The Reptile Survival Guide Online 'Mini Series'

Session 3:
Reptile Anaesthesia and Surgery

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Respiratory and cardiovascular anatomy and physiology

Respiratory anatomy and physiology have influences on the methods of anaesthesia and the effectiveness of any monitoring devices used.

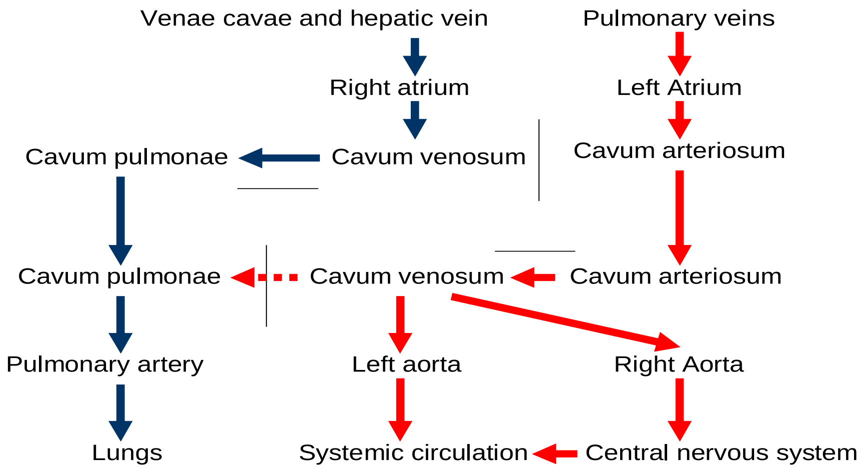
Tortoises have a simple glottis at the base of their fleshy tongue. Their trachea is made of solid tracheal rings and the trachea bifurcates very proximally. In some species this can be at the base of the skull and others at the thoracic inlet. This means that endotracheal tubes should be uncuffed and short such that one bronchus is not inadvertently intubated. The bronchi course dorsally into the lungs. This limits the ability of a tortoise to clear respiratory secretions. The lungs are multi-chambered and split into up to 15 regions.

Squamates have a simple glottis at the base of their fleshy tongue (most lizards) or just behind the forked tongue (in snakes and monitors). The trachea of squamates has incomplete rings like a mammal. Snakes have an initial solid section to prevent trauma and collapse of the trachea when consuming large prey items. Endotracheal tubes should be uncuffed and the length needs to be appropriate based on the species. Small lizards obviously require short tubes. Most of the colubrid snakes we will see have only the right lung functional. Boas and pythons have two lungs but the left is much reduced in size. Many snakes have tracheal lungs which form from pouches of the tracheal membrane dorsally. In lizards the trachea divides into bronchi which course into the lungs. The longitudinal anatomy of snakes limits their ability to clear respiratory secretions. Lizard lungs can range from simple to multi-chambered. Snakes start off with a parenchymous part which progressively simplifies down to form the air sac. This air sac can extend for over 75% of the snout vent length of the snake.

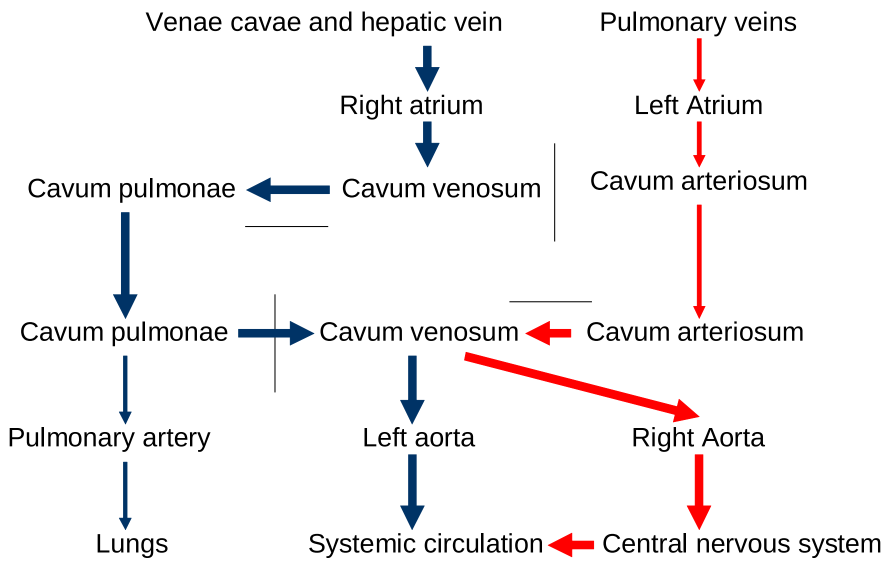
The heart is three chambered and consists of two atria and one ventricle. The ventricle is functionally split into three chambers. The cavum arteriosum receives blood from the left atrium. The cavum venosum receives blood from the right atrium. There is communication between these chambers during systole. In diastole there is no communication as the AV values occlude the communication. Blood exits the cavum venosum into the left and right aortae. Below these two chambers is the cavum pulmonae. Blood exits from here into the pulmonary artery.

