

ADVANCES IN REPTILE ANESTHESIA & ANALGESIA JOURNAL PAPERS 2000-2008

1: J Wildl Dis. 2008 Jan;44(1):143-50.

Propofol anesthesia in loggerhead (*Caretta caretta*) sea turtles.

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Rapid, safe, and effective methods of anesthetic induction and recovery are needed for sea turtles, especially in cases eligible for immediate release. This study demonstrates that intravenous propofol provides a rapid induction of anesthesia in loggerhead (*Caretta caretta*) sea turtles and results in rapid recovery, allowing safe return to water shortly after the procedure. Forty-nine loggerhead sea turtles were recovered as local fishery by-catch in pound nets and transported to a surgical suite for laparoscopic sex determination. Treatment animals (n = 32) received 5 mg/kg propofol intravenously (i.v.) as a rapid bolus, whereas control animals (n = 17) received no propofol. For analgesia, all animals received a 4 ml infusion of 1% lidocaine, locally, as well as 2 mg/kg ketoprofen intramuscularly (i.m.). Physiologic data included heart and respiratory rate, temperature, and a single blood gas sample collected upon termination of the laparoscopy. Subjective data included jaw tone and ocular reflex: 3 (vigorous) to 0 (none detected). Anesthetic depth was scored from 1, no anesthesia, to 3, surgical anesthesia. Turtles receiving propofol became apneic for a minimum of 5 min with a mean time of 13.7 +/- 8.3 min to the first respiration. Limb movement returned at a mean time of 21.1 +/- 16.8 min. The treatment animals were judged to be sedated for approximately 30 min (mean anesthetic depth score > or = 1.5) when compared to controls. Median respiratory rates for treatment animals were slower compared to controls for the first 15 min, then after 35 min, they became significantly faster than the controls. Median heart rates of control animals became significantly slower than treatment animals between 40 and 45 min. Physiologic differences between groups persisted a minimum of 55 min. Possible explanations for heart rate and respiratory rate differences later in the monitoring period include a compensatory recovery of treatment animals from anesthesia-induced hypoxia and hypercapnia or, alternatively, an induced response of the nonsedated control animals. The animals induced with propofol were easier to secure to the restraint device and moved less during laparoscopy. In conclusion, propofol is a safe and effective injectable anesthetic for use in free-ranging loggerhead sea turtles that provides rapid induction and recovery.

2: Vet Rec. 2007 Jul 7;161(1):15-21.

Field anaesthesia of leatherback sea turtles (*Dermochelys coriacea*).

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Ten nesting leatherback sea turtles on Trinidad were anaesthetised for electroretinogram (ERG) measurements, using ketamine and medetomidine, reversed with atipamezole. They weighed 242 to 324 kg and were given initial doses of 3 to 8 mg/kg ketamine and 30 to 80 microg/kg medetomidine administered into an external jugular vein; six of the turtles received supplementary doses of 2.6 to 3.9 mg/kg ketamine combined with 0 to 39 microg/kg medetomidine. The lower doses were used initially to ensure against overdosage and reduce the chances of residual effects after the turtles returned to the water, but successful ERGs called for step-wise dose increases to the required level of anaesthesia. Respiratory rate, heart rate, electrocardiogram, cloacal temperature, and venous blood gases were monitored, and blood was collected for plasma biochemistry. At the end of the ERG procedure, atipamezole was administered at 150 to 420 microg/kg (five times the dose of medetomidine), half intramuscularly and half intravascularly. The turtles were monitored and prevented from re-entering the water until their behaviour was normal. No apparent mortalities or serious anaesthetic complications occurred. The observed within-season return nesting rate of the anaesthetised turtles was comparable with that of unanaesthetised turtles.

3: J Zoo Wildl Med. 2005 Jun;36(2):169-75.

Comparison of isoflurane and sevoflurane anesthesia after premedication with butorphanol in the green iguana (*Iguana iguana*).

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The anesthetic and cardiopulmonary effects of butorphanol followed by sevoflurane or isoflurane were compared in 23 male green iguanas (*Iguana iguana*). Heart and respiratory rates were recorded before administration of butorphanol (2 mg/kg i.m.) and at 30 min after premedication. Anesthesia was induced in 12 iguanas (group 1) with isoflurane (5%) and in 11 iguanas (group 2) with sevoflurane (7%). Heart rate, relative arterial oxygen hemoglobin saturation (SpO₂), and end-tidal CO₂ concentrations (EtCO₂) were measured every minute for the first 5 min and every 5 min thereafter. Arterial blood gas parameters were determined at 10 and 40 min after induction. Thirty minutes after butorphanol administration, no significant changes in heart and respiratory rate were seen as compared with baseline values. Quality and time to induction were superior with butorphanol-sevoflurane (6 +/- 3 min) than with butorphanol-isoflurane (9 +/- 4 min). Vaporizer settings during maintenance ranged between 1-3% and 2-4%, respectively. No significant differences in heart rate were noted between groups. In the sevoflurane group, SpO₂ values were > 90% throughout. Although SpO₂ values were < 90% at 20, 25, and 30 min in the isoflurane group, no significant differences in SpO₂ values were seen over time and between groups. A significant decrease in EtCO₂ with time was present in both groups, with no significant differences between the groups. At 10 and 40 min, arterial blood oxygen saturation values were > 90% in

both groups and no significant differences were noted with time and between groups. Recovery time was significantly longer in the butorphanol-isoflurane group (35 +/- 27 min) than in the butorphanol-sevoflurane group (7 +/- 4 min). The cardiopulmonary effects of butorphanol-isoflurane and butorphanol-sevoflurane assessed in this study are similar, and both inhalants appear to be safe and effective for induction and maintenance in the green iguana.

4: J Zoo Wildl Med. 2005 Mar;36(1):62-8.

Inhalation anesthesia in Dumeril's monitor (*Varanus dumerili*) with isoflurane, sevoflurane, and nitrous oxide: effects of inspired gases on induction and recovery.

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Induction and recovery from inhalation anesthesia of Dumeril's monitors (*Varanus dumerili*) using isoflurane, sevoflurane, and nitrous oxide (N₂O) were characterized using a randomized crossover design. Mean times to induction for isoflurane in 100% oxygen (O₂), sevoflurane in 100% O₂, sevoflurane in 21% O₂:79% nitrogen (N₂; room air), and sevoflurane in 66% N₂O:34% O₂ were 13.00 +/- 4.55, 11.20 +/- 3.77, 10.40 +/- 2.50, and 9.40 +/- 2.80 min, respectively, at 26 degrees C (n = 10). Mask induction with sevoflurane was significantly faster than with isoflurane. There was no significant difference between the induction time for sevoflurane in O₂ or in room air, but sevoflurane combined with N₂O resulted in significantly faster inductions than were obtained with sevoflurane in 100% O₂. All treatments resulted in a significantly higher respiratory rate than in undisturbed animals. There were no significant differences in respiratory rate among lizards receiving O₂, isoflurane in 100% O₂, sevoflurane in room air, and sevoflurane combined with N₂O, but animals receiving sevoflurane in O₂ had a lower respiratory rate than those receiving pure O₂. The sequence of complete muscle relaxation during induction was consistent and not significantly different among the four treatments: front limbs lost tone first, followed by the neck and the hind limbs; then the righting reflex was lost and finally tail tone. There were no significant differences in recovery times between isoflurane and sevoflurane or between sevoflurane in 100% O₂ and sevoflurane combined with N₂O. Similar recovery times were observed in animals recovering in 100 and 21% O₂.

