SOFT TISSUE SURGERY IN REPTILES

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Skin incisions are generally made between scales in the thin softer tissue between them. It is assumed that healing in this skin is more rapid than when an incision is made through the tough scales. A number 11 scalpel blade is particularly useful for skin incision as its fine tip allows the surgeon to incise with more precision between scales. There is no difference in healing when the incision for celiotomy in snakes is made through the scutes (large ventral scales) on the midline compared with a lateral incision between scales. However, the author prefers not to place the incision on the ventrum, where it will be in constant contact with substrate and water.

The incised skin of most reptiles has a tendency to invert. Because of this, an enverting skin closure pattern, such as an interrupted horizontal mattress, is commonly used. Alternatively, skin staples are designed to slightly evert the skin edges when applied. The skin of reptiles is very tough and is considered the holding layer for wound security. Sutures are tightened to gently appose the skin edges. Sutures tightened excessively will cause necrosis of the skin within the suture and dehiscence of the incision. Reptiles rarely traumatize their skin incisions or remove sutures intentionally.

Anatomy

Prior to undertaking a surgical procedure in a reptile patient, the surgeon must become familiar with the unique anatomy of the particular family of reptiles to which the patient belongs. There is variation in anatomy among families of reptiles, for example, crocodilians are considered to have a 4 chambered heart while squamates (lizards and snakes) and chelonians (turtles and tortoises) have a 3 chambered heart. There is also variation within a family of reptiles. In green iguanas, the kidneys are normally located within the pelvic canal while in monitor lizards they are within the coelomic cavity.

Some features are relatively consistent across species of reptiles. In general, reptiles do not have a muscular diaphragm and, as such, have a ceolomic cavity rather than a thoracic and abdominal cavities; however, crocodilians do have a relatively well developed septum between the thoracic viscera and the abdominal viscera. Reptiles do not have lymph nodes. They do not store fat in the subcutaneous tissue but have descrete fat bodies within the coelom. In some species the spleen and pancreas are intimately associated with each other forming a splenopancreas.

The urinary system of reptiles is substantially different from mammals. Reptiles have a renal portal system such that, when the portal vein is open, blood from the caudal half of the body passes through the kidney prior to reaching the systemic circulation. Urine leaves the kidneys through the ureters which empty into the cloaca, not the urinary bladder. Urine then travels from the cloaca into the bladder of those species with a urinary bladder (chelonians and some lizards) or into the colon in those species without a bladder (snakes, crocodilians, and some lizards) where water absorption and ion exchange occur. Urine does not flow through the reproductive system and the short urethra only connects the bladder to the cloaca.

The cloaca receives excretions from the ureters; colon and urinary bladder in those species with a bladder; and the reproductive system. Chelonians and crocodilians have a single copulatory organ (penis) while squamates have paired copulatory organs called hemipenes (hemipenis, singular). The copulatory organs do not contain tubular structures such as a urethra. Semen travels along a groove in the hemipenis into the cloaca of the female. The female reproductive tract is bilateral in reptiles with each oviduct having a separate opening into the cloaca.

Celiotomy

The approach for celiotomy in reptiles varies with the family of reptiles. Because reptiles lack a diaphragm celiotomy can allow access to both thoracic and abdominal viscera.

Lizards and crocodilians have a body structure more similar to mammals than chelonians and snakes. A paramedian incision is recommended in these species because of the ventral abdominal vein. This vein receives blood from the caudal abdominal wall and courses along the ventral midline 2-3 mm inside the body wall. It is located between the umbilical scar and the pubic bones and is suspended by a short mesovasorum. Some surgeons prefer a midline approach using meticulous dissection to avoid damaging this rather large vein. Making a paramedian incision 2-4 mm lateral to midline minimizes the risk of lacerating this vessel. This vein may be ligated without consequence.

