Avian Anesthesia and Analgesia

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Abstract

Wildlife rehabilitators with the proper federal permits are often presented with injured birds. We recognize that birds are not dogs and cats, and therefore require specialized protocols for anesthesia and analgesia. This talk will cover recent research on anesthesia and analgesia in birds, with focus on a multimodal approach. Rehabilitators will need to work closely with veterinarians to provide the best care for their wild bird patients.

Introduction

Those with federal rehabilitation permits for avian species may find themselves having to treat birds that are in pain, or that need anesthesia, for a variety of reasons. Procedures requiring excessive restraint, any surgery, wound care, physical therapy, bandage changes, and even in some cases the initial exam, may require anesthesia in order to be done with the least amount of stress to the bird. You must work closely with your veterinarian to develop protocols for pain control (analgesia) in your patients, and to provide safe and effective anesthesia when procedures are needed. As the person most familiar with wild birds and their safe capture and restraint, you may be asked to help monitor anesthesia for your veterinarian. Be prepared to keep a close eye on the bird and communicate well with your veterinarian.

Unique Avian Anatomy and Physiology

When considering anesthetic procedures for avian patients, it is critical to be aware of their unique physiology when compared to mammals. The upper airway has the nares (nostrils), which continue into the choana which is the opening seen in the top of the mouth. When the bird's mouth is closed, the choana sits opposite to the glottis, the opening into the trachea, located at the base of the tongue. When the bird's mouth is closed this creates a direct airway from the nares through to the trachea. Birds do not have an epiglottis like mammals, and in most species the opening of the glottis is actually larger than the diameter of the mid to lower trachea (which is important when you consider using an endotracheal tube for gas anesthesia). Birds have complete tracheal rings, which means that your endotracheal tubes should not have a cuff, or else mucosal damage from compression can occur.

There is a lot of species variation in anatomy, and some species are obligate mouth-breathers, with no external nares. This includes gannets, cormorants, anhingas, frigate birds, pelicans, and many diving birds; keep their mouth open during restraint! Many waterfowl species have a syringeal bulla, an enlargement of the trachea at the syrinx that plays a part in vocalization. Cranes, swans and birds of paradise have extremely complex, elongated tracheas for the same reason. Pelicans, gulls and hornbills have a crista ventralis, a cartilaginous projection at the glottis, while pelicans have a vestigial tongue (glottal mass). Ruddy ducks (males) and emus have a tracheal sac-like diverticulum that can be mistaken for a ruptured trachea.

The avian respiratory system actually separates ventilatory and gas exchange compartments, making it highly efficient. More efficient gas exchange leads to rapid induction of gas anesthesia and recovery from gas anesthesia. The ventilatory compartment includes the major airways, the air sacs, and the thoracic skeleton (pneumatic bones, which are hollow). Most species have 9 air sacs, the paired cervical, cranial thoracic, caudal thoracic and abdominal, and the single intraclavicular. Some species have subcutaneous air sacs such as pelicans, boobies, tropic birds, and gannets. Pneumatic bones include the vertebral ribs, sternum, humerus, pelvis, femur, cervical and some thoracic vertebrae. In pelicans and California condors the ulna is also a pneumatic bone.

Rigid lungs and lack of a diaphragm mean that external body wall movement (excursions) are necessary for breathing. Overall, the lung capacity in birds is much smaller than that of mammals, but the total respiratory volume (with air sacs) is 2-4 times that of dogs. This smaller functional reserve means that brief apnea (lack of breathing) leads to marked hypoxia (lack of oxygen in the tissues). In some birds, lying on their back can cause the weight of the abdominal organs to compress the abdominal and caudal thoracic air sacs, reducing effective volume of the respiratory system. Intermittent positive pressure ventilation (IPPV) may be needed under anesthesia to ensure adequate ventilation. Studies of Red-Tailed Hawks under gas anesthesia showed the greatest lung and air sac volumes in sternal (compared to lateral or dorsal) recumbency, with no changes in ventilatory rate as a function of position.

There is a dive response in many species of waterfowl. Episodes of apnea and bradycardia (low heart rate) can occur during induction of anesthesia. This is a stress response initiated by the stimulation of receptors in the beak and nares, and can be triggered simply by placing a mask snugly over a bird's beak. If this happens, turn off anesthetic gas, remove the mask from the head and provide flow-by oxygen until the bird has recovered.

