Anaesthesia of Psittacine Birds

Fiona Stewart*

Summary

Knowledge of the physiologic, pathologic and anatomic peculiarities of birds is important in implementing successful avian anaesthetic protocols. Their high metabolic rates, thermoregulatory mechanisms and cardiovascular responses to restraint and surgery, must be considered. Also, their efficient respiratory system has important implications during inhalation anaesthesia; greatly facilitating anaesthetic uptake and removal and speeding changes in anaesthetic planes.

There are dangers, unique to birds, which increase the risk of anaesthesia. The protocols, while following the basic principles of those used for mammals, usually demand more attention to detail and involve unique requirements of which the anaesthetist should be aware. Pre-anaesthetic considerations involve a routine, relatively detailed patient work-up; measures to avoid crop regurgitation, compromised glycogen reserves and undue stresses; and methods to stabilise the patient.

The safest anaesthetic regime involves the use of isoflurane, and there are definite disadvantages using injectable agents. Premedicants and local anaesthetics are generally not used. Support during anaesthesia involves paying particular attention to preserving the patient's body heat, and full-time patient monitoring is emphasised; with depth assessment methods placing more significance on respiratory pattern rather than particular reflex responses. Ideally, recovery should be rapid and smooth, and managed so that the patient is perching and eating as soon as possible.

Physiologic, Pathologic and Anatomic Features

The high metabolic rates of birds and subsequent predisposition to glycogen depletion, their thermoregulatory mechanisms, cardiovascular system and its response to stress and surgery, respiratory system and cutaneous sensation distribution should all be addressed when considering avian anaesthesia.

Glycogen depletion

If a bird is fasted for any extended period of time before anaesthesia, its body metabolism will deplete liver glycogen stores. Altman (1980) stated that this can occur in smaller psittacine birds (such as budgerigars) within 12 to 24 hours and in larger species (such as parrots and cockatoos) within 24 to 48 hours. Hypoglycaemia and reduced hepatic detoxification of certain anaesthetic agents will result (Steiner and Davis, 1981).

Body temperature

The normal body temperature of birds (40 to 44EC) is maintained by their high basal metabolic rate and plumage. Fluffing of the feathers is a cold response that increases the insulating effect of the feathers.

Carter-Storm (1987) reported that surgical anaesthesia suppresses the anterior hypothalamic-preoptic region responsible for pilorector activity and also noted that heat is lost from the respiratory tract when anaesthetic gases are supplied at high flow rates. In addition, metabolism is slowed, muscle tone lowered and there is loss of the shivering reflex; thus resulting in less heat production (Matushek, 1984).

* **Veterinary Science V, The University of Sydney, Private Bag 3, Camden NSW 2570**

The temperature of anaesthetised birds for which temperature preserving precautions were not taken, has been observed by Matushek (1984). He found that significant losses (to as low as 30EC) resulted and that most loss occurred within the first 25 minutes.

Other authors observed that suppressed ventilation (Hubbell, Muir and Skarda, 1989), increased recovery times and increased risk of stress-induced hypoglycaemia (Forsyth, 1992), and a predisposition to cardiac arrhythmias (Sinn, 1994) are consequences of allowing hypothermia to develop.

Cardiovascular system

The sympathetic response to capture and restraint, hypotension, blood loss and blood sampling methods are of relevance during the anaesthetic procedure.

Carter-Storm (1987) referred to the fight-or-flight response of birds as the "**cardiac racing syndrome**". Reduced cardiac output and arterial pressures are induced when the heart rate has risen to the point that blood filling of the chambers is inadequate and cardiac oxygen demand is increased. Lethal cerebral hypoxia is possible within 20 to 30 seconds.

Once the patient is anaesthetised, there exist many potential causes of hypotension. Severe hypotension will result in hypoxia and eventual cardiac arrest. Carter-Storm (1987) included in her list: blood loss, respiratory evaporation dehydration, sudden changes in body position (orthostatic hypotension), dorsal recumbency, lowering of the head, and trauma to the brachial and lumbosacral plexuses when taping overstretched wings and legs during surgery. In each case, decreased venous return to the heart causes the reduced blood pressure. Cardiac output can also be reduced upon reduction of myocardial contractility by certain anaesthetic agents.

Loss of blood volume is a real concern during any haemostatic-challenging procedure. The small blood volumes of birds (5 to 20% of body weight [G.M. Cross pers. comm.)) renders the loss of even minute volumes significant.

It is worth noting, however, that birds are able to mobilise extravascular fluid to a greater degree than mammals and so are relatively resistant to the effects of lower than critical amounts of blood loss (Sturkie, 1986). Ritchie (1990a) stated that acute blood loss of 30% total volume can occur without significant problems in the normal patient.

The clotting system of birds is commonly impaired. Madill (1991) attributed this to liver function reductions (low vitamin K) occurring as a secondary disease phenomena.
This observation, and the thin-walled nature of avian veins means that pinching of the area (Cannon, 1991) and two minutes of local pressure (Madill, 1991) is required following venipuncture to prevent peri-vascular haemorrhage and haematoma formation.

Sites available for venipuncture, noted by Madill (1991), include the ulnar (wing) vein and jugular veins (right jugular is usually larger). Blood volumes equivalent to 1% of the bird's body weight are a safe upper limit for collection (Taylor, 1990).

The method of short clipping claws has been recommended by Doolen and Jackson (1991) as a quick, easy method of capillary tube sampling for PCV and TPP tests. Taylor (1990) however finds it more stressful and painful to the patient than venipuncture and has noted that poor blood flow (due to arteriovenous anastomoses shunting) in stressed birds may occur and tissue thromboplastins (post-nail crushing) may lead to clotting in the sample.

Respiratory system

The avian respiratory system consists of unique structural and functional aspects.

The larynx is a small slit that lies at the base of a large fleshy tongue. Altman (1980) noted that passage of an endotracheal tube is possible in all but the very smallest of psittacine species. When intubation is not performed another means of mechanically holding the tongue is required to prevent it occluding the glottis while in dorsal recumbency. Altman (1980) suggested using a bent paper clip.

