SURGICAL APPROACHES TO THE COELOM OF REPTILES: GETTING IN IS HALF THE BATTLE

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**ABSTRACT**

The surgical approach to the coelomic cavity of reptiles varies with the family. The approach in lizards and crocodilians is basically the same and a function of their body conformation being similar to mammals. Chelonians have the shell that protects them from predators and trauma but makes surgical approaches more challenging. The internal anatomic location of organs and their mode of locomotion affect the surgical approach used in snakes.

Preparation for the procedure is important. Little special equipment is needed for reptile soft tissue surgery. When approaching the coelomic cavity of chelonians, some type of saw is generally needed to cut the shell. An oscillating bone saw is idea but circular blades are available for use with a rotary woodworking tool such as Dremel. The diamond wheel is very thin and made for cutting. Another blade has teeth and is marketed by Micro Mark (Micromark.com; 0.021” thick, 7/8th” diameter, 36 teeth). These blades dull quickly and should be replaced frequently (after a couple of uses). Dull blades generate a lot of heat and take more time to cut through the bone. Excessive heat can delay bone healing. These blades are not made of surgical steel and will rust if autoclaved. It is better to gas or plasma sterilize these blades. The rotary tool can also be gas or plasma sterilized. If this is not possible, it should be wrapped in a sterile shroud for intraoperative use. Fast setting epoxy glue works well for securing the cut shell to allow the bone to heal. Fiberglass cloth used for auto and boat body work is used to bridge the osteotomy gap. Since these are applied to the external surface, it is not critical that they be sterilized but the cloth is glass and autoclaveable and it is unlikely bacteria can live in epoxy cement.

A preoperative fast is usually not necessary in reptiles. Regurgitation and aspiration are uncommon in reptile patients. The patient should be kept warm during surgery and in recovery. This helps them maintain normal body functions and has been shown to promote healing. It is generally not recommended to keep the patient cool to minimize the amount of anesthesia needed.

Standard aseptic technique is used in reptile patients. Alternating cleansing between chlorhexidine or povidone iodine and sterile saline is appropriate. Alcohol is flammable and should be avoided or thoroughly removed if electrosurgery, radiosurgery, or laser will be used. A sterile field should be created as in mammals using quarter drapes first, then a patient drape on top of the quarter drapes. It is best to create a sterile field of the entire table rather than only a
small area to avoid intraoperative contamination. For chelonians with a more dome shaped carapace, a towel rolled into a circle will help stabilize the patient from rolling on the table.

**Chelonian Celiotomy**

The most commonly used approach to the coelomic cavity of chelonians is via an osteotomy of the plastron. The plastron is composed of bone with an epidermal covering. The externally visible epidermal shields do not match up with the bone plates except on midline and where the pectoral and abdominal shields meet on the plastron. Box turtles have a soft tissue hinge at this location that allows them to close the cranial portion of the plastron against the carapace to protect their head and legs. A three sided plastron osteotomy with the fourth side at the hinge will allow the bone to be reflected cranially preserving its soft tissue attachments at the hinge and the insertion of the pectoral muscles along the dorsocranial aspect of the bone flap.

In species that do not have a hinge, the flap is usually cut in the abdominal and femoral shields avoiding the pelvic bones attached to the dorsocaudal aspect of the femoral and anal shields. Radiographs can help determine their location. The exact location will vary somewhat depending on the coelomic structure being approached.

The cut is made at an angle (approximately 45°) while irrigating the blade to minimize the heat and to control the bone dust. The body wall/coelomic membrane and the caudal attachments prevent the piece from falling into the coelom so the cut is made at an angle to get better bone-to-bone contact which should help bone healing. The cranial and 2 lateral cuts are made before the caudal cut. Initially, a shallow cut is made to outline the osteotomy on all 4 sides. Then the three sides are cut in a manner similar to cutting off a cast. The blade is pushed straight down (do not move it from side-to-side), lifted, advanced, and pushed down again. You should feel when the blade has cut all of the way through the shell. By not advancing the blade while cutting you will minimize the amount of deep, soft tissue that you cut. You should be able to cut the shell without damaging the body wall/coelomic membrane deep.

After cutting three sides, cut the fourth side, most of the way through the bone. By making only a partial cut caudally, the piece will be more stable when it is replaced. Insert a periosteal elevator into the cranial cut and lever against the cranial portion of the abdominal shield to lift the osteotomized piece of bone. You will see muscles attaching along the inner surface of the plastron. This is the caudal insertion of the pectoral muscles. Carefully elevate the muscles off the inner aspect of the plastron. Continue elevating the muscles and body wall off the inner aspect of the plastron. At some point, as you elevate the bone, you will crack it along the caudal edge. You may need to deepen the caudal cut if you are not able to crack it.