The avian renal (kidney) system is also unique. There is an arrangement of smooth muscle to form a valve within the external iliac vein which can cause blood flow from the back half of the body to pass through the kidneys before reaching the front half of the body (and heart/brain). This is called the renal portal system. Though its true significance is still unknown, it is recommended that drugs that could potentially harm the kidneys, or drugs with high renal excretion, be administered in the front half of the body.

Pain and Multimodal Analgesia

Analgesia, or the relief of pain, is critical in our care of wildlife. Ethically it is important, but it also is important to prevent physiological changes such as changes in blood pressure, altered endocrine function, tachycardia (high heart rate), dysrhythmias (abnormal heart rhythm), hyperglycemia (excess glucose in the blood), decreased immunity, and decreased wound healing. Wild animals typically hide their pain as much as possible, as an injured or hurt animal is likely to become food for another animal.

Therefore close observation of our patients is key to determining pain. Some things to look for to help recognize pain in birds include (Malik and Valentine 2018):

- changes in posture and appearance including a hunched appearance, drooping demeanor with fluffed up feathers, closing eyes, poor feather quality, tucked-up abdomen, standing on one leg
- changes in locomotion including lameness, decreased weight bearing on a limb, slower speed, difficulty perching/climbing, falling, stumbling, decreased confidence in mobility
- changes in temperament/personality, including aggression/passivity depending on normal behavior, lethargy, apathy, decreased interest in surroundings, anxiety, fear or restlessness, escape reactions, passive immobility, sleep deprivation
- guarding behavior including protecting/hiding the affected area
- changes in grooming behavior including destroying feathers, overgrooming, self-multilation
- changes in normal eating, drinking or toileting including inappetence or constipation
- changes in vocalization including increased or decreased vocalization, vocalizing on physical manipulation of the affected area
- changes in physiological parameters including tachypnea, tachycardia, hypertension (acute pain)
- changes in weight including weight loss or loss of muscle mass (chronic pain)

The pathway of pain from pain stimulus to the brain goes through a number of steps. Transduction is when the pain receptors sense the pain stimulus and start the electrical signals that will be sent through the nerves to the spinal cord. Transmission takes the stimulus from that 1st nerve to the 2nd nerve within the spinal cord. Modulation occurs by neurotransmitters or other substances either amplifiying or tamping down that signal from the 1st nerve at the point of transmission. Perception is the actual signal detection by the brain. Multimodal analgesia is the use of multiple types of pain medications, to work at different points along these pain pathways. Transduction of pain stimuli can be decreased with NSAIDs, local anesthetics and opioids. Transmission can be decreased by alpha-2 agonists. Modulation to decrease pain can occur through epidurals and NMDA antagonists. Finally, we can decrease pain perception with opioids. Each of these types of drugs is discussed in further detail below.

Whenever possible, pre-emptive analgesia is important to prevent “wind-up”, a response where once pain has already started it is increasingly more difficult to stop the pain due to more and more nerves sensing the pain. So when possible, deliver pain medications before the pain has started, for example before a surgery, rather than waiting until after the event. Proper analgesia is also key to maintenance of anesthesia. With appropriate analgesics, especially used as pre-medications, the doses of anesthetics can be decreased, which can in turn decrease the risks of anesthesia.

Types of Analgesics

In the lecture itself I will present the research for each of the different drugs in various bird species. The main take-away is that response is highly variable by species, so what works well in one species may have no effect on another species.

Opioids

Opioids are powerful analgesics that are controlled substances that generally can only be used with the direct supervision of a veterinarian. Different opioids work as agonists or antagonists at different types of receptors in the brain, called Mu, Kappa and Delta receptors. In birds, opioid receptors are detectable as early as 10 days in embryonic chicks. In mammals the distribution of Mu, Kappa and Delta receptors is consistent across different parts of the brain, while in Pigeons 75% of the receptors in the fore- and mid-brain are Kappa (>Delta>Mu). In day-old chicks, there are more Mu receptors (>Kappa>Delta), and in adult peregrines also more Mu receptors (>Detla>Kappa). Opioids are most commonly used in birds for moderate to severe pain such as from fractures, trauma or surgery. There is a significant first-pass effect when given orally, which means that the concentration of drug is greatly decreased by absorption in the liver before it can reach the rest of the body. The most common opioids used in wildlife are probably buprenorphine and butorphanol.