Birds' tracheas have complete (360E) calcified tracheal rings (Hubbell *et al.*, 1989) and therefore have little circumferential distensibility. Flammer (1989) warned that the use of an endotracheal tube cuff may cause pressure necrosis and tracheal damage.

The lower airways consist of air sacs (paired: cervical, anterior thoracic, posterior thoracic and abdominal and a single interclavicular) connected to the bronchi and lungs. They are not connected to the pneumatic bones (save the humerus) and so these bones are not important to respiration (Gandal, 1982).

Birds lack a diaphragm and create a continuous, unidirectional air flow through the lungs (see Fig. 1) by means of elevating and depressing the sternum to produce a bellow-like action of the air sacs (Gandal, 1982). Flammer (1991) warned that restriction of sternal movements by drapes or instruments can therefore compromise ventilation.

The air sacs are thinly membranous, lightly vascular, non-respiratory in function, not directly interconnected and can be opened to the atmosphere without risk of lung collapse (Turner, 1985). Carter-Storm (1987) noted they are also highly distensible, which accounts for the comparable compliance of the avian respiratory system to that of mammals; despite the relatively stiffness of avian lungs.

In addition to a larger exchange surface per unit volume and a gas exchange system (see Fig. 2. "cross-current-model") that maximises diffusion of gases into the bloodstream, the continuous airflow creates a system of increased exchange efficiency (Carter-Storm, 1987).

Avian lungs therefore have the potential to extract relatively more oxygen and anaesthetic agent for a given volume of inspired air than do mammalian lungs. Hence, induction and recovery from inhalation anaesthesia will be more rapid and overdosage will occur more readily than in mammals.

In comparing birds to mammals of equal size, Heard (1988) stated that the avian tidal volume is four times as large and respiratory rate one third as fast, and so small changes in the respiration of birds will have a greater effect on their overall minute ventilation.

Respiratory rates of the conscious patient will vary with the body temperature, body size, sex and excitement level of the bird. Gandal (1982) reported values such as 36 bpm (breaths per minute) for parrots and 80 to 100 bpm for parakeets; and noted that normally there is no pause between inspiration and expiration.

Fig. 1. Representation (modified from Swenson (1989)) of continuous, unidirectional air flow through the lungs. Studies indicate that aerodynamic valving in the air sac system controls the direction of air flow within the air sacs and lungs (Keuthe, 1988 and Butler, Banzetl, Fredberg, 1988).

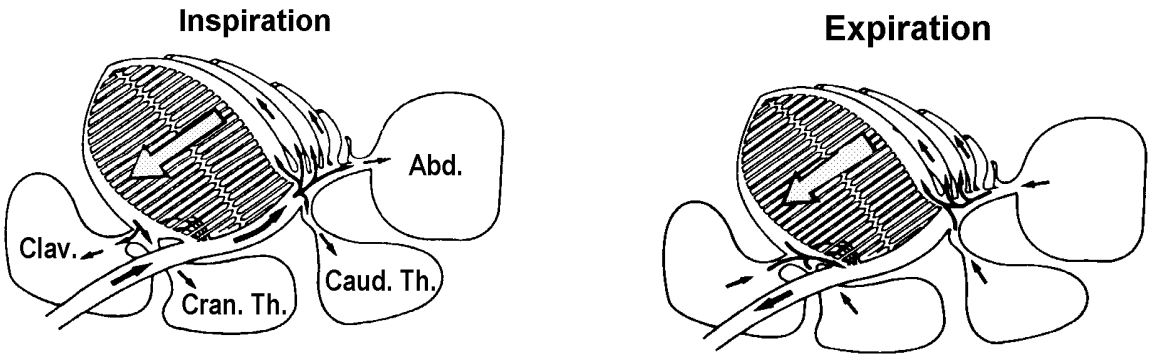
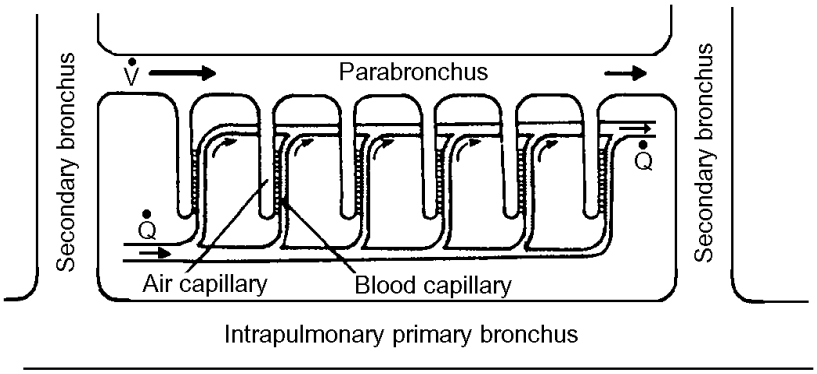


Fig. 2. Schematic model of the cross-current gas exchange system in the avian lung. V represents the convective flow of gas through the parabronchus and Q is the blood perfusion of the parabronchus (Swenson, 1989).



Nociceptor distribution

Pain receptors of birds are sparsely distributed over large areas of the skin. Certain areas, such as the cere, head, scaled parts of the legs, limb joints and vent are highly sensitive to painful stimuli (Turner, 1985).

General Anaesthesia

Indications

Apart from the obvious requirement for anaesthesia during major surgical procedures, Harrison (1986b) noted that light planes may well be used for radiology, blood collection, fluid therapy, bandaging and even nail or wing trimming in fractious birds. However, if a procedure can be completed within a few seconds

without unnecessary pain; anaesthesia may not be justified, as its administration is likely to cause relatively more pain and stress (Rosskopf, Woerpel, Reed, Snider and Dispirito, 1989).

Pre-anaesthetic Considerations

Minimal stress and handling of the patient before and during induction is made possible by being adequately planned and experienced in bird handling.