As you proceed caudally, you will encounter a different set of muscles which are the pelvic muscles inserting along the inner surface of the plastron from caudally. It is preferred to leave these muscles attached providing blood supply to the osteotomized section of bone postoperatively. You should be able to retract the piece of plastron caudally to allow you to do what you need to within the coelom. Place moist gauze over the muscle and bone. If you removed the piece and sever all of its attachments, you will have created a devitalized piece of
bone. Bones heal better when muscle attachments are preserved; however, a devitalized piece of bone can revascularize and heal if it is rigidly immobilized.

The body wall should be intact. There is a large venous sinus on each side about half way between midline and the bridge. This sinus quickly spasms and becomes difficult to identify. Be careful to avoid damaging these. Clinically, if they are sacrificed it does not appear to cause problems. If they are damaged, there may be a risk that when they dilate they may hemorrhage internally. Make the body wall incision on or near midline mainly to avoid damaging these vessels.

Once the procedure is complete, the body wall is closed with a simple continuous suture since it is not under much stress. The flap of bone is replaced and pushed to achieve bone-on-bone contact. The epidermal surface is cleaned and dried thoroughly. Fast curing epoxy is mixed and placed over the plastron bone flap using an applicator stick or tongue depressor. Avoid the osteotomy site as glue in the cut could inhibit healing. Apply the glue to the plastron peripheral to the osteotomy for a distance appropriate to the patient size. Cut a piece of fiberglass cloth to cover the flap and the perimeter outside the cut. Place the fiberglass on top of the wet glue and work the cloth into the glue with the applicator stick. At this point, there should be no glue in the osteotomy and the epoxy/fiberglass should bridge the gap.

Allow this first layer to cure. Mix another batch of epoxy and apply it over the entire surface, but only apply a light layer over the osteotomy to prevent the cement from oozing into the gap. Allow this layer to cure. Mix more epoxy and apply. Keep doing this until you can no longer see the pattern of the fabric of the fiberglass on the surface of the epoxy. The surface should be completely smooth, glass-like. After the initial curing time the epoxy will still adhere to many surfaces. Apply a piece of wax paper over the epoxy surface until the next day. Wax paper will not stick and easily peels off the epoxy.

Clinically, it seems to take 6-12 mo for the osteotomy to heal. There is usually no need to remove the patch. These patches can remain in place for many years before falling off on their own. It is important to note that if a bur is used to remove the epoxy, the dust generated can be carcinogenic so a mask should be worn and this should be done in a well ventilated area.

In young animals where the plastron is not well mineralized, it is possible to make an incision with a scalpel. Be very careful not to cut deeper structures. Follow the lines between epidermal shields. Remember that the epidermal shields and bone plates only match up at the hinge and midline. Use heavy suture material to suture the plastron back together. Then apply a layer of epoxy over the incision.

In chelonians with a small plastron (marine and snapping turtles) a flank or prefemoral approach will allow access to some viscera without the need to cut the plastron. While exposure is limited, by not cutting the plastron, healing in these aquatic species is much faster. The patient is positioned with the cranial aspect of the body elevated allowing the viscera to fall caudally making them more accessible. Use a band of tape on the leg to pull it caudal and medial opening the prefemoral area as much as possible. Make an incision starting at the bridge midway between
the plastron and carapace through the skin and subcutaneous tissues toward the leg. The incision is carried through the abdominal oblique and transverse abdominal muscles or the muscle fibers can be separated using a grid technique for the approach. Identify the coelomic membrane and sharply incise it with blunt scissors. Be careful to avoid accidentally incising the bladder wall which might look like the coelomic membrane. Exposure is limited and it is difficult to exteriorize organs. Close the coelomic membrane with a simple continuous pattern of an absorbable monofilament material. Close the muscles and subcutaneous tissues with a simple continuous pattern. The skin is closed with a simple interrupted or an everting pattern as indicated. The prefemoral area is used bilaterally for minimally invasive surgical procedures.