Fentanyl is a Mu receptor agonist that has been used IM, IV and in transdermal forms. It can cause apnea (lack of breathing) so be prepared to breathe for the bird if necessary while under anesthesia. Common doses in rehabilitation start at a loading dose of 2 ug/kg IM then 0.15-0.5 ug/kg/min IV in a constant rate infusion. Fentanyl can be very harmful to humans so use with caution and care.

Hydromorphone is another Mu receptor agonist used IV, IM or SQ, with common doses of 0.1-0.6 mg/kg every 3-6h, studied in American Kestrels. These same dosages had no effect on pain in cockatiels, using a thermal foot withdrawl test.

Buprenorphine is a partial Mu receptor agonist, as well as a Kappa receptor agonist and antagonist, commonly used at 0.3-0.6 mg/kg every 8h, and can be paired with midazolam at 1 mg/kg for analgesia and sedation.

Butorphanol is a mixed agonist/antagonist that is often used at 2-4 mg/kg every 1-2h, and can be paired with midazolam 1-2 mg/kg. It has poor oral availability so IM injection is recommended, and it can cause sedation at higher doses.

Non-Steroidal Anti-Inflammatories (NSAIDs)

Cyclooxygenase enzymes COX-1 and COX-2 are widely distributed in birds, and can be modulated with NSAIDs. NSAIDs work to decrease the production of prostaglandins, which promote inflammation, pain and fever. They also work locally to decrease nerve ending sensitization. Only COX-1 produces prostaglandins that protect the gastrointestinal (GI) system, so over the years medicine has promoted the use of COX-2 specific drugs to prevent any adverse GI effects caused by inhibiting COX-1. NSAIDs should not be used if there is any sign of kidney disease, heart disease, and GI disease (do not use after GI surgery). Response is very species-specific, even amongst birds. For example, diclofenac has been used in some species, but kills Old World Vultures. Meloxicam is likely the most widely used NSAID in wildlife.

Flunixin Meglumine (Banamine) is not COX-selective, and causes muscle damage with IM injections. It has been shown to cause kidney lesions in quail, cranes, and budgies, and use is NOT recommended in birds.

Meloxicam (Metacam) is COX-2 preferential (not COX-2 specific, as at higher doses its COX-2 specificity is diminished), and has been used in a wide variety of species. It is available as an injectable and as an oral formulation. It has been used at 0.25-2.0 mg/kg PO every 12-24h, and ensuring adequate hydration is essential.

Carprofen (Rimadyl) has been researched in some species, but has shown no effects in broiler chickens (25 mg/kg), only a short-term effect in Hispanolan Amazon Parrots (3 mg/kg), and caused renal, hepatic and muscle damage in pigeons (2, 5 and 10 mg/kg).

Ketoprofen (Ketofen) has been shown to have low bioavailability and a short half-life in quail, caused high mortality in Eiders (2-5 mg/kg) and Cape Griffon Vultures (5 mg/kg), and renal tubular necrosis in Budgies (2.5 mg/kg). Use in birds is generally not recommended.

Piroxicam (Feldene) is a COX-1 specific drug with good oral absorption and a long half-life, though in cats and dogs it is used primarily for its antitumor activity. Used in cranes there was mild to moderate improvement of chronic degenerative joint disease at 0.5-1 mg/kg. In chickens there was no effects at 0.15 mg/kg, and gut ulceration at 0.6 mg/kg.

Aspirin is a COX-1 inhibitor that is broken down by the body to its active state as Salicylic Acid. In chickens Salicylic Acid provided good analgesia for up to 2 hours at 50 mg/kg, but Aspirin did not. At 400 mg/kg of either it caused GI ulceration.

Local Analgesics

Local analgesics work to block sodium ion channels, decreasing local nerve transmission. Anecdotally the toxic doses are lower in birds than in mammals, but there is little research to back this claim. They can be used to do “local blocks” by actually injecting into the tissue around where an incision is to be made, “regional blocks” injecting into the nerves leading to that area, or even for epidurals in some species (though use of epidurals is limited in birds due to fusion of the lumbosacral spine).

EMLA cream is a 2.5% lidocaine and 2.5% prilocaine that is used topically. It can be useful for things like catheter placement, however it requires 30-45 minutes of contact time to work, and toxicity can occur with uptake after prolonged occlusion.

Ophthalmic topicals such as tetracaine and proparacaine are widely used for eye procedures.