Gandal (1982) noted that gentle handling, quiet surrounds and use of a hood over the bird's head reduces stress. All equipment, anaesthetic agents, emergency drugs and necessary staff should be prepared.

The anaesthetist should have an appreciation of "baseline" (at rest) heart rate (HR), respiratory rate (RR) and depth to aid later evaluation of anaesthetic level (Rosskopf *et al.*, 1989).

Admitting avian patients 24 hours prior to their planned anaesthesia has been advised by Gandal (1982). It allows time for the bird to become familiar with its surroundings and to recover from the stress of a physical examination.

Patient work-up

Diseases in birds often progress to an advanced stage and yet remain subclinical. Gill (1991) stated that this gives them a competitive edge in the wild. Flammer (1991) related this phenomenon to the increased importance avian clinicians have placed on performing a thorough pre-anaesthetic work-up.

Complete history-taking, physical examination and "minimal" lab work is required in order to detect any health problems. Such problems may alter the risk classification of the patient and so influence the anaesthetic protocol (duration and drugs used for safe anaesthesia) and prognosis.

Harrison (1986a) advised particular note of the patient's response to the stress of handling, the "respiratory recovery time" (a return to normal respiratory rate within 3 to 5 minutes after 2 minutes of handling reflects adequate respiratory vigour) and the bird's weight should be made.

Authors vary in their opinions as to what constitutes a "minimal" lab work-up. Realistically, the amount of pre-anaesthetic work-up beyond baseline values required will depend upon the patient's details, procedure to be performed and the wishes of the informed owner.

Steiner and Davis (1981), Flammer (1991) and Heard (1988) suggested a PCV, TPP and blood glucose should be measured. Matushek (1984) would also perform blood smears to look for blood parasites.

For all but the shortest (5 to 10 minutes) procedures, Harrison (1990) performed a Gram stain on faecal and choanal smears and a faecal parasite check.

Sinn (1994) also included a PCV, TPP, WBC and differential count, a platelet estimation, bile acids, AST (aspartate aminotransferase), LDH (lactate dehydrogenase) and uric acid assessment.

Pre-anaesthetic therapy

If possible, any abnormalities detected in the work-up should be evaluated further and the bird stabilised before anaesthesia.

Administration of 10 or 50% dextrose has been advised by Abou-Madi and Kollias (1992) when blood glucose values less than 200mg/dL of glucose are measured. An initial dose of 1 ml/kg of 50% dextrose can be administered intravenously and oral glucose given to help correct the deficit.

A PCV of less than 15% suggests a blood transfusion is required (Abou-Madi and Kollias, 1992). When a psittacine donor of the same species is not available, a heterologous transfusion is safe but should not be repeated within three weeks (Hubbell *et al*., 1989). Abou-Madi and Kollias (1992) reported that iron dextran may be helpful for milder anaemic cases.

Increased PCV (ref. range: 40 to 55), TPP (ref. range: 2.5 to 6 g/L) and blood urea nitrogen (uric acid) suggests dehydration and the need for fluid therapy (Ritchie, 1990a). Volumes required are based on fluid deficits plus ongoing losses and maintenance requirements (50ml/kg/day); and the maximum fluid rate tolerated has been quoted by Hubbell *et al*. (1989) as 90ml/kg/hour. Clinical signs of overhydration or improved hydration are as for mammals (Ritchie, 1990b).

Abou-Madi and Kollias (1992) recommended the use of intravenous (IV) or intraosseous (IO) routes when administering fluids to severely dehydrated or critically-ill patients requiring rapid blood volume expansion. The IO route provides absorption equivalent to IV administration and may be indicated when peripheral veins are either too small or collapsed. The catheter is not placed in pneumatic bones and the distal ulna is the site of choice.

Intravenous catheters can be used, but Redig (1984) developed the use of bolus IV fluids as a means of avoiding the complications of indwelling catheters. He used 23 to 25 gauge needles and volumes of 10 to 25 ml/kg spread evenly throughout the day.

In all but the most severe cases Cannon (1991) used oral administration (via a crop needle). 24 hour volumes are divided into 4 to 6 doses; the maximum of any one volume being based upon 50 to 60% of maximal crop volume (Table 1; Cannon, 1991).

TABLE 1.

Species:	Finch	Budgie	Cockatiel	Small parrot	Medium parrot	Large parrot
Max dose (ml):	0.1-0.5	0.5-1.0	2 - 4	3 - 6	10 - 15	20 - 25

Subcutaneous (SC) fluids are recommended by Abou-Madi and Kollias (1992) as safe and reliable; and Martin, Palmore and Kollias (1987) showed that there is little difference between the absorption rates of SC and oral routes. However, in severely dehydrated or shocked patients, peripheral vasoconstriction retards SC fluid absorption and fluid therapy via this route will not be effective (Ritchie, 1990b).

Subcutaneous sites available include the inguinal, axillary or intrascapular areas. 25 to 27 gauge needles should be used and maximum volumes advised by Abou-Madi and Kollias (1992) are 5 to 10 ml/kg/site (isotonic preparations only).

Due to the risks associated with fluid administration into the coelomic cavity (laceration of internal organs or infusion into air sacs (Abou-Madi and Kollias, 1992)), it is not commonly performed.

Recommendations for fluid therapy supplements in hypokalaemic** and base deficient*** patients have been made by Redig (1984).

** 0.1-0.3 mg/kg KCl

*** Body weight X deficit X 0.3 = mEq bicarbonate requirement; or empiric administration of 1 mEq Na bicarbonate/kg to a maximum of 4 mEq added to fluids at 10-30 minute intervals.

Total parenteral nutrition has been discussed briefly by Ritchie (1990b) as a means of nutritionally stabilising critically-ill patients. A formulation offering 150 kcal/kg/day; with 30% and 70% of total energy supplied as fat and glucose respectively; and providing protein at 4.8g/kg/day was suggested.