Closure is accomplished using a simple continuous pattern with a synthetic absorbable material on a fine, atraumatic swaged-on needle. Because the muscle of the body wall is thin and tightly adhered to the skin, care must be taken with suture placement and tension on the suture or tearing through the muscle will occur. Suturing the body wall will pull the skin edges into apposition. Skin staples or an everting pattern of a nonabsorbable material maintain skin apposition.

In laterally compressed lizards, such as chameleons, a flank incision is more appropriate. The incision is initiated 2-4 mm caudal to the last rib on one side of the body, through the skin and then through the body wall. Closure is as described above.

Snakes have organs arranged in a linear configuration. In most cases, the specific organ being approached must be identified preoperative as celiotomy will not allow access to all of the viscera. It is essential to know the location of the specific organ being approached.

The coelomic membrane may be closed as a separate layer or incorporated in the body wall closure. The body wall is a thin pale muscle which is tightly adhered to the skin. The coelomic membrane is not attached to the skin. The muscle of the body wall is closed with a simple continous pattern using a synthetic absorbable material on a fine atraumatic needle which will also approximate the skin edges. The skin is closed with either skin staples or an everting pattern such as a horizontal mattress.

Chelonians present a unique challenge for celiotomy because of their shell. For most procedures a plastron osteotomy is required. In species with a small plastron, such as snapping turtles and sea turtles, many procedures can be accomplished through a flank incision. Some procedures, such as cystotomy, can be accomplished through this approach in other chelonians.

The pelvic bones are avoided during plastron osteotomy to avoid injury to the appendicular skeleton. In most species, osteotomy through the femoral and abdominal epidermal shields will allow access to coelomic viscera while avoiding injury to the appendicular skeleton and heart. The osteotomy must be large enough to allow the procedure to be accomplished and located in a position to allow access to the target organ.

Standard surgical preparation is performed and the surface of the plastron must be completely free of debris and soil. This requires a surgical scrub brush. Alcohol, ether, or acetone is used to remove grease from the surface of the plastron to allow a better bond to form between the epithelium and the epoxy resin that will be used to stabilize the plastron osteotomy postoperative.

The plastron is dermal bone and efforts are made to improve the environment for bone healing. The osteotomy cut is beveled slightly and the blade should be as thin as possible so when the segment of plastron is replaced, bone-to-bone contact will be achieved. The blade is

irrigated while preforming the osteotomy to dissipate heat and control bone dust. An osteotomy is made on both sides as well as the caudal margin of the proposed flap. The segment of plastron is then reflected craniad based on the intact hinge which will provide blood supply to the segment of intact bone.

There are two large venous sinuses within the coelomic membrane located paramedian on each side between the midline and the bridge. The incision into the coelom is made along the ventral midline. The membrane is thin and transparent in the central region where there is no muscle.

Closure is accomplished using a synthetic absorbable material in the coelomic membrane and body wall. The bone flap is replaced and secured using epoxy resin and fiberglass cloth. Enough layers of epoxy are applied to create a completely smooth surface with no texture from the cloth remaining. During the final curing process, a piece of plastic sheeting or wax paper is applied to the patch to prevent paper or soil from adhering to the resin. This will not stick to the epoxy and is removed the following day.

Flank celiotomy is used in chelonians with a small plastron or in tortoises with small cystic calculi or a small intestinal foreign body. With the animal in dorsal recumbency, the left hindlimb is pulled caudally exposing the inguinal depression. The skin is incised in either a longitudinal or transverse manner and the muscles are bluntly separated until the coelomic membrane is identified. The membrane is grasped with tissue forceps and incised to allow access to the coelomic cavity.

Surgery of the Female Reproductive Tract

Female reptiles have a bilateral reproductive tract but their reproductive physiology varies considerably. Some reptiles lay eggs (crocodilians, chelonians, and some squamates) while others have live birth (some lizards and some snakes). Dystocia, prevention of reproduction, and neoplasia are the major indications for surgery of the female reproductive tract. Surgical management of dystocia is indicated when husbandry changes and medical management have failed to relieve the dystocia or if there is evidence (such as radiographic) that the eggs are unable to pass because they are too large or of an abnormal shape. Ovariosalpingectomy is performed to treat dystocia or to prevent future problems related to the reproductive tract such as yolk peritonitis, dystocia, and salpingitis.

