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2.2.6 Blood transfusions

Severe blood loss is much better tolerated in birds than in mammals, especially in flighted birds (Quesenberry & Hillyer 1994). This tolerance is the result of an increased rate of absorption of tissue fluids to replace lost blood volume, and baroreceptor reflexes that maintain normal blood pressure (Quesenberry & Hillyer 1994).

Indications for transfusion of whole blood include clinical signs of severe anaemia (tachypnoea, tachycardia, weakness, pallor), a PCV of less than 15–20%, (normal: 38–54%, Appendix 3) or acute blood loss of greater than 25% of the total blood volume (Hoefer 1992). Birds with a more chronic anaemia may be able to tolerate a lower PCV, and it is suggested that a PCV of below 12% may be indicative of the need for transfusion in chronically anaemic birds (B.D. Gartrell, Massey University, pers. comm.). However, these recommendations are anecdotal, especially in kiwi, and are useful as guidelines only.

There is little information on blood typing in avian species (Gilmour 1971), and blood transfusion in avian species is controversial and poorly understood (Degernes et al. 1999). In clinical practice, heterologous (between different species) transfusions are often used because homologous (of the same species) donors are seldom available (Degernes et al. 1999). However, recent consultation with iwi has determined that, at the time of writing, only homologous blood transfusions (i.e. kiwi to kiwi) are culturally acceptable, and heterologous transfusions should not be performed (K. McInnes, DOC, pers. comm.).

Studies of both homologous and heterologous transfusions in cockatiels (*Nymphicus hollandicus*) showed no apparent transfusion reactions or other complications during the study (Degernes et al. 1999). Single, whole-blood transfusions have been performed on kiwi on at least three occasions (to the author's knowledge), without any apparent complications.

The donor kiwi should be healthy at the time of blood collection, and should be anaesthetised for the collection procedure. A suggested maximum blood volume for collection is between 1 and 2% of the bird's body weight, with the assumption that 1 g of body weight equates to 1 mL of blood. On this basis, a 2-kg bird is able to donate between 20 mL (1%) and 40 mL (2%) of blood. The donar bird should receive three times the volume of collected blood of an isotonic crystalloid fluid such as LRS or 0.9% NaCl (N. Smith, Massey University, pers. comm.). Collection of whole blood from the donor should be done via the right jugular vein and the blood should be collected into a citrate-filled syringe using a relatively large-bore needle or catheter (20 gauge). A concentration of 0.14 mL CPD (citrate phosphate dextrose) is recommended per 1 mL of blood collected (V. Walsh, Massey University, pers. comm.). Blood should be filtered using a blood filter fitted to the syringe (see Fig. 5), and administered to the recipient via a peripheral vein. The medial metatarsal vein and the right jugular vein are common sites for blood administration, but intraosseous administration can also be used. For further information on this procedure in kiwi, contact the New Zealand Wildlife Health Centre (see Appendix 2).

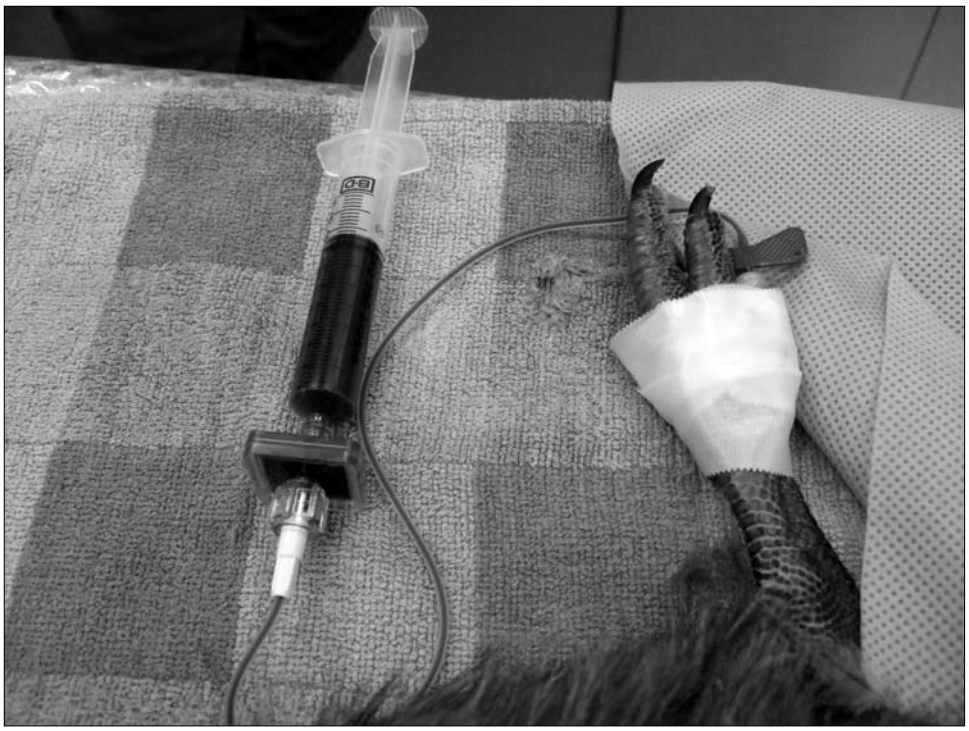

Figure 5. Transfusing whole blood to a kiwi. Note the use of a blood filter attached to the syringe.
Photo: J. Youl.