Patients with respiratory compromising pathology should be given oxygen; administered by a mask for 5 minutes or chamber for 10 to 15 minutes prior to anaesthesia (Cross, 1994).

Crop evacuation

To avoid passive regurgitation and aspiration of crop fluid during induction, the crop should be empty before beginning. This can be achieved by removing the fluid with a syringe and tube or prior fasting of the bird (Flammer, 1989).

Authors vary in their recommendations for the duration of pre-anaesthetic fasts (that can be safely tolerated by the patient) and use of active crop evacuation. Harrison (1986a and 1990) has put forward different protocols; the most recent being a 3 to 6 hour food and water fast for all but the larger psittacine birds (6 to 12 hour fast), and routinely removing crop fluid. Sinn (1994) agreed these times are required for emptying of the upper gastrointestinal system, but restricts these fasts to food only.

Heard (1988) and Flammer (1991) are more conservative; suggesting times of 1 to 3 hours with water made available until one hour before anaesthesia.

In emergency situations, regurgitation can be prevented by holding the patient upright and using a finger to block the oesophagus just below the mandible. Once anaesthetised, manual evacuation and positioning the bird with its head elevated is also recommended (Sinn, 1994).

Premedication

Premedicant drugs are not routinely used in avian anaesthesia as they have variable effects and prolong recovery (Heard, 1988). Hence, only two groups of drugs are given note in the literature.

Atropine (IM) or glycopyrollate (IM) are parasympatholytics that have been recommended for use prior to a ketamine anaesthesia; to reduce the associated respiratory secretions (Gandal, 1982). However, Sinn (1994) noted that they slow gastrointestinal motility, increase the HR (glycopyrollate effect is not as marked), and actually cause thickened respiratory secretions that have the potential to occlude endotracheal tubes.

Diazepam (benzodiazepam tranquilliser) has been used by Taylor (1987) to calm fractious individuals and psittacine species known to be excitable; such as African Grey Parrots. He recommended a dose of 0.5 to 1.5 mg/kg IM or IV. Effects can be variable, particularly with IM administration; but generally good muscle relaxation, little cardiopulmonary depression and additive effects with anaesthetics are obtained (Taylor, 1987).

General Anaesthesia: Inhalation Agents

Inhalation anaesthetics are generally preferred to those administered by injection. Sinn (1994) noted the volatiles' more consistent therapeutic index, relative ease of "titration-to-effect" and little or no metabolism required for drug excretion.

The bird's efficient respiratory system enables rapid inductions, prompt alterations of anaesthetic planes and rapid, smooth, more complete recoveries to be achieved with inhalation agents. As a consequence, the bird suffers less stress, the period of hypothermia and post-anaesthetic depression is reduced and less intensive post-anaesthetic care is necessary (Flammer, 1989).

Preferred agent

Of the inhalation agents commonly used, isoflurane is the safest anaesthetic. Its low blood solubility (1.4 compared to halothane: 2.4 and methoxyflurane: 13) further enhances the speed of inductions and recoveries and depth alterations (Sinn, 1994).

In particular, recoveries (even with prolonged anaesthesia) have been observed by Harrison, Christensen, Crawford, Miller and Shivaprasad (1985) to be faster and associated with much reduced post-anaesthetic depression. Birds quickly return to normal behaviour and often begin eating soon after isoflurane anaesthesia.

Such a recovery, especially for the smaller psittacine birds with higher metabolic rates, will help prevent post-anaesthetic hypoglycemia (Flammer, 1989)

The minimal metabolic breakdown of isoflurane (0.3% is metabolised versus halothane: 15% and methoxyflurane: 50 %) accounts for the lower incidence of anaesthetic hepatotoxicity (Heard, 1988).

For avian patients, where hepatic compromise is a common occurrence (Harrison *et al.*, 1985); this feature is especially valuable.

Sinn (1994) reported isoflurane to have reduced arrhythmogenic properties, reduced cardiovascular depression and reduced respiratory depression. While apnoeic episodes remain associated with its use at high levels or with rapid inductions, the interval between apnoea and cardiac arrest is usually sufficient to enable resuscitation. This is in contrast to other inhalation agents (Rosskopf *et al*., 1989).

Volatile anaesthetic delivery

Both isoflurane and halothane require a precision vaporiser for proper anaesthetic delivery (Sinn, 1994). Sinn (1994) advised that induction is best achieved via suitably sized masks connected to an Ayre's T-piece anaesthetic circuit. He also suggested the use of modified disposable plastic cups or wide-bore syringes as a step towards avoiding nosocomial infections.

Non-rebreathing anaesthetic systems (500ml/min flow rates) are advised for patients less than 10 kg (Heard, 1988); and the reserve bag should be suited to the patient's size to enable better control and monitoring of respiration (rubber balloons or commercially available dispensable avian anaesthetic bags have been suggested by Jenkins (1989)).

McDonald (1989) stressed the importance of using scavenger systems to help limit staff exposure to the toxic anaesthetic gases. For the same reason, Sinn (1994) advised against chamber inductions.

Uncuffed endotracheal tubes that are suitably shortened and as large a bore as possible to reduce dead space should be placed in all but short procedures in healthy birds (Flammer, 1991).

Delivery into the air sacs

Oxygen and gaseous anaesthetics can also be delivered via a tube placed into an air sac.
Rosskopf and Woerpel (1990) described the procedure and its use in managing emergency tracheal blockages (eg: from foreign body inhalation or localised syringeal aspergillosis) or when doing upper respiratory tract surgery where an endotracheal tube gets in the way.

The site suggested for placement is on the left, just behind the last rib, to gain access into the abdominal air sac. Harrison (1990) reported this to be the preferred sac for anaesthetic administration in all but abdominal surgery cases. Tube placement into the interclavicular or caudal thoracic sacs has also been described by MacCoy (1991). Tube/catheter size is selected based on the bird's size (eg: 14 French for large parrots) and it is sutured in place after being passed approximately 2 to 3 cm into the air sac.

Systemic antibiotics are recommended, and removal can be performed upon recovery or delayed for several days (Rosskopf and Woerpel, 1990).