Preovulatory egg stasis is characterized by the development of yolks on the ovary which are not ovulated. Postovulatory stasis occurs when the eggs are within the oviduct but do not pass normally. In either case, it is recommended that the ovaries as well as the oviducts be removed. It appears that if the oviduct is removed without removing the ovary, yolks will be released into the coelom potentially inducing yolk peritonitis. If the ovaries are removed and the oviducts left, they simply atrophy and are unlikey to cause problems in the future. Removal of one side of the reproductive tract (unilateral ovariosalpingectomy) for treatment of reproductive disease allows the patient to remain reproductively viable which may be important for herpetoculturists.

The female reproductive tract is relatively mobile within the coelom. In lizards and chelonians it is readily accessible through a standard celiotomy approach. In snakes, the tract is very long and if the entire oviduct contains eggs or feti which must be removed, it is often necessary to make several celiotomy approaches.

When reproductively active, the blood vessels supplying the ovary and oviduct become engorged and hypertrophied making surgical removal more challenging. For this reason, in pet reptile species with a high incidence of with dystocia, prepubertal elective ovariosalpingectomy

should be considered. The procedure is much easier when the vessels, ovary and oviduct are small and the patient is in good metabolic condition.

In iguanas, the right ovary is very close to the right external iliac vein, while the left is more loosely attached with the left adrenal gland interposed between the left external iliac vein and the ovary. When the ovary is active as with preovulatory egg stasis, the ligament is stretched out and it is easy to apply hemostatic clips to the vessels supplying the ovary. Two clips are applied to each vessel and the vessel is transected between the clips. The process is continued until all vessels are clipped and the ovary with its multitude of yolk follicles is removed.

When the ovary is not active, removal is more challenging. Removal of the right ovary is accomplished by gently elevating the ovary, applying one or two clips between the right ovary and the right external iliac vein, then transecting the tissue distal to the clip to allow removal of the ovary. The left ovary is removed in a similar manner with the clips applied between the ovary and the left adrenal gland. The tissue distal to the clips is transected allowing removal of the ovary without damaging the adjacent adrenal gland.

Following removal of the ovaries, the oviducts are removed. Dissection is initiated at the infundibulum and continued to the cloaca. With preovulatory egg binding, the oviduct is empty and vessels are easily controlled either with hemostatic clips or bipolar cautery. One or two clips are applied to the base of each oviduct at the cloaca prior to their transection and removal.

In cases of postovulatory egg binding where the oviducts are full of eggs, the ovaries are relatively small and inactive as they have already released their yolks. The oviducts full of eggs will obscure visualization of the ovaries and are removed prior to ovariectomy. The vessels to the oviducts are generally engorged and numerous. Each vessel is identified, two hemostatic clips are applied, and the vessel is transected between them. Dissection is initiated at the ovaries and continued caudad until the oviducts can be ligated or clipped at the cloaca prior to transection. After the oviducts are removed the ovaries are visualized as described above. The ovaries are removed as described previously. Closure is routine.

Postoperative care is supportive. Most patients will have been anorectic for 2-4 week prior to surgical intervention. Fluid therapy is administered through an intravenous or intraosseous catheter. Antibiotics are indicated in the management of bacterial salpingitis. Again, the patient should be maintained at the upper end of its preferred temperature range for proper function of the immune system and the digestive system.

Orchidectomy

Castration is primarily performed in male green iguanas that have become aggressive toward their owner. Castration has been shown to decrease testosterone levels and sexual aggressive behaviors in some lizards. Most commonly, orchidectomy is performed in iguanas after the aggressive behavior has developed and it may be more appropriate to perform the procedure in prepubertal iguanas before the inappropriate behaviors have developed. When performed in an aggressive animal, it appears that the aggression is not ameliorated until the following breeding season. In the authors experience, the prognosis for attenuation of the behavior is about 50% following orchidectomy.