2.2.7 Analgesia

Not only do birds perceive and respond to noxious stimuli, but they also feel pain (Paul-Murphy 2006). Misconceptions about the ability of birds to perceive pain arise because of difficulties in recognising bird behaviour associated with both acute and chronic pain (Paul-Murphy 2006). These challenges are probably a result of the preservation reflex that birds demonstrate, which may have evolved as a way of minimising the attention of predators (Paul-Murphy 2006). If the bird demonstrates changes in posture, temperament or behaviour, or if a procedure or injury involves tissue damage, it should be assumed that the bird is in pain (Machin 2005).

Timely administration of analgesics is important, as persistent pain perception can have a negative effect on homeostasis and healing (Wright et al. 1985; Clyde 1994).

Pain management in birds includes the use of analgesics in combination with non-pharmacological methods of analgesia, such as supporting or bandaging the traumatised area. Provision of a dry, warm, quiet and non-stressful environment is also important for pain control (Machin 2005).

There is much uncertainty amongst non-avian veterinary practitioners as to the most appropriate analgesic therapy to use in birds (Hawkins & Machin 2004). Choices of analgesics for birds include opioids and non-steroidal anti-inflammatory drugs.

The current recommendation for opioid analgesia in parrots is butorphanol given at 1–3 mg/kg IM (intramuscularly) (Paul-Murphy 2006). In one study, plasma concentrations of 2 mg/kg butorphanol in African grey parrots (*Psittacus erithacus*) had a mean residence time of less than 2 hours (Paul-

Murphy 2006), and there are reports suggesting that butorphanol should be readministered every 2–4 hours (Clyde 1994; Clyde & Paul-Murphy 1999). Other references for the frequency of medication give values that vary from every three hours to once daily (Marx 2006).

The New Zealand Wildlife Health Centre uses a dose rate for butorphanol of 4 mg/kg IM or IV at least twice daily in kiwi (pers. obs.). Because of their flightlessness, kiwi lack large pectoral muscles for intramuscular administration of therapeutics, and intramuscular injections are usually given in the hindlimbs. To minimise muscular damage, the intravenous route is preferred to intramuscular injection for any more than short-term parenteral administration of therapeutics.

Pre-anaesthetic use of butorphanol will also allow a reduction in the concentration of isoflurane needed for induction and maintenance of anaesthesia (Paul-Murphy 2006).

Pigeons possess a higher proportion of κ receptors in their forebrains than mammals (Hawkins & Machin 2004; Paul-Murphy 2006). For this reason, birds do not appear to respond to μ agonists in the same manner as mammals, and there are conflicting reports of the efficacy of other opioids in avian species (Hawkins & Machin 2004).

Non-steroidal anti-inflammatory drugs (NSAIDs) for use in birds include meloxicam (Metacam™) and carprofen (Rimadyl™). NSAIDs are useful for relief of musculoskeletal and visceral pain, acute pain associated with trauma and surgery, and chronic pain such as that associated with osteoarthritis (Paul-Murphy 2006). These drugs are contraindicated when severe hypovolaemia, renal or hepatic dysfunction and gastric ulceration are present (Paul-Murphy 2006). It is absolutely imperative that the kiwi is well hydrated prior to NSAID administration. For this reason, the author does not recommend the use of NSAIDs in the initial medical treatment of injured kiwi (i.e. during the first 24 hours). Butorphanol should be used for analgesia until the bird is stable, with a restored circulatory system. To reduce the risk of renal side effects, NSAIDs should always be given in conjunction with fluid therapy.

Suggested dosage regimes for meloxicam in avian species are variable and are, in general, anecdotal or published without reference. Frequency of administration is generally recommended as once daily. Intravenous administration of meloxicam in ostriches (*Struthio camelus*) demonstrated a rapid half-life compared with other avian species (Hawkins 2004), and Wilson et al. (2004) make the suggestion that the larger the bird, the shorter the half-life. The New Zealand Wildlife Health Centre uses a regime of once-daily administration of oral meloxicam in kiwi at a dose rate of 0.1–0.2 mg/kg, with concurrent fluid therapy.

Carprofen may be given to birds at a dose rate of 2–10 mg/kg intravenously, intramuscularly, subcutaneously or orally (Marx 2006). Dosing intervals are also variable, and are reported as once to twice daily (Marx 2006).

Paul-Murphy (2006) advocates the use of multimodal therapy, using a combination of both butorphanol and a NSAID. This may provide a wider spectrum of analgesia, and usually allows the dosages of each drug to be reduced, minimising side effects (Paul-Murphy 2006).

2.2.8 Antimicrobial therapy

The use of antimicrobial therapy in injured or sick kiwi should be considered. In many situations, it is immediately obvious when antimicrobial medication is warranted, e.g. possum trap injuries, open fractures, and yolk sacculitis in chicks. Septicaemia and bacteriaemia should be considered in any bird that is severely depressed, and prophylactic antibiotics are often used in birds that are immunocompromised from a non-infectious disease (Quesenberry & Hillyer 1994).

In such cases, treatment with antibiotics and, possibly, antifungals in combination with supportive care, should begin without delay. In other instances, the decision to start antimicrobial therapy will depend upon results of diagnostic testing, including faecal Gram stains, and culture and sensitivity of body fluids and tissue.