Anaesthetic concentrations

Levels of inhalation agents used for maintenance have been quoted by Rosskopf *et al*. (1989) as being in the range of 0.5-1.5% for halothane, and 1.5-3% for isoflurane (a less potent anaesthetic). Checks for kinks or mucus occluded tubes and reviewed respiration assessment should be made if higher levels are required (MacCoy, 1991).

There are two sets of opinion as to what concentrations are suitable for induction. Harrison *et al.* (1985) and Sinn (1994) have argued that an initial 5% isoflurane setting will allow rapid induction. Harrison (1986b) stressed however that high halothane concentrations are contraindicated because of the frequently induced apnoea and the brief apnoea-cardiac arrest interval.

The other method is to slowly increase the gas level to a maximum of 2.5 to 3 % isoflurane. Advocates (Flammer, 1989 and Heard, 1988) stated that the minute or two longer taken for induction is worth the reduced concern of variable species/individual responses and induction-apnoeic incidents.

Balanced (inhalation) anaesthesia:

Nitrous oxide (N_2O) can be used for balanced anaesthesia protocols to achieve the same results in birds as seen with mammals (ie: reduced anaesthetic agent and accelerated induction due to second gas effect). It is used in the usual 2 : 1 ratio (N_2O : O_2); thus reducing the inspired oxygen concentration; and Heard (1988) advised it should not be used in birds with marginal respiratory reserves. Its use is also contraindicated in patients with closed (air sacs are open), gas-filled spaces in the body.

General Anaesthesia: Injectable Agents

Marked species and individual variation in therapeutic doses and physiological effects, difficulty in controlling anaesthetic levels, and requirement for drug removal via metabolic pathways make injectable anaesthesia more hazardous (Sinn, 1994).

Relatively prolonged recoveries are a feature of their use and are even more protracted in metabolically compromised patients (Flammer, 1991).

For these reasons, injectable agents are used only when isoflurane is unavailable, or for surgery around the head when intubation is difficult and if air sac cannulation is not an option.

Doolen and Jackson (1991) advised that injections may be given IV (jugular, cutaneous ulnar) or intramuscular (IM) (pectoral muscles; into the centre of each muscle mass).

Preferred agents

Authors agree that if parenteral agents must be used, the preferred protocol is one of a combined anaesthesia, involving either ketamine/xylazine or ketamine/diazepam. These drugs offer a higher margin of safety relative to other parenteral agents (such as the barbiturates (Sinn, 1994) or propofol (Fitzgerald and Cooper, 1990)).

The combinations are reported by Flammer (1991) to produce better muscle relaxation and analgesia, more rapid induction, smoother maintenance and less violent recoveries than with the ketamine used alone.

Ranges of dose rates have been quoted (table 2) by Sinn (1994), with which he advised dose ratios of 1:10 (mg/kg) (ketamine : xylazine/diazepam); but Taylor (1987) reported that ratios used vary between 1:5 and 1:10.

To avoid overdosages, Harrison (1990) recommended the use of incremental (1/8 - 1/4 full doses) dosing-to-effect. He also noted that the dose rate (mg/kg) required for birds greater than 250g will be lower than for those weighing less than 250g, and has recorded more specific "species" doses (Table 3).

Harrison (1990) used a 1:5 (mg/kg) xylazine : ketamine ratio using preparations of ketamine (100mg/ml) and xylazine (20 mg/ml); and so was able to simply draw up equal volumes of each drug.

TABLE 2	***Dose Rates (mg/kg)***	
	IM	**IV**
ketamine ...AND	10 - 30	2.5 - 5
xylazine ...OR	1 - 4	0.25 - 5
diazepam	0.5 - 2	0.5 - 2

TABLE 3	*ketamine and xylazine doses (mg)*			
SPECIES	**IM**		**IV**	
	ketamine	**xylazine**	**ketamine**	**xylazine**
budgies	1	0.2	0.5	0.1
cockatiels	2	0.4	1	0.2
conures	5	1	2.5	0.5
rosellas lories	7	1.4	3.5	0.7
amazons min. macaws	5 - 10	1 - 2	2.5 -5	0.5 - 1
african grey	8 - 10	1.6 - 2	4 - 5	0.8 - 1
cockatoos	12 - 15	2.4 - 3	6 - 7	1.2 - 1.4
macaws	15 - 20	3 - 4	7.5 - 10	1.5 - 2

Forsyth (1992) stressed the importance of correct dosing by obtaining accurate patient weights and accurate volumes using tuberculin syringes. The two agents are mixed in the same syringe, and to avoid the adverse effects of pure xylazine in the needle hub; it is drawn up first (Harrison, 1990).

Incremental-dose-effect is expected within 5 to 10 minutes of IM, or within 1 minute of IV injection (Harrison, 1990). IV doses, while more difficult, allow for faster recovery times (minimal times quoted by Sinn (1994) were 15 to 45 minutes).

Recovery from injectable agents

Methods used to help speed a prolonged recovery include stroking and turning the patient every 15 minutes and giving IV fluids to diurese the bird and thereby enhance renal excretion of ketamine (Flammer, 1991).

The use of the á-2 adrenoceptor-antagonist (yohimbine) for reversal of ketamine/ xylazine anaesthesia and promotion of a premature recovery has been reported by Heaton and Brauth (1991). They observed reduced perching latencies (by an average of 74%) in budgerigars previously anaesthetised with ketamine/xylazine (dose: 40 mg/kg ketamine and 40 mg/kg xylazine IM) and dosed with yohimbine (0.275 mg/kg IM) 45 minutes after induction.

Balanced anaesthesia

Other parenteral agents that may prove to be of use in balanced avian anaesthesia include the analgesics; butorphanol and flunixin (Bauck, 1990) and the skeletal muscle relaxant; atracurium and reversal agent; edrophonium (Nicholson, 1992). Clinical trials in psittacine birds are yet to be performed.

