SNAKE ANESTHESIA AND SURGERY

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In general, performing anesthesia and surgery on a snake should be approached with the same principles as those used for domestic animals. However, there are obvious anatomic considerations, as well as unique aspects of patient preparation, positioning, and equipment with which the reptile clinician should be familiar.

ANESTHESIA

The secrets to successful snake anesthesia are an appreciation of anatomy, physiology, and detailed preparation. In particular, understanding the cardiorespiratory system, and the need to maintain appropriate species-specific temperatures throughout the entire hospital period, are essential. There are many ways to anesthetize a snake, and readers are directed to detailed reviews for complete coverage\(^4,5\); however, only the preferred options used by the author will be described here. Although nonvenomous snakes form the mainstay of the article, venomous-specific methods will be indicated; however, practitioners are advised to seek specialty training before working with these animals.

Pre-anesthetic Assessment

All snakes should be monitored from a distance (without handling) to record resting respiratory rate. A complete physical examination, including accurate weight and heart rate should also be conducted. The extent of pre-op blood testing will depend upon the situation, and can include hematology (ideally a complete blood count, but minimally hematocrit and estimated counts from a blood smear) and a biochemistry profile (including total protein, albumen, globulin, aspartate transaminase, bile acids, uric acid, and electrolytes). Consideration should be given not only to the amount of blood that can be safely collected from a healthy snake but also the potential blood loss from that snake during surgery. Total blood loss should not exceed 0.5 mL/kg. The VetScan VS2 analyzer (Abaxis) provides a full reptile profile with only 0.2 mL whole blood. Pre-anesthetic assessment of venomous species is typically restricted to visual appraisal.

Premedication

Given the preliminary findings reported by Sladsky, it seems dubious whether opiates are effective. Nevertheless, until confirmed, morphine at 1.5 mg/kg IM can be considered. In addition, meloxicam at 0.2 mg/kg IM is also useful, but should probably be given post-operatively if there are any doubts regarding hydration status and/or renal function. If infection has been confirmed (and culture has already been collected) then pre- and intraoperative antibiotics should be considered. Premedication is generally ill-advised when dealing with venomous species.

Induction and Intubation

For small snakes (<500 g), it is frequently easier to place them into a ziplock bag, flush and fill the bag with 5% isoflurane or 8% sevoflurane, seal, and leave for 15 to 30 minutes in an incubator or vivarium (27-30°C, 80–88°F) for gaseous induction. This creates sufficient restraint for intubation (or easier intravenous access if deeper induction is necessary). For larger snakes, intravenous propofol (5–10 mg/kg) via the caudal vein or intracardiac injection facilitates intubation. For small snakes, uncuffed tubes are preferred for intubation using intravenous catheters or endotracheal tubes up to 2.5 mm in diameter. Tubes are typically taped (not tied) in place. For larger snakes, appropriately sized cuffed endotracheal tubes can be used but should be inflated with care, just enough to avoid gas leakage during ventilation. Maintain the snake in sternal and on a high level of anesthetic gas (eg, 4–5% isoflurane, 6–7% sevoflurane) until a surgical plane of anesthesia is achieved.

All venomous snakes should be transported to the practice in secure, double containers, that are locked and clearly marked. The inner container should be transparent and have a small hole drilled into one end to permit the insertion of an anesthetic gas line. This will permit induction without having to handle a dangerous species. When all righting reflexes have been lost, the snake can be removed using snake hooks, tongs and/or plastic tubes, taking all necessary precautions, and assuming that the snake is still conscious and capable of striking. Syringe cases are placed over the maxilla and mandible to cover the fangs, and the snake is carefully intubated using a long endotracheal tube. Evenomation is still possible from an anesthetized snake, and so a large syringe case (with the end cut-off) is placed over the endotracheal tube and snake’s head to provide protection during the entire procedure.