5: Am J Vet Res. 2006 Oct;67(10):1670-4.

Pharmacokinetics of inhaled anesthetics in green iguanas (*Iguana iguana*).

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OBJECTIVE: To test the hypothesis that differences in anesthetic uptake and elimination in iguanas would counter the pharmacokinetic effects of blood:gas solubility and thus serve to minimize kinetic differences among inhaled agents.

ANIMALS: 6 green iguanas (*Iguana iguana*).

PROCEDURES: Iguanas were anesthetized with isoflurane, sevoflurane, or desflurane in a Latin-square design. Intervals from initial administration of an anesthetic agent to specific induction events and from cessation of administration of an anesthetic agent to specific recovery events were recorded. End-expired gas concentrations were measured during anesthetic washout.

RESULTS: Significant differences were not detected for any induction or recovery events for any inhalation agent in iguanas. Washout curves best fit a 2-compartment model, but slopes for both compartments did not differ significantly among the 3 anesthetics.

CONCLUSIONS AND CLINICAL RELEVANCE: Differences in blood:gas solubility for isoflurane, sevoflurane, and desflurane did not significantly influence differences in pharmacokinetics for the inhalation agents in iguanas.

6: Am J Vet Res. 2006 Mar;67(3):392-7.

Median effective dose of isoflurane, sevoflurane, and desflurane in green iguanas.

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OBJECTIVE: To determine the median effective dose (ED₅₀); equivalent to the minimum alveolar concentration [MAC] of isoflurane, sevoflurane, and desflurane for anesthesia in iguanas.

ANIMALS: 6 healthy adult green iguanas.

PROCEDURE: In unmedicated iguanas, anesthesia was induced and maintained with each of the 3 volatile drugs administered on separate days according to a Latin square design. Iguanas were endotracheally intubated, mechanically ventilated, and instrumented for cardiovascular and respiratory measurements. During each period of anesthesia, MAC was determined in triplicate. The mean value of 2 consecutive expired anesthetic concentrations, 1 that just permitted and 1 that just prevented gross purposeful movement in response to supramaximal electrical stimulus, and that were not different by more than 15%, was deemed the MAC.

RESULTS: Mean +/- SD values for the third MAC determination for isoflurane, sevoflurane, and desflurane were 1.8 +/- 0.3%, 3.1 +/- 1.0%, and 8.9 +/- 2.1% of atmospheric pressure, respectively. The MAC for all inhaled agents was, on average, 22% greater for the first measurement than for the third measurement.

CONCLUSIONS AND CLINICAL RELEVANCE: Over time, MACs decreased for all 3 agents. Final MAC measurements were similar to values reported for other species. The decrease in MACs over time may be at least partly explained by limitations of anesthetic uptake and distribution imposed by the reptilian cardiorespiratory system. Hence, for a constant end-tidal anesthetic concentration in an iguana, the plane of anesthesia may deepen over time, which could contribute to increased morbidity during prolonged procedures.

7: J Am Vet Med Assoc. 2005 Aug 15;227(4):575-8.

Anesthetic potency of sevoflurane with and without nitrous oxide in mechanically ventilated Dumeril monitors.

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OBJECTIVE: To determine the minimum alveolar concentration (MAC) of sevoflurane and assess the sevoflurane-sparing effect of coadministration of nitrous oxide in mechanically ventilated Dumeril monitors (*Varanus dumerili*).

DESIGN: Prospective crossover study.

ANIMALS: 10 healthy adult Dumeril monitors.

PROCEDURE: Anesthesia was induced with sevoflurane in 100% oxygen or sevoflurane in 66% nitrous oxide (N₂O) with 34% oxygen, delivered through a face mask. Monitors were endotracheally intubated, and end-tidal and inspired isoflurane concentrations were measured continuously; MAC was determined by use of a standard bracketing technique. An electrical stimulus (50 Hz, 50 V) was delivered to the ventral aspect of the tail as the supramaximal stimulus. A blood sample for blood gas analyses was collected from the ventral coccygeal vessels at the beginning and end of the anesthetic period. An interval of at least 7 days was allowed to elapse between treatments.

RESULTS: The MAC +/- SDs of sevoflurane in oxygen and with N₂O were 2.51 +/- 0.46% and 1.83 +/- 0.33%, respectively. There was a significant difference between the 2 treatments, and the mean MAC-reducing effect of N₂O was 26.4 +/- 11.4%. Assuming simple linear additivity of sevoflurane and N₂O, the MAC for N₂O was estimated to be 244%. No significant differences in blood gas values—with the predictable exception of oxygen pressure—were detected between the 2 groups.

CONCLUSIONS AND CLINICAL RELEVANCE: The MAC of sevoflurane in Dumeril monitors is similar to that reported for other species. The addition of N₂O significantly decreased the MAC of sevoflurane in this species.

8: J Am Vet Med Assoc. 2005 Apr 1;226(7):1098-101.

Minimum alveolar concentration of isoflurane in mechanically ventilated Dumeril monitors.

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OBJECTIVE: To determine minimum alveolar concentration (MAC) of isoflurane in mechanically ventilated Dumeril monitors (*Varanus dumerili*).

DESIGN: Prospective study.

ANIMALS: 10 healthy adult Dumeril monitors.

PROCEDURE: Anesthesia was induced with isoflurane in oxygen delivered through a face mask. Monitors were endotracheally intubated, and end-tidal and inspired isoflurane concentrations were continuously measured. After equilibration at an end-tidal-to-inspired isoflurane concentration ratio of >0.9 for 20 minutes, an electrical stimulus (50 Hz, 50 V) was delivered to the ventral aspect of the tail for up to 1 minute and the monitor was observed for purposeful movement. End-tidal isoflurane concentration was then decreased by 10%, and equilibration and stimulation were repeated. The MAC was calculated as the mean of the lowest end-tidal isoflurane concentration that prevented positive response and the highest concentration that allowed response. A blood sample for blood gas analysis was collected from the tail vein at the beginning and end of the anesthetic period.

RESULTS: Mean +/- SD MAC of isoflurane was 1.54 +/- 0.17%. Mean heart rates at the upper and lower MAC values were 32.4 +/- 3 beats/min and 34 +/- 4.5 beats/min, respectively. During the experiment, PaCO₂ decreased significantly from 43.1 mm Hg to 27.9 mm Hg and blood pH and HCO₃ concentration increased significantly from 7.33 to 7.64 and from 25.3 to 32.9 mmol/L, respectively.

CONCLUSIONS AND CLINICAL RELEVANCE: The MAC of isoflurane in Dumeril monitors was similar to that reported in mammals but lower than values reported in other reptiles. This difference may be reflective of the more advanced cardiovascular physiologic features of monitor lizards.

9: J Am Vet Med Assoc. 2004 Feb 15;224(4):547-52.

J Am Vet Med Assoc. 2004 Apr 15;224(8):1245; author reply 1245.

