common.

Intramuscular Administration

Administrations of drugs in the hindlimb and tail have been historically avoided due to concerns regarding first passage of drugs through the kidneys via the renal portal system common to many reptiles. However, studies in turtles and the green iguana have shown that this may be more of a theoretical than practical concern as only a small amount of blood from the hindlimbs and tail pass through the kidney. However, it is probably still best to avoid administering nephrotoxic drugs or those highly metabolized or excreted by the kidneys into the hindlimb and tail. The epaxial muscles provide a suitable injection site in most snakes. In lizards the muscle mass of the forelimb (triceps and biceps), hindlimb (quadriiceps, semimembranosus and semitendinosus) and tail can be used. Caution should be used in species known to autotomize (drop) their tails. In chelonians, intramuscular injections are most often given in the triceps area. The pectoral muscles can also be used but in many species there is a lack of significant muscle mass in this area.

Intravascular Administration

Intravascular injection sites have been described for all the major reptile classes and can be used to obtain blood samples for diagnostic testing or administration of drugs (see "Intravascular Access Options in Reptiles – What's Reasonable?"). Intravascular injection decreases the time to onset and the variability of uptake that can be associated with intramuscular injections in reptiles. Some drugs are irritating when given intramuscularly and intravenous injection can minimize this discomfort.

PREMEDICATION

Premedications are used to facilitate handling and catheterization of patients, reduce the stress associated with the overall anesthetic period, minimize adverse reactions associated with anesthesia, provide preemptive analgesia, and reduce the dose of subsequent anesthetic drugs administered.

Anticholinergics such as atropine and glycopyrrolate should probably not be used to decrease salivation; however, these drugs may be indicated if bradycardia develops. Anticholinergics can increase saliva viscosity and this may increase the risk of obstructions from highly viscous mucus in small diameter airways or endotracheal tubes. In addition, anticholinergic drugs can alter intracardiac shunt fractions in reptiles and this may alter a patient’s response to anesthetic drugs, in particular the uptake and elimination of inhalant anesthetics.

Phenothiazines such as acepromazine tend to be relatively ineffective sedatives in reptiles, require large doses, and are associated with prolonged effects. Acepromazine thus is not a very useful drug in reptile anesthesia.

Ketamine, a phencyclidine, is generally regarded as a general anesthetic but at subanesthetic doses ketamine does produce analgesia and can facilitate restraint by inducing a profound restraining effect. At subanesthetic doses ketamine alone induces a state of "catalepsy" in which the animal may still have some voluntary and involuntary muscle movement but is unable to coordinate these actions into a purposeful reaction in response to external stimuli. It is important to stress that an animal in this state is not in an anesthetic plane suitable for surgery. Since ketamine reliably produces
restraining effects, it is commonly used as part of a premedication protocol in chelonians and other reptiles that resist physical restraint and intravenous drug administration either due to size or their aggressive nature. Ketamine alone generally tends to produce hypertension, tachycardia, hyperventilation, and bradypnea. However, since ketamine is also associated with muscle rigidity even at anesthetic doses, it is most often combined with a drug producing muscle relaxation such as a benzodiazepine or an alpha-2 agonist.

Telazol is a proprietary combination of tiletamine and zolazepam. Tiletamine is a long-acting phencyclidine similar to ketamine and zolazepam is a long-acting benzodiazepine similar to diazepam. Telazol has been used in reptiles with variable results. The long duration of action and prolonged recoveries make Telazol a less desirable combination than ketamine and midazolam. Telazol is occasionally used in very large reptiles to reduce the volume of injectate, however prolonged recoveries may be anticipated.