Maintenance

The snake is positioned on a heated surface, with the forced warm air blankets appearing most effective at maintaining temperature (Bair Hugger, Arizant). A temperature probe is inserted into the esophagus or cloaca, and an ultrasonic doppler probe is taped over the heart or major peripheral artery. A pediatric, mainstream, end-tidal capnography unit is connected to the endotracheal tube, which is then connected to a ventilator and anesthetic machine. The Small Animal Ventilator (Vetronics) connects to an existing anesthetic machine, is simple to use, and effective. Starting from a maximum inspiration pressure of 2 cm water and expiration length of 2 sec, the maximum inspiration pressure is increased until normal coelomic breathing excursions are achieved. The rate at which inspiration occurs is controlled by the oxygen flow rate. The expiration length is then adjusted to initially equal the pre-anesthetic resting respiratory rate.
Vascular access can be achieved by placing an intravenous catheter into the caudal vein or, in an emergency, into the ventricle. For most noncritical cases, intracoelomic or subcutaneous fluids can be administered prior to surgery to ensure hydration, and repeated intraoperatively at a site distant to the surgical area. Accurate pulse oximetry readings can be difficult to maintain, but a reflectance probe inserted into the cloaca or esophagus, or a tongue clip probe across the mandible or maxilla is often successful. No values for MAC, isoflurane or sevoflurane, have been determined for any species of snakes; however, data from other reptiles suggests MAC values for isoflurane and sevoflurane of around 2 and 3, respectively.

Monitoring
Anesthetic monitoring should include an assessment of reflexes (eg, tongue, tail, vent, ventrum), ETCO₂, SpO₂, pulse or heart rate, ventilation depth and frequency, oxygen flow, and vaporizer setting, with a dedicated anesthetist to record and make adjustments to suit individual patient requirements. While it is impossible to give strict guidelines, the following are offered as mere guidelines;

- Heart rate: > 30, and not less than 60% of conscious values.
- SpO₂: readings often highly variable but monitoring the trend is more informative.
- ETCO₂: Maintain between 10 and 20 mmHg. Hyperventilation and values <10 mmHg are associated with respiratory alkalosis and prolonged apnea during recovery.
- Ventilation: Adjust depth and frequency to maintain appropriate ETCO₂, typically 1 to 4 breaths/min.
- Core temperature: 27–30°C, 80–88°F. Hypothermia leads to prolonged recovery.

Recovery
Before the end of surgery, anesthetic gas should be discontinued, and several minutes later, ventilation decreased to 0.25 to 1 breath/min in order to increase ETCO₂, decrease SpO₂, and induce spontaneous respiration. At the end of surgery, oxygen should be discontinued and replaced by air (ambulance bag), again at 0.25 to 1 breath/min. Once spontaneous breathing has returned, the snake should be moved to an incubator and continuously monitored. Venomous snakes should be extubated at this stage and placed in their original locked container and observed. Nonvenomous snakes can be extubated once righting reflexes or body movement has returned. However, they should still be monitored every 5 to 10 minutes as some individuals may regress and become apneic. Full anesthetic recovery has occurred once the snake is moving freely around the vivarium, and may take several hours.

SURGERY
Equipment
Proper surgical lighting and, for small snakes or microsurgery, magnification (operating loupes, Surgitel) are required. Radiosurgery (eg, Surgitron, Ellman) utilizes high frequency radiowaves to create hemostasis, is versatile and cost effective, and creates less collateral damage than CO₂ laser. Hemoclips (Weck closure systems) and LoneStar retractors are also invaluable (Table 1). Surgical instruments are listed in Table 2 and shown in Figure 1.

### Table 1. Useful Equipment Suppliers

<table>
<thead>
<tr>
<th>Supplier</th>
<th>Address</th>
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<tbody>
<tr>
<td>Lone Star retractor</td>
<td>11211 Cash Road, Stafford, TX 77477</td>
</tr>
<tr>
<td>Surgitron loupes, General Scientific Corporation</td>
<td>77 Enterprise Drive, Ann Arbor, Michigan 48103</td>
</tr>
<tr>
<td>Weck Closure Systems</td>
<td>2917 Weck Drive, P.O. Box 12600, Research Triangle Park, NC 27709</td>
</tr>
<tr>
<td>4.0 MHz dual radiofrequency Surgitron</td>
<td>Ellman International, 1135 Railroad Ave, Hewlett, NY 11557</td>
</tr>
<tr>
<td>Adhesive surgical drape, Veterinary Specialty Products</td>
<td>P.O. Box 812005, Boca Raton, FL 33481</td>
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### Table 2. Useful instruments for reptile surgery