This set up actually allows for a differential flow of blood depending on the animals physiological state.

When breathing the pressure on the pulmonary side of the circuit is lower than the systemic side. The following blood flow pattern occurs.



As can be seen there is a small left to right shunt of blood. During breathing there is reduced parasympathetic tone. When breath holding (when diving for example) the parasympathetic tone is increased and this leads to vasoconstriction of the pulmonary artery and a reduction in heart rate. This leads to increased pulmonary resistance and a right to left shunt now occurs. This leads to a pulmonary bypass during diving.



As blood pH drops during a dive the Bohr Effect leads to increased offloading of O_2 to the tissues. Once this reaches a critical stage the pulmonary vessels dilate temporarily allowing reoxygenation of blood (and the uptake of O_2 is enhanced by increased pH). This in combination with cutaneous and pharyngeal respiration allows aquatic species to dive for long periods. Resistance to anoxia is high. Aquatic chelonians can hibernate in hypoxic mud. In these circumstances a turtle may be seen swimming (under ice for example) to reoxygenate itself prior to once again submerging in the mud. Pharyngeal respiration is of greatest importance in soft shelled turtles. Aquatic turtles have survived in a nitrogen atmosphere for 27 hours. Monitor lizards have a higher aerobic scope and their heart functions like a four chambered heart all the time. They even have a differential in ventricular size.

This means that tortoises that fall in ponds can survive. It also means that mask induction of chelonians is pointless as they can just shut the lungs out of circulation. Some authors suggest that maintaining a tortoise under injectable anaesthesia is preferable to gaseous anaesthetics given the shunting reported above. However under anaesthesia the parasympathetic tone is lost leading to a reduced right to left shunt and so gaseous anaesthesia should be effective. Complications can occur such as ventilation perfusion mismatches or inadequate ventilation. Despite these changes gaseous induction can be used for terrestrial squamate species. This can be performed by directly intubating the animal conscious (snakes), using a face mask (lizards) or using an induction chamber (small squamates). I prefer to use transparent zip lock bags which can be filled with 5% isoflurane in oxygen. The reptile can be manipulated within the bag and once the righting reflex is totally lost the bag can be opened an intubation performed.

Anaesthesia

Anaesthesia protocols vary and a variety of agents have been used. My preferred approach is to use alfaxalone at 10mg/kg given intravenously although propofol at 10 mg/kg is still in common use.

As there is no concern regarding lymph dilution any vein is fine for induction (jugulars, subcarapacial, dorsal tail vein, ventral tail vein or intracardiac).

Other agents to consider for intravenous use are ketamine at 2 – 5 mg/kg. Ketamine has been combined with medetomidine for IV use as well in chelonians (ketamine 5mg/kg and medetomidine 0.1 mg/kg), but caution is to be advised regarding the cardiorespiratory effects.

Although top up doses of intravenous agents can be used, I prefer to intubate and use gaseous anaesthesia for maintenance. It should be noted that propofol or alfaxalone alone will give 10 – 20 minutes surgical time.

Even in tiny chelonian patients IV access is possible via the subcarapacial sinus so IM sedation/induction is generally not required. However there is the risk of spinal damage using the subcarapacial route. Medetomidine/Ketamine combinations have been used IM in chelonians.

Dosages vary depending on the level of sedation required; -
300µg/kg and 15mg/kg respectively for aquatic species.
100µg/kg and 10mg/kg respectively for terrestrial species.

Alfaxalone can be given IM at twice the IV dose.

