Anaesthesia

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Not too long ago, it was only with extreme caution that a bird was anaesthetised. The choices for anaesthetic agent were limited and survival rates were poor. With the recent advances in anaesthetic agents, the risks are approximately the same as for dogs and cats. Anaesthesia of the avian patient is now a well-established and relatively safe procedure.

There are some simple and routine procedures that can be performed without anaesthesia, using "Bruticaine". These procedures do not require the patient to be completely unconscious, particularly in a high-risk situation such as the application of a splint to a leg fracture in a small finch. The anaesthetist needs to evaluate each situation and decide if the technique requires the risk and stress that is inevitable with any anaesthetic.

INJECTABLE ANAESTHESIA

There is only one injectable anaesthetic that, in my opinion, falls within the acceptable risk category. This is the combination of Ketamine (100mg/ml) mixed with an equal volume of Xylazine (20mg/ml). This may be given intramuscularly, but the preferred route is intravenously.

Dose: IM 0.10ml per 100g body weight
IV 0.05ml per 100g body weight

This combination provides good muscle relaxation and good anaesthetic depth but it does have a prolonged recovery time. The bird needs to be wrapped in a towel to avoid any injury during recovery.

INHALATION ANAESTHESIA

Administration of Inhalation Agent
This can be achieved by placing the bird in a perspex anaesthetic chamber, or by wrapping them in a towel and placing their head in a face mask. The latter is the preferred method.

In some cases such as Pelicans where the beak is too long for a face mask, The bird can be intubated and restrained while still conscious. This may seem cruel and stressful, but with gentle restraint, there is minimal struggling and the induction is rapid.

I prefer to use a transparent face mask as I prefer direct visualisation of the bird's head and eyes. As the depth of anaesthesia progresses during induction, the birds blink more slowly and are at surgical plane when they close their eyes.

For quick procedures, maintenance is carried out with the face mask left in place. For longer procedures, an endotracheal tube is used. Beware over-inflating the cuff as birds have a rigid trachea with complete tracheal rings.

Intubation can be difficult in some waterbirds, such as Pelicans and swans as they have a small keel at the glottis which reduces the size of endotracheal tube that may be passed. In most other birds, the tongue is gently grasped with fine forceps and the glottis drawn cranially for ease of passing the tube.

Hepatic and Renal Toxicity

This was a significant problem with some of the earlier inhalation anaesthetic agents and may cause a problem for any personnel who are regularly exposed to these agents. Isoflurane, the agent of choice does not suffer with this problem, as it is metabolised the least of any of the inhalation agents. Compare the following figures from Rosskopf et al (1989).

Table 1. Inhalation Agents

Drug	% Metabolised
Methoxyflurane	45.0
Halothane	25.0
Enflurane	2.4
Isoflurane	0.2
Desflurane	<1.0
Sevoflurane	<1.0

Methoxyflurane

In the past this agent was used by the open drop method via a face mask. When used, it required constant monitoring with frequent removal and replacement of the mask.

Halothane

Halothane delivered via an out-of-circle precision vaporiser by an open non-rebreathing method, such as a T-piece, is still popular in some veterinary practices, but is being replaced by Isoflurane.

Until recently, Halothane was regarded as the safest avian anaesthetic agent. It can be hepatotoxic to humans with chronic exposure. It provides rapid induction, but there is a close interval between apnoea and cardiac arrest, so that careful, constant monitoring is required. There is a "hangover" period following recovery to the standing position.

Induction: 2.5-3.0%; Oxygen 1-2 litres/min
Maintenance: 1.0-1.5%; Oxygen 1-2 litres/min

Isoflurane

This is the anaesthetic agent-of-choice. It is not hepatotoxic. It is a profound respiratory depressant, so it is common to have a period of apnoea during induction. This factor causes some concern to those initially using this agent. Although this is a drawback, it is more than compensated for by the fact that

there is a relatively long interval between apnoea and cardiac arrest. There is minimal to no hangover after recovery. It causes minimal myocardial depression (with the highest margin of safety for the cardiovascular system). It is not flammable and is not irritating to the mucous membranes. It provides good muscle relaxation and analgesia.

Recovery time is nearly instantaneous - considerably faster than Halothane, due to its lower blood solubility. The depth of anaesthesia can be altered repeatedly during the procedure without adverse effects. It is such a useful drug that a bird can be taken from a client, anaesthetised for a simple procedure and then returned to the client a short time later without them being convinced that the bird has been anaesthetised. As with all cases, the use of an anaesthetic should always be discussed with the client, prior to it being carried out.

Induction: 3.0-5.0%; Oxygen 1-2 litres/min
Maintenance: 2.5-3.5%; Oxygen 1-2 litres/min

Sevoflurane

Sevoflurane (Ultane™, Abbott laboratories) is similar to Isoflurane as it is a halogenated ether and it differs from Isoflurane as being halogenated solely with fluorine[5]. It is possible it may supersede isoflurane as the preferred avian inhalation anaesthetic agent in the future, just as isoflurane superseded Halothane – this will require much investigation and significant trials to determine. Sevoflurane has a more rapid induction than Isoflurane as well as a more rapid recovery, especially after prolonged procedures[5]. Patients become alert sooner than with isoflurane and do not exhibit ataxia. There is usually a smooth recovery with minimal wing flapping[5]. Sevoflurane is degraded by carbon dioxide absorbents to a nephrotoxic haloalkene in rats, but this has not been a similar problem in humans[5]. This should not be a problem in birds as they are maintained on a non-rebreathing system. Unlike Desflurane, Sevoflurane is not an irritant to the respiratory tract. It does not sensitise the myocardium to catecholamine-induced arrhythmias but does produce similar CNS, cardiovascular and respiratory depressant effects to isoflurane[5]. Sevoflurane requires its own calibrated precision vaporiser, but as the vapour pressure is much less than Desflurane, the vaporiser is much cheaper (Abbots may offer a vaporiser if you commit to purchase a given volume of Sevoflurane).