Antimicrobials should be used cautiously, as there are adverse effects associated with their use. These include the direct toxic effects of some antimicrobial drugs (e.g. nephrotoxicity associated with gentamicin and amphotericin B), and inhibition of normal gastrointestinal flora, resulting in yeast and bacterial overgrowths. It is important to consider possible side effects and toxicities before beginning antimicrobial therapy.

Antibiotics

Parenteral (injected) antibiotics are recommended for the initial treatment of birds that are weak, sick, debilitated or in shock (Ritchie 1991). Intravenous administration of antibiotics gives a peak plasma concentration within seconds, intramuscular injection takes 30 to 60 minutes to reach peak plasma concentration, and oral administration takes between 60 and 120 minutes (Quesenberry & Hillyer 1994).

If an IV line is set up for fluid therapy, antibiotics can be given intravenously. This is ideal, as it saves handling and stress on the bird when further medications are administered. Alternatively, subcutaneous or intramuscular routes can be used. Repeated intramuscular injections are not recommended because of the possibility of injection-site muscle necrosis (Quesenberry & Hillyer 1994). In addition, kiwi lack pectoral muscles, requiring intramuscular injections to be given into the hindlimbs. The renal portal blood flow system of birds may allow passage of the drug through the kidney prior to systemic circulation. If the drug used is renally excreted, this may mean that it is cleared prior to distribution to target tissues (Flammer 1994). Disadvantages associated with subcutaneous administration include the possibility of leakage from the injection site and poor absorption (Quesenberry & Hillyer 1994). Oral medications can be used once the bird's condition is stable.

Initially, before the results of culture and sensitivity testing are available, antibiotics should be chosen depending upon the clinical signs and history of the bird, and any initial diagnostic results. Birds with suspected gram-negative septicaemia should be treated with a bactericidal antibiotic effective against the most common avian pathogens, including *Escherichia coli, Enterobacter* spp., *Klebsiella* spp. and *Pseudomonas* spp. (Ritchie 1991). Examples of commonly used first-choice broad-spectrum antibiotics in avian medicine effective against Enterobacteriaceae include amoxicillin/clavulonic acid, enrofloxacin and trimethoprim-sulfa (Quesenberry & Hillyer 1994).

Antifungals

Antifungal therapy should be instigated when fungal infections are suspected, and may be used prophylactically during antibiotic therapy to decrease the risk of secondary yeast overgrowths in the gastrointestinal system, especially in immunosuppressed birds (Harrison et al. 2006).

Yeast infections confined to the gastrointestinal tract, candidiasis in particular, can be treated with nystatin (Flammer 1994). This drug is not absorbed from the gastrointestinal tract, and relies on contact for effect (Flammer 1994).

Itraconazole is currently the first-choice oral antifungal for treatment of aspergillus infections in birds (Dahlhausen 2006). Concurrent nebulisation with an antifungal (e.g. fluconazole, amphotericin B) is recommended for treatment of fungal air sacculitis.

Dahlhausen (2006) recommends the use of amphotericin B for aspergillosis. It may be administered intratracheally, intravenously, in sinus flushes and via nebulisation. However, this drug should be used for short durations only, as it is eliminated renally and there is an associated risk of nephrotoxicity (Dahlhausen 2006). For this reason, amphotericin B should be used with extreme caution in dehydrated birds or those suspected of having renal disease.

Nebulisation

Nebulisation may be beneficial for birds with air sacculitis. Blood supply to the air sacs is extremely limited (King & McLelland 1984), and parenteral and oral antimicrobial therapeutics are thus ineffective in treatment of air sacculitis. Nebulisation provides topical, localised treatment of the internal air sacs and is not dependent upon absorption. In general, most parenteral medications formulated for intravenous use (i.e. particle size less than 3 μm) can be suspended in saline and used for nebulisation therapy (Quesenberry & Hillyer 1994). The suggested protocol for nebulisation is for 10 to 30 minutes, two to four times daily.

Agents that are commonly used for nebulisation at the New Zealand Wildlife Health Centre include amphotericin B and enrofloxacin. Diluted forms of the disinfectant F-10™ are also being used by avian practitioners for nebulisation. However, recent histopathological evidence suggests that this may cause a chemically-induced pneumonia (B.D. Gartrell, Massey University, pers. comm.).

2.2.9 Other medications

Corticosteroids

The use of corticosteroids in birds has been widely debated because of the potential complications arising from their use (Orcutt & Flinchum 2001). Potential side effects of corticosteroid use include immunosuppression, adrenal suppression, delayed wound healing, and gastrointestinal ulceration (Harrison et al. 2006). Corticosteroids are contraindicated in birds with a history of immunosuppression or fungal disease. The author recommends that corticosteroids are not used in routine therapy of injured or sick kiwi.

Glucose therapy

Hypoglycaemia may occur in cases of starvation or malnutrition, sepsis or hepatic dysfunction. Intravenous dextrose alone should not be used in dehydrated patients, and should be given in conjunction with IV fluids (e.g. half-strength LRS and 2.5–5% dextrose). Alternatively, 25% dextrose can be given as an intravenous bolus at a rate of 1–2 mL/kg, slowly to effect (Harrison et al. 2006). This can be continued in fluids at 2.5–10% IV or IO (intraosseous). Oral glucose solutions can be used in birds that are not prone to aspiration (Harrison et al. 2006).

