Anesthesia Of Exotic Animals
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Citation

Abstract
Limited access to a number of patients and wide variety in species of exotic animals require special instrumentation, routes of drug administration, techniques, and pharmacology to perform a safe anesthesia. Drug application of air-activated darts with a blow pipe is the most commonly used remote delivery system in zoo work. Immobilization is mostly performed with drug combinations of opioids, cyclohexamines alpha2-adrenergic agonists, and neuroleptics. Anesthesia may be maintained by the inhalant anesthetics halothane or isoflurane administered with portable precision-calibrated vaporizers. Induction is performed with various designs and sizes of face masks, induction chambers, or endotracheal tubes. Minimal monitoring equipment includes thermometers to assess rectal body temperature and a pulse oximeter. Medical emergencies in anesthetized exotic animals mostly result from cardiovascular and respiratory dysfunction as well as special conditions like bloat, vomiting and aspiration, and various life-threatening syndromes known as capture myopathy.

INTRODUCTION
Veterinarians are frequently called upon to anesthetize a wide variety of mammals, birds, reptiles, and fish. In contrast to the basic principles of anesthesia in humans a lot of additional factors have to be taken into account in free-ranging or zoo animals. First of all there is a wide variety of species of exotic animals. Some of them, such as rabbits, rats, and mice, have been used through the years to assess anesthetics, and a large amount of data is available concerning anesthesia in these species. Others have been anesthetized rarely if at all, and specific information on the effects of anesthetics and methods of achieving anesthesia is minimal. Furthermore, special attention has to be directed to the different anatomy and physiology of pulmonary and cardiovascular systems in birds, reptiles, and fish.

Another point is that access to dangerous or free-ranging animals and application thereto of an anesthetic is difficult, neither exact weight nor actual health status can be predetermined. Additional factors such as nutrition, disease, parasite load, infection, estrus, pregnancy, and lactation are also major anesthetic considerations, but usually cannot be assessed with certainty at a distance. In these cases, special remote drug delivery systems are necessary for anesthesia.

INSTRUMENTATION AND ROUTES OF DRUG ADMINISTRATION
In the late 1950s, the first complete remote delivery system became available (1) but the concept was not new. People of South America, Asia, and Africa have for centuries used arrows and spears with plant or animal poisons for hunting. Poison-coated darts have been used by South American Indians for hunting of birds and small mammals by the means of a blow pipe (Fig. 1). Made from wood or cane and using palm wood splinters for darts, the blow pipe is about 3 meters long and has an effective range of up to 40 meters (!) in the hands of an experienced hunter.
Figure 1
Fig 1: South American Indian hunting with a blow pipe. Blow pipes have been used by South American Indians for hunting.

The blow pipe is the most basic of all remote drug delivery systems and is commonly used in zoo work (Fig. 2). By blowing into a 1 to 2 meter pipe, a trained operator can accurately propel a lightweight (3mL) drug dart a distance of up to 10 meters.

Figure 2
Fig 2: Blow pipe used at the Zuerich Zoo. Application of anesthetics in a Snow leopard (Uncia uncia).

The darts used in the Zurich Zoo have an air-activated mechanism and consist of a plastic body into which air is introduced through a one-way valve in the tail piece and compressed behind the plunger. At impact a silicone seal is displaced, exposing a port in the side of the needle. The plunger is pushed forward by air pressure, and the drug is expelled through the port (Fig. 3).

Figure 3
Fig 3: The darts used in the Zurich Zoo. Blow pipe darts before and after drug expulsion: a) silicon seal, b) port in the side of the needle, c) drug chamber, d) plunger, e) compressed air chamber, f) stabilisator

Instead of compressed air, butane gas can be used as discharge mechanism. Other systems include rifle- and pistol-type projectors and darts with explosive- or spring-activated mechanisms. Dart propulsion is either a blank .22 caliber powder charge, carbon dioxide (CO2) gas, or compressed air (2, 3). Larger volumes and longer distances can be achieved, e.g. darting wildlife from helicopters. Laser
sights can increase accuracy when darting takes place at twilight or in darkness. The usual injection sites are the large muscle masses of the proximal hindlimb and forelimb (Fig. 4), with the former being the most commonly used.