Patient Monitoring and Support During Anaesthesia

Continual assessment of the patient's status is required to gain an appreciation of the plane of anaesthesia and to detect the need for cardiovascular, respiratory or thermoregulatory support.

Anaesthetic depth

One should aim for the lightest plane of anaesthesia at which the planned surgical procedure can be accomplished. Flammer (1991) recommended that the RR, respiratory pattern, depth and response to stimuli; in combination with the HR, reflexes, response to feather plucking and positional changes be used to monitor anaesthetic depth.

At the lightest anaesthetic plane one can expect a deep, rapid respiration, no voluntary movement and only mild depression of palpebral, corneal and pinch reflexes (Flammer, 1991).

The surgical (medium) plane is evidenced by a slow, deep respiration, absence of some reflexes (corneal and toe pinch are usually last to be lost) and no response to positional changes or feather plucking (Flammer, 1991).

RR will be slow and irregular, all reflexes will be lost and the HR may be slowed and/or irregular when the patient has become too deep. Wing flutter is an early indication that the bird has become too light (Sinn, 1994).

Rosskopf *et al*. (1989) reported that visualisation of the bird is aided by using clear plastic drapes and that baseline values of temperature, HR, RR and respiratory depth are used as assessment guidelines.

Thermoregulation

The degree of hypothermia occurring during anaesthesia can be reduced by keeping the operating theatre warm, minimising the amount of alcohol used in the surgical scrub, limiting feathers removed for surgical site exposure; and using heat lamps and pads, heated lavage solutions, heated IV fluids (38 to 39EC was quoted by Redig (1984)) and/or hot towels wrapped around the gaseous delivery tube (Sinn, 1994).

Cloacal digital thermometers can be used to monitor the extent of heat loss (Flammer, 1991) and thus evaluate the effectiveness of heat preservation procedures used, and give an insight into any recovery problems that might be expected.

Respiration

Observing the amount of sternal movement gives one an idea of respiratory depth and Doolen and Jackson (1991) stated that rapid, low volume respiration may be an indication for applying intermittent positive pressure ventilation (IPPV). The potential for hypoventilation during anaesthesia has been previously mentioned.

Sinn (1994) noted that most self-ventilating birds will maintain an oxygen saturation between 80 to 85%, and that routine IPPV would therefore be valuable to increase the oxygen saturation.

Assisted ventilation is particularly indicated during long procedures when spontaneously breathing birds can become apnoeic and acidotic (Flammer, 1989). Rates of 10-30 times per minute using pressures producing baseline sternal excursions (pressures of 12 to 24 cm H_2O can be tolerated) are recommended.

When used with inhalation anaesthetics, IPPV has the added advantage of providing a more even plane of anaesthesia (Heard, 1988).

Respiratory arrest may occur as a result of the respiratory depression of anaesthetic agents and /or due to the increased p_aO_2 and decreased p_aCO_2 that occurs with air sac oxygen perfusion.

The latter is resolved by flushing the bird with oxygen to remove residual anaesthetic and disconnecting the gaseous flow. Increased p_aCO_2 levels occur with the continuing apnoea and are associated with return of spontaneous ventilation within minutes (Sinn, 1994).

Sinn (1994) advised that respiratory assessment may be aided by oximeters (best results with probe over tibiotarsal area) or respiratory monitors (only sufficiently sensitive for use with medium-sized and large birds). Continual assessment ensures that respiration revival steps for anaesthetic-induced apnoea will be performed with minimal delay.

If inhalation anaesthetic is being used, the anaesthetic concentration is turned to 0% and the system flushed with oxygen. Intubation (endotracheal or air sac) of birds given parenteral anaesthetic agents should be performed. The sternum is gently depressed at a rate of 40 to 50/minute and IPPV administered as required (Sinn, 1994).

Doxapram HCl on the tongue may stimulate respiration and administration of reversal agent is indicated when injectable anaesthetics have been used (Sinn, 1994).

Cardiovascular

If the patient progresses into cardiac arrest, an intracardiac injection of norepinephrine is recommended by Doolen and Jackson (1991). Harrison (1986b) reported the use of cardiac massage through the thoracic air sac as a final option.

Cardiovascular monitoring includes observing oral/cloacal mucous membrane colour and capillary refill time and assessing peripheral veins for loss of venous-fill (Doolen and Jackson, 1991). Use of oesophageal stethoscopes is possible in birds the size of Amazon Parrots and larger (Sinn, 1994).

Sinn (1994) reported that useful aids include pulse oximeters, electro-cardiography (ECG) and even a doppler probe placed on the globe of the eye to rapidly obtain a HR. He suggested that ECG waveform characteristics can be used to monitor anaesthetic depth (T-waves become smaller and R-waves increase in magnitude with increasing depths).

Harrison *et al*. (1985) remarked that ECG alligator clips are traumatic for avian patients and recommended attaching the clamps to hypodermic needles inserted into the wing and skin over the cranial femoral area. The mean electrical axis (MEA) range has been reported in one study to be -83E to -162E (versus canine: +40E to +130E); and hence the QRS in Lead II is negative (Zenoble, 1979).

Cardiovascular support in the form of fluid therapy and/or blood transfusion is critical if blood loss has occurred, and fluids may even be advantageous for a patient during an extended anaesthetic episode (Flammer, 1991).

Heard (1988) stated that atropine (0.O4 mg/kg IV) may be useful in a patient with a persistent bradycardia.

Management of the Post-Anaesthetic Recovery

Ideally, recovering patients should not be left unsupervised until they perch without difficulty (Sinn, 1994), and should be fully recovered before being placed in a cage with other birds (Flammer, 1991).
Various suggestions for a suitable recovery cage have been made, and include a cardboard box with a towel for perching (Flammer, 1991), a small, padded aquarium (Doolen and Jackson, 1991) and a paediatric or avian incubator (Sinn, 1994). Flammer (1991) advised it should be an unobstructed container, pre-heated to a temperature of ~ 27 to 29°C.