Nutritional support

A sick or debilitated bird should always have its hydration corrected prior to any attempt to initiate oral gavage feeding (Harrison et al. 2006). In practice, nutritional support is rarely provided to debilitated kiwi in the first 24–48 hours of care. Useful nutritional formulas for kiwi include tube feeding of Hill's a/d™ diet or Wombaroo™ Insectivore Mix, and various preparations of a captive kiwi mince mix (see section 5.1 and Appendices 4 and 5).

Figure 6. Kiwi with a modified external fixator stabilising multiple mandibular fractures. An oesophagostomy tube was placed to allow feeding in the initial phase after surgery. *Photo: K. Morgan.*

An oesophagostomy feeding tube may be placed in birds with bill injuries (see Fig. 6). However, it is difficult to maintain the bird's body weight when feeding by this method (see section 5.1).

2.3 INITIAL WOUND AND FRACTURE MANAGEMENT

2.3.1 Wound management

During patient stabilisation, and prior to thorough wound assessment and management, Burke et al. (2002) recommend protecting the wound with a temporary bandage. This can be achieved by packing the wound with moistened sterile gauze swabs or by filling the wound cavity with a water-soluble lubricating gel (e.g. KY™ jelly).

Once the bird is in a stable condition, the wound should be thoroughly assessed for location, extent and age (Degernes 1994). Evaluation of underlying orthopaedic injuries and the vascular and nerve supply to the tissue is especially important (Degernes 1994; Burke et al. 2002). Development of a greenish discolouration of traumatised skin is normal in birds. This often occurs 2–3 days post-injury as a result of the accumulation of biliverdin pigment following the breakdown of haemoglobin, and it may persist for over a week (Degernes 1994). Necrotic tissue is black or blanched white (Burke et al. 2002).

Initially, feathers surrounding the wound should be plucked or trimmed to allow the full extent of the wound to be clearly visible. Feather plucking in birds is extremely painful, and it should be done under general anaesthesia. Alternatively, a water-based lubricant (KY™ jelly) can be applied to flatten-down surrounding feathers and allow better visualisation and assessment of the wound.

The wound should be lavaged with copious amounts of warmed sterile saline (with or without 0.05% chlorhexidine or 0.5–1.0% povidone iodine) to remove debris (Degernes 1994). This helps to reduce the number of bacteria present, as well as providing tissue rehydration. It is recommended that samples for cultures be obtained after surface contaminants have been removed from the wound and before any antiseptics have been applied (Degernes 1994; Burke et al. 2002).

Surgical debridement of dead and devitalised tissue under general anaesthesia (isoflurane with oxygen) is recommended once the bird is stable (Burke et al. 2002). The goals of wound debridement include removing as much of the devitalised and necrotic tissue as possible until viable, vascularised tissue can be seen (Degernes 1994).

Application of topical wound medication is indicated when treating infected wounds (Burke et al. 2002). These medications need to be water soluble to avoid the loss of insulation resulting from soiled feathers and to prevent feather contamination with oily substances (Degernes 1994). Useful topical medications include iodine, antibiotic creams, Solosite™ and silver sulfadiazine.

Suturing of wounds is only indicated if the wound is clean and less than 8 hours old (Degernes 1994). This is very rarely the case in wildlife medicine. Most wounds will need to be managed as open wounds and allowed to heal via secondary intention, requiring the application of dressings and bandages.

Bandaging principles

The primary layer is in direct contact with the wound, and is the most critical layer for optimal wound healing. Functions of the primary layer include provision of a moist wound environment and debridement of the wound (Degernes 1994). This layer should be sterile and remain in place even when the bird moves. Adherent and non-adherent dressings can be used, depending upon the stage of wound healing.

Adherent dressings, such as sterile saline-soaked gauze swabs, are useful in the initial stages of wound management when there is a large amount of necrotic debris that cannot be surgically debrided (Degernes 1994; Burke et al. 2002). They act to absorb exudates, and contribute to wound debridement during dressing changes. These adherent dressings need to be changed on a daily basis, and should only be used for 2–4 days before being replaced with a non-adherent bandage. Prolonged use of adherent dressings will interfere with granulating epithelium. Other disadvantages of such wet-to-dry bandages include tissue maceration and bacterial colonisation in the moist environment (Degernes 1994).

Non-adherent bandages do not adhere to the healing wound surface (Degernes 1994). Semi-occlusive, non-adherent dressings (e.g. Melolin™) are the most useful for avian medicine. These are indicated after tissue debridement, or for use on clean fresh wounds that do not require debridement. They should be changed at least every 48–72 hours.

Occlusive hydrocolloidal bandages (e.g. Duoderm™) have been used for management of wounds in raptors (Aguilar 2004). These bandages keep the wound surface moist, preventing the formation of a scab and increasing the rate of re-epithelisation and wound healing. They should only be used on non-infected wounds. Initially, dressings should be changed every 72 hours, then replaced weekly thereafter (Aguilar 2004).

The secondary layer of the bandage consists of soft padding (e.g. Sofban™) that acts to absorb fluids and exudates, as well as providing protection and immobilisation of the wound.

Self-adhesive bandaging (i.e. which sticks only to itself) (e.g. Vetrap™, Coflex™) should be used as the tertiary layer. Adhesive bandaging materials (i.e. those with a sticky surface) should not be used, as they adhere to and damage feathers.