Midazolam can be used in combination with ketamine to facilitate handling and induction of anesthesia in reptiles. Midazolam used alone produces variable results. Midazolam is a water-soluble benzodiazepine and can be administered both intramuscularly and intravenously. Diazepam is not recommended for intramuscular use as it is very poorly absorbed via this route of administration. Intravascular diazepam can be used to improve muscle relaxation in reptile

Alpha-2 agonists produce analgesia, sedation, and muscle relaxation in mammalian species, and in reptiles it appears capable of producing at least the latter two effects. The analgesic effects of alpha-2 agonists have not been specifically studied in reptiles but clinical impressions would suggest they possess analgesic effects in reptiles as well. Xylazine in combination with ketamine has been effective in turtles. More recently medetomidine, a more specific alpha-2 agonist, has been used in place of xylazine. Medetomidine alone and combined with ketamine has been shown to be effective in tortoises. When alpha-2 agonists are combined with ketamine in appropriate doses, complete general anesthesia suitable for surgery can be obtained. This combination is often used for sedation sufficient to perform endotracheal intubation prior to inhalant anesthesia. Alpha-2 agonists are associated with marked cardiovascular changes in mammals. Medetomidine alone induces a significant decrease in mean heart rate, respiratory rate, ventricular pressures and ventricular blood oxygen content in tortoises. Medetomidine when combined with ketamine produced a moderate increase in arterial pressure, and moderate hypercapnia and hypoxemia.

A distinct advantage of using alpha-2 agonists is that they are reversible, facilitating more rapid recoveries (30–60 minutes after atipamezole reversal). Atipamezole administered intravenously has been associated with marked arterial hypotension while intramuscular administration did not appear to induce alterations in ventricular pressures. It is recommended, therefore, that the drug be administered intramuscularly for reversal of medetomidine. Vomiting has been reported in association with atipamezole reversal in one tortoise species.

In general, opioids are poor sedatives in reptiles but are commonly used as preanesthetics to provide preemptive analgesia. Unfortunately there is very little information regarding the use of opioids for pain and analgesia in reptiles. It is strongly recommended, however, that an analgesic drug be administered preemptively for all potentially painful procedures.

INDUCTION
Ketamine
Both ketamine and Telazol can be used alone to induce light anesthesia or a level of restraint adequate for endotracheal intubation. However, satisfactory surgical anesthesia is often not obtained using ketamine or Telazol alone in reptiles. Many reptiles maintain reflex movement even when very high doses of ketamine and Telazol are used. Ketamine should be administered in combination with a drug that induces muscle relaxation such as midazolam or medetomidine to achieve a level of anesthesia suitable for surgery. Combinations of ketamine and medetomidine or ketamine and midazolam are popular for the induction of anesthesia in chelonians.

Propofol
Propofol is quickly becoming the induction agent of choice when intravenous access can be obtained. Propofol has proven itself to be a very reliable and practical induction agent for general anesthesia without unnecessarily prolonging recovery. Propofol is an alkylphenol unrelated to other anesthetics such as barbiturates, eugenol, or steroids. It is prepared in an intralipid solution intended for intravenous administration. Propofol produces a rapid and generally smooth induction in reptiles with a relatively predictable duration of action. Propofol is unique in that its elimination in mammals does not require hepatic or renal involvement suggesting alternative sites of metabolism such as the lung. Propofol can lead to apnea and hypotension through vasodilation in mammals. Apnea is commonly seen in reptiles; the effects on blood pressure have not been determined.

Inhalant Anesthetics
Inhalant anesthetics can be used for inducing anesthesia using induction chambers or facemasks. The least-soluble inhalant anesthetics (sevoflurane, desflurane, and isoflurane) are preferred. In some reptiles species, inhalant inductions can be very prolonged as a result of breath holding. Chelonians can be difficult to mask induce as a result of their ability to breath hold and limited access to the head. Snakes and lizards are typically easier to induce using inhalant anesthetics but are also capable of prolonged periods of breath holding. To overcome this difficulty the animal can sometimes be stimulated to breathe by stroking the lateral thorax and spine. The addition of nitrous oxide to the inhaled gas mixture may hasten inhalant anesthetic inductions.
Many reptiles can be tracheally intubated while awake and then manually ventilated to induce anesthesia. This can reduce the time for inhalant induction but the stress of intubating patients while awake may be undesirable for the patient and is not routinely recommended by this author except in exceptional circumstances. If it must be done, topical anesthesia should be provided.