Dexmedetomidine has similar cardiovascular effects to medetomidine and can be used instead at half the dose of racemic medetomidine.

Attention must be paid to analgesia as well and pre medication with agents such as ketamine IM (I typically use 10 – 30 mg/kg) alongside either butorphanol (2 mg/kg) or morphine (2 mg/kg) will provide mild sedation plus multimodal analgesia prior to an invasive procedure.

Once the animal is sufficiently sedated intubation is possible. Small diameter endotracheal tubes are required and these should be short to avoid bronchial intubation. Customised tubes can be made from urinary catheters. Endotracheal tubes as small as 1mm are commercially available. It is relatively easy to achieved intubation by waiting for a breath and inserting the tube when the glottis is open.

Direct intubation has been performed in Desert tortoises (*Gopherus agassizzi*) without any premedication. Sevoflurane was administered by positive pressure ventilation until anaesthesia was achieved.

A T-piece can be used for ventilation but there is variation in both the tidal volume and the rate of respiration depending on the nurses' concentration! I would rather use a mechanical ventilator. Respiration rate should be 6 breaths per minute. Initially higher ventilation rates can be used to deepen anaesthesia. Pressure cycling ventilators can be acquired fairly cheaply now. The Vetronics SAV03 ventilator is a model I have used for over 10 years. There are two settings, expiration time and pressure. Increasing pressure increases depth of ventilation and increasing expiration time reduces the respiratory rate. It is best to start off with a low pressure and build up until the front legs move to the level expected for a conscious tortoise or evaluate the movement of the body wall in squamates. Low flow rates will be required for animals requiring small endotracheal tubes. Caution is to be advised in lizards with respiratory disease as the presence of liquid pus in the lung can act as a one way valve preventing deflation of the lung field. The result is increasing inflation with each inspiration until the animal is like a balloon.

Isoflurane is fine for maintaining anaesthesia. Sevoflurane has shown to have some advantages in reducing recovery times, but this has not been consistent in all studies and there is still a prolonged recovery time whatever agent is used.

Initially 5% isoflurane is used to deepen anaesthesia. I prefer to keep the reptile on 5% until surgical stimulation. If there is no voluntary movement then the percentage can be reduced to 2 - 3%. Generally the anaesthetic agent is turned off well before surgery is completed.

Anaesthesia is best monitored using a Doppler probe. Heart rate can be predicted by metabolic scaling, HBR = $34w^{-0.25}$. Practically most conscious reptiles at their T_o have a heart rate approximately 70 BPM. Anaesthetised reptiles have a rate of 30 – 40 BPM. I prefer to listen to the Doppler and identify changes in the rate and rhythm.

The probe is best placed at the thoracic inlet in chelonians or over the carotid vessels. In juveniles it can be placed over the plastron at the junction of the abdominal and pectoral scutes. In lizards the probe is usually placed ventrally over the thoracic girdle or on the lateral thoracic inlet. Monitor lizards have a more caudally placed heart. In snakes the apex beat can be visualised and marked prior to placing the probe (22 – 33 % of the SVL).

Capnography and pulse oximetry are other options to consider. ECG and blood pressure monitoring can also be performed. Pulse oximetry has been validated in the green iguana. A reflectance probe can be placed down the oesophagus.

Capnography has problems due to the cardiovascular shunting possible in reptiles. This means the pulmonary circuit can be bypassed completely and the $ETCO_2$ may have no bearing on the $PaCO_2$ value. Equally even if blood does pass to the lungs intrapulmonary shunts can reduce gas exchange as well. However looking at trends may yield useful results. Side stream machines can work if there is sufficient air movement on expiration, mainstream units are more costly and may increase resistance.

Reflexes such as the toe pinch, tail pinch, head withdrawl, palpebral reflex, tongue withdrawl reflex (snakes) and jaw tone can be used to assess the depth of anaesthesia.

Recovery can be protracted. Plan to perform reptile anaesthetics early in the day. Many cases can be given an intravenous bolus for a short procedure to be performed and allowed to recover without any gaseous anaesthesia.

Recent work has shown that many reptiles become hypocapnic during anaesthesia which leads to reduced respiration during recovery. Allowing them to become hypoxic elevates the respiration rate and hypercapnia ($ETC0_2$ of 65 mmHg) elevates both rate and depth of ventilation. During diving this reflex is overridden.