2.3.2 Fracture management—external coaptation

Distal hindlimb fractures

Bandaging techniques for fracture management in kiwi are limited to fractures of the lower hindlimb. The modified Robert Jones bandage (Fig. 7) is the most useful and practical form of external coaptation (joining the bone edges together).

Indications for the Robert Jones bandage include fractures to the distal third of the tibiotarsus, fractures of the tarsometatarsus, injuries involving the hock joint, soft tissue wounds of the tibiotarsus or tarsometatarsus, and following orthopaedic repair of the distal two-thirds of the limb (Degernes 1994).

Figure 7. Modified Robert Jones bandage on a North Island brown kiwi with a trapping injury to the distal hindlimb.
Photo: J Youl.

The Robert Jones bandage is contraindicated for fractures of the femur and the proximal two-thirds of the tibiotarsus (Degernes 1994) and may cause further tissue disruption and discomfort to the bird (pers. obs.)

A thick layer of cotton wool casting material (Sofban™) is wrapped from the most proximal part of the leg (i.e. the part closest to the body) (Degernes 1994). The leg should be slightly flexed in a normal standing position. Conforming gauze material is tightly applied around the padding, and a self-adherent material is used to cover the bandage (Degernes 1994). The toes of the bandaged limb should be monitored for swelling and discolouration if they are not incorporated within the bandage (Degernes 1994).

Proximal hindlimb fractures

There are no effective bandaging techniques for upper tibiotarsal, femoral or pelvic fractures in kiwi. Any attempts to bandage high up the limb results in poor immobilisation of the stifle, and no immobilisation of the hip, and may cause further tissue disruption and discomfort to the bird (pers. obs.). In this instance, provision of soft bedding and confinement in a small enclosure is indicated to minimise further trauma and pain associated with the fractures until surgical stabilisation (if indicated) is achieved.

3. General anaesthesia

3.1 IMPORTANT CONSIDERATIONS IN AVIAN ANAESTHESIA

3.1.1 Air sacs and positioning

The respiratory system in birds differs from mammals in that the lungs are small and undergo little change in volume during breathing, and birds do not have a diaphragm (O'Malley 2005). Instead, birds possess a system of airsacs which act as bellows to provide airflow to the rigid avian lung during both inspiration and expiration (O'Malley 2005; Edling 2006). The air sac system of the flightless kiwi appears to be much less extensive than those of other avian species (pers. obs).

How a bird is positioned during anaesthesia can significantly alter its ventilation. In dorsal recumbency, the weight of the visceral organs can compress caudal air sacs, reducing their effective volume (O'Malley 2005). For this reason, tidal volume (the amount of gas passing through the lungs on each breath) may be reduced by as much as half when the bird is lying on its back (O'Malley 2005). Birds should be maintained in sternal (upright) or lateral (side) recumbency as much as possible. If a bird must be kept in dorsal recumbency for a period, adequate ventilation can be achieved by the use of intermittent positive pressure ventilation (IPPV) (Edling 2006).

3.1.2 Patient stabilisation

During the early stages of assessing a sick or injured kiwi, it may not be possible to perform basic necessary procedures on a conscious bird. A brief period of anaesthesia may be required in order to establish intravenous or intraosseous access for fluid therapy, to address any wounds or fractures, and to obtain a blood sample for haematology and biochemistry. This anaesthesia should be kept as light and short as possible to allow the necessary procedures to be carried out without compromising an already debilitated patient. Once the bird's body temperature and hydration have been stabilised, it will be able to tolerate longer periods of anaesthesia. This is generally 24 hours or more after initial presentation of the bird.

Thermal regulation

Birds are not efficient homeotherms and they rapidly lose heat when they do not remain metabolically active (Forsyth et al. 1999). The low surface area to volume ratio of birds facilitates heat loss, and anaesthesia reduces a bird's physiologic response to the reduction in body temperature (Edling 2006). The use of dry anaesthetic gases further increases heat loss, as does the removal of feathers for surgical procedures and the use of surgical skin preparations (Edling 2006).

Thermal regulation in anaethetised birds includes minimising anaesthetic time, as well as providing an external heat source during anaesthesia. Heat sources may be heated surgery tables (e.g. heat pads), overhead heat lamps,

warm towels and warm IV fluids (Edling 2006). Warming the room prior to anaesthesia will also help. Radiant heat sources are more effective than under-bird heating because of the insulating properties of the bird's feathers. Insulation is necessary between the patient and the surgical table, and may be provided with towels or plastic bubble wrap.

3.1.4 Fasting

In general, for large birds in good physical condition, removing food the night before and water 2–3 hours prior to anaesthesia does not appear to be harmful (Franchetti & Kilde 1978). In contrast, it has been recommended that fasting be limited to no more than 2–3 hours in smaller bird species because of their high metabolic rate and poor hepatic glycogen storage (Edling 2006).

In kiwi, the author recommends a fasting period of 12–24 hours prior to anaesthesia in order to reduce the hazards associated with regurgitation. Kiwi do not possess a crop or a large proventriculus for storage of food (Fergus et al. 1995), and for this reason, if a bird is fasted appropriately before anaesthesia, the risk of regurgitation and aspiration is minimal.

3.1.5 Restraint

During induction of gaseous anaesthesia, using a towel to encircle the patient enables careful restraint of the bird while allowing the sternum freedom of movement for respiration (Edling 2006).