Long-acting drugs such as bupivacaine, levobupivacaine and ropivacaine can be very useful for brachial plexus blocks before wing fracture repair, though use of a nerve locator/stimulator is advised. Common dosages are 1-2 mg/kg.

Lidocaine has been used in a variety of species, but has often had no effects (Mallards ineffective at 15 mg/kg, Chickens at 20 mg/kg), dosages often used are 1-4 mg/kg.

Other

Gabapentin has analgesic effects and can prevent allodynia (sensation of pain resulting from a normally non-noxious stimulus) or hyperalgesia (exaggerated response to painful stimuli). It also has antiseizure activity. The mechanism of action is not fully understood, but it appears to bind to voltage-gated calcium channels to decrease calcium influx, which inhibits the release of excitatory neurotransmitters such as Substance P, glutamate and norepinephrine. It appears to work synergistically with NSAIDs and/or opioids. Research in Great-Horned Owls started with 11 mg/kg dose, and common dosages start at 10 mg/kg and have gone up as high as 80 mg/kg. Gabapentin is considered a controlled substance in some states, and must be used under direct supervision of a veterinarian.

Acetaminophen is the generic name for Tylenol. The exact mechanism of action of acetaminophen is not completely understood. It produces analgesia and inhibits fever via a weak, reversible inhibition of COX-3 and COX-1. It is not anti-inflammatory. It has been used in broilers but has low bioavailability but showed no nephrotoxicity. There are anecdotal reports that doses proven toxic in other species may be okay in many parrots, but there is little research behind its use in many bird species.

Tramadol is a synthetic Mu opioid agonist that also inhibits reuptake of norepinephrine and serotonin, and has NMDA antagonist effects. As in many of the drugs, the effects vary greatly by species, and in mammals there is currently evidence that it is ineffective for osteoarthritis. In birds doses range from 5-30 mg/kg PO every 6-12h, and it is recommended to not use it as the sole analgesic. Larger birds require lower doses at decreased frequency compared to smaller birds. Tramadol is now a controlled substance and must be used under the direct supervision of a veterinarian.

Other supplements/Treatments:

- Omega-3 Fatty Acids such as EPA, DHA- no studies in birds at this time
- Glucosamine, MSM, Chondroitin- no studies in birds at this time
- Physical Therapy- can be KEY in prevention of patagial contracture, highly recommended for orthopedic procedures of the limbs
- Low Level Laser Therapy- anecdotally promising, research needs to be done
- Cold compress- recommended in the acute phase (up to 3 days post-injury/surgery), 15-20 min at a time up to 3-4 times per day, if the patient will tolerate it
- Warm Compress- recommended after acute phase (after 3 days post-injury/surgery), 10-15 min at a time 3 times a day, if the patient will tolerate it
- Polysulfated Glycosaminoglycan (PSGAG) (Adequan)- associated with adverse events (fatal coagulopathies) in some species

Types of Anesthetics

Pre-anesthetics

Your veterinarian is likely to recommend pre-anesthetic medications, likely including a sedative, tranquilizer and/or an analgesic, to prevent the “wind-up” response. In many cases it may also be beneficial to pre-oxygenate by holding oxygen up to the nares of the bird before they are completely sedated. Many of the drugs used as pre-anesthetics are controlled substances that must be used under direct supervision of your veterinarian.

Some common pre-anesthetics:

Anti-cholinergics such as atropine and glycopyrrolate are not commonly used in birds due to the already high resting heart rate

Tranquilizers/Sedatives

Benzodiazepines are tranquilizers. Diazepam and midazolam are commonly used, and can be reversed with flumazenil.

Alpha-2 Adrenergic Agonists provide analgesia, decrease anxiety, and cause sedation. These include xylazine, medetomidine and dexmedetomidine. They can be reversed with atipamazole (detomidine products) or yohimbine (xylazine). They commonly cause cardiac effects such as irregular and very slow heart rates, and respiratory depression.

Intranasal midazolam (3 mg/kg) and midazolam/butorphanol (3 mg/kg each) results in rapid onset of sedation in cockatiels (Doss et al 2018).