Evaluation of the use of anesthesia and analgesia in reptiles.

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OBJECTIVE: To determine anesthetic techniques and the drugs used to provide anesthesia and analgesia to reptiles.

DESIGN: Mail-out questionnaire.

SAMPLE POPULATION: 367 members of the Association of Reptile and Amphibian Veterinarians.

PROCEDURE: 1,091 members listed in the 2002 directory of the Association of Reptile and Amphibian Veterinarians were asked to complete a questionnaire regarding anesthesia and analgesia.

RESULTS: 367 of 1,091 (33.6%) individuals completed the questionnaire; 88.8% used inhalants (particularly isoflurane) for anesthesia, and ketamine, propofol, and butorphanol were the most commonly used injectable agents. Intubation, fluids, and having a dedicated anesthetist were most commonly used for patient support, and pulse oximetry and Doppler ultrasonography were most commonly used for monitoring. Respiratory depression, difficulty monitoring anesthetic depth, prolonged recovery, and hypothermia were the most frequent complications. Nearly all respondents believed that reptiles feel pain, but analgesics were used infrequently for many reasons.

CONCLUSIONS AND CLINICAL RELEVANCE: Providing anesthesia in reptiles is difficult, especially regarding anesthetic depth and vital parameters, and methods of support are used less frequently than in domestic species. Provision of analgesia is uncommon. Research regarding pain and its assessment, response to analgesics, and drug pharmacokinetics is needed. Dissemination of this information to practitioners needs to be improved for enhancement of the standard of care for reptiles.

10: Vet Anaesth Analg. 2004 Jan;31(1):64-72.

The cardiovascular dose-response effects of isoflurane alone and combined with butorphanol in the green iguana (*Iguana iguana*).

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OBJECTIVE: To assess the cardiovascular effects (arterial blood pressure, heart rate, and metabolic acid-base status) of three doses (MAC multiples) of isoflurane alone and combined with butorphanol in the green iguana (*Iguana iguana*).

STUDY DESIGN: Prospective randomized double-blind, two-period cross-over trial.

ANIMALS: Six mature healthy green iguanas (*Iguana iguana*).

METHODS: The iguanas received each of two treatments, saline 0.1 mL kg⁻¹ (SAL) and butorphanol 1.0 mg kg⁻¹ (BUT) during isoflurane anesthesia. Treatments were separated by at least 1 week. The iguanas were exposed to each of the three minimum alveolar concentration (MAC) multiples (1.0, 1.5, and 2.0) in random order. Anesthesia was induced with isoflurane and maintained using controlled ventilation. Instrumentation included use of an ECG, airway gas monitor, cloacal thermometer, esophageal pulse oximeter, and the placement of a femoral arterial catheter. Body temperature was stabilized and maintained at 32 degrees C. The treatment was administered, and the animals were equilibrated for 20 minutes at each MAC multiple. At each concentration, the heart rate, blood pressure (systolic, mean, diastolic), end-tidal CO₂, and SpO₂ were measured. At 1.0 and 2.0 MAC, simultaneous blood samples were drawn from the tail vein/artery complex and femoral catheter for blood gas analysis. Data were analyzed using a two-way analysis of variance for repeated measures looking for differences between treatments and among MAC multiples.

RESULTS: There were no significant differences in any of the cardiovascular variables between the treatments. Significant differences among isoflurane MAC multiples were observed for HR, mean, diastolic, and systolic blood pressures. Blood pressure and heart rate decreased with an increasing dose of anesthetic. There were no significant differences between treatments or MAC multiples for any of the blood gas variables. The blood pH, PCO₂, HCO₃⁻, and hemoglobin saturation differed significantly between sites. Pulse oximetry values measured from the carotid complex did not correlate with and were significantly different from the calculated hemoglobin saturation values determined using the gas analyzer.

CONCLUSION AND CLINICAL RELEVANCE: Cardiovascular depression associated with isoflurane anesthesia in the green iguana is dose dependent. The degree of cardiovascular depression was not significantly different when isoflurane was combined with butorphanol. This finding suggests that the pre-emptive or intraoperative use of butorphanol is unlikely to be detrimental to cardiovascular function. Butorphanol may be a useful anesthetic adjunct to isoflurane anesthesia in the green iguana.

11: J Am Vet Med Assoc. 2003 Jun 1;222(11):1565-8.

The cardiac anesthetic index of isoflurane in green iguanas.

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OBJECTIVE: To determine the cardiac anesthetic index (CAI) of isoflurane in green iguanas and whether butorphanol affected the CAI. **DESIGN:** Prospective randomized controlled trial.

ANIMALS: 7 healthy mature iguanas.

PROCEDURE: In 5 iguanas, CAI was determined after induction of anesthesia with isoflurane alone, and in 5 iguanas, CAI was determined after induction of anesthesia with isoflurane and IM administration of butorphanol (1 mg/kg [0.45 mg/lb]). Three iguanas underwent both treatments. Animals were equilibrated for 20 minutes at 1.5 times the minimum alveolar concentration (MAC) of isoflurane and observed for evidence of cardiovascular arrest. If there was no evidence of cardiovascular arrest, end-tidal isoflurane concentration was increased by 20%, and animals were allowed to equilibrate for another 20 minutes. This process was repeated until cardiovascular arrest occurred or vaporizer output could no longer be consistently increased. The CAI was calculated by dividing the highest end-tidal isoflurane concentration by the MAC.

RESULTS: None of the iguanas developed cardiovascular arrest and all survived. Mean +/- SD highest end-tidal isoflurane concentration during anesthesia with isoflurane alone (9.2 +/- 0.60%) was not significantly different from mean concentration during anesthesia with isoflurane and butorphanol (9.0 +/- 0.43%). The CAI was > 4.32.

CONCLUSIONS AND CLINICAL RELEVANCE: Results suggest that the CAI of isoflurane in green iguanas is > 4.32 and not affected by administration of butorphanol. Isoflurane appears to be a safe anesthetic in green iguanas.

12: J Am Vet Med Assoc. 2003 Jun 1;222(11):1559-64.

Minimum alveolar concentration of isoflurane in green iguanas and the effect of butorphanol on minimum alveolar concentration.

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OBJECTIVE: To determine minimum alveolar concentration (MAC) of isoflurane in green iguanas and effects of butorphanol on MAC. **DESIGN:** Prospective randomized trial.

ANIMALS: 10 healthy mature iguanas.

PROCEDURE: In each iguana, MAC was measured 3 times: twice after induction of anesthesia with isoflurane and once after induction of anesthesia with isoflurane and IM administration of butorphanol (1 mg/kg [0.45 mg/lb]). A blood sample was collected from the tail vein for blood-gas analysis at the beginning and end of the anesthetic period. The MAC was determined with a standard bracketing technique; an electrical current was used as the supramaximal stimulus. Animals were artificially ventilated with a ventilator set to deliver a tidal volume of 30 mL/kg (14 mL/lb) at a rate of 4 breaths/min.