In recovery it is important to elevate or keep ETCO2 levels by ventilating with room air or carbon dioxide. Reducing both the rate and depth of ventilation can help CO_2 levels to build up and O_2

levels to drop. Careful monitoring of the capnogram and capnograh during anaesthesia is also vital. Ventilation can be achieved using an inspiratory, ambu bag or inhaling into the ET tube.

Providing warmth is important. Keep the reptile at 26^{0}C. Do not place it under a heat lamp as it will be unable to thermo regulate at this stage. Only when mobile can a hot spot be used. Extubate when jaw tone increases and voluntary respiration occurs.

Surgery

Shell trauma

The chelonian shell is a biologically active modification of both the epidermis and dermis and consists of an upper carapace and a lower plastron connected laterally by boney bridges. The carapace has evolved from the ribs and vertebrae. The plastron has evolved from the clavicles, interclavicles and the gastralia. The boney shell consists of dermal bone plates and is covered by epidermal keratin scutes. These do not directly overly the bone plates. All of the tissue is capable of regeneration in the event of injury. New epidermal scutes are produced with each growth period and they are retained for an extended time period before being lost. It is impossible to age a chelonian by the number of scutes present. Many chelonians have marked modificiations to the shell and can have hinged sections. It is important to identify these prior to handling. Scute terminology is important to accurately identify the location of a lesion. The carapace consists of a number of vertebral scutes in the midline. Lateral to these pleural scutes can be found and the marginal scutes complete the rim of the carapace. The nuchal scute is immediately behind the head. The plastral scutes consist of (from front to back) the intergular, gular, humeral, pectoral, abdominal, femoral and anal scutes. Axillary and inguinal scutes are present at either end of the bridges.

Trauma can be from lawnmowers, dogs, fires, other tortoises, being dropped or infections. Devitalised areas of bone and keratin can be seen forming sequestrate and fractures may also be evident. Surgical intervention is required in many cases including shell repair. Do not be scared to treat chelonian wounds as you would a dog or cat.

A chelonian presenting with shell injury requires a thorough examination as underlying structures can be damaged depending on the location of the injuries. Thankfully the scutes are named according to the structures they overly. Penetrating wounds and fractures may be evident and can involve the pelvic structures, respiratory tract, spinal column and coelomic cavity. The animals mobility should be assessed and the limbs, cloaca and head examined for signs of trauma or neurological deficits. Puncture wounds entering the coelomic cavity or the lung fields should be noted and may require further evaluation. Radiography and ideally CT examination may be required for the full evaluation of orthopaedic injuries.

Most shell injuries consist of gnawing and lead to damage to the keratin scutes and the dermal bone, which can be superficial. It is important to note that the shell is living tissue and pain is likely to be significant andanaesthesia is likely to be required to facilitate thorough assessment and management of wounds. Contaminated wounds should be gently flushed and grossly debrided in the first instance with a conscious chelonian. Caution is to be advised should the coelomic cavity be penetrated to prevent contaminating deeper structures and to prevent drowning the patient if the lung fields have been breeched (this is obviously a real problem in aquatic species). As chelonians have no diaphragm and respiration is accomplished by contraction of smooth muscle within the lung and skeletal muscles of the limbs it is not necessary to create a negative pressure within the lung fields. As a result respiration can continue normal despite the breech. If the lung fields have been compromised typically a bloody foamy discharge can be visualised as the animal breathes. Holes that are big enough to allow an endoscope to be passed (1mm or greater) provide an opportunity is not to be missed. The coelomic cavity and lung fields may be breached. A thorough examination under anaesthesia is warranted and radiography or even CT may be required for a complete evaluation. Underlying damage to the thoracic and pelvic girdles and spine are possible.

Typically many fractures are compression fractures and these will require either removal (if devitalised) or lifting back into place and surgically repaired under anaesthesia. Thankfully in most cases underlying coelomic structures may just be compressed.

Shell infections can be seen and are typically more commonly seen in aquatic species with poor husbandry but are also a consequence of shell trauma. As mentioned any wounds or lesions require aggressive debridement and flushing and this will require anaesthesia to be thorough.