Injectable Anesthetics

There are many advantages and disadvantages to injectable anesthetics. Advantages include: useful when surgery would be complicated by presence of the endotracheal tube used for gas anesthesia, useful for surgery of the coelomic cavity, can decrease inhalant dosage, used in field when gas anesthesia/oxygen not present. Disadvantages include: variability in effect between species, poor induction of anesthesia, inadequate muscle relaxation, cardiopulmonary depression, prolonged/violent recoveries, route of delivery can affect efficacy and dosage, elimination depends on drug distribution, liver and/or kidney metabolism, some cannot be reversed and instead must be metabolized. It is vital to have an accurate body weight when dosing injectable anesthetics, and to calculate emergency/supportive drugs in advance. Close cardiopulmonary monitoring is required, and have endotracheal tubes and oxygen on hand in case of emergency. Many injectable anesthetics are controlled substances that must be used under direct supervision of your veterinarian.

Ketamine is an NMDA antagonist that causes anesthesia, doses are usually 2.5-10 mg/kg IM or IV for induction. It has little cardiopulmonary depression but can cause violent recoveries, has no reversal agent, and can cause seizures, excitation and salivation in Old World Vultures.

Propofol is used at 1 mg/kg/min IV. It cases smooth, rapid induction of anesthesia, though apnea is very common; be prepared to intubate and ventilate immediately after induction. It causes profound respiratory depression, prolonged recovery, CNS signs when used in constant rate infusion, and there are less adverse effects if given to effect.

Alfaxalone is a neuroactive steroid that binds GABA-a receptors. There is no reversal, and it is generally given at 5-10 mg/kg IV or IM.

Inhalant Anesthetics- Isoflurane, Sevoflurane, Desflurane

The advantages of inhalant anesthetics include rapid induction and recovery, the ability to rapidly change depth of anesthesia, they do not require an accurate body weight, there is little metabolism, and recovery is independent of kidney/liver function. Disadvantages include the pollution of the work environment, the expense of anesthesia and equipment, they require oxygen for use, they cause dose dependent cardiopulmonary depression, and hypotension (decreased blood pressure) is common.

- Isoflurane- considered safe but hypotension common
- Sevoflurane- lower solubility- faster induction/recovery, expensive
- Desflurane- requires expensive, specialized vaporizer, little data in birds

Anesthesia equipment

Your veterinarian should be able to guide you in the use of the anesthesia equipment. Use non-rebreathing circuits and uncuffed tubes inserted only far enough to prevent the tip from slipping easily out of the trachea. You may need to get creative! Intubation is usually not attempted for very short procedures, not at all in birds less than 150 g, and not in sharp-shinned hawks. In the tiny birds the inside diameter of the tube that would fit inside the trachea becomes too small and too prone to blockage by mucus. However, appropriately sized tubes should be available, to provide a means for rapid intubation and ventilation should the bird become apneic. Most birds will need 1-2L of oxygen/min, and the percent of gas needed to maintain anesthesia will depend on the pre-anesthetic drugs used and which gas anesthetic is used. Your veterinarian should guide you. Careful monitoring of the bird is required during anesthesia and recovery, especially the heart and respiratory rate and character (see below).

Supportive care during anesthesia:

Fluids are recommended, most often a SQ bolus before anesthesia of 5ml/100g. Larger birds may be catheterized, and put on a constant fluid drip. Maintenance fluids in birds are generally 40-60 ml/kg/d. Sites for fluid administration IV include the jugular, medial metatarsal, and in the pelican the pouch vein. Avoid the basilic in all birds. In some cases an intraosseous catheter may be used in the distal ulna (not pelicans) or proximal tibiotarsus, avoiding the pneumatic bones.

Instead of using an endotracheal tube, your veterinarian may instead install an air sac cannula, especially if an endotracheal tube would be in the way, or if the surgery was involving those upper airways. The left abdominal caudothoracic air sac is commonly used. The cannula can remain in place 3-5 days. Use a cuffed tube for this purpose.

Maintenance of body temperature (104-110F) is important. Because of the high body-to-surface area ratio, birds generally radiate heat rapidly. Once anesthetized, the bird is immobile and relaxed so it will generate less heat from muscle contraction. It is also subject to evaporative loss from the respiratory tract (dry anesthetic gases), skin surfaces (surgical prep solutions), and open-body cavities, conduction of heat via surface contact, and convection of warm gases from around the bird. Anesthesia redistributes blood flow and depresses thermoregulatory response, promoting heat loss. Hypothermia can decrease anesthetic requirement and metabolism and will prolong recovery. Monitoring core body temp and providing thermal support are mandatory to reduce anesthetic morbidity and mortality in the anesthetized and recovering patient. Large species and northern owl species may become hyperthermic due to the insulating effects of the feathers, which can be prevented or reversed by placing ice packs along the body of the patient.