For patients that received halothane or isoflurane; Flammer (1991) recommended maintaining oxygen flow; and Sinn (1994) advised leaving all monitoring devices attached for as long as the bird will tolerate them.

If injectable anaesthesia was performed, promotion of a smooth, atraumatic recovery is necessary. Administering reversal agents, fluids for diuresis and/or rolling the patient as previously discussed, may be useful to speed recovery.

The bird should be wrapped in a towel to prevent seizure-like movements and wing-flapping trauma, and exposed only to dimmed lights and minimal noise levels to prevent violent reactions (Doolen and Jackson, 1991).

Wiping the oral cavity in all birds to remove secretions that might block the glottis is recommended by Flammer (1991), and Sinn (1994) advised checking ketamine-anaesthetised-recovery patients for vomit accumulations.

Administration of 40% oxygen to a sealed recovery cage is indicated if the bird is compromised following anaesthesia (Flammer, 1991). Studies reported by Stauber, Krinke, Greene and Wilkerson (1991) suggested these levels will not be harmful in avian patients and that up to 100% oxygen may be administered if used for no greater than 12 hours.

Attempts to minimise the post-anaesthetic starvation period and thus reduce the chance of hypoglycemia developing, should also be made.

Lowering the patient stress (quiet, warm, dark cage) and alleviating pain will promote return of appetite. Analgesics that may be used include flunixin meglumine; at a repeatable dose of 1 to 10 mg/kg IM (Clubb, 1986) or butorphanol; using a dose of less than 3mg/kg (Bauck, 1990).

Tube feeding to overcome prolonged inappetence or parenteral nutrition for nothing-per-os post-surgical cases may be necessary; and weighing the bird daily to get an indication of post-anaesthetic nutritional care is advised by Harrison (1986a).

Local Anaesthesia

Gandal (1982) discussed two factors limiting the use of local anaesthetics in avian practice. He observed that surgical situations, where use of a local anaesthetic would provide adequate analgesia, frequently also required prolonged restraint. General anaesthetics are preferred as they not only provide a resting patient but also protect the bird from handling stresses.

In addition, it has previously been reported (eg: Turner, 1983 and Altman, 1980) that birds are intolerant to local anaesthetics. Gandal (1982) suggested that the problem was not one of unique increased sensitivity, but of actual overdosage. He reported that adequately diluted local agents (eg: 0.2-0.25% procaine) are well tolerated in birds. Altman (1980) also reported the use of local agents to aid ophthalmic examinations (proparacaine HCl topical ointment) and to reduce the discomfort and tenesmus following a reduced prolapsed cloaca (lidocaine HCl ointment).

DISCUSSION

Despite the success rates some avian clinicians have reported with anaesthetic protocols; particularly those involving isoflurane; many small animal practitioners still fear anaesthetising birds and much prefer to refer cases away.

An anaesthetic regime that succeeds in one person's hands may well be a lethal failure in another's. Experience is a key element. Correct handling of the patient, ability to recognise the importance that a combination of subtle changes in the patient's vitals may have, and being familiar with expected variations in individual and species responses is integral to the success.

Isoflurane is now commonly available and provides practitioners with a relatively higher safety margin, and may allow experience to be gained without causing numerous, confidence-shattering failures in the process.

Research concerning avian pharmacology still lags behind that of cats and dogs and is made more complicated by the number of species to be investigated. Avian analgesics have received little attention to date; but as the need for control of pain is realised this situation is likely to change.

Conclusion

Accomplishing diagnostic, therapeutic and surgical procedures as safely as possible is a primary aim in veterinary practice. The fact that birds are often easily stressed to a point where their safety is endangered, should motivate us to reduce exposure to pain and handling stresses.
Whether or not anaesthesia of an avian patient is indicated to achieve this will depend on the procedure intended, the competence of those involved and the patient's physical well-being and nature.

The anaesthetic agent of choice for use in birds is isoflurane. When its margin of safety and induction/recovery speed is combined with experience and dedicated monitoring and support, success rates similar to those achieved with other small animal protocols can be obtained.
The only real indication for use of injectable anaesthetic agents is lack of access to volatile anaesthesia. The variability, reduced control and longer recoveries encountered with their use inevitably lead to riskier anaesthesia and increased failures.

References

Abou-Madi, N. and Kollias, G.V. (1992) Avian fluid therapy, in *Current Veterinary Therapy* XI, ed. R.W.

Kirk, J.D. Bonagura. W.B. Saunders Co., Philadelphia: 1154-1159

Altman, R.B. (1980) Avian anesthesia, *Comp Cont Educ* **2**, (1): 38-42.

Bauck, L. (1990) Analgesics in avian medicine, *Proceedings AAV*; Seattle, Washington: 239-244.

Butler, J.P, Banzetl, R.B. and Fredberg, J.J. (1988) Inspiratory valving in avian bronchi: aerodynamic considerations. *Resp Physiol* **72**: 241-256.

Cannon, M.J. (1991) Avian fluid therapy avian fluid and electrolyte dynamics, in *Avian Medicine.*, Post Graduate Committee in Veterinary Science. University of Sydney, Sydney: 14-17.

Carter-Storm, A. (1987) Special considerations for general anesthesia of birds. *Mod. Vet. Pract.*: 358-360.

Clubb, S.L. (1986) Therapeutics, in *Clinical Avian Medicine and Surgery*, G.J. Harrison, L.R. Harrison. W.B. Saunders Co., Philadelphia: 327-355.

Cross, G.M. (1994) *Bird Veterinary Medicine* - Vet V notes. Dept. of Animal Health., University of Sydney, Sydney: 287.

Doolen, M.D. and Jackson, L. (1991) Anesthesia in caged birds. *Iowa State Univ Vet* **53** (2): 76-80

Fitzgerald, G. and Cooper, L.E. (1990) Preliminary studies on the use of propofol in the domestic pigeon (*Columba livia*). *Res Vet Sci* **49**, (3): 334-338.