Shell infections can include both aerobic and anaerobic bacteria, but fungal infections can also be seen. Cultures should be taken and a bone biopsy is a good way to obtain a sample for culture. The reasoning behind this is to obtain a deeper sample identifying the true underlying pathogens as opposed to surface contaminants. Bone biopsies can also be submitted for histopathology. These samples must be taken under anaesthesia, as must and surgery involving dermal bone. Bone rongeurs and Volkmann spoons are useful instruments to facilitate debridement of lesions. All surfaces should be debrided back until wound edges are clean and the surface is pink and bleeding. Aged boney sequestrate can be present and are generally white and loose and can easily be lifted out using a dental pick. Typically these are of no clinical significance. Primary closure should only be attempted if there is no infection evident, otherwise wounds should be treated as open wounds and allow healing by secondary intention. Some lesions can remain for the life of the tortoise and ultimately slough off revealing new bone growth underneath. These can actually act as a useful dressing to prevent bacterial ingress, conversely removal should aid in granulation and new bone growth.

Thermal injuries can present as exudative areas of the shell (typically carapace from heat lamps or fires and plastron if the tortoise has been on a heat mat). Obvious charring may be evident in extreme cases. Immediate attention to analgesia, fluid therapy and antibiosis is required. Debridement under anaesthesia is required by in many cases it is best to treat medically until the full extent of thermal damage can be appreciated, alternatively anaesthesia may be required in recalcitrant animals to allow a full evaluation of the extent of injuries.

Standard dressings and products used for dogs and cats are appropriate based on the wound type. The aim of dressing a wound is to provide a number of functions. Firstly they limit further contamination, secondly they can provide further debridement and finally they provide a suitable environment for granulation and leucocyte migration. These all speed wound healing which is ultimately the primary objective. Wounds can be dressed with standard human or veterinary dressings. Typically this will involve moisturising dressings such as Granuflex® or Allevyn thin® which have the advantage of being adhesive. Silver based such as Acticoat® can also be utilised. These have the advantage of being bacteriostatic as well as providing a moist environment for maximising leucocyte activity.

More advanced wound care techniques have recently been reported. These include negative pressure wound therapy or vacuum assisted closure. These are used to accelerate the debridement and promote healing. The negative pressure assists with removal of interstitial fluid, decreasing oedema, increasing blood flow (up to 300% more) and stimulating granulation tissue (up to 35% faster). Bacterial contamination is also much lower. Sterile foam is applied to the wound and an adhesive dressing secured over the top. A drain tube is placed and connected to a vacuum source. The foam ensures an even application of negative pressure over the whole wound. This is best reserved for carapacial wounds that are centrally located. Commercial units are available and can be used to provide cyclical therapy which is the most effective method. Traditional surgical suction devices can be used with air filter foam, adhesive dressings and any tubing to reduce costs. Continuous therapy is also effective and has been advocated in the first 48 hours for maximum debridement.

However clean fractures presented promptly are suitable for surgical repair. There are a number of techniques available.

Fresh and non infected compressed and displaced fractures can be replaced and shell repair techniques used to assist shell healing. For non infected wounds preparations such as technovit, Dental acrylic or Epoxy resin can be used. Epoxy resin has fallen out of favour due to the prolonged drying time and the need for repeat layers. This also occludes the whole site and prevents any visualisation of underlying tissues. Dental acrylic and technovit can be applied circumferentially around a lesion allowing some visualisation. Dental acrylic is probably the most favourable option as it is less exothermic when setting compared to technovit.

Given that most non surgical wounds are likely to be potentially contaminated then these wounds require other techniques for repair that allow a more thorough evaluation during the healing process yet still provide stabilisation.

Bone plating still has its place in the repair of wounds. Typical sites for a bone plate will be on the central plastron or towards the more mobile femoral or pectoral scutes. The plate provides a rigid longitudinal fixation which no other method will provide, if there is complete loss of bony union in a distal fragment. Care has to be taken when selecting screw length to prevent trauma to underlying soft tissues.

Screws and IMEX external fixator pins can be used to act as anchor points in bone fragments and then orthopaedic wire can be used as a tension band to appose the bone. Alternatively screws and external fixator pins can be used to fix a small lateral fragment in place. Orthopaedic wire can be placed as a hemicerclage wire to hold a fragment in place via two pre drilled holes. Implant removal can be performed after 12 months and any holes filled with intrasite gel and covered with either an adhesive dressing (which can be regularly replaced while the wound is healing and allow assessment) or technovit for example.