**Snake Celiotomy**

Because of their elongated body, it is important to know the location of the organ or object being approached. There are published reports describing the anatomic location of body organs based on a percent of body length (head to tail). Radiography and ultrasonography are also useful for determining the location of the structure to be approached. While there are no studies comparing healing of ventral midline celiotomy with a lateral celiotomy, in a retrospective study of dystocia in snakes, a comment was made that there was no apparent difference. Intuitively, a more lateral approach makes sense as the incision is somewhat away from the substrate. The incised skin of snakes tends to invert so an everting closure is commonly used. When a midline incision is made and the scutes are everted, a ridge is created. Snakes also have a ventral abdominal vein along the ventral midline in the caudal part of their coelom. Because squamate and crocodilian reptiles do not have a distinct linea alba, rectus sheath, or well developed body wall musculature, making the incision off midline does not appear to be associated with an increase in morbidity or postoperative complications. Most prefer the lateral approach over the ventral midline approach.

I prefer to make the incision between the two most ventral rows of scales lateral to the large ventral scutes. By making the incision in this area, when the skin is sutured with an everting pattern, these two rows of scales are everted slightly rather than evert the scutes. Note that there is one rib associated with each scute and it is best to avoid cutting the ends of the ribs. Most sources recommend cutting between scales rather than through them. This will result in a zigzag incision line.

Using a number 11 scalpel blade with the cutting edge directed outward, make a small stab incision between two scales. Lift the blade outward cutting the skin between the two scales. This allows you to cut the skin without cutting anything deeper. This method is different from the way we incise mammal skin and is recommended because the skin of these reptiles is very tough and the body wall muscle very thin. When pushing down to make an incision, it is easy to cut not only the skin but also the body wall and internal organs. After making the first incision between two scales, change the angle to direct the blade between the next two scales. Insert the blade and lift out again. Repeat this process until the skin incision is as long as is needed.

The body wall should be intact after skin incision. Lift the body wall up with forceps a couple of millimeters ventral to the ribs and make a small incision with scissors, then extend the incision the desired length. To close, place a simple continuous monofilament absorbable material in the
body wall. The muscle is very thin and tightly adhered to the skin. You will have to evert the skin to place the suture in the body wall muscle. Run the needle between the skin and muscle following the curve of the needle to allow it to come out in the coelom. Then insert the needle into the body wall inside the coelom to exit between the skin and muscle. This is very delicate work and the muscle does not hold suture well. Do not pull too tightly on the suture.

Because the skin tends to invert, an everting pattern is used for skin opposition. A horizontal mattress works well but other patterns that slightly evert the skin are also acceptable. Note that skin staples are designed to evert the skin slightly. The sutures should be tightened only to evert the skin enough to get the cut edges in opposition. They should NOT be tightened enough to create a ridge or to expose the cut edges to the environment. If the sutures are tightened too much, they will cut off the blood supply to the ridge of skin created and it will slough. This is NOT desirable and should not occur. If the skin and sutures slough, you are tightening them too much.

**Lizard and Crocodilian Celiotomy**

Lizard and crocodilian body type is more like mammals and the approach to the coelom in most species is ventral. I prefer to make a paramedian approach much like described above for snakes. The ventral abdominal vein is located along the ventral midline from the umbilical scar cranially entering into the liver. It is a large vein but clinical evidence suggests that if it is accidentally incised, it can be ligated without consequence. I prefer to avoid it.

Like snakes, the incised skin of these reptiles also tends to invert. In most lizards, the scales are small and it is not feasible to make the incision between scales. As described in snakes, use a number 11 blade with the cutting surface directed outward. Initiate the incision caudal to the umbilical scar and cut only the skin. Once the skin is incised, make a nick incision into the body wall caudal to the umbilical scar where the ventral abdominal vein approaches the body wall. Insert a hemostat into the opening in the body wall and advance it cranially to push the ventral abdominal vein to the opposite side and protect other, deeper structures from accidentally being incised with the body wall. The hemostat can be used to guide the incision in the body wall and to protect structures or the incision can be extended in small bites lifting the body wall to make sure you are not too close to the ventral abdominal vein. Cut the body wall 2-3 mm lateral to midline to give you an edge to suture to without concern for entrapping the ventral abdominal vein during closure.

Closing is similar to the method described for snakes. You need to roll the skin out to be able to get sutures placed in the body wall. Place a simple continuous suture in the body wall being delicate and careful. Place interrupted everting sutures such as horizontal mattress sutures in the skin. Again, the sutures should only be tightened to achieve opposition of the cut skin surface. Do not over tighten them.

In laterally compressed lizards a lateral approach is preferred. Position the patient in lateral recumbency. Make a skin incision 2-3 mm caudal to and parallel to the last rib. Ventrally, extend the incision paramedian and caudally. Make the skin incision before cutting body wall. Make a
stab incision into the body wall and continue the incision along the skin incision. The ventral paramedian incision will help avoid the ventral abdominal vein. You will have created a flap. Retract the flap caudodorsally providing exposure to the coelomic viscera.