Intermittent Positive Pressure Ventilation (IPPV) is essential during extended anesthetic periods (>30 min). Monitor excursion of the sternum in dorsally recumbent birds, or elevations of the base of the tail in ventrally recumbent birds. Anesthetic agents depress ventilation to a greater extent in birds than in mammals, therefore hypoventilation (not breathing enough) should be presumed in all anesthetized birds. IPPV in spontaneously breathing birds at two cycles per minute is sufficient to maintain blood gases in a suitable range. If apneic, the rate of ventilation should be 6-12 respirations per minute. Have your veterinarian teach you how to properly provide breaths to your anesthetized patients using their anesthesia equipment.

Monitoring

Heart rate can be monitored using stethoscopes: regular, pediatric or esophageal. Doppler can also be used. Heart rates in avian species vary greatly, from 200 bpm to 1000 bpm, depending on species (measure before anesthesia!). Maintenance of an even, steady rate appropriate for the species is more important than an absolute number. Decreased heart rate should prompt a reduction in anesthetic gas concentration, evaluation and treatment of hypotension, and review of the patient's surgical situation (pain, tissue trauma, and positioning). Unfortunately, cardiac arrest is typically not successfully reversed. ECG can be used to diagnose arrhythmias and monitor the heart rate. In birds an esophageal probe is more accurate. Changes in heart rate should be communicated with the veterinarian so they can instruct you in changing anesthetic depth.

Changes in respiratory rate and character usually precede cardiac changes, therefore respiration is probably the single most important factor to monitor. If apnea occurs, anesthetic gases should be turned off, the delivery system purged, oxygen flow re-established and the patient manually ventilated. It is vital that any change in respiration be communicated with the veterinarian promptly.

Reflexes are vital to determination of anesthetic plane. For most surgical procedures you should still see a mild palpebral (eyelid) reflex, the corneal reflex should be present (but slow), and there should be no pedal (foot) withdrawl.

Indirect blood pressure can be monitored, to look for trends. Direct blood pressure is very difficult in most birds. Again, the exact number is less important than the overall trends.

Capnography is the measurement of end-tidal carbon dioxide (ETCO2), the amount of carbon dioxide in exhaled air. This is a measure of ventilation. In African Greys ETCO2 consistently overestimates arterial CO2 by approximately 5 mmHg. ETCO2 of 30-45 mmHG indicated adequate ventilation. Use a side stream capnograph, and minimize dead air space.

Pulse Oximetry is unfortunately not useful in birds, and sufficient oxygenation does not necessarily mean that the bird is being adequately ventilated.

Maintaining perfusion of the tissues is vital. This can be monitored by checking the color of the mucous membranes as well as the capillary refill time, or the refill time at the basilic vein in birds.

Common Emergency Treatments:

- Doxapram can be used to stimulate breathing. It has a direct action on respiratory centers in the medulla of the brain.
- Isotonic crystalloid fluids can be used to treat or prevent hypotension by expanding blood volume, increasing tissue perfusion.
- Epinephrine HCl can be used in cases of cardiac arrest to initiate heartbeats, it increases the heart rate and cardiac output.

- Atropine may be used to correct slow heartrate or bradyarrhythmias (slow irregular heartrate) by stimulating supraventricular pacemakers in the heart.

Recovery

Recovery is a vital phase of anesthesia, and monitoring should be continued through recovery. Recovery is often rapid once gas is removed. Maintain the bird on oxygen during recovery, and be prepared for mechanical ventilation in the event of apnea. A brief excitatory stage is likely, which may be accompanied by regurgitation. Remove the endotracheal tube when the bird starts to move its head. Pay special attention to accipiters: do not use injectables except as pre-anesthetics, and start induction at low levels of iso and increase gradually. They are prone to sudden cardiac arrest, especially during recovery.

Conclusion

Stress in captivity is likely the number 1 killer of wildlife in rehabilitation. Therefore it is vital that wildlife rehabilitators work closely with their veterinarians to decrease stress, especially for any procedures involving pain. Multimodal analgesia and anesthesia are important tools to decrease stress, and wildlife rehabilitators familiar with these protocols will have patients that are more comfortable, less stressed, and more likely to recover quickly from injuries and procedures with better outcomes.

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