Induction: 3.0-5.0%; Oxygen 1-2 litres/min
Maintenance: 2.0-3.0%; Oxygen 1-2 litres/min

(as with all inhalation anaesthesia, the dose is calibrated to effect – the doses listed above are still being trialled and should be used with caution)

Desflurane

Desflurane (Suprane™, Anaquest), another halogenated ether that is also recently being assessed , but it is not regarded as a likely replacement for isoflurane in avian anaesthesia[5]. It is quite irritant to the respiratory tract and is flammable at concentrations above 17%. Because of its high vapour pressure it requires a special temperature controlled, pressurised vaporiser to accurately deliver the agent[5]. Costs of a vaporiser are estimated at US$6,000[5]. It cannot be used in an isoflurane or Halothane vaporiser, as this will produce lethal concentrations.

Monitoring Anaesthetic Depth

This is done by my veterinary nurse, who is quite experienced in avian anaesthesia. As a result, I am able to concentrate on the surgical technique. The result is faster surgery, better recoveries and an excellent anaesthetic record. I cannot emphasise enough the importance of having someone you can trust monitoring the anaesthetic. There should be no distractions to either the surgeon or the nurse during avian anaesthesia.

As with any anaesthetic, the depth is monitored by visual cues. The best and most practical guide is the depth and rate of respiratory movements (abdomen/keel) and the degree of relaxation of the legs. As well you can monitor the presence of common reflexes. However because of the small size of most of our patients, there is not enough room for someone to reach over to test reflexes. Commonly used reflexes in larger birds are: Eye reflexes (corneal, palpebral) and interdigital (toe pinch) reflex.

Stages of Anaesthesia

Light	reflexes present deep, rapid respiration no voluntary movement legs flexed
Medium	sluggish reflexes slow, deep, regular respiration legs relaxed
Deep	no reflexes slow, shallow respiration close to cardiac/respiratory arrest

Variation in Anaesthetic Tolerance

Each species reacts slightly differently to anaesthesia. If you are anaesthetising an unfamiliar species, take more care. You need to develop a "sixth sense" that has more to do with the art of anaesthesia, than the science. Each bird must be treated as an individual. Beware of developing the habit of treating them all the same - even within the same species.

Waterfowl and raptors often become apnoeic after induction with Isoflurane.

Waterfowl and pigeons (particularly native Australian pigeons) need higher concentrations of anaesthetic agent for both induction and maintenance.

Raptors often need higher concentrations for induction but lower concentrations for maintenance.

Albatross need lower concentrations for both induction and maintenance.

Parrots as a general rule are less likely to have apnoea on induction and stabilise more easily. Macaws are the exception - they take longer for induction, they usually need higher concentrations for maintenance and require closer monitoring - you need to be more expectant of a "crash" or a sudden "wake-up".

Recovery from Anaesthesia

I prefer to roll all my patients in a light paper or cloth towel. They are then placed into their cage (or on a cool day into the humicrib) to recover. Once they have opened their eyes and are able to crawl out of the restraint wrap, they have good balance and do not flap their wings with excitement. With very nervous or flighty birds, I like to provide a visual barrier over the cage or humicrib to allow them to recover in muted light. These precautions are more necessary with Halothane. Birds anaesthetised with Isoflurane recover very quickly and usually without any excited flapping of the wings.

In most cases, the birds are recovered from short procedures such as surgical sexing and ready to travel home within 30 minutes. I will not allow a bird leave the veterinary hospital until it is perching and has its postural reflexes present.

Resuscitation

The message here is to avoid having to carry out any resuscitative procedures as they are often unsuccessful. The most common cause is too deep a plane of anaesthesia. Careful monitoring by a person, who has no other responsibilities during the anaesthetic, is mandatory. They should be constantly monitoring the bird's respiratory movements and the plane of anaesthesia and giving the surgeon a regular update.

The use of Isoflurane has removed many of the sudden cardio-respiratory arrests that can occur with Halothane.

If you need to resuscitate a bird, rhythmic regular pressure on the sternum (place a thumb and forefinger on the sternum and press twice per second) to provide cardiac massage, must be combined with oxygen delivered through cannulation into the caudal abdominal air sac. This can be achieved in an emergency with a large gauge hypodermic needle or a urinary catheter that has been placed into the air sac through paralumbar fossa (the same site as used for surgical sexing). If oxygen cannot be attached to the catheter, the air sac can be filled and emptied with a syringe. Because of the double inspiration/expiration cycle of bird respiration, oxygen delivered through the trachea is not successful in oxygenating the blood for resuscitative procedures.

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Pre-operative Considerations

Pre-op Assessment and Preparation

The temptation in any surgical procedure is to be so focused on the operation as to forget the patient. The safety of the patient and the ability of the patient to survive the invasive process is a paramount consideration.

The post-operative result also needs careful consideration. In some instances it may be better to perform a simpler procedure rather than a technically more difficult one if the simpler procedure gives the patient an increased chance of survival.

The surgeon needs to be critical of his own skills and limitations. Decisions made in the pre-operative period can have a major impact on the long-term result.

The Patient

Closely assess your patient and determine its long-term requirements. Is this a pet bird, a breeding bird or a wild bird? Simple considerations such as this will affect the manner in which the case should be handled.

Pet birds will be able to survive well with some dysfunction as they have supportive care and do not need to fend for themselves. Discuss any potential problems in detail with the owner prior to surgery as people live in close contact with pets and they need to understand the impact the surgery may have on the quality of life of their pet. Emotions will play a significant part in decisions involving these birds.

Breeding birds must be able to mate successfully. If there is an injury to a leg and it will be unable to stand for mating then this must be discussed with the owner prior to surgery. These birds are similar to farming stock. They have an economic value and must breed successfully to meet the owners needs.

As a general rule wild birds must be returned to good functional use for rehabilitation to be successful. If this is not possible, euthanasia is strongly recommended unless a permanent, good quality home is available. The surgical technique used to repair a fracture in a Wedge-tailed eagle will be different to that required by a Peregrine Falcon, because the flying ability of each bird is quite different. The functional return of the eagle can be lower than in a falcon and still be successful, as it is a slow ponderous flier that feeds quite often on carrion. While the falcon being such a high performance bird and needing to catch its prey on the wing has little room for error before it expends too much energy in hunting.

Having considered these parameters, you still need to discuss all options with the owner. Avoid the temptation to decide the best option. It is surprising how often clients will amaze you and choose an option you thought they could not afford or be willing to accept.

The Surgical Technique

Assess if surgery is really required or if alternative techniques may be applicable.