Orchidectomy is performed through a standard celiotomy. As with the ovaries, the right testicle is more closely attached to the right external iliac vein by its short, vascular mesorchium. The right adrenal gland is located on the other side of the external iliac vein. The left testicle is more loosely attached to the left external iliac vein and the left adrenal gland is located between

the left testicle and the external iliac vein. The adrenals are elongated, granular, pink glands easily distinguished from the smooth, white testicles. The testicles are covered by a capsule which can be ruptured during aggressive manipulations. Rupture of the capsule does not result in hemorrhage but the contents flow out making it difficult to continue with the dissection.

The testicles are removed in a manner similar to that described for removal of inactive ovaries. The right testicle is gently elevated and one or two hemostatic clips are applied between the testicle and the external iliac vein. The tissue distal to the clips is transected allowing removal of the testicle. The left testicle is removed following application of hemostatic clips between the left adrenal gland and the testicle. If there is hemorrhage from the external iliac vein one or two hemostatic clip are applied longitudinally along the damaged side of the vessel to control hemorrhage. Partial occlusion of the external iliac vein has not been associated with clinical disease; however, if over half of the diameter of the external iliac vein is attenuated, signs of vascular obstruction would be anticipated.

Cystotomy

Urinary calculi can develop in any species of reptiles that has a urinary bladder but seem to occur most frequently in desert tortoises and green iguanas. Improper nutrition and inadequate access to water or dehydration have been suggested as initiating causes. Clinical signs of cystic calculi include anorexia, depression, constipation from occlusion of the colon, dystocia from occlusion of the oviduct, cloacal prolapse from tenesmus, and paraparesis secondary to compressive injury to the pelvic nerves. A definitive diagnosis is made based on radiographs or palpation. Calcium urates calculi are radiopaque while ammonium urate calculi can be very difficult to visualize radiographically.

In chelonians, cystic calculi are palpated in the left inguinal fossa. The urinary bladder of chelonians is bilobed and the right liver lobe lays over the right lobe of the urinary bladder. Because the right portion of the bladder is compressed by the right liver lobe, most cystic calculi are present in the left lobe of the bladder. A finger is inserted into the fossa with the chelonian in a sternal recumbency. With the finger left in place, the tortoise is tipped to verticle (90°) and the stone is felt hitting the finger as it falls to the dependent portion of the bladder. In lizards, cystic calculi are easily identified by abdominal palpation.

Cystotomy is performed through a standard celiotomy approach. The bladder is large and easily identified when a calculus is present. The bladder wall is very thin and transparent but becomes somewhat thicker because of the cystitis usually associated with a calculus. The bladder is isolated with moist gauze sponges or laparotomy pads prior to making the cystotomy to minimize coelomic contamination. The urine of reptiles contains mucus and urates giving it a thick, cloudy appearance which may not be easily aspirated through small suction tips. Following removal of the calculus, the bladder is irrigated to remove residual debris. Closure is accomplished using a fine (5-0 to 7-0) monofilament, absorbable material on a small, swaged-on, atraumatic needle in a simple continuous appositional pattern oversewn with an inverting pattern. Celiotomy closure is routine.

Because dehydration may cause dessication of urates within the bladder initating calculus formation attention must be paid to maintaining adequate hydration. Antibiotics are indicated if bacterial cystitis is present. Husbandry changes (nutrition, temperature, access to water) are made where appropriate.