3.1.6 Surgical preparation

Feathers should be plucked for surgical preparation. This is an extremely painful procedure, and should only be done under general anaesthesia. Feathers should be pulled 1–2 at a time in the direction the shaft is growing (usually caudally) (Cannon 2001). Cutting feathers is not recommended as the bird will need to go through a normal moult to replace those feathers, and this prolongs the rehabilitation process.

Skin should be prepared for surgery using a chlorhexidine or iodine scrub and aqueous chlorhexidine (0.05%). Alcohol should not be used in birds as it has a significant cooling effect, contributing to the risk of hypothermia (Cannon 2001).

3.2 ANAESTHETIC EQUIPMENT

3.2.1 Inhalant anaesthetics

The author advocates the sole use of inhalational anaesthetic agents for the induction and maintenance of anaesthesia in kiwi. Isoflurane is the anaesthetic agent of choice for avian anaesthesia (Cannon 2001). Sevoflurane is also an excellent anaesthetic agent for use in birds (Edling 2006), although it is not regularly available in New Zealand practice.

Halothane is no longer considered safe for use in avian species as there is a close time interval between apnoea (cessation of unassisted breathing) and cardiac arrest (Cannon 2001), and halothane sensitises the heart to catecholamine-induced cardiac dysrhythmias (Edling 2006). There have been fatalities associated with use of halothane for anaesthesia in stressed birds with high pre-existing levels of catecholamines (Edling 2006).

3.2.2 Breathing circuits

Non-rebreathing circuits, such as the Ayre's T-piece and the Bain circuit, are indicated for use in avian species as they have the least dead space and the lowest resistance (Forsyth et al. 1999; Edling 2006).

3.2.3 Induction of anaesthesia

A mask for the induction of anaesthesia in kiwi can be fashioned from a 20-mL syringe barrel or a syringe case. A disposable latex glove can be taped over the end of the mask opening with a small central hole for placement of the kiwi bill (Fig. 8).

Induction techniques include a period of pre-oxygenation, after which the concentration of gaseous anaesthetic agent is slowly increased until the desired effect has been attained (Edling 2006). This is the author's preferred method, especially for inexperienced avian anaesthetists, as it allows a more gradual attainment of anaesthesia.

The oxygen flow rate should be approximately 1.5–2 L/minute, and a period of pre-oxygenation of approximately 30 seconds is recommended. The concentration of isoflurane should be increased in 0.5% increments, with a period of approximately 20–30 seconds between each increase. The vaporiser setting can then be reduced to a setting near the minimum anaesthetic concentration (MAC) for maintenance (Edling 2006). The author finds that a light to surgical plane of anaesthesia in kiwi is usually reached at 3–4% isoflurane, and can be maintained at around 1.5–2%.

Figure 8. Induction of isoflurane anaesthesia using a modified syringe case with a latex glove over the end for a mask.
Photo: K. Morgan.

3.2.4 Intubation

Intubation is usually not necessary for short (less than 10 minutes), non-invasive procedures (Edling 2006). For longer periods of anaesthesia, intubation can be crucial.

The glottis can be easily seen in kiwi at the base of the tongue (Fig. 1). Avian species do not possess an epiglottis, making intubation relatively easy.

The endotracheal tube should provide a good seal with the glottis but should not fit tightly. Birds have complete cartilaginous tracheal rings, contraindicating inflation of cuffed endotracheal tubes. Inflation of the cuff can cause pressure necrosis and consequential stricture of the tracheal mucosa (Edling 2006). Non-cuffed avian tubes are available (Cole™ tubes). In adult kiwi, size 25–35 Cole's tubes are typically adequate. If a Cole tube is unavailable, normal endotracheal tubes (sizes 2.5–3.5) may be used without inflating the cuff. Silicone tubes are preferable to the more rigid plastic ET tubes, as they are softer and are less likely to cause injury to the tracheal mucosa.

Once a kiwi is intubated, the endotracheal tube should be securely attached to the lower and/or upper bill, with Sleek™ or similar tape (Fig. 9).

3.2.5 Pre-anaesthetic agents

The use of butorphanol prior to anaesthesia has been found to reduce the concentration of isoflurane needed to maintain anaesthesia in other avian species (Edling 2006; Paul-Murphy 2006). (See section 2.2.7 for further details.)

Figure 9. Intubated kiwi connected to anaesthetic machine.
Photo: V. Gray.

3.3 PATIENT MONITORING

The most common problems associated with avian anaesthesia include apnoea, hypoventilation, hypothermia and regurgitation (Edling 2006). Veterinary equipment, including a Doppler flow monitor and/or pulse oximeter attached to a toe or lower leg can provide a useful audio tool for monitoring pulse rate.

3.3.1 Respiratory system

Respiration during anaesthesia should be monitored both visually and by auscultation. Ideally, end tidal CO_2 (i.e. that expired at the end of each breath) would also be measured via capnography (monitoring the pressure of CO_2 in respiratory gases). However, this is often not possible because of the lack of appropriate monitoring equipment in many general veterinary practices.

3.3.2 Cardiovascular system

The aneasthetised bird should be regularly monitored via auscultation to observe changes in heart rate and rhythm. The heart rate should be quantified to monitor for change. The normal kiwi heart rate has been documented as 70–240 beats per minute (Doneley 2006).