Lipomas often will respond well to controlled dieting and food intake. In some cases low dose thyroid supplement may aid weight loss.

Many wing fractures will respond better to conservative strapping than to invasive surgery (see the orthopaedics article elsewhere in these proceedings).

If performing a new technique always spend time researching in proceedings and journals such as those from the Association of Avian Veterinarians or books such as Ritchie, Harrison and Harrison[6]. These regularly have new surgical techniques and approaches that will improve your results.

Surgical Time

The main aim with bird surgery is speed. This comes only with experience and practise. There are no short cuts. Always use the opportunity while doing a post-mortem examination on a bird to refresh your familiarity with the anatomy, particularly with some of the less commonly encountered species. When first embarking on some of the more complex surgical procedures such as suing K.E. Devices for fractures, it is always recommended that you practise on cadavers with your nurse or surgical assistant several times before attempting it on your first patient. Alternately take advantage of skills of other experienced veterinarians and organise visits to assist them with surgery for techniques you need to learn.

If I have not performed a particular surgery within the last month I always read through and visualise the steps as a means of focussing and preparing for the surgery. I find it most convenient to do this while my nurses are setting up the surgical theatre so it is still fresh in my mind.

Prior to surgery have all the equipment you will need on hand so it is readily available. Even equipment that you think you may only need as a last resort. There is not time to go searching in the middle of surgery.

Spend some time planning the flow of preparation so that you time the anaesthesia so that the bird is reaching surgical depth as you are scrubbed, gowned and ready to begin your incision. A well-trained assistant is the only option here. As the surgeon, you do not have time to focus on the patient's anaesthetic depth. You need to be completely focused on the surgery - there must be no distractions.

Patient Evaluation

As with any patient a thorough clinical examination must be performed prior to surgery and anaesthesia (see appendix 3 for a detailed description). Your aim should be to detect and correct any underlying pathology prior to anaesthesia and surgery[8].

Important points to note are the presence of:

* Abnormal respiratory sounds
* `Prolonged dyspnoea following handling (should return to normal within 3-5 minutes)
* poor body condition or obesity
* abnormal droppings

For short procedures, a physical examination and history may be all that is required but for major surgery or for a procedure requiring anaesthesia longer than ten minutes, other tests may be indicated[7]:

* PCV & TPP
* WBC with differential
* Platelet estimate
* estimated clotting time
* Biochemistry profile: look for elevations of
  - Bile Acids
  - AST
  - Serum Cholesterol
  - UA
  - LDH
* Blood Glucose is useful in anseriformes and raptors[8]
* Faecal examination
  - Smear
  - Flotation
  - Gram
* Choanal Gram
* Radiographs

If any abnormalities are detected, the decision to proceed with surgery should be re-assessed. Wood[2] offers the following guidelines to aid this decision:

Guidelines:

- If the PCV is <20%, surgery should be postponed or a blood transfusion provided.
- A total serum protein of less than 2 mg/100ml is a sign of impending trouble.
- If Blood Glucose < 10 mmol/l (200 mg/dL), defer or infuse 2.5% glucose during surgery. Birds have limited glycogen storage capacity and surgical shock can cause hypoglycaemia.
- Uric Acid levels > 450 umol/l (30 mg/dL) - defer if possible. Suspect renal disease or dehydration
- AST (GOT) > 200 U/l (650 IU/dL) - postpone
- LDH > 350 U/l (600 IU/dL) - postpone
- Cholesterol > 700 mg/dL - postpone

- Lipomas. These are commonly encountered tumours, usually found on obese birds fed high fat diets. Beware, fat on the outside, fat on the inside. These birds will often have fatty infiltration of the liver - a death sentence using Halothane, but also often causing clotting problems. Test the bleeding time by plucking a blood feather (if a mature feather is removed there should be virtually no haemorrhage around the follicle[8]) or clipping a toenail.
- Other signs of hepatopathy include an overgrown beak or discoloured feathers.
- Ascites. Commonly seen in patients with egg peritonitis. Surprisingly large volumes can be found in chooks and ducks and if removed at the time of surgery can severely compromise the patient, causing hypovolaemic shock. These birds are best treated with needle aspiration and systemic antibiotics for up to 2 weeks before operating.

Other factors to consider are:

- If the PCV is > 60% suspect dehydration. Give fluid therapy.
- Liver disease[7] should be suspected with low TPP levels, abnormal bile acids or tissue enzymes (elevated or depressed), enlarged or reduced hepatic silhouette on radiography. These patients should not be given anaesthetics that are metabolised in the liver (most injectables, Halothane, methoxyflurane). The best anaesthetic agent in these patients is Isoflurane.
- Take care with abnormal body positions in anaesthetised birds, especially if they are obese. As excess fat deposits compound the respiratory depression of anaesthesia by interfering with normal respiratory efforts.
- Birds with ascites should be placed in an upright position when anaesthetised to prevent the excessive fluid entering the lungs through any tears in the adjacent air sacs. Attempt to aspirate this fluid, over several days, prior to surgery.

Risk Classification

Sinn[7] uses a system of risk classification of a patient to help estimate the duration of safe anaesthesia, the intensity of monitoring required and the supportive care and technical assistance required to ensure patient safety. It also provides a prognosis to discuss with the owner.

- **Class 1 (minimal risk)** - a young, healthy patient undergoing an elective procedure.
- **Class 2 (some risk**) - a young healthy patient undergoing a non-elective procedure, or a healthy patient undergoing an elective procedure.
- **Class 3 (risky)** - a patient with an ongoing health problem undergoing a procedure for this or another problem.
- **Class 4 (very risky)** - a patient with a major health problem (unstable in nature) undergoing a procedure
- **Class 5 (moribund)** - last ditch effort to save a bird's life.

Fluid Therapy

All ill birds should be regarded as having some degree of dehydration. Stabilising the dehydration will improve the bird's ability to cope with the anaesthesia and surgery.

It is safe to assume that many birds in need of surgery are 10% dehydrated because of associated disease. Use the following formula to calculate the fluid requirements:

Fluid Deficit (ml) = normal body wt (g) x 0.1
Maintenance Fluid (ml) = normal body wt (g) x 0.05

Give the maintenance volume plus 50% of deficit in first 24 hours, then maintenance volume plus 25% of deficit during days 2 & 3.