RESULTS: Mean +/- SD MAC values during the 3 trials (2 without and 1 with butorphanol) were 2.0 +/- 0.6, 2.1 +/- 0.6, and 1.7 +/- 0.7%, respectively, which were not significantly different from each other. Heart rate and end-tidal partial pressure of CO₂ were also not significantly different among the 3 trials. Mean +/- SD heart rate was 48 +/- 10 beats/min; mean end-tidal partial pressure of CO₂ was 22 +/- 10 mm Hg. There were no significant differences in blood-gas values for samples obtained at the beginning versus the end of the anesthetic period.

CONCLUSIONS AND CLINICAL RELEVANCE: Results suggest that the MAC of isoflurane in green iguanas is 2.1% and that butorphanol does not have any significant isoflurane-sparing effects.

13: J Am Vet Med Assoc. 2002 Oct 1;221(7):1019-25.

Medetomidine, ketamine, and sevoflurane for anesthesia of injured loggerhead sea turtles: 13 cases (1996-2000).

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OBJECTIVE: To determine safety and efficacy of an anesthetic protocol incorporating medetomidine, ketamine, and sevoflurane for anesthesia of injured loggerhead sea turtles.

DESIGN: Retrospective study.

ANIMALS: 13 loggerhead sea turtles.

PROCEDURE: Anesthesia was induced with medetomidine (50 microg/kg [22.7 microg/lb], IV) and ketamine (5 mg/kg (2.3 mg/lb), IV) and maintained with sevoflurane (0.5 to 2.5%) in oxygen. Sevoflurane was delivered with a pressure-limited intermittent-flow ventilator. Heart rate and rhythm, end-tidal partial pressure of CO₂, and cloacal temperature were monitored continuously; venous blood gas analyses were performed intermittently. Administration of sevoflurane was discontinued 30 to 60 minutes prior to the end of the surgical procedure. Atipamezole (0.25 mg/kg [0.11 mg/lb], IV) was administered at the end of surgery.

RESULTS: Median induction time was 11 minutes (range, 2 to 40 minutes; n = 11). Median delivered sevoflurane concentrations 15, 30, 60, and 120 minutes after intubation were 2.5 (n = 12), 1.5 (12), 1.25 (12), and 0.5% (8), respectively. Heart rate decreased during surgery to a median value of 15 beats/min (n = 11). End-tidal partial pressure of CO₂ ranged from 2 to 16 mm Hg (n = 8); median blood gas values were within reference limits. Median time from atipamezole administration to extubation was 14 minutes (range, 2 to 84 minutes; n = 7).

CONCLUSIONS AND CLINICAL RELEVANCE: Results suggest that a combination of medetomidine and ketamine for induction and sevoflurane for maintenance provides safe, effective, controllable anesthesia in injured loggerhead sea turtles.

14: J Zoo Wildl Med. 1999 Mar;30(1):64-9.

Sevoflurane anesthesia in desert tortoises (*Gopherus agassizii*).

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The effects of sevoflurane on anesthesia induction, recovery, ventricular pressures, heart rate, ventricular pH, blood gas values, and electrolytes were evaluated in desert tortoises (*Gopherus agassizii*). Tortoises were orotracheally intubated while awake and ventilated manually with 3-7% sevoflurane in oxygen (1 L/min) to achieve desired expired sevoflurane concentrations. Data, consisting of induction time, recovery time, systolic, diastolic, and mean ventricular pressures, heart rate, ventricular pH, blood gas values, and electrolytes, were collected prior to anesthesia and sequentially at 2.50% and 3.75% expired sevoflurane as measured at the junction of the endotracheal tube and the breathing circuit. Blood pressure was measured and blood samples were collected through a 25-ga needle passed through a cardiac access port that was placed while the tortoises were in dorsal recumbency. Mean (+/-SE) induction time was 2.55 +/- 0.55 min, recovery time was 27.58 +/- 7.55 min, and duration of anesthesia was 105 +/- 12 min. Mean (+/-SD) values for systolic, diastolic, and mean ventricular pressures in awake tortoises were 28 +/- 3 mm Hg, 22 +/- 2 mm Hg, and 24 +/- 2 mm Hg, respectively. Sevoflurane (2.5% expired) significantly decreased systolic (14 +/- 3 mm Hg), diastolic (12 +/- 1 mm Hg), and mean (13 +/- 1 mm Hg) ventricular pressures compared with those of awake tortoises. Ventricular pressures did not decrease further with increasing depth of anesthesia. Heart rate (32 +/- 4 beats/min) did not change significantly under sevoflurane anesthesia. Sevoflurane administration increased ventricular PO₂ but did not change Na⁺, K⁺, or iCa⁺⁺ concentrations. Sevoflurane appears to provide safe and effective anesthesia with rapid induction and recovery.

15: J Am Vet Med Assoc. 1998 Jan 1;212(1):93-8.

Cardiopulmonary and anesthetic effects of propofol administered intraosseously to green iguanas.

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OBJECTIVE: To determine cardiopulmonary effects of intraosseous administration of propofol in green iguanas (*Iguana iguana*). DESIGN: Prospective study.

ANIMALS: 14 green iguanas.

PROCEDURE: Anesthesia was induced in 4 iguanas with propofol (10 mg/kg [4.5 mg/lb] of body weight, intraosseously). Heart and respiratory rates, functional hemoglobin oxygen saturation (SpO₂), end-tidal CO₂ concentration, and cloacal temperature were recorded. Ten additional iguanas were given propofol intraosseously for induction (5 mg/kg [2.3 mg/lb] and maintenance (0.5 mg/kg/min [0.23 mg/lb/min], q 30 min) of anesthesia. Heart and respiratory rates, cloacal temperature, and SpO₂ were recorded.

RESULTS: Mean induction time for the first 4 iguanas was 1.2 minutes. A significant decrease in heart rate was seen 1 minute after induction of anesthesia. All iguanas were apneic, but spontaneous ventilation resumed within 5 minutes. End-tidal CO₂ concentration decreased from 46 mm of Hg 4 minutes after induction of anesthesia to 32 mm of Hg 30 minutes after induction of anesthesia. Mean duration of anesthesia was 27 minutes. Mean induction time for the other 10 iguanas was 3 minutes. A significant decrease in heart rate was detected 35 minutes after induction of anesthesia and persisted until 120 minutes. Mean SpO₂ value decreased from 79% 5 minutes after induction of anesthesia to 64% 30 minutes after induction of anesthesia. Mean recovery time was 57 minutes.

CLINICAL IMPLICATIONS: Propofol is an effective anesthetic agent for use in green iguanas. It is recommended that iguanas be intubated, provided oxygen, and given assisted ventilation after administration of propofol to prevent hypoxemia and hypercapnia.

16: J Zoo Wildl Med. 2002 Mar;33(1):36-44.

Evaluation of medetomidine-ketamine anesthesia with atipamezole reversal in American alligators (*Alligator mississippiensis*).