More recently cable ties have been used in place of orthopaedic wire. Techniques using dental acrylic or technovit to fix hooks or blocks on the shell to act as anchor points have been used as a low cost way of stabilising fractures. These may remove the need for extensive surgery when budget repairs are required.

These techniques allow wound irrigation where infection and contamination may progress unchecked. However if deeper irrigation is required then an irrigating catheter can be placed. This can be used for ongoing flushing, antibiotic therapy and analgesia. A small drill hole is made and a 24 gauge catheter (cut short) is placed and secured with technovit or dental acrylic. The catheter removed at a later date and the hole can be covered with dental acrylic or technovit.

Skin diseases

Trauma can be from other household pets, conspecifics, prey items (livefood) or due to burns from inappropriate heat sources such as mats or hot rocks. Infections with bacterial or fungal agents are commonly seen in traumatised areas. These can occur as primary conditions where husbandry is poor and the animal is in squalid conditions. Do not be scared to treat wounds as you would in a dog or cat. Wounds require aggressive debridement and flushing. Cultures can be taken and biopsy may be indicated. This must be performed under anaesthesia. Underlying damage to the body wall and bony elements is possible. Punctures into the coelomic cavity are also highly likely. A thorough examination under anaesthesia is warranted and radiography may be required for a complete evaluation.Should primary closure be indicated it is important to use horizontal mattress sutures to close with a monofilament material such as polydioxanone as reptile skin has a tendancy to invert on closure. Skin staples have also been used with success but are not preferred by this author.

Cloacal organ prolapse

Organs that can prolapse can be the bladder, colon, cloaca, oviduct or hemipenis. Ureteral prolapse has not been reported.

Causes for prolapses can vary. Anything that can cause straining or a weakening of the musculature of the reptile can lead to prolapses. As such a full faecal examination and blood profile (including ionised calcium) is required along with radiography to check for eggs, bladder stones, intestinal foreign bodies, tumours etc. Surgical intervention is likely and can vary from replacement and a purse string suture to amputation or a plastronotomy/exploratory surgery.

Most cases presented are hemipenile prolapses and the approach taken to these cases will be considered here. The hemipenis is so called as it only performs one of the functions of the mammalian penis. The reptile hemipenis is solely used for reproduction it has no excretory function and so unless the tortoise is intended for breeding it can be amputated. Lizards and snakes have two and the loss of one hemipenis does not influence reproductive success (they just use the other!). These are situated caudally in the tail base and everted for mating purposes. Chelonians only have one cloacal organ present in both sexes which originates in the ventral urodeum.

This condition commonly presents in juvenile lizards and tortoises with nutritional secondary hyperparathyroidism. In mature animals it can present due to trauma from mating, or due to foreign body entrapment, dysecdysis and possible vitamin A deficiency.

This procedure can be performed under propofol or alfaxalone anaesthesia. The penis is extracted using tissue forceps. A haemostat can be clamped close to the cloacal mucosa. The main blood supply is in the centre of the hemipenis. Horizontal mattress sutures using a monofilament material can be used to compress the main part of the stump. The tissue distal to the clamp can be removed and the end over sewn in a simple continuous fashion.

Colonic prolapses can occur with substrate ingestion and subsequent blockage or be due to nutritional secondary hyperparathyroidism. Obstipation is a common cause of colonic prolapse in bearded dragons and snakes. However a pathological fracture secondary to spinal osteomyelitis can cause a prolapse and is worth bearing in mind. Clinical history, physical examination, radiography and blood ionised calcium is required to evaluate the animals status. If the tissue is viable then it can be replaced and a purse string suture used to hold it in place. It is important to try to restore normal anatomy. The reptile will require anaesthesia and cloacal endoscopy could be used to confirm correct placement. Percutaneous colonopexy can be performed as a budget was of resolving the problem. Any form of pexy will interfere with normal female reproductive function. If the tissue is not viable then exploratory surgery is required.

Other prolapses are likely to require exploratory surgery to resolve. The next most likely organ to prolapse is an oviudct. This is discussed under reproductive surgery.

Aural abscessation in chelonians

Clinically the ear drum is distended beyond the side of the head. The infection is considered to be an ascending infection from the pharynx. Predisposing factors such as hypovitaminosis A (which can be secondary to organochlorine poisoning) have been reported. These lead to squamous metaplasia of the lining of the ear allowing infection to colonise the area.