The ideal fluid in most cases is Lactated Ringer's Solution (Hartmann's). These are best warmed prior to delivery to avoid hypothermia. The best routes of administration are intravenous, intramuscular or intraosseous. Oral or subcutaneous routes are not as effective at restoring circulating volume but do have a place in long term management of cases other than emergencies.

The maximum rate of administration for a healthy bird is 90 ml/kg/hr[7]. In a Cockatiel this would be a maximum of 9 mls in an hour or 0.15 ml per minute[7]. However, it should be noted that the majority of patients are compromised and unable to cope with these maximum volumes.

Fasting

Fasting prior to surgery is an area of some argument. Relate your decision to the birds diet and its metabolic activity as well as the ambient temperature. For practical purposes, the bird should have food removed to allow the upper GIT to be empty[7].

Small birds or those that are nectarivorous should be fasted minimally. All birds that are not fasted should have their crop palpated immediately prior to induction and any excessive fluid aspirated. In an emergency, you must hold the bird in an upright position for anaesthetic induction and occlude the proximal oesophagus gently, with a finger, to retard fluid entering the mouth and being aspirated.

As a general guide, Sinn[7] recommends removing food overnight in large birds and four to six hours in smaller birds. Raptors or piscivorous birds should be fasted for 12-24 hours, particularly if gastrointestinal surgery is to be undertaken.

Pre-medication

As a general rule tranquillisers and atropine, that are used as a standard premedication in mammals, are not used in birds. In fact the use of atropine is contra-indicated as it only limits the production of part of the light, fluid fraction of the respiratory secretion and leaves a mucoid, tenacious secretion that will obstruct the trachea or endotracheal tube. As birds do not possess a diaphragm or cilia on their respiratory epithelium, they have problems coughing and removing the accumulation of this type of material.

In some instances tranquillisers are used. This is determined by the preference of the anaesthetist. Some prefer to use low doses of Diazepam, Ketamine, Zoletil® or similar products in Raptors to reduce struggling for masking down with gaseous induction. You need to balance this against the prolonged recovery that may occur.

In some instances pre-operative antibiotics may be indicated. If antibiotics are to be used they should be given during the pre-operative period with sufficient time for them to reach peak blood levels - one to two hours is usually sufficient[8]. Blood levels of antibiotics should be maintained for eight to sixteen hours post-operatively[8]. Use of antibiotics beyond this time is not indicated (unless there is evidence of infection or significant contamination) and has been shown not to decrease the incidence of surgical wound infections[8]. The intention here is for the antibiotic to be at a level to be present in any

blood clots that may form at the operation site as they will be unable to penetrate the clot after its is formed. This should help to reduce the availability of blood clots as a harbourage site for bacteria.

Temperature Control

Many of the processes used in preparation for surgery increase the bird's rate of heat loss, and may result in hypothermia if not addressed. Plucking feathers, application of fluids such as alcohol, heat loss from the cold anaesthetic gases, contact with cool surfaces on the operating table and loss of central temperature control reflexes during anaesthesia can all contribute to heat loss.

The side effects of hypothermia can lead to cardiac arrhythmias, poor return of normal physiological reflexes and general slow recovery from anaesthesia.

The use of a thermistor probe[1], that is inexpensive and accurate, to monitor cloacal temperature continuously probe has been advocated. Alternate measuring devices include common bulb thermometers and tympanic scanners inserted into the cloaca[2].

Since the main contributing factor to the heat loss is duration of anaesthesia and the surgical process, the primary goal of the surgeon is to complete the surgery as quickly as possible.

Other techniques should be considered to reduce heat loss. Use of heating pads or thermal barriers under the patient; use minimal amounts of alcohol for skin preparation; use warmed fluids for IV infusion, skin preparation and especially for lavage; use towels and thermal barriers to cover any cold surfaces. Have any heating pads pre-warmed before placing the patient on them. Regularly check heating pads to be sure they are still functioning correctly. If heating pads are not available, use hot water bottles or heat lamps.

The use of supportive heat should be continued into the post-operative period and until the bird is stable.

Surgical Site Preparation

This should be a simple and quick procedure. The main aim is to remove a minimal number of feathers while still providing a good sterile surgical field.

- Feathers immediately adjacent (2-3 cm[8]) to the incision should be plucked. Pull the contour and covert feathers, 1-2 at a time, in the direction the shaft is growing (usually caudally). Do not pluck too many at a time or too roughly or you will tear the relatively thin skin. Smaller feathers should be pulled in groups of three or four in a direction opposite to their growth[8]. In large birds (e.g. Ostriches) it is possible to use clippers to remove the feathers effectively - just as you would in a cat or dog. Avoid removing primary or secondary flight feathers if possible as this may easily damage the follicle

- Feathers further away from the incision can be held away with drapes (e.g. Gladwrap), stockinette, masking tape or water-soluble gel (e.g. K-Y gel). Only use the minimal amount required. Avoid oil-based gels/ointments as they will club the feathers and destroy their insulative properties.

Aseptic technique is as important as with other species. Solutions used for skin preparation are usually diluted Chlorhexidine diacetate (0.05%), Chlorhexidine gluconate (4%) or Povidone Iodine (e.g. 1.0%

Iovone or Betadine)[8]. Chlorhexidine is preferred over povidone as it has a broader spectrum of antimicrobial activity, longer residual antimicrobial activity, is efficacious in the presence of blood and organic matter and is non-toxic and hypo-allergenic[8]. In some instances alcohol may be used but beware using large amounts as its evaporative properties will chill the bird and add to the hypothermia.

Clear plastic adhesive surgical drapes are available commercially overseas.

Post-operative Care

Hypothermia is a constant finding immediately post-operative in all birds. The use of a heating pad during surgery is unable to completely control this but there is anecdotal evidence to support the impression that birds that are given supplemental heat during surgery do recover their normal body core temperature more quickly than those that do not. This supplemental heat needs to be continued during the post-operative time by using a heated cage or similar. Initially the bird is maintained at 30°C. The bird should be placed in a darkened quiet area to recover slowly. With Isoflurane anaesthesia this is quite rapid.

Philip[7] (appendix 2) recommends temperature ranges for post-surgical recovery based upon the bird's body weight.