**Muscle Relaxants**

Depolarizing (succinylcholine) and nondepolarizing muscle relaxants (atracurium and rocuronium) both have been used in reptiles. They have been used primarily to facilitate immobilization and tracheal intubation of crocodilians but have also been used in chelonians. Muscle relaxants are not anesthetics and have no analgesic or amnesic properties. The routine use of muscle relaxants for immobilization of reptiles should be avoided.

**Intubation**

Intubation is generally easy to accomplish via direct visualization in most reptile species. The glottis is positioned quite rostral in most snakes and at the base of the tongue in lizards and chelonians. A small drop of lidocaine (diluted to 1%) can be used to desensitize the glottis and facilitate tracheal intubation. In some aquatic reptile species, modifying glottal folds may obscure direct visualization of the glottis. The animal should be intubated with the largest diameter tube that can be easily placed. The saliva of reptiles tends to be very viscous and mucoid plugs can form in endotracheal tubes during longer procedures. Observation for this possibility is important and it can be recognized as an inability of the lungs to fully deflate to functional residual volume during expiration.

The trachea of chelonians bifurcates quite early and single lung intubation is possible. The tracheal rings in chelonians and crocodiles are complete and in most reptiles cuffed endotracheal tubes are avoided to prevent accidental over inflation and potential tracheal damage. In addition, a larger diameter uncuffed tube can usually be placed compared with a cuffed tube.

**MAINTENANCE**

Inhalant anesthesia is commonly used for maintenance of anesthesia in reptiles. Advantages of the newer halogenated anesthetics (isoflurane, sevoflurane, and desflurane) include minimal uptake, minimal metabolism, and predictable recovery. Both isoflurane and sevoflurane have been evaluated in reptiles. MAC values reported for isoflurane range from 1.54 to 3.14% in reptiles and are more variable than those reported for mammals and birds. This may be a reflection of differences in the techniques used for MAC determination, the body temperature of the patient, or actual species differences. With comparable techniques the MAC values in the green iguana (2.1 ± 0.6%) and Dumeril's monitor (1.54 ± 0.17%) were found to be substantially different with greater variability in MAC values from green iguanas. The pronounced right to left intracardiac shunt in snakes, turtles, and non-varanid lizards may account for some of these differences. In animals capable of significant right-to-left shunting, end tidal anesthetic concentrations may not be reflective of those in the blood and hence the brain. Levels in the lung may substantially overestimate levels in the brain leading to erroneous (elevated) MAC values when using traditional methods for the estimation of the MAC.

Inhalant anesthetics appear to be associated with dose-dependent cardiovascular depression similar to that seen in mammals. The effects may not be as predictable or consistent among different reptile species.

**Equipment**

Standard small animal inhalant equipment is suitable for administering inhalant anesthetics to most reptiles. In very small patients (< 1 kg), a non-rebreathing or a pediatric circle system is preferred. The dead space associated with a standard adult circle system may lead to substantial rebreathing of carbon dioxide. In reptiles there is evidence that adding carbon dioxide to the inhaled gases may improve ventilation during inhalant anesthesia; although more controlled studies are required to assess the efficacy and safety of this technique. Flow rates used for standard small animal patients are suitable for most reptiles; for a re-breathing system (circle), 50–100 ml/kg and for a non-rebreathing system (Bain, Ayres T-Piece) 200–300 ml/kg/min can be used. The lower limit of oxygen flow rate required to maintain vaporizer accuracy is about 200 ml/min; therefore, this should be the lower limit regardless of patient size. Automated ventilators are also very useful equipment when anesthetizing reptile patients as many become apneic when given inhalant and injectable anesthetics. Unfortunately most commercial ventilators are not well suited to delivering the small tidal volumes required in many reptile patients. It is important to be aware that fresh gas flow rate will contribute to the delivered tidal volume of most anesthetic ventilators. In the majority of patients, this contribution is trivial; however, when ventilating very small patients using high oxygen flow rates this contribution can be substantial. Specially designed small animal (rodent) ventilators are best; as they have been designed to specifically meet the requirements of very small patients.