<table>
<thead>
<tr>
<th>Standard exotic animal surgery pack</th>
<th>Standard exotic animal microsurgery pack</th>
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<tbody>
<tr>
<td>Plain ophthalmic fine thumb forceps</td>
<td>Mini gelpi retractor</td>
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<tr>
<td>Adson ½ forceps, very fine</td>
<td>k-wire pin driver vice</td>
</tr>
<tr>
<td>Small scissors (top sharp tip, bottom blunt tip)</td>
<td>Doolen avian bone holding device</td>
</tr>
<tr>
<td>Castroviejo retractor</td>
<td>Stevens tenotomy scissors</td>
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<tr>
<td>Small suture scissors</td>
<td>Two balanced micro scissors</td>
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<tr>
<td>Derf needle holder</td>
<td>Doolen avian spay hook</td>
</tr>
<tr>
<td>Strabismus scissors</td>
<td>Extra delicate mosquito forceps, straight</td>
</tr>
<tr>
<td>Four curved ophthalmic mosquito forceps</td>
<td>Extra delicate mosquito forceps, curved</td>
</tr>
<tr>
<td>Twenty 3x3 gauze sponges</td>
<td>Sontec curved tying forceps</td>
</tr>
<tr>
<td>Twenty cotton tipped applicators</td>
<td>Ring-tipped thumb forceps with holes</td>
</tr>
<tr>
<td>Clear plastic adhesive drape</td>
<td>Two spring bulldog clamps</td>
</tr>
<tr>
<td>Vetrap 2''</td>
<td>LoneStar retractor</td>
</tr>
</tbody>
</table>
Preparation and Positioning
Consideration should also be given to appropriate surgeon and patient positioning to reduce surgeon fatigue, prevent patient compromise, and maximize surgical site access. Aseptic surgery should be carried out in an appropriately clean and sterile room by surgeons wearing surgical masks, hats, sterile gloves and gowns. The surgical site should be aseptically cleaned using chlorhexidine or povidone-iodine concentrate—a toothbrush is particularly useful for cleaning scaled skin. Transparent, adhesive drapes (Surgical drape, Veterinary Specialty Products) are preferred over cloth drapes.

SURGICAL PROCEDURES
Snake integument is composed of keratinized scales and thinner intercalar skin. Incisions should be made between the scales, thus making most surgical wounds scalloped. When reptile skin is incised, it has a tendency to invert. Therefore, evertting suture patterns (eg, horizontal or vertical mattress) using polydioxone or nylon are recommended to ensure opposition of tissue without future dysecdysis. Fine polydioxone causes less reaction than polyglactin and is preferred for internal sutures. Skin sutures are typically removed after 6 to 8 weeks. Some of the most common surgical procedures performed on snakes are outlined below.

Wound Treatment
Wounds, usually grossly infected, are a frequent presentation, and given the caseous nature of the reptilian inflammatory response, surgical debridement is often always necessary. Sharp dissection is employed to remove all adherent necrotic and infected tissue that should then be submitted for histopathology and microbiology. The maintenance of topical medications, dressings and bandages can be challenging in some cases, and although slow, the ability of reptiles to recover from serious trauma is remarkable. Allogenic and xerogeneic grafts have been documented in reptiles. Successful xerogeneic skin grafts using porcine small intestinal submucosa (Biosist, Cook Veterinary Products) have been reported in reptiles.

Cutaneous Abscess/Mass Removal
Subcutaneous abscesses are most common, neoplasia less so. Abscesses typically present as firm discrete swellings. If the skin is unaffected, a craniocaudal incision is made over the length of the abscess, and the skin reflected to facilitate complete removal of the abscess (including any fibrous). A piece of the abscess capsule should be submitted for bacterial and fungal culture. The underlying tissue is thoroughly irrigated with antiseptic solution. If the entire abscess including pyogenic capsule was removed, the skin can be closed in a routine manner. If there is any doubt the skin edges should be trimmed to leave an open wound that should be cleaned daily.