Food is withheld until the bird is perching well with a normal posture. Most birds will eat quite soon after they are able to stand. Halothane anaesthesia will result in a 'hangover' period that may last for 1-2 hours. Monitor the bird's recovery closely. Once you are accustomed to your anaesthetic technique, you will be comfortable judging what is the normally expected recovery time.

Monitoring of the bird should be maintained for at least 24 hours with major surgery. . Observe for problems such as haemorrhage, dyspnoea or picking at the surgical site/sutures. Simple procedures where the bird is only lightly anaesthetised (e.g. surgical sexing) do not require this prolonged monitoring in hospital. You need to balance the frequency of close observation with the bird's reaction to your presence. If the bird is becoming stressed you need to decrease the frequency or increase the distance from which the observation is performed.

A simple routine method of monitoring the bird's recovery is to weight it. This can help with assessment of dehydration as well as a measure of its appetite. As well monitor the food for signs that the bird is eating well. In seed eating birds this is easily assessed by noting the volume of seed husks present. After major surgery the bird should not be discharged until it is eating well and able to maintain its body weight. Balance this against the problem pet bird, which will not eat at all in hospital or without its owner present. Some of these very spoilt birds will not eat until they have gone home to their secure surroundings.

Analgesia

To date there has been little research into pain and the use of analgesics in birds. Most studies suggest that bird's perception of pain is similar to mammals[3,4]. Consideration should be given to using some of the medications mentioned below in both the pre-operative and post-operative periods.

A recent issue of the Journal of the Association of Avian Veterinarians had an issue devoted to alternative medicine[5]. Some authors had use Acupuncture, Electroacupuncture and Acupressure to aid with pain and healing. This is an area that needs more clarification .

A list of medications and doses that have been reported are listed in the previous module on medications.

Opioids have been used with some success. Morphine has been used but with varying results depending upon the species. Butorphanol appeared to give good analgesia without any effect on heart or respiratory rate.

Alpha$_2$-adrenergic agonists aid by providing sedation, analgesia and reducing anxiety in mammals and appear to work similarly in mammals[2]. Xylazine can be used alone or in combination with Ketamine. Mix equal volumes of Xylazine (20 mg/ml) with Ketamine (100 mg/ml). Detomidine and Metomidine are both effective sedatives in many species of birds.

The suspected problems with alpha$_2$-adrenergic agonists is short duration of action, hypotension, bradycardia, hypothermia and gastrointestinal tract inhibition[2]. They do have an advantage by having reversal agents.

Non Steroidal Anti-inflammatory Drugs (NSAID) do have a place in analgesia. While they are not sufficient to control sharp or acute pain, they will reduce pain from inflammation. Non-steroidal anti-inflammatories are preferred because of the possible immunosuppression from the corticosteroids. The most useful one appears to be Flunixin Meglumine (Finadyne®). Aspirin has been used in birds. The dose used was a 500mg tablet dissolved in 250ml drinking water[2]. There is some concern about the efficacy of Aspirin. Fortunately birds appear to have good resistance to the gastrointestinal side effects often reported with NSAIDs.

To increase the efficacy of analgesics, sedatives can be given concurrently. While they do not give pain relief, they do help reduce the perception of pain for the patient as well as providing muscle relaxation.

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General Surgical Principles

Avian surgery is similar in many aspects to surgery in other animals. Some modification for the patient size and variations in anatomy and physiology are required, but any veterinary surgeon is capable of performing surgery on an avian patient.

Patient position

Lateral and dorsal recumbency positions are the two preferred to place an avian patient for surgery. Neither position is the physiological state for a bird.

Some concern is expressed for dorsal recumbency as gravitational forces are reversed for the normal perching bird. A perching bird relies on gravity to assist the downward motion of the keel bone and viscera but this is reversed in dorsal recumbency. This is cited as a justification for assisted ventilation and deserves consideration.

Similarly ventral recumbency is a problem as the bird's weight is borne by the keelbone so it does not elevate easily.

Surgical Drapes

It is recommended that you use drapes that are as lightweight as possible, to minimise pressure on the bird.

Products that have been used include Gladwrap® (Saran wrap) and paper towelling.

Veterinary Specialty Products Inc. in Boca Raton, Florida produce a special avian surgical drape that retails for approximately US$50 for a pack of 12.These are transparent, sterile and disposable with adhesive surrounding the surgical site. They are 24" x 24" with 3.5' x 5" adhesive surface.

In smaller patients it may be necessary to use a surgical bridge to tent the drape so the anaesthetist can monitor respiration.

Surgical Instrumentation

As a general rule, ophthalmic instruments or small, delicate surgical instruments are preferred. Choose instruments that are small and minimise trauma to the tissues, e.g. I prefer rat-toothed forceps with very small teeth.

My basic Avian Surgical Kit contains the following instruments:

- 1 each of Adson rat-toothed tissue forceps 1:2 (fine and extra-fine)
- 1 x blunt:blunt 45º Iris scissors 9cm
- 1 x sharp:sharp 45º Iris scissors 9cm
- 4 x Micro-mosquito Artery Forceps
- 1 x Olsen-Haeger needle Holders
- 10-12 Cotton buds
- 5cm x 5cm cotton surgical swabs
- Extra-fine pair of Alligator forceps

Other instruments are added as required, e.g.:

- Eyelid retractors for abdominal musculature
- Micro-pin Holder for IM pinning
- K-wires and Small IM pins
- Fine Cerclage wire

Tissue Handling

Avian tissues are different to mammalian in that they tend to be drier, thinner and have less tensile strength. Fat deposits in the skin may accompany obesity and allow the skin to be more friable, as these deposits lower tensile strength even more.

Tissues should be treated and handle more gently than for mammals. You should take a relatively bigger tissue bite for suture placement. Avian skin is less elastic than mammalian skin so you must avoid excess tension in the skin, with suture placement.

Manipulation of the surgical instruments should be guided by the fingers and wrist, not the arms. I prefer to sit on a surgical stool for all my avian surgery and have my forearms resting on the operating table or appropriately placed sandbags.