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Sixteen captive and wild-caught American alligators (*Alligator mississippiensis*), seven juveniles (≤ 1 m total length [TL]; 6.75 \pm 1.02 kg), and nine adults (> 2 m TL; 36.65 \pm 38.85 kg), were successfully anesthetized multiple times ($n = 33$) with an intramuscular (i.m.) medetomidine-ketamine (MK) combination administered in either the triceps or masseter muscle. The juvenile animals required significantly larger doses of medetomidine ($x = 220.1 \pm 76.9$ microg/kg i.m.) and atipamezole ($x = 1,188.5 \pm 328.1$ microg/kg i.m.) compared with the adults (medetomidine, $x = 131.1 \pm 19.5$ microg/kg i.m.; atipamezole, $x = 694.0 \pm 101.0$ microg/kg i.m.). Juvenile alligators also required higher (statistically insignificant) doses of ketamine ($x = 10.0 \pm 4.9$ mg/kg i.m.) compared with the adult animals ($x = 7.5 \pm 4.2$ mg/kg i.m.). The differences in anesthesia induction times (juveniles, $x = 19.6 \pm 8.5$ min; adults, $x = 26.6 \pm 17.4$ min) and recovery times (juveniles, $x = 35.4 \pm 22.1$ min; adults, $x = 37.9 \pm 20.2$ min) were also not statistically significant. Anesthesia depth was judged by the loss of the righting, biting, corneal and blink, and front or rear toe-pinch withdrawal reflexes. Recovery in the animals was measured by the return of reflexes, open-mouthed hissing, and attempts to high-walk to the opposite end of the pen. Baseline heart rates (HRs) were significantly higher in the juvenile animals ($x = 37 \pm 4$ beats/min) compared with the adults ($x = 24 \pm 5$ bpm). However, RRs (juveniles, $x = 8 \pm 2$ breaths/min; adults, $x = 8 \pm 2$ breaths/min) and body temperatures (juveniles, $x = 24.1 \pm 1.1$ degrees C; adults, $x = 25.2 \pm 1.2$ degrees C) did not differ between the age groups. In both groups, significant HR decreases were recorded within 30-60 min after MK administration. Cardiac arrhythmias (second degree atrio-ventricular block and premature ventricular contractions) were seen in two animals but were not considered life-threatening. Total anesthesia times ranged from 61-250 min after i.m. injection. Although dosages were significantly different between the age groups, MK and atipamezole provided safe, effective, completely reversible anesthesia in alligators. Drug-dosage differences appear to be related to metabolic differences between the two size-classes, requiring more research into metabolic scaling as a method of calculating anesthetic dosages.

17: J Am Vet Med Assoc. 2002 May 15;220(10):1516-9.

Cardiopulmonary effects of a medetomidine-ketamine combination administered intravenously in gopher tortoises.

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OBJECTIVE: To determine whether IV administration of a combination of medetomidine and ketamine depresses cardiopulmonary function in healthy adult gopher tortoises.

DESIGN: Prospective study.

ANIMALS: 3 adult male and 3 adult female nonreleasable gopher tortoises.

PROCEDURE: Prior to the study, carotid and jugular catheters were surgically placed in each tortoise for blood collection, direct arterial blood pressure monitoring, and drug administration. Heart rate, direct carotid arterial blood pressure, and body temperature were measured before and every 5 minutes for 45 minutes after IV injection of medetomidine (100 microg/kg [45.5 microg/lb]) and ketamine (5 mg/kg [2.3 mg/lb]). Carotid arterial blood samples were collected before and 5, 15, 30, and 45 minutes after medetomidine-ketamine administration to determine pH, PO₂, and PCO₂. Atipamezole (500 mg/kg [227 microg/lb], IV) was administered 30 minutes after administration of medetomidine-ketamine.

RESULTS: The medetomidine-ketamine combination caused a moderate increase in arterial blood pressure, and moderate hypercapnia and hypoxemia. There were no significant changes in heart rate or body temperature. Intravenous administration of atipamezole rapidly induced severe hypotension.

CONCLUSIONS AND CLINICAL RELEVANCE: The combination of medetomidine and ketamine administered IV resulted in effective short-term immobilization adequate for minor diagnostic procedures in gopher tortoises. This combination also caused moderate hypoventilation, and it is recommended that a supplemental source of oxygen or assisted ventilation be provided. Atipamezole administration hastens recovery from chemical immobilization but induces severe hypotension. It is recommended that atipamezole not be administered IV for reversal of medetomidine in tortoises and turtles.

18: Contemp Top Lab Anim Sci. 2001 May;40(3):9-11.

Medetomidine-ketamine anesthesia in red-eared slider turtles (*Trachemys scripta elegans*).

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This study evaluated the effects of high and low dosages of medetomidine-ketamine in red-eared slider turtles (*Trachemys scripta elegans*) and the reversibility of the anesthesia with atipamezole. Thirty healthy adult turtles were assigned randomly to one of two dosage groups. The lower dosage group received 0.1 mg medetomidine/kg body weight intramuscularly (i.m.) combined with 5 mg ketamine/kg i.m. The higher dosage group received 0.2 mg medetomidine/kg i.m. combined with 10 mg ketamine/kg i.m. Physiologic parameters evaluated included heart rate, palpebral reflex, limb and neck relaxation, and cloacal temperature. Responses to minor procedures such as i.m. injection (0.1 ml 0.9% NaCl) and endotracheal intubation also were evaluated. In addition, the higher dosage group was evaluated for responsiveness to a skin incision and placement of a skin suture. Both dosage trials resulted in a level of anesthesia deep enough for performing a physical examination, minor procedures, and endotracheal intubation. The higher dosage produced a level of anesthesia sufficient for performing a skin incision and suture placement. Heart rate and cloacal temperatures remained stable throughout the entire procedure for both groups. Atipamezole was administered i.m. at five times the dose of medetomidine (0.5 mg/kg i.m. or 1 mg/kg i.m.) 60 min after the medetomidine-ketamine was administered. All of the turtles were swimming 60 min after atipamezole administration.

19: *J Zoo Wildl Med.* 2000 Mar;31(1):28-35.

Sedative and cardiopulmonary effects of medetomidine and reversal with atipamezole in desert tortoises (*Gopherus agassizii*).

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Ten desert tortoises (*Gopherus agassizii*) were given i.m. injections of 150 microg/kg of medetomidine. Sedation was achieved in all tortoises by 20 min postinjection and was accompanied by a significant decrease in mean heart and respiratory rates, systolic, diastolic, and mean ventricular pressures, and mean ventricular partial pressure of oxygen (PO₂). There was no change in mean blood pH, HCO₃, Na⁺, K⁺, ionized calcium values, and mean ventricular partial pressure of carbon dioxide (PCO₂). There were statistically significant but clinically insignificant changes in mean base excess and pH-corrected ionized calcium values. Atipamezole given to five of the tortoises at 0.75 mg/kg i.m. significantly reversed the sedative effects of the medetomidine, with all tortoises returning to a normal state by 30 min after administration of the reversal agent. In comparison, the other five tortoises given an equal volume of physiologic saline in place of atipamezole (control group) remained significantly sedated for the duration of the study. In addition, the heart rate and ventricular PO₂ returned to baseline, but the respiratory rate and ventricular blood pressures were not significantly altered by the atipamezole as compared with those of the control group. These cardiopulmonary and physiologic effects are similar to those seen in some domestic mammals. Medetomidine can be used to safely induce sedation in desert tortoises. For procedures lasting greater than 120 min, supplemental oxygen should be provided. Atipamezole will reverse the sedation but not all of the cardiopulmonary effects, thus necessitating continued monitoring after reversal. Future studies should address the anesthetic and cardiopulmonary effects of medetomidine in combination with other agents such as ketamine and/or butorphanol.