Flammer, K. (1989) Update on avian anethesia, in *Current Veterinary Therapy* X, ed. R.W. Kirk. W.B. Saunders Co., Philadelphia: 776-780

Flammer, K. (1991) Avian anesthesia, in *Avian Medicine*, Post Graduate Committee in Veterinary Science. University of Sydney, Sydney: 143-147.

Forsyth, S. (1992) Avian anaesthesia, in *Veterinary Anaesthesia*, Veterinary Continuing Education. Massey University, Palmerston North: 43-44

Gandal, C.P. (1982) Anesthetic and surgical techniques, in *Diseases of Cage and Aviary Birds*, 2nd ed. M.L.Petrak. Lea and Febiger, Philadephia: 304-312.

Gill, J. (1991) Practical anatomy, physiology and physical examination, in *Avian Medicine*, Post Graduate Committee in Veterinary Science. University of Sydney, Sydney: 57-60.

Harrison, G.J. (1986a) Evaluation and support of the surgical patient, in *Clinical Avian Medicine and Surgery*, G.J. Harrison, L.R. Harrison. W.B. Saunders Co., Philadelphia. pp. 543-548.

Harrison, G.J. (1986b) Anesthesiology, in *Clinical Avian Medicine and Surgery*, G.J. Harrison, L.R. Harrison. W.B. Saunders Co., Philadelphia. pp. 549-558.

Harrison, G.J. (1990) Anesthesia and common surgical procedures. - Basic Avian Symposium: *Proceedings of the Association of Avian Veterinarians*, 460-468.

Harrison, G.J., Christenson, K.A., Crawford, J.F., Miller, M.S. and Shivaprasad, H.L. (1985) A clinical comparison of anesthetics in domestic pigeons and cockatiels. *Procs Ass Avian Vet*, Boulder: 7-22.

Heard, D.J. (1988) Overview of avian anesthesia. *AAV Today* **2**, (2): 92-95.

Heaton, J.T. and Brauth, S.E. (1992) Effects of Yohimbine as a reversal agent for ketamine-xylazine anesthesia in budgerigars. *Lab Anim Sci*, **42**, (1): 54-56.

Hubbell, J.A.E., Muir, W.M. and Skarda, R. (1989) *Handbook Of Veterinary Anesthesia*, The CV Mosby Co., Toronto: 234-244.

Jenkins. (1989) Balloons as respiration bags. *J Ass Avian Vet*, **3**, (4): 187.

Keuthe, D.O. (1988) Fluid mechanical valving of air flow in bird lungs. *J Exp Biol*, **136**: 1-12.

MacCoy. (1991) Anesthesia, *Comp Cont Educ*, **13**, (6): 990-991.

Madill, D.N. (1991) Drug administration in birds, in *Avian Medicine*, Post Graduate Committee in Veterinary Science. University of Sydney, Sydney: 93-96.

Mandelker, L. (1987) Anesthesia and surgery, in *Companion Bird Medicine*, ed. E.W. Burr. Iowa State Uni. Press; Ames, Iowa: 148-154.

Martin, H., Palmore, P. and Kollias , G. (1987) Studies of parameters used to monitor)hydration status in avian patients. *Proceedings Ass Avian Vet*, Oahu, Hawaii: 403-405. Cited by Cannon, M.J. (1991) Avian fluid therapy avian fluid and electrolyte dynamics, in *Avian Medicine*, Post Graduate Committee in Veterinary Science. University of Sydney, Sydney: 14-17.

Matushek, K.J. (1984) Principles of avian anesthesia, *Proceedings Ass Avian Vet*: 1-24.

McDonald, S.E. (1989) Avian anesthetics. *J Ass Avian Vet*, **3**, (4): 181.

Nicholson, A. (1992) Neuromuscular and cardiovascular effects of atracurium in isoflurane anesthetised chickens. *Vet Surg*, **21** (2): 164-165.

Redig, P. (1984) Fluid therapy and acid-base balance in the critically ill avian patient. *Proceedings of the Association of Avian Veterinarians Interational Conference on Avian Medicine*: 59-73.

Ritchie, B.W. (1990a) Emergency care of avian patients. *Veterinary Medicine Report*, **2**: 230-245.

Ritchie, B.W. (1990b) Fluid therapy in avian patients. *Veterinary Medicine Report*, **2**: 316-319.

Rosskopf, W.J., Woerpel, R.W., Reed, S., Snider, K. and Dispirito, T. (1989) *Avian Anesthesia Administration*, Proceedings Department of Animal Health, University of Sydney, Camden: 181-194.

Rosskopf, W.J and Woerpel, R.W. (1990) Abdominal air sac breathing tube placement in psittacine birds and raptors - its use as an emergency airway in cases of tracheal obstruction. *Procs Ass Avain Vet*: 215-217.

Sinn, L.C. (1994) Anesthesiology, in *Avian Medicine : Principles and application*, ed. B.W. Ritchie, G.J. Harrison, L.R. Harrison. Wingers Publishing, Florida: 1066-1080.

Stauber, E., Krinke, M., Greene. S. and Wilkerson, M. (1991) Effects of increased concentration of inspired oxygen. *Procs European Chapter Ass Avian Vet*: 105-114.

Steiner, C.V. and Davis, R.B. (1981) *Caged Bird Medicine - selected topics*; Iowa State Uni Press; Ames, Iowa: 131-137.

Sturkie. P.D. (1986) *Avian Physiology*, Springer-Verlag, New York: 104.

Swenson, J. (1989) *Dukes' Pysiology of Domestic Animals*. 10th ed. Cornell Univ. Press; New York: 257-259.

Taylor, M. (1987) Avian anesthesia - a clinical update, *Procs Ass Avian Vet*; Seattle, Washington: 519-524.

Taylor, M. (1990) A practical look at avian clinical pathology. *Procs Ass Avian Vet*: 458-466.

Turner, T. (1985) Cagebirds, in *Manual of Exotic Pets*, ed. J.E. Cooper, Brit. Small Animal Vet. Association, West Sussex: 109-112.