Sutures

For most applications, I use either 4/0 Dexon or 4/0 Vicryl for parrots and finches. In larger ducks and poultry or raptors, I prefer 2/0 –0 Dexon or Vicryl. These materials are my preference for non-contaminated wounds. Both these are synthetic braided suture material and come with a very fine needle attached. I use 4 throws and this gives extremely good knot security. I find that these materials allow good control of skin/tissue tension. They do cause some visible tissue reaction at the site during healing but are usually resorbed or fall out in 8-10 weeks.

I have tried PDS but it is a monofilament which is harder to tie, causing problems with skin tension and requires 4-5 throws for knot security. It takes up to 120 days to be resorbed. PDS is indicated for contaminated wounds or where there is a lot of trauma, as it is less likely to act as a wick for carrying microorganisms into deeper tissues and it holds strength for a longer period after placement.

Suture patterns should be as simple as possible. For most applications, I use simple continuous suture pattern. This pattern allows the least amount of suture material to be exposed to the tissues, and minimises the local inflammatory reaction. It also quick to use, reducing the surgery time.

A simple interrupted suture pattern is used to close viscera and the lumen of structures such as intestines or for an area where the bird may chew or scratch and remove the sutures, such as the face and distal limbs.

Radiosurgery

Radiosurgery is used for most incisions in avian surgery, as it allows for good haemostasis and can reduce surgical time.

For my surgeries, I use an Ellman Surgitron. It is different to most electrosurgical units as it uses radiowaves to form the current. It was developed for dental surgery in humans and allows fine and accurate precision with cutting and coagulating. It produces a fully rectified filtered current allowing a pure frequency of 3,800,000 cycles per second.

The electrode tip is the active electrode that transmits the radiofrequency wave to the tissue. The ground plate acts as an antenna to focus the waves emitted by the active electrode. I this system the ground plate does not have to be in contact with the patient or its tissue but should be as close as possible – preferably with as much contact with the patient as possible. Unlike other electrosurgical ground plates, it is covered by plastic to allow insulation.

Radiosurgery takes advantage of the lateral heat produced by a high frequency power oscillator (a radio transmitter) to vaporise intracellular fluid along the line of the incision and so develop the cutting effect or to dehydrate cells and so coagulate and seal small blood vessels in the coagulating setting. The lateral heat is produced by the tissue's resistance to the alternating electromagnetic waves as they pass through the tissue.

Four wave forms are used by this unit and each has a different application:

Wave Form	% Cutting	% Coagulating	Application
Fully rectified filtered current	90	10	Collecting biopsy sample with minimal tissue damage at margins
Fully rectified unfiltered current	50	50	Skin & soft tissue incision and dissection during surgery
Partially rectified current	10	90	Coagulation, desiccation, haemostasis
Fulguration across a spark gap	0	superficial	Not used for avian surgery, but for superficial coagulation of tissue in mammals

Tuning the Radiosurgical Unit

Tuning the radiosurgical unit is essential for proper use and can be achieved with some practice and experience with your machine, in your surgery area. Tuning the unit is like fine-tuning into a normal radio station to achieve clear reception. This will need to be re-tuned whenever the unit is moved.

To tune the unit, initially use the following procedure:

Place the dial to Cutting (fully rectified filtered) or Cut/Coagulate (fully rectified unfiltered).

Place the power dial to full power.

Place a piece of meat on the ground plate

Make an incision – there will be sparks and a lot of tissue damage

Adjust the power dial until there is a slight drag on the electrode as it incises. There will be meat shreds attached to the electrode.

Slightly increase the power dial until the drag is removed. An ideal cutting level is mild blanching of the tissue with no spark or drag and minimal smoke production

Contraindications

Do not use in the presence of unshielded cardiac pacemakers (those manufactured prior to 1976).

Normal active monopolar electrodes do not function well in the presence of tissue fluids. Swab the area well or use a bipolar electrode.

Beware using flammable or volatile products, e.g. ether, alcohol or methylated spirits used for site preparation – allow them to evaporate fully before using the electrode.

When the electrode is charged it may cause interference with electronic monitoring devices, radios and telephones.

Radiosurgical Skills

Correct technique when using the electrode will minimise lateral heat (and so tissue damage) and make for a more effective procedure.

Use as fine an electrode tip as possible as this requires less energy and allows a finer incision.

Maintain the electrode perpendicular to the tissue to maintain the same lateral heat exposure to each side of the incision.

Initiate the current by applying the foot pedal prior to contacting the tissue, so the electrode is fully charged when it first strikes the tissue and maintain this until the electrode is removed, so that it is applied and removed as part of a smooth sweep.

Move the electrode across the incision site rapidly with a smooth motion of your wrist.

Do not allow an electrode to remain in contact with the same tissue for more than 3 seconds.

If you need to deepen an incision, allow 10 seconds to pass before the electrode is re-applied, to allow the tissues to cool. Usual recommendation is cut for 10 seconds then rest for 10 seconds.

When applying a ball electrode for haemostasis, only apply very light pressure for a moment. Use the opposite technique for incising – place the ball in contact with the tissue then charge

To clean an electrode during surgery is important. A build-up of tissue interferes with heat dissipation and may damage the electrode as well as causing tissue damage. Turn the wave form to fully rectified filtered or unfiltered setting. Place the electrode between a swab dampened with sterile saline. Charge the electrode for 1-2 seconds while wiping the electrode back and forth between the pieces of swab. The steam produced will clean the electrode.

From here it is a matter of practice and experience. You need to become accustomed to your machine and how it functions in your circumstances. If used correctly, radiosurgery enhances your surgery and makes for a much quicker and more efficient process.

Soft Tissue Surgery

Soft tissue surgery is similar to that used in mammals. Below are presented some of the more commonly encountered surgical procedures.