20: *J Zoo Wildl Med.* 2006 Sep;37(3):405-8.

Use of a nerve locator to facilitate administration of mandibular nerve blocks in crocodilians.

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As part of a clinical workup of dental problems in a large crocodilian collection, mandibular nerve blocks were performed in the animals. A nerve locator was used to facilitate placement of the nerve blocks in American alligators (*Alligator mississippiensis*), Yacare caiman (*Caiman yacare*), and a dwarf crocodile (*Osteolaemus tetraspis*). Provision of analgesia is a frequently underused aspect of patient care in reptiles. Use of a nerve stimulator provides an objective measurement of nerve conduction blockade and may be useful in exotic species in which anatomic landmarks for nerve block placement are not well established.

21: *J Am Vet Med Assoc.* 2003 Apr 15;222(8):1111-5.

Use of rocuronium for endotracheal intubation of North American Gulf Coast box turtles.

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OBJECTIVE: To determine whether rocuronium, a reversible neuromuscular blocking agent, would provide safe, short-term immobilization to facilitate endotracheal intubation in turtles.

DESIGN: Prospective study.

ANIMALS: 30 healthy adult Gulf Coast box turtles.

PROCEDURE: Turtles were given rocuronium, and responses were recorded every 3 minutes. Times to onset of effects, intubation, and recovery were recorded and analyzed for associations with dose and patient characteristics to determine an optimal dose range. Neostigmine and glycopyrrolate were given to augment recovery from neuromuscular blockade.

RESULTS: Rocuronium administered at a dose of 0.25 to 0.5 mg/kg (0.11 to 0.23 mg/lb), IM, permitted intubation; lower doses were not effective. Mean +/- SD time to loss of the palpebral reflex was 6.4 +/- 4.0 minutes, and mean time to intubation was 9.2 +/- 6.4 minutes. Mean time to return of the palpebral reflex was 44 +/- 13.2 minutes, and mean time to walking was 55 +/- 16.6 minutes. Time to onset of effects was not associated with dose, but recovery times were prolonged with higher doses of rocuronium. Cardiac arrhythmias were observed in 13 (43%) turtles.

CONCLUSIONS AND CLINICAL RELEVANCE: Administration of rocuronium at a dose of 0.25 to 0.5 mg/kg is a safe and effective adjunct to general anesthesia in Gulf Coast box turtles. Because rocuronium does not provide any analgesic or sedative effects, the duration of neuromuscular blockade without anesthesia should be minimized to avoid undue distress.

22: J Am Vet Med Assoc. 2002 Apr 1;220(7):982-5.

Anesthesia case of the month. A suitable choice for anesthetic management of a green iguana for an orchidectomy.

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23: Vet Clin North Am Exot Anim Pract. 2001 Jan;4(1):83-117, vii.

Reptile anesthesia.

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Successful reptile anesthesia requires patience, planning, and understanding of normal anatomy and physiology in health and disease. Reptiles make good anesthetic patients because of their physiologic resilience. New drugs that are not only safe and efficacious, but also result in relatively short recovery times, have greatly enhanced the design of anesthetic regimens. Further studies are required to quantitatively evaluate the physiologic effects of drugs used and validate available monitoring modalities for use in a wide variety of reptiles.

24: Vet Clin North Am Exot Anim Pract. 2001 Jan;4(1):19-33.

Fish, amphibian, and reptile analgesia.

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Pain perception and appropriate behavioral responses are important for survival. The conservation of the opioid ligand and receptor suggests evolution of opioid receptors mediating antinociception throughout vertebrate phylogeny. Fish, amphibians, and reptiles have appropriate neurologic components, display the appropriate behavior in response to a painful stimulus, and possess antinociceptive mechanisms to modulate pain. Because pain perception in these species is therefore likely to be analogous to that of mammals, invasive and painful procedures should always be accompanied by appropriate analgesia and anesthesia. Although specific doses have not been established in clinical trials, clinicians should attempt to provide lower vertebrates with appropriate analgesia during painful procedures. Further experimental and clinical investigations are necessary to expand the current veterinary literature in the area of pain and analgesia in lower vertebrates such as fish, amphibians, and reptiles.

25: Vet Clin North Am Exot Anim Pract. 2001 Jan;4(1):119-45, vii.

Crocodilian anesthesia.

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With declining crocodilian populations worldwide, a greater interest in the conservation of these animals in the wild and in captivity is ongoing. This effort has created a demand for safe and effective ways to handle and immobilize crocodiles for transport and relocation. With the advent of new anesthetic protocols, working with crocodilians has now been made safer for both the animal and the handler. Unfortunately, current anesthetic protocols have been limited to a few species and further application of these protocols need to be undertaken with new species.

26: J Am Vet Med Assoc. 2008 Jul 15;233(2):267-73.

Analgesic efficacy of butorphanol and morphine in bearded dragons and corn snakes.

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OBJECTIVE: To test the hypothesis that administration of butorphanol or morphine induces antinociception in bearded dragons and corn snakes.

DESIGN: Prospective crossover study.

ANIMALS: 12 juvenile and adult bearded dragons and 13 corn snakes.

PROCEDURES: Infrared heat stimuli were applied to the plantar surface of bearded dragon hind limbs or the ventral surface of corn snake tails. Thermal withdrawal latencies (TWDLs) were measured before (baseline) and after SC administration of physiologic saline (0.9% NaCl) solution (equivalent volume to opioid volumes), butorphanol tartrate (2 or 20 mg/kg [0.91 or 9.1 mg/lb]), or morphine sulfate (1, 5, 10, 20, or 40 mg/kg [0.45, 2.27, 4.5, 9.1, or 18.2 mg/lb]).

RESULTS: For bearded dragons, butorphanol (2 or 20 mg/kg) did not alter hind limb TWDLs at 2 to 24 hours after administration. However, at 8 hours after administration, morphine (10 and 20 mg/kg) significantly increased hind limb TWDLs from baseline values (mean +/- SEM maximum increase, 2.7 +/- 0.4 seconds and 2.8 +/- 0.9 seconds, respectively). For corn snakes, butorphanol (20 mg/kg) significantly increased tail TWDLs at 8 hours after administration (maximum increase from baseline value, 3.0 +/- 0.8 seconds); the low dose had no effect. Morphine injections did not increase tail TWDLs at 2 to 24 hours after administration.

CONCLUSIONS AND CLINICAL RELEVANCE: Compared with doses used in most mammalian species, high doses of morphine (but not butorphanol) induced analgesia in bearded dragons, whereas high doses of butorphanol (but not morphine) induced analgesia in corn snakes.

27: J Am Vet Med Assoc. 2007 May 1;230(9):1356-62.

Analgesic efficacy and respiratory effects of butorphanol and morphine in turtles.

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OBJECTIVE: To test the hypothesis that butorphanol or morphine induces antinociception with minimal respiratory depression in conscious red-eared slider turtles.

DESIGN: Prospective crossover study.

ANIMALS: 37 adult male and female red-eared slider turtles (*Trachemys scripta*).