Subspectacular Abscess
Blockage of the lacrimal duct results in fluid accumulation between the spectacle and the cornea. Often this fluid becomes infected. A 30 degree wedge is removed from the ventral aspect of the spectacle. The caseous material is removed for cytology and microbiology, and the subspectacular space thoroughly flushed. The patency of the lacrimal duct must be assured. It is generally easier to catheterize the buccal opening of the duct as it emerges close to the cranial margin of the palatine teeth, and flush retrograde. The spectacle wedge incision is left open and frequent topical ophthalmic medication is recommended until the spectacle heals at the next shed.
Prolapsed Hemipenes
Snakes possess paired copulatory organs (hemipenes) that may by become prolapsed through the vent. If the tissue appears viable, it can be cleaned, moistened and gently replaced by inversion through the vent opening and caudally into the tail base. Two simple interrupted sutures can be placed across the lateral margins of the vent to prevent immediate recurrence for 2 to 5 days. A purse suture should not be utilized. If the tissue appears necrotic, hemipenal amputation is the treatment of choice. As the hemipenes do not contain a urethra, mattress sutures or circumferential ligatures can be placed at the base and the organ safely resected. Obviously, this procedure will compromise future breeding although snakes with a single remaining hemipenis can still breed. All affected animals will benefit from systemic antibiotics and topical wound care given the proximity of the surgical site to the cloaca.

Prolapsed Cloaca and/or Colon
Prolapse of the cloaca and distal colon are not uncommon. However, they are often treated inappropriately by replacement and purse-string sutures without due regard for the underlying cause. Minor prolapse can be replaced and two simple interrupted sutures can be placed near the edges of the vent to prevent recurrence. More severe prolapse is treated by transcutaneous cloaco- or colopexy, which is aided by using a rigid endoscope to visualize needle entry into the cloaca/colon. Uncommonly, this procedure will fail and a coeliotomy is required to anchor the colon to caudal ribs using nylon. In cases of severe cloacal and colonic necrosis, resection and end to end anastomosis is essential, and a combination of cloacal and coeliotomy approaches may be required. Great care is needed to identify and preserve the openings of the ureters and oviducts within the urodeum.

Coeliotomy
The elongated nature of snakes makes it impossible to make a single coeliotomy incision to access all major organs. Therefore, it is vital that the precise surgical site is accurately determined ahead of time using anatomy references, palpation, clinical pathology, and diagnostic imaging. A permanent marker is used to mark the surgical site, both on the snake and on white tape placed on the table (Figure 2). In general, the incision is made between the first and second rows of lateral scales, taking care to incise between the scales whenever possible. This ensures that the incision is positioned laterally and off the floor when the recovered snake is ambulatory. Radiosurgery, laser or blunt dissection is continued through the muscle layer, just ventral to the ribs. Entry into the coelom is made between the ribs and ventral musculature. It is often necessary to navigate through multiple fascial layers to gain access to the coelom, and extensive fat bodies can hinder visualization. A two-layer closure is routine with the

Figure 2. Positioning of a large snake in preparation for coeliotomy. The zigzag line indicates the preferred skin incision between the second and third rows of lateral scales. Note the tape marker on the table to remind the surgeon of the precise area of interest. (B) Using bipolar radiosurgery to incise through the coelomic musculature.
muscle layer closed using absorbable suture in a simple interrupted or continuous pattern. Skin closure is routine.

A variety of intracoelomic procedures can be attempted following successful entry into the coelom. These include, among others, salpingotomy (egg/ova/fetus removal), gastrotomy, enterotomy, pneumotomy, transmitter implantation, mass/tumor removal, and surgical biopsy.

**POSTOPERATIVE CARE**

All things being well, snakes are typically discharged the day after surgery, and rechecked a week later. Sutures are typically removed 6 to 8 weeks after surgery.

**REFERENCES**