Approach to the Abdominal/Coelomic Cavity – Laparotomy

Indications:

Egg-binding that is non-responsive to medical therapy

Removal of a foreign body from the GIT

Exploratory laparotomy

Reduce Cloacal prolapse and perform Cloacapexy

Surgical Approach

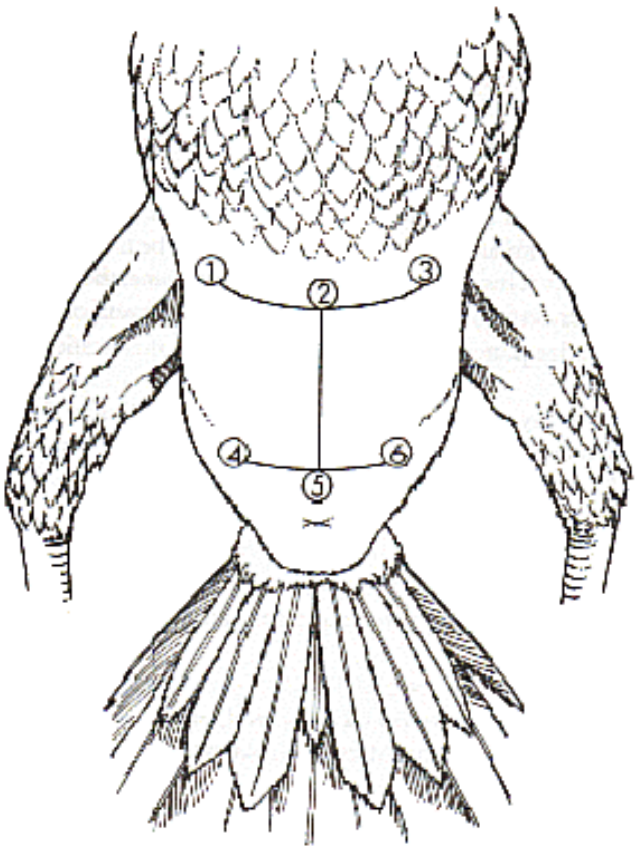
Varies with the organs to be examined.

Transabdominal: offers good access to both sides of the abdomen and has good tissue strength for closure.

Ventral midline: extends from posterior margin of sternum down to just cranial to the cloaca. Useful for caudal abdomen and cloaca.

Flap incision – Partial or Full Flap. Exposure can be limited to only one side of the abdomen. They may weaken the abdominal wall.

A Double Flap exposure can be used but it is not recommended as it offers the best exposure but does leave the abdominal wall weakened.



after Altman (1997)

You can combine any of the above incisions to achieve exposure of the area of interest:

2-5 = ventral midline approach

1-2-5-4 or 3-2-5-6 = ventral partial flap approach

1-2-5-4 + 3-2-5-6 = double flap approach (not recommended)

1-2-5 or 3-2-5 = triangular approach

4-5-1 or 6-5-2 = less common triangular approach

To make your incision, elevate the abdominal wall with forceps to create a tenting effect. Make an incision with radiosurgery electrode (or a No. 15 or 11 scalpel blade)to just incise the skin, avoiding deeper structures. Repeat the tenting with the abdominal wall and perform a similar incision. If you are uncertain, palpate the abdomen gently but well prior to surgery to identify possible organ position and depth. Be careful where you suspect a swollen liver or other major organ.

Once you enter the abdomen, spend a few seconds identifying structures and orienting yourself. Use the handle of the scalpel or blunt forceps to gently elevate and move the superficial structures to identify any deeper structures of interest.

Right side: Right liver lobe, duodenum containing pancreas in its loop,

Left side: Gizzard (Ventriculus)

Air sacs on both sides, may need to be incised to aid visualisation of deeper structures.

Closure: I prefer a two-layer closure – abdominal wall, then skin. I use 4/0 Dexon in a simple continuous pattern.

Ingluviotomy

Indications:

Removal of foreign bodies

Food impaction

Approach for passing endoscope into Proventriculus and/or Gizzard

Repair damage from crop burn or puncture with feeding tube

Surgical Approach:

To allow the crop to empty as much as possible, fast the bird for approximately three hours prior to surgery.

The position of the crop varies with species, but parrots are all on the right side just proximal to the thoracic inlet. Pigeons are on both the right and left sides. Passerines do not have an actual crop but a potential space that can dilate to store food.

Incise the skin parallel to the spine over the crop where it is palpable. The size of the incision will be determined by the size of the instruments to be inserted or the size of the foreign body present.

Blunt dissect to separate the subcutaneous layer from the skin.

Position the incision in the crop wall away from the skin incision so they will not be overlying each other at closure. Elevate with forceps and incise through the wall in the same direction as the skin incision.

Collect any swab samples or biopsies, as indicated, after a thorough examination of the crop wall.

Closure: I prefer a two layer closure – A simple continuous inverting pattern in the crop wall, then a simple continuous everting pattern in the skin. Both layers with 4/0 Dexon.

Hints:

Do not perform surgery on burns until the full extent of tissue damage is apparent – this usually takes 3-5 days. Place the bird on a liquid diet (hand-rearing mix or similar) via gavage tube or gastrostomy tube for at least 1 week post-operatively.

Cloacapexy

Indications:

Cloacal prolapse

Common in Cockatoos and Budgerigars. There may be damage to the nervous supply to the cloacal tissues.

Surgical Approach:

Minor Prolapse: manipulate tissues back into position with a blunt probe, e.g. thermometer, and place a purse-string suture in the peri-cloacal tissue, using small, shallow bites with 3/0 Non-absorbable material. Alternately place two single interrupted sutures across the cloacal opening at 1/3 the distance from the cloacal edge. These are often a temporary measure to stabilise the patient in preparation for cloacapexy.

Cloacapexy

Begin with a ventral midline incision as for a standard laparotomy (described above)

Expose the cloaca by incising the cloacal fat pad, if present, and incising through the caudal abdominal air sac on each side.

An assistant places their gloved finger into the cloaca to allow you to visually identify the cloacal wall.

Dissect away any cloacal fat pad that is remaining

Use 4/0 Dexon or Vicryl to place stay sutures at 2 and 10 o'clock in the cloacal wall. These should penetrate into the lumen of the cloaca.

Pass the stay sutures around the last rib on each side and tighten to provide enough tension to slightly invert the vent opening

Closure:

Standard two-layer as described for laparotomy. I often will include the ventral cloacal wall in the abdominal wall closure to maintain its position into the abdomen..

Salpingohysterectomy

Indications:

Egg binding that has not responded well to medical management

Chronic egg laying that is causing health problems and does not respond well to medical management

Pathology of the oviduct (neoplasia or pyometron)

Surgical Approach:

Ventral Midline incision allows good visualisation of the coelomic cavity if need to check for peritonitis or retained egg remnants. Alternately use left lateral abdominal incision as this allows good visualisation of the oviduct and ovary.