These are surgical cases. There is only one ossicle in tortoises the columella. This attaches dorsally on the tympanum. The ear drum can be incised from three o'clock to nine o'clock direction. The bottom segment can then be removed or cut at six o'clock. The abscess should be removed in one piece. Check there is a small bobble at the back end (which is the pus within the Eustachian tube).

Flushing should be performed and the /Eustachian tube can be cannulated to ensure patentcy. The ear drum can be closed if you wish to, using monofilament suture material. Antibiotics should be given in the short term. Culture and sensitivity and cytology are indicated in persistent cases.

Exploratory celiotomy

The surgical approach differs between species. Although there are soft tissue approaches reported in chelonians the most common procedure performed is the plastron osteotomy.

The surgical approach to plastron osteotomy and subsequent management of the surgical wound does have parallels with the treatment of shell trauma. A plastronotomy may be indicated for many reasons, coelomitis, follicular stasis, exploratory surgery, bladder stone, gastrointestinal foreign bodies or cloacal prolapse surgery.

Some equipment will be required to perform this procedure and diamond discs are most commonly used to cut through the shell attached to DIY equipment such as a dremmel®. Use of a saggital saw is suitable should you have access.

There are many vital structures underneath the plastron including the heart and pelvis. However the thick bony bridge and limb musculature also limit the size hole that can be made. Hinges should be avoided and a caudal plastral hinge between the abdominal and pelvic scutes is found in all spur thighed tortoises. Radiography can be used to locate the pelvis if required.

A degree of heat is generated when using the diamond disc and the surgical area should be irrigated with sterile saline to dissipate heat and to reduce the dust level created. In most cases a bevel edged incision is made in the abdominal scutes, allowing sufficient space for the plastral hinge if present. The wounds are not made too lateral to avoid the boney bridge. The incision has bevelled edges to prevent the flap from falling into the tortoise and allowing bone to bone contact to encourage healing. Primary healing is unlikely and typically the flap created will die and is used as a user friendly bandage while new bone is formed from the coelomic membrane.

If the bone flap is completely detached keep it on moistened saline swabs during surgery, although some authors consider that primary healing is possible and maintain soft tissue attachments. Depending on the extent of the soft tissue attachments primarily healing is possible, but sections of tissue may retain viability which is to be preferred.

Care has to be taken not to go too deep when cutting the shell. Checking the incisions made with a fine instrument can guide the surgeon should further cutting be required. The flap can be gently lifted using retractors, screwdrivers or periosteal elevators. It is probably best to find a suitable instrument and keep it so it can be used for this purpose. The coelomic membrane and pectoral and pelvic musculature is adherent to the plastron and careful dissection is required to minimise trauma to the muscles and the ventral coelomic veins. For this a scapel blade can be used. Care must be taken to dissect the tissue flush with the bone. Once the bone is removed the coelomic membrane will be identified and the soft tissue surgery can begin. If the attachments to the flap are to be retained then the tissue must be gently retracted sufficient to allow access underneath the musculature without displacing it.

Tortoises have two abdominal veins running caudo-cranially. These should be avoided if possible but if they are cut accidentally then just ligate them. A cranio-caudal incision can be made in the membrane to get access to the coelomic cavity.

Closure of the wound is routine with monofilament material. The flap is replaced. The wound edges can be packed with gel to seal the wound. The flap can be secured in place with either technovit®, Fibreglass, dental repair kits or screws, wire or plates. Many authors are turning to screws and wires as the wound edges can be closely observed for infection. This is of vital importance in traumatic as opposed to surgical wounds where the chances of infection are high.

Once the coelomic membrane has been closed the flap is replaced. The wound edges can be packed with hydrocolloid gel to seal the wound. This should prevent the ingress of any liquid used to seal the flap as this may impair wound healing. The flap can be secured in place with either technovit®, Fibreglass and epoxy resin, dental repair kits, screws, wire or plates. Some authors drill holes through the shell and suture the flap in place with wire or monofilamant suture material first. This is certainly recommended in juvenile chelonians as with these patients the plastron is too thin to allow for a bevel edge to be made. As a result ligation is required to hold the flap in apposition with the shell.