Reproductive Organ Prolapse

The cloaca of reptiles consists of three compartments: the copradaeum, the urodaeum, and the proctodaeum. Each of these compartments and their associated structures can,

theoretically, prolapse. The copradaeum is the most cranial compartment of the cloaca and is where the rectum enters. This compartment receives urinary and fecal wastes from the terminal colon. Urinary wastes of reptiles pass into the cloaca and then into the urinary bladder, in chelonians and most lizards, or into the terminal cloaca, snakes and some lizards, where water absorption occurs. The urodaeum is the middle section of the cloaca and contains is where the ureters and the reproductive systems terminate. The proctodaeum is the caudal compartment of the cloaca and is a reservoir for fecal and urinary wastes prior to excretion.

The anatomy and location of the male copulatory organ varies among reptile orders. Squamate reptiles (most lizards and snakes) have hemipenes (paired copulatory organs). Hemipenes in these reptiles are hollow organs that are inverted within the tail. Some lizards, crocodilians, and chelonians have a single penis. The penis of these reptiles is within the cloaca or coelomic cavity, is a solid organ, and is everted during copulation. Neither the reptile penis or hemipenis contains a urethra. These organs are not for urination but strictly for the transport of semen.

Paraphimosis occurs more commonly in chelonians than in squamates reptiles. Causes include excitement, stress, trauma to the exposed organ from cage mates, substrate, forced separation during copulation, iatrogenic trauma secondary to probing for sex determination, infection or inflammation, neurologic deficits, and cloacal impaction.

The prolapsed organ is often edematous form venous engorgement, lacerations form cage mates or substrate, and may be infected, necrotic, and covered with an inflammatory exudate. If the tissue is very edematous and necrotic it may be difficult to determine if the prolapsed tissue is penis/hemipenes or another cloacal structure. It is simple to ascertain the nature of the tissue in most squamates. If the base of the prolapsed tissue is coming from the distal aspect of the vent (coming from the tail) it is most likely to be hemipenis or hemipenes. If the prolapsed tissue is coming from the cloaca in a squamate it is unlikely to be hemipenes. In crocodilians and chelonians, with severely affected prolapsed tissue, it may be difficult to determine the origin of the tissue without entering the coelomic cavity.

The reptile is sedated or placed under general anesthesia and the prolapsed organ is cleaned and lubricated. If lacerations are noted attempts to suture are made but most edematous tissues will not hold sutures well. The tissue is then replaced into the tail in squamate reptiles or into the cloaca in chelonians and crocodilians. Moistened cotton-tip applicators are useful in reducing the prolapsed tissue. If the prolapase does not reduce that application of a cold compress or hypertonic fluids may help. In addition, the placement of stay sutures in the center of the vent, both proximal and distal, helps with traction. The vent can also be incised laterally on one or both sides. Once the prolapse is reduced it is kept in place by a purse string or transverse sutures in the vent. Transverse vent sutures have the benefit of allowing fecal and urinary wastes to be passed and are preferred by the author. Regardless of the technique used the sutures are removed in 2-3 weeks.

If the tissue is necrotic or infected it should be amputated. Amputation of the hemipenis or hemipenes will not compromise urination. In snakes and lizards, amputation of the hemipenis still allows reproductive viability. Mattress sutures or encircling sutures are placed around the base of the prolapsed tissue, and the organ is amputated distal to the suture. The mucosa of the stump is sutured with a simple continuous pattern, and the stump is replaced in its normal anatomic location.

Prolapse of the oviducts or shell gland has occurred in female reptiles. In some cases it is possible to reduce the prolapsed tissue; however, the viability of the tissue and assessment of

damage to the suspensory ligament of the oviduct is limited. Amputation of the tissue has been performed but celiotomy for complete assessment of the prolapsed tissue and repair or removal of the reproductive tract is recommended. If only one side of the reproductive tract is removed, the contralateral side allows for reproductive viability.

Other Surgical Procedures

A variety of surgical procedures such as, ovariectomy, ovariosalpingectomy, castration, cystotomy, and enterotomy for removal of foreign bodies may be performed in reptile patients once the surgeon is familiar with the unique anatomy of and surgical approaches used in reptile patients. Once the approach to the celomic cavity is made, most procedures are analogous to those performed in domestic animal surgery.

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