Identify the oviduct and follow it cranially to identify the infundibulum.

Identify and ligate the branch of the Ovarian Artery found in the dorsal suspensory ligament.

Incise the ligament and oviduct as close as possible to the ovary. Do not damage the ovary at all – err on the side of caution. Do not attempt to ligate the ovary.

Elevate the oviduct, adjacent to your incision, and trace it back towards the cloaca.

Ligate the oviduct where it joins the cloaca. This will remove the eggs-shell gland as well, as this has an influence on ovulation.

Use blunt dissection to remove the ventral ligament attachment to the oviduct remove it from the coelomic cavity.

Closure:

Standard two-layer closure as for laparotomy.

Ophthalmic Surgery – Eye Ablation

Indications:

Trauma that does not respond to medical management
Generalised infection of the globe (panophthalmitis)
Glaucoma
Neoplasia

Surgical Approach:

Perform a circumferential incision 2-3 mm from the eyelid margin.

Use sutures or Allis Tissue forceps to join the eyelid margins to aid manipulation for dissection

Blunt dissect the palpebral conjunctiva from the overlying skin

Dissect the fibrous attachment at the medial canthus until the eyelids are fully free from the orbit.

Apply tension to the eyelid margins by pulling gently on the sutures of Allis Tissue forceps.

Gently dissect around the globe by continuing the dissection from the palpebral conjunctiva. Only use slight tension to elevate and manipulate the tissues, as pressure on the Optic nerve may damage the contra-lateral Optic nerve.

Transect the muscles and fat pad posterior to the globe and use curved artery forceps to ligate the Optic nerve and its blood vessels.

Use curved scissors to transect the Optic nerve as close to the base of the eye as possible.

Use the radiosurgical unit to coagulate any bleeding points

If you cannot control haemorrhage, do not use artery forceps to grasp the Optic nerve stump, as you may damage the contra-lateral Optic nerve. Use gel-foam as packing to stem bleeding. If no gel-foam is available use gauze soaked in Iovone as packing – this must be removed later.

Leave as much non-secretory tissue as possible as this will cause less concavity with healing, and a more cosmetic result. Any secretory tissue that remains will form a fistula and require more surgery to remove it at a later date.

Close the eyelids with 4/0 – 6/0 Dexon as indicated

Over-inflated Air Sacs/Subcutaneous Emphysema

Indications:

Generalised or localised subcutaneous emphysema anywhere on the body but more commonly around the head, neck and thorax.

Aetiology is unknown but some appear to be under voluntary control, while others recur frequently. Trauma is often suspected but not commonly documented.

Many of these are not subcutaneous emphysema (leaking from a damaged air sac) but are an over-inflated, intact air sac.

Surgical Approach:

Some people recommend placing a stent in the area. I find that these are often difficult to maintain and they eventually become blocked with tissue and/or discharges.

In my experience, many will respond to preparing the skin as for surgery, then incising over the area of inflation with a sharp hypodermic needle or scalpel blade – avoiding the large cutaneous blood vessels that are easily visualised when the skin is sprayed with alcohol.

This allows the over-inflation to collapse and contact the skin.

Open the incision further or snip away a small crescent of skin, to interfere with closure for several days.

The skin will usually heal within 1 week.

The procedure may require several repeats of this process until there is no more buildup of air. This can be quite frustrating for the client.

The majority of birds will eventually respond to this treatment.

Biopsy

Indications:

Aiding diagnosis and confirmation of problems in tissues such as : liver, kidney, lung or testes

Adjunct to endoscopy

Surgical Approach:

See the notes supplied with the Endoscopy section in module 3

Castration/Caponisation

Indications:

Reduce aggression

Reduce crowing at inappropriate times of the day

Surgical Approach:

Perform at the beginning of the breeding season or during the non-breeding season as the testes are smaller and their blood supply is not as engorged.

In most galliforms use a transabdominal approach to allow good access to both sides of the abdomen

The testes' blood supply and attachments can be ligated with a hemoclip or use 3/0 Dexon and artery forceps

I have not tried it but Altman describes a technique of aspiration and radiosurgical coagulation of testes in pigeons and a parrot to control aggressive behaviour. He feels it is best performed on young, undeveloped testes. In mature birds, with well-developed testes, there was a higher rate of testicular regeneration.

Closure:

Standard two-layer closure as for laparotomy.

Feather Cysts

Indications:

Removal of feather cysts

Common in canaries and occasionally seen in some psittacines as well.

Possible aetiologies include: hereditary predisposition, nutritional imbalance, deformed feather formation, trauma, infection (bacteria, virus, fungi).

Surgical Approach:

Incise over the cystic mass with a fine radiosurgical electrode.

Express or remove all the contents.

Dissect out the lining or coagulate it with radiosurgery. All the lining must be removed or destroyed or the cyst is likely to recur.

Some of these cysts have a large blood supply and this must be controlled or significant haemorrhage may occur.

Avoid damaging adjacent tissue during the surgery.

Individual cysts can be removed with local excision. Multiple cysts may require removal of the full feather tract.

Closure:

Standard closure with simple continuous pattern with 4/0 Dexon. You may need significant undermining of the skin to allow closure without tension as the skin has low elasticity, particularly on the dorsal aspect.

Abdominal Hernia

Indications:

Often difficult to differentiate from neoplasia, ascites and lipomas or obesity.

May have an association with hormonal triggers in Budgerigars, Cockatiels Sulphur Crested Cockatoos, as there is a significant predominance in cycling females.

These are usually not a hernia but more a stretching of the abdominal wall without herniated abdominal structures and a hernial ring.

Surgical Approach:

Perform a ventral midline incision

Identify the structures involved and identify the abdominal musculature, if possible.

In most cases you should perform a salpingohysterectomy as this is the underlying cause.

Perform a tummy tuck in the abdominal wall. Use 2/0 - 3/0 Dexon or Vicryl to approximate the site you wish to suture. Pre-place sutures and approximate the structures prior to tying the knots. Remove and fat deposits from the site to be sutured. Use single interrupted pattern to tie each suture. You need to strike a balance between restoring the normal abdominal profile and interfering with abdominal distension used for normal respiration.

Standard closure of the skin with 4/0 Dexon

Warn the client that the stretching of the abdominal wall may continue with time.

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