**Figure 4**

Fig 4: Injection at the forelimb. Forelimb injection sites for immobilization of a Siberian tiger (Neofelis tigris altaica) in the Zurich Zoo

Hindlimb injections preferably should be aimed at the rear so as to avoid the femur; forelimb shots, at the front. Although of small size, a surprising number of darts strike the spine of the scapula. Darts striking the bone are painful, can cause fractures, and may not inject the drug properly. There is also some evidence that the rate of intramuscular absorption can vary depending on site; absorptions are most rapid in the neck, the shoulder, and the hip in that order (4). In the zoo environment the blow pipe is still the best choice because it is silent, uncomplicated to use and maintain, and the variable distance to a moving animal can be easily accommodated by adjusting blow power, even for smaller animals. Because of their light weight, limited mass, and low velocity, blow-pipe darts cause minimal impact damage and tissue trauma (5).

All remote delivery systems require training on non-living targets in order to gain a high accuracy (Fig. 5). In the field, failure of the first dart seems to reduce the chances of success for the next ones: the animal becomes alert, feels that something is going on, and keeps on moving. Animals in an advanced evolutionary status like chimpanzees or gorillas do get very angry, they start to throw every object at hand, including feces or even the loaded dart, back to the blow piper. A successful darting technique needs special skill, careful planning, knowledge of animal behavior and biology, and experience.

In order to achieve surgical analgesia, the immobilized animal has to be further anesthetized with inhalant anesthetics. Ruminants should be intubated whenever possible because even when they are fasted, residual food is present in the rumen and may be regurgitated causing fatal inhalation pneumonia. In young animals or small-size species, anesthesia may be directly induced with inhalation agents. Veterinary devices are commercially available and work like devices for humans. The number and variety of techniques for inducing gas anesthesia in animals are only limited by the anesthetist’s imagination. There are commercially available masks, or homemade masks fabricated from plastic bottles, syringe cases, syringes, or breathing hose connectors. Induction chambers from plexiglass boxes or plastic bags can be used for small mammals. Examples are given in Fig. 6 and 7.
Figure 6
Fig. 6: Induction-mask for small reptiles. Inhalant anesthesia of a Two-banded monitor (Varanus salvator) administered with a face mask.

Figure 7
Fig. 7: Induction-mask for a Black stork. Inhalant anesthesia of a Black stork (Ciconia nigra) administered with a face mask, made of a waste-pipe.

Any animal weighting more than 100 grams (a cockatiel) can be intubated. The limiting factor is the internal tube diameter which can cause resistance to ventilation. Unique anatomic features can interfere with intubation, such as the median tracheal septum found in some penguins. In birds, chelonians, and crocodiles the trachea is usually composed of complete rings of cartilage and therefore the cuff should not be inflated or must be inflated with extreme care because an overly inflated cuff can traumatize and even rupture the tracheal mucosa and rings. Various sizes of tracheal tubes are available (Fig. 8). In some animals the glottis is difficult to visualize because of limited laryngeal access of long and narrow oral cavities (cervids, bovids, camelids) (6). In these cases, special equipment like a long bladed laryngoscope and an endotracheal tube exchanger are needed. In some breath-holding reptile species it may not be possible to induce inhalant anesthetics at all.

Figure 8
Fig 8: Intubated lion. Endotracheal tube for inhalant anesthesia of a lion (Panthera leo).

Pharmacology
The requirements of an ideal anesthetic drug for exotic animal anesthesia are:

- large therapeutic index to compensate weight estimation errors and lack of preanesthetic evaluation of the patient
- high concentrativeness to permit one-dart application (3mL for blow pipe darts).
- long durability
- high compatibility if mixed with other drugs
- rapid induction time
- good sedative, muscle relaxant, and analgesic qualities
- minimal local or systemic side effects
- safe intramuscular application for remote delivery
- availability of an antagonist

Practice and field experience have often demonstrated that a combination of compatible and complementary drugs may constitute the safest and most effective method to meet the ideal requirements for anesthesia for selected species.
Historically, paralyzing compounds including neuromuscular blockers were used but today centrally acting compounds are favored and available for a large variety of animal species. Centrally acting compounds include five classes of drugs that act on the central nervous system (c):

1. **OPIOIDS**

   These are potent synthetic opiates, primarily oripavine derivatives or 4-amino-piperidine compounds. They are commonly used for immobilization of ungulates, elephants, and rhinoceroses (r). The opioids have good analgesic but only limited muscle relaxant properties. They have a wide margin of safety, are predictable in action, and can be reversed with the administration of a suitable antagonist (diprenorphine, naloxone or nalorphine). A neuroleptic synergist can potentate the opioid and produce a smoother induction. The side effects of opioid immobilization include excitation following administration, resulting in aimless running, pacing, or walking, which may lead to hyperthermia or capture myopathy (see later); regurgitation; critical depression of respiration; muscular tremors, hyper- or hypotension; tachycardia; and recycling. They are extremely toxic and must be handled with the greatest care to avoid accidental exposure in humans.