PROCEDURES: Antinociception (n = 27 turtles) and respiratory (10 turtles) experiments were performed. Infrared heat stimuli were applied to the plantar surface of turtle limbs. Thermal withdrawal latencies were measured before and at intervals after SC administration of physiologic saline (0.9% NaCl) solution, butorphanol tartrate (2.8 or 28 mg/kg [1.27 or 12.7 mg/lb]), or morphine sulfate (1.5 or 6.5 mg/kg [0.68 or 2.95 mg/lb]). Ventilation was assessed in freely swimming turtles before and after SC administration of saline solution, butorphanol (28 mg/kg), or morphine (1.5 mg/kg).

RESULTS: For as long as 24 hours after injection of saline solution or either dose of butorphanol, thermal withdrawal latencies among turtles did not differ. Low- and high-dose morphine injections increased latencies significantly by 8 hours. Ventilation was not altered by saline solution administration, was temporarily depressed by 56% to 60% for 1 to 2 hours by butorphanol (28 mg/kg) administration, and was significantly depressed by a maximum of 83 +/- 9% at 3 hours after morphine (1.5 mg/kg) injection. Butorphanol and morphine depressed ventilation by decreasing breathing frequency.

CONCLUSIONS AND CLINICAL RELEVANCE: Although widely used in reptile species, butorphanol may not provide adequate antinociception for invasive procedures and caused short-term respiratory depression in red-eared slider turtles. In contrast, morphine apparently provided antinociception but caused long-lasting respiratory depression.

28: Am J Physiol Regul Integr Comp Physiol. 2008 Sep 10. [Epub ahead of print]

Inhibitory and excitatory effects of mu (MOR), delta (DOR), and kappa (KOR) opioid receptor activation on breathing in awake turtles (*Trachemys scripta*).

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For ectothermic vertebrates, such as reptiles, the effects of opioid receptor subtype activation on breathing are poorly understood. Based on previous studies on mammals and lampreys, we hypothesized that mu (MOR) and delta (DOR) receptor activation would cause respiratory depression while kappa opioid (KOR) receptor activation would have no effect. To address this question, respiration was measured in awake, freely-swimming adult red-eared slider turtles (*Trachemys scripta*) before and after injection with agonists for specific opioid receptors. DAMGO injections (MOR agonist; 1.5 or 6.5 mg/kg) decreased ventilation (VE) by 72 +/- 9% and 95 +/- 3%, respectively, at 4.0 h post-injection due to decreased breath frequency and no change in tidal volume (VT). DOR agonists, such as DPDPE (5.0 mg/kg) or DADLE (6.3 mg/kg), decreased VE by 44 +/- 10% and 89 +/- 4%, respectively, at 4.0 h post-injection due to decreased breath frequency and no change in VT. DADLE also increased breath duration by a maximum of 25 +/- 9% at 6.0 h post-injection. U-50488 (KOR agonist; 6.2 mg/kg) increased VT by a maximum of 52 +/- 30% at 5.0 h post-injection with variable nonsignificant changes in VE and breath frequency. Naloxone injections (0.25-0.5 mg/kg) given 1.0 h prior to opioid agonist injections blocked all DAMGO-dependent effects, DPDPE-dependent frequency depression, and DADLE-dependent breath duration augmentation for 2.0 h after agonist injections. These results show that MOR and DOR receptor activation causes respiratory depression via decreased breath frequency while VT is increased following KOR receptor activation.

All Anesthesia/analgesia papers from the ARAV (BARAV/JHMS)

Tricaine Methane Sulfonate (MS-222) Anesthesia in Spiny and Florida Soft-shell Turtles, *Apalone spinifera* and *Apalone ferox*
Assoc Reptilian Amphibian Vet 7[2]:9-11, 1997

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- The use of MS-222 on soft-shelled turtles, in our experience, has resulted in excellent surgical anesthesia. It is a relatively easy to administer anesthetic, either by injection or immersion. Induction times were relatively short with reasonable recovery time. Its disadvantages might include: variability in induction and recovery times, its unavailability in a ready-to-inject sterile solution, and brief solution shelf life (five to seven days). We feel, in research, MS-222 would be an acceptable choice for surgical procedures in soft-shelled turtles requiring good muscle relaxation.

Ketamine Sedation followed by Propofol Anesthesia in a Slider, *Trachemys scripta*, to Facilitate Removal of an Esophageal Foreign Body
Assoc Reptilian Amphibian Vet 8[1]:16-17, 1998

Geoffrey W. Pye, BVSc, MSc; James W. Carpenter, MS, DVM, Dipl., ACZM

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- Surgical anesthesia of chelonians can be difficult to achieve using injectable anesthetic agents without prolonged recovery periods. Ketamine as the sole anesthetic agent requires doses of 55-90 mg/kg IM to achieve surgical anesthesia in chelonians and recovery may take one to several days. Some veterinarians consider propofol to be the injectable agent of choice for reptile anesthesia and recommend a dose of 10-15 mg/kg IV. Surgical anesthesia lasts 15-25 minutes and recovery takes 25-40 minutes. Because propofol must be given intravenously, administration in chelonians can prove difficult when the tail vein cannot be found and the head cannot be extracted for jugular venipuncture without sedation. Metomidate has been used at a dose of 10-20 mg/kg IM in snakes to facilitate intravenous infusion of propofol. Following metomidate premedication, the propofol dose was reduced to 5 mg/kg. Ketamine at a dose of 22-44 mg/kg produces sedation in chelonians and this allows extension of the neck so that the jugular vein can be accessed. This report describes three episodes of anesthesia in an individual slider, *Trachemys scripta*, in which premedication with ketamine (25-30 mg/kg IM) was used to facilitate exposure of the jugular vein and propofol (7 mg/kg) was given IV to achieve short term surgical anesthesia for esophageal examination and fishhook removal.

Preliminary Evaluation of Medetomidine/Ketamine Combinations for Immobilization and Reversal with Atipamezole in Three Tortoise Species
Assoc Reptilian Amphibian Vet 8[4]:6-9, 1998

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- Twenty immobilizations, for various minor clinical procedures, were performed on 12 adult and sub-adult leopard, *Geochelone pardalis*, yellow foot, *Geochelone denticulata*, and Aldabra, *Aldabrachelys gigantea*, tortoises with a combination of medetomidine and ketamine. An intravenous dose rate of 100 ug/kg medetomidine for leopard and yellow foot tortoises and 25-80 ug/kg for Aldabra tortoises resulted in induction times (time from drug injection until the head could be pulled out and the mouth opened) that ranged between 4 and 16 minutes (median 10) and 15-45 minutes (45) respectively. Recovery times (time from drug injection until the tortoise was able to withdraw its head with strength) using intravenous atipamezole at a dose rate of 400 ug/kg for leopard and yellow foot and 100-380 ug/kg for Aldabra tortoises ranged between 2 and 30 minutes (5) and 5-15 minutes (5) respectively. Most (90%) of leopard and yellow foot tortoises experienced a drop in heart rate from baseline following medetomidine/ketamine administration, however no clinical complications were noted. Two leopard tortoises vomited post intravenous injection of atipamezole. One Aldabra tortoise exhibited penile prolapse following intravenous injection of medetomidine/ketamine and one yellow foot and three Aldabra tortoises exhibited a transient bilateral hindlimb paralysis even after reversal with atipamezole.