When epoxy resin has been used care has to be taken to allow the material to set and the tortoise may require propping up for a while. Typically with technovit the methylmethacrylate has set prior to recovery. Roughening the plastron and cleaning with a solvent to increase the binding of material has been suggested. Many authors are turning to screws and wires as the wound edges can be closely observed for infection.

Some authors have advocated burring all the adhesive material away, loosening the flap a little (if possible) and then reapplying more material to alleviate pressure on the healing wound periodically during the recovery process. It has also been advocated to discard any plastral flap after a short period of bandaging alone giving just sufficient time for the coelomic membrane to heal. These techniques allow for increased healing as the bone flap is not impeding wound healing by acting as a bone sequestrum.

If wound infection has occurred or the flap has become dislodged then these cases should be managed as an open wound. Surgical debridement of the area is important to facilitate granulation tissue formation and subsequent ossification. Generally by about twelve weeks after surgery a firm granulation bed should be present depending on the temperature of the patient. Regeneration is from the coelomic membrane and not from the wound edges, thus the size of the wound has no bearing on its rate of healing. The coelomic membrane forms granulation tissue that then ossifies. Thermal necrosis of the flap and surrounding bone is also possible and may also require debridement to facilitate wound healing this should be performed under anaesthesia.

There can be deeper cuts at the corners, which may be devitalised due to the diamond disc, which need to be debrided. Dressings and topical therapies used on traumatic wounds can equally be applied in this situation. Typically topical creams are used to assist in wound healing and are covered in a dressing although cling film can work well. Once granulation tissue has formed the risk of infection is much reduced and the wound will now just take time to heal. X ray film and adhesive tape provides a most useful and economical dressing to cover the wound which can be easily reapplied by the owner at home. It can take up to twenty four months for complete bone regrowth. For small chelonians burring the technovit to allow for growth is important and this is usually scheduled 3 to 4 months after the initial surgery.

In lizards there is a large ventral abdominal vein that arises from the confluence of the pelvic veins and passes in the ventral midline (on a short mesovasorum) to the liver. It passes through this organ and enters the hepatic vein and on into the heart. Some authors recommend a midline incision. I however prefer a paramedian incision to avoid this vessel. The skin is cut with a scalpel blade directed dorsally to avoid traumatising the muscle. Blunt dissection through this layer can be performed with scissors in most species parting the fibres longitudinally. The coelomic membrane is then breached.

It has always been reported that the skin is the holding layer. This is true. Suturing this layer in a horizontal mattress fashion with suture materials such as PDS is ideal. Skin staples have also been used. The muscle layer should be closed if possible and a continuous layer of suture such as PDS is appropriate.

Exploratory surgery in snakes can be performed at any point along their length. Usually the site of entry is indicated by a swelling or a specific indication to assess an individual organ. The snout vent length is used to approximate the location of internal organs.

% of snout to vent length.

Heart – 22- 33%
Lung field – 35 – 45%
Liver – 45 – 55%
Stomach – 55 – 65%
Right gonad – 60 – 70%
Right kidney – 65 – 75%
Left gonad - 70 – 80%
Left kidney – 75 – 85%

Surgical access is best performed between the first and second row of scales. This approximates the end of the ribs. The skin is incised between the scales (which may necessitate careful dissection. The abdominal muscle is then bluntly dissected to enter the body cavity. The muscle layer is closed using a continuous suture and the skin closed in a horizontal mattress fashion with the knots upper most to reduce contamination.

Reproductive surgery

Animals with follicular stasis can have large numbers of follicles (over 70) present at exploratory surgery. An ovariectomy may also be considered prophylactically in lizards and chelonians to prevent reproduction. The ovaries are easy to discern at surgery. The follicles are very friable and gentle manipulation is required. Haemostatic clips are required to ligate the vessels as the ovaries are closely associated with the caudal vena cava and adrenal glands.

The oviducts should be removed if any pathology is suspected.

If the animal is in egg stasis the oviducts are easily visualised. The eggs can be removed and the oviducts left in place. The oviducts should be sutured with an inverting suture using monofilament material such as monocryl to allow for future reproduction.

If the oviducts are removed it is important to remove the ovaries as well to avoid a yolk coelomitis. Removal of the oviduct down to the cloaca is required with a circumferential monofilament suture placed at the junction. The oviduct has many vessels and these can be ligated with suture, ligated with haemostatic clips or radiosurgery can be used for coagulation.