   Opioids used for immobilization include the most commonly used etorphine HCl (M99. Lemmon Co., Sellersville, Pennsylvania), fentanyl citrate (Janssen Lab., Beerse, Belgium), carfentanil citrate (Wildnil; Wildlife Lab., Ft. Collins, Colorado), and A-3080 (Anaquest Div., British Oxygen Co., Montvale, New Jersey). Etorphine hydrochloride is used in the Zurich Zoo but under strict regulations. Its use is limited to trained zoo vets and work is always performed in a team of two. A human (and animal!) emergency kit is always on hand. Wear of eye protection, face masks, and gloves is important to prevent accidental exposure to the drug or contact to the blood of the anesthetized animal to mucous membranes. An Etorphine HCl/acepromazine formulation is available in Europe: 2.45mg/mL Etorphine with 10mg/mL acepromazine (Large Animal Immobilon, C-Vet Ltd., Suffolk, England). With 2-3mL of this formulation it is possible to get a 3,500 kg elephant in lateral recumbence and achieve a surgical anesthesia (r)!

2. **CYCLOHEXAMINES**

   Drugs in this class are rapid-acting, dissociative anesthetics. They are used in many species, but have been particularly effective in carnivores, bears, primates, birds, and reptiles. During the state of unconsciousness known as cataleptoid-dissociative anesthesia, the treated animal retains normal pharyngeal and laryngeal reflexes while being unresponsive to stimulation. Side effects are muscle rigidity, excessive salivation, hyper- or hypotension, vocalization, or convulsions. The cyclohexamines are fast acting, have a wide margin of safety, cause only moderate depression of respiration and circulation at optimum doses, and have a quick recovery because of rapid metabolism of the drug. They are often used in combination with neuroleptics and there are no known antagonists. Ketamine hydrochloride (Ketamine; Bristol Lab., Syracuse, New York) has been used successfully in many species. A combination of a cyclohexanone dissociative anesthetic agent (tiletamine) combined with a benzodiazepine (zolazepam) with smooth induction and good muscle relaxant qualities is available.

3. **ALPHA2-ADRENERGIC AGONISTS**

   The alpha2-adrenergic agonists are potent central nervous system depressants with sedative, muscle relaxant, and some analgesic properties. They may be used singly for immobilization or as synergists with opioids or cyclohexamines. Their effect is dose dependent and ranges from mild sedation to deep sleep. At high doses, they may cause critical depression of respiration and blood circulation. In very excited animals, they do not produce a satisfactory level of immobilization. They may also disrupt the thermoregulatory mechanisms, leading to hyper- or hypothermia. Recovery from high dosages is usually prolonged and difficult. The development of specific antagonists has increased the usefulness of the alpha2-adrenergic agonists for animal immobilization (r).

   Alpha2-agonists presently available include xylazine (Rompun; Haver-Mobay Corp., Shawnee, Kansas), detomidine (Domosedan; Pfizer Inc., Westchester, Pennsylvania) and medetomidine (Domitor; Pfizer Inc., Westchester, Pennsylvania) (r). An example of a widely used immobilization drug combination is the five-to-one mixture of ketamine and xylazine. Ketamine, as the primary drug, will cause a rapid onset of drug action, and the inclusion of xylazine will result in a smoother induction and also counteract the adverse side effects of ketamine. This combination has been used effectively in carnivores such as bears, cats, coyotes, dogs, foxes, racoons, skunks, and wolves (r).

4. **NEUROLEPTICS**

   The neuroleptics produce a calming or tranquilizing effect
with little or no analgesia. They do not produce immobilization and are primarily used as synergists with opioids or cyclohexamines. In that capacity they have proven effective in potentiating the immobilizing drug, decreasing the total dose, causing a smoother and more speedy induction, and negating undesirable side effects. The drugs in this group include the phenothiazine derivatives, the butyrophenones, and the benzodiazepines.

5. LONG-ACTING NEUROLEPTICS

The use of long-acting neuroleptics (LANs) in exotic animals to facilitate adaptation to a new environment or transportation is a relatively new concept. Activities such as capture, confinement, transportation, or integration into a new herd or group are traumatic events for any wild animal. Some are particularly susceptible to stress and are unable to calm down. This may lead to high anxiety levels, which in turn can result in refusal of food and water, self-injury, injury from other animals (rank fights), and exhaustion with fatal consequences. Stress may exacerbate aggression and lead to territorial or dominance conflicts causing injury or death. There is clearly a need for neuroleptics with a more prolonged duration of effect. One answer has been the long-acting neuroleptics used to relieve