3.3.3 Central nervous system

Parameters that can be used to assess anaesthetic depth in birds include eye reflexes, jaw tone, cloacal reflex, pedal reflex and muscle relaxation. Muscle tone is assessed by progressive relaxation of the leg, and appropriate anaesthesia is generally achieved once muscle tone in the limb is absent. One study described the ideal anaesthesia level as when the patient's eyelids were closed, pupils mydriatic, the pupillary light reflex was delayed, the nictitating membrane moved slowly over the entire cornea, all muscles were relaxed and all pain reflexes were absent (Korbel et al. 1998).

Cannon (2001) gives the following guide to stages of anaesthesia (commonly used reflexes in larger birds include the eye reflexes (corneal, palpebral) and the interdigital (toe pinch) reflex):

Light plane of anaesthesia	Reflexes present Deep, rapid respiration No voluntary movement Legs flexed
Medium plane of anaesthesia	Sluggish reflexes Slow, deep, regular respiration Legs relaxed
Deep plane of anaesthesia	No reflexes Slow, shallow respiration Close to cardiac/respiratory arrest

3.3.4 Oxygenation

The colour of the mucous membrane can be monitored for signs of change, but it is not an effective monitoring tool for patients in critical condition (Edling 2006). Pulse oximetry (using red and infrared light sources) is not consistently accurate for measuring oxygen saturation in birds (Schmitt et al. 1998).

3.3.5 Temperature

Without thermal support, birds under anaesthesia rapidly lose heat (Edling et al. 2006). A long, flexible, oesophageal thermometer inserted to the level of the heart can be used to reliably monitor body temperature (Edling et al. 2006). Cloacal temperature may be monitored during anaesthesia. However, this is less reliable than using an oesophageal thermometer, as reported temperature can change depending on body position and cloacal activity (Edling et al. 2006). The normal body temperature of kiwi has been documented as being lower than that of other avian species at 38°C ±1.75°C (Farner et al. 1956).

3.4 ANAESTHETIC EMERGENCIES

Table 1 lists emergency drug treatments extrapolated from those commonly used for other anaesthetised avian species (Edling 2006; Marx 2006).

TABLE 1. AVIAN EMERGENCY DRUGS FORMULARY.

DRUG	WHAT ACTION DOES DRUG PERFORM?	DOSAGE*
Adrenaline	Adrenaline is a positive inotrope and chronotrope. It initiates heartbeats, and increases heart rate and cardiac output.	0.1 mg/kg (10000IU/mL) IO/IV/IP/IT
Atropine	Atropine has parasympatholytic effects. It may correct supraventricular bradycardia or a slow ventricular rhythm by stimulating supraventricular pacemakers.	0.01–0.02 mg/kg IM, IV
Doxapram HCl	Doxapram HCl is a positive inotrope and stimulates breathing.	5–20 mg/kg IV/IO/IM/IT; can also place a drop on tongue for cardiac arrest
Isotonic crystalloids	These expand blood volume and increase tissue perfusion during hypotension.	(See section 2.2.5)
Diazepam	For control of seizures.	0.5–1 mg/kg IM

* IV = intravenous, IO = intraosseous, IP = intraperitoneal, IT = intratracheal, IM = intramuscular.

4. Diagnostics

4.1 EVALUATION OF DROPPINGS

The droppings of a bird consist of three compartments—the faecal fraction, the white urates and the liquid urine. Gross evaluation of the colour, texture, consistency and volume of each of these will provide information about a bird's appetite, and gastrointestinal, renal and hepatic functions (Harrison & Ritchie 1994).

A reduction in the frequency of defecation and/or volume of excrement can be an indication of decreased food intake, decreased gastrointestinal transit time, or an obstruction. Food and water deprivation may be indicated by dry, scant droppings (Harrison & Ritchie 1994).

4.1.1 Faeces

Normal faeces should be well formed, homogenous and brown. They have a strong odour, and the colour may depend on the diet. Kiwi that have been eating berries may have pigmented faeces. Normally, faeces are smooth and present as a tight-gelled cylindrical shape. However, a stressed bird may have stress-related polyuria indicated by an increased urinary fraction, and/or diarrhoea.

Diarrhoea may be stress related, or it may indicate bacterial or parasitic enteritis, or a dietary change. The physical characteristics of the faecal fraction of a bird's faeces may be influenced by any medications administered (Harrison & Ritchie 1994).

Meleana has been described as looking like coffee granules, and is indicated by dark-coloured faeces. Meleana suggests the presence of old blood. The colouration may originate from the gastrointestinal tract, the oviduct/testes, kidneys or the cloaca. The presence of frank blood may be associated with coagulopathies (blood clotting problems), liver disease, cloacal pathology, pre/post-ovulation, malnutrition, enteritis or traumatic gastritis (Harrison & Ritchie 1994).

Faecal diagnostics

Direct wet mount

Direct wet mounts require ultra-fresh faeces (<15 minutes old) to enable diagnosis of motile protozoa, and are also useful for diagnosing helminths and coccidia. A drop of faeces is placed on a (preferably warm) glass slide, a drop of 0.9% saline is added, a coverslip is placed on top, and the wet mount is evaluated microscopically.