Cardiopulmonary Effects and Efficacy of Propofol as an Anesthetic Agent in Brown Tree Snakes, *Boiga irregularis*

Assoc Reptilian Amphibian Vet 9[2]:9-15, 1999

* Nancy L. Anderson; DVM, DABVP (Avian) Raymund F. Wack; DVM, DACZM; Liz Calloway, BS; Thomas E. Hetherington, PhD; Joseph B. Williams, PhD

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- Nine wild-caught brown tree snakes, *Boiga irregularis*, were anesthetized with 5 mg/kg of propofol. Mean duration of anesthesia was 24 minutes. Eight of nine the snakes experienced 30 to 60 seconds of self-limiting apnea immediately following propofol injection. Two of the nine snakes failed to achieve a surgical level of anesthesia, as assessed by positive response to tail and vent pinch. Only mild changes in heart rate, cardiac blood gases, ET CO₂, and SpO₂ were observed. The magnitude of these changes were small, which correlated with smooth, uncomplicated anesthetics experienced by all study snakes. Propofol appears to be a safe and effective anesthetic for restraint or minor procedures in brown tree snakes. Standard techniques used to monitor heart and respiratory rates should be adequate to assess cardiopulmonary status of healthy brown tree snakes anesthetized with a single 5 mg/kg bolus of propofol.

Anesthesia Roundtable

J Herpe Med Surg 9[4]:20-27, 1999

R. Avery Bennett, DVM, MS, DACVS, Stephen J. Divers, BSc(Hons), BVetMed, CertZooMed, CBiol, MIBiol, MRCVS, Juergen Schumacher, DVM, DACZM, Jeffrey Wimsatt, DVM, PhD, James Gaynor, DVM, DACVA, Scott J. Stahl, DVM, DABVP (Avian)

New anesthetic drugs have become available over the last several years and many of them may be useful in reptile and amphibian anesthesia. As we gain experience, we can provide increasingly safe and effective anesthetics and analgesics. This roundtable is composed of clinicians who have extensive experience with reptilian and amphibian anesthesia. Hopefully, the information provided will allow us to offer even safer and more effective care for our patients.

Reptile and Amphibian Analgesia

J Herpe Med Surg 15[1]:24-30, 2005

* Cheryl Greenacre, DVM, DABVP (Avian); Joanne Paul-Murphy, DVM, DACZM; Kurt K. Sladky, MS, DVM; Timothy Storms, DVM; and Moderator: Eric Klaphake, DVM

* Associate Professor The University of Tennessee College of Veterinary Medicine Department of Small Animal Clinical Sciences C247 Veterinary Teaching Hospital Knoxville, TN 37996, USA

Evaluating and providing analgesia are challenging and frustrating goals for any medical practitioner. These goals are even more difficult to attain in patients that cannot verbally respond if pain management is adequate. The dearth of information on this topic in reptilian and amphibian patients compounds this complication. Yet, not attempting to provide adequate analgesia borders on malpractice in today's veterinary practice. The following practitioners represent individuals currently involved in research involving analgesia in exotic animal species, and they provide their insight on analgesia in answering the provided questions.

Intracoelemic Administration of Propofol in Hatchling Green Iguanas, *Iguana iguana*

J Herpe Med Surg 16[1]:20-26, 2006

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ABSTRACT: Hatchling green iguanas, *Iguana iguana*, weighing between 16 -26 g were injected intracoelemically (IcE) with either propofol (n=6) at an empirical 10 mg/kg dose or physiologic saline (0.9% sodium chloride) solution at 2 ml/kg as sham treatment controls (n=3). Propofol effect from IcE administration was variable and induced mild sedation to a light plane of anesthesia in five of six iguanas based on their graded reflexes or

responses (0 = absent, 1 = decreased and 2 = normal) and had no measured effect in one iguana. Decreased graded responses were seen primarily in jaw tone and righting reflex. Tracheal intubation was possible in only one of the five (83%) of six iguanas that responded. Analgesia was minimal or absent based on toe and vent pinch responses, and on corneal reflexes. Onset of maximum propofol effect was seen between five and 15 min post ICE propofol and provided 10-30 min of useful sedation or anesthesia. Heart rate and respiratory rate were measured for each iguana responding to propofol ICE at baseline (0 min), at the maximum effect and at recovery. Propofol ICE did not cause a significant decrease in heart rate at maximum effect or at recovery, but did cause a significant decrease in respiratory rate at maximum effect and recovery. There were no significant differences between the propofol and saline injected iguanas in the estimated total WBC at pre or 24 h' post ICE injection, or 14 d later at the time of euthanasia. All nine iguanas gained between 2 to 12.4 g (median 6.9 g) during this study and there was no significant difference in weight gains between Group 1 (mean of 7.0 g with median of 7.3 g) and Group 2 (mean of 8.3 g with median of 8.9 g) iguanas. No lesions attributable to ICE injections of either propofol or saline solution were seen on gross or histologic examinations. It appears that ICE propofol can induce sedation or light anesthesia and may be a viable and safe alternative to intravenous or intraosseous administration in small iguanas. An optimum or consistently effective dose for propofol administered ICE remains to be established.

Comparative Antinociception of Morphine, Butorphanol, and Buprenorphine Versus Saline in the Green Iguana, Iguana Iguana, using Electrostimulation

J Herp Med Surg 16[3]:88-92, 2006

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ABSTRACT: Pain management in reptiles is poorly understood and most published reptile opioid doses are empirically derived. In this study, five adult (3 male, 2 female) green iguanas, *Iguana iguana*, were given either 0.5 ml saline or an opioid analgesic agent intramuscularly 30 min prior to electrostimulation of the tail to compare responses. Opioid analgesic agents evaluated were butorphanol at 0.4, 1.5, 4.0 and 8.0 mg/kg, buprenorphine at 0.02 and 0.1 mg/kg, and morphine at 0.4 and 1.0 mg/kg. Electrostimulation was administered with a Grass stimulator® with the two electrodes placed 1 cm apart at the measured junction of the first and second thirds of the tail, randomly delivering currents of 2, 10, 20 and 40 mA for a duration of 500 mS, 10 min apart. The iguanas' responses were recorded on videotape so three evaluators, blinded to the agent given, could determine a score (0-20) based on a response scale developed for this study. Increasing scores correlated with increases in heart rate, and movement of the head, eye, body and tail. Body movement response scores were significantly ($P < 0.05$) lower at all currents for morphine at 1.0 mg/kg and for butorphanol at both 1.5 and 8.0 mg/kg, when compared to saline. There was no significant difference in body movement response scores between saline and butorphanol at 0.4 and 4.0 mg/kg, buprenorphine at 0.02 and 0.1 mg/kg and morphine at 0.4 mg/kg. These results indicate that antinociception is provided in green iguanas from morphine at 1.0 mg/kg IM, or butorphanol at 1.5 mg/kg or 8.0 mg/kg IM and that these drugs, at these dosages, would be expected to provide analgesia to green iguanas in a clinical setting. Electrostimulation of the tail provided a good model of antinociception for use in further research on analgesia in green iguanas.