Gram's stain (or Dif-Quik)

A faecal Gram's stain is useful for determining the type and relative number of each microbial organism present in a faecal sample (i.e. gram positive v. gram negative bacteria, yeasts). Dif-Quik is useful for evaluating yeasts and cytology, but this stain does not enable gram-positive and gram-negative bacteria to be distinguished.

A small amount of fresh faeces is applied to a pre-cleaned glass slide using the wooden end of a cotton-tipped applicator. The sample is spread into a uniform, thin film, and heat fixed prior to staining. Once stained, the slide should be scanned under low microscopic power to determine a suitable evaluation site; then, using oil immersion, several fields should be scanned.

Normal faecal cytology of kiwi includes mixed gram-negative and gram-positive bacteria, with scant, non-budding yeasts. An abnormal faecal cytology includes a low bacterial count, an increased number and percentage of budding yeasts, and a relative overgrowth of a particular bacterial type.

Evaluation of the Gram's stain requires the clinician to determine if the organism detected is pathologically colonising a mucosal surface. Unnecessary antibiotic therapy instituted from an improperly evaluated Gram's stain can precipitate the colonisation of opportunistic pathogens (Harrison & Ritchie 1994).

Cloacal culture

The New Zealand Wildlife Health Centre advocates routine screening by cloacal cultures for *Campylobacter* spp., *Salmonella* spp. and *Yersinia* spp. during translocation of kiwi. Recent evidence suggests that *Campylobacter* spp. may not be pathogenic for kiwi and many other New Zealand bird species, and this bacteria may be able to be removed from the screening programme (B.D. Gartrell, Massey University, pers. comm.). However, *Campylobacter* can cause severe gastrointestinal disease in humans and care should be taken to prevent human infection from birds. *Escherischia coli* are present in most cloacal/faecal samples from kiwi, suggesting that (as with other omnivorous and insectivorous avian species) this organism is part of the normal enteric flora of the kiwi (B.D. Gartrell, Massey University, pers. comm.).

Cloacal cultures are also indicated when a bacterial enteritis is suspected. Commonly, the gram negative Enterobacteriaceae are the causative organisms of bacterial enteritis in avian species (Gelis 2006).

Routine sterile transport culture swabs are used for insertion into the cloaca. It is best to moisten the swab with sterile transport media or LRS before insertion to prevent the dry swab from causing tissue damage. Transportation media is required for transportation of the swab for culture, and it should be sent immediately to prevent bacterial overgrowth. If there is a delay in transportation, the swab should be refrigerated.

Faecal floatation

A faecal floatation should be performed to detect the presence of endoparasite eggs and coccidial oocysts. These can be done in-house or at a commercial laboratory.

4.1.2 Urates/urine

Urates are normally pasty white-yellow and slightly moist. Uric acid is synthesised in the liver and excreted through the kidneys by glomerular filtration as insoluble nitrogenous waste (Harrison & Ritchie 1994).

Yellow-green discolouration of the urates is indicative of haemolysis or hepatitis, or may indicate a recent traumatic event with the breakdown of red blood cells. Fresh droppings need to be evaluated, as urates may

become green-stained due to leaching of pigments from the faecal fraction. Haematuria or bleeding from the gastrointestinal tract, cloaca, urinary tract or genital tract may be evident as red staining of the urates or urine (Harrison & Ritchie 1994).

Urine is usually clear, colourless and small in volume, forming the outer portion of the excrement. It is difficult to collect urine on its own for urinalysis due to contamination by faeces and urates. Birds often develop a stress polyuria.

4.2 HAEMATOLOGY AND BIOCHEMISTRY

A blood sample should be collected as soon as possible from injured or sick kiwi, ideally prior to any form of treatment. This will ensure optimal diagnostic value as well as providing a good tool for monitoring progression of treatment.

One of the most important points to note is that kiwi whole blood lyses rapidly in EDTA (see section 4.2.1).

4.2.1 Blood collection

A suggested protocol for blood sampling in kiwi is as follows:

- Fresh smear (without anticoagulant)
- > 0.25 mL into lithium heparin microtainer for haematology
- > 0.5 mL into a second lithium heparin microtainer for biochemistry

Blood volume

It is recommended that no more than 1% of a healthy bird's total body weight is taken in a blood sample (Hume 1995; Fudge 2000). For example, in a healthy 1-kg bird, 10 ml is the maximum blood volume recommended to be taken at any one time. In an unhealthy bird, 0.5% of the total body weight (i.e. 5 ml from a 1-kg bird) may be safer.

Collection equipment

A fine needle (23–25 gauge) and a 1–3-mL syringe are ideal. Avian veins are subject to collapse if a high negative pressure is applied to a large syringe. The use of a 1-mL syringe can minimise this.

Blood sampling sites

The preferred sites for blood collection in kiwi are the medial metatarsal vein (see Fig. 3) or the right jugular vein. The medial metatarsal vein is located above the hock joint on the medial side of the leg. Haematoma formation at this site is uncommon because it is substantially immobilised by surrounding tissues (Fudge 2000). The site should be aseptically prepared with an alcohol swab prior to venipuncture.

The right jugular vein is larger than the left, and is located in a featherless tract along the jugular furrow. The jugular vein is located dorsal to the trachea, which should be manipulated ventrally to allow the vein to be located. The bird must be securely manually restrained, or under general anaesthetic.

For both sites, haematoma formation can be minimised by careful compression of the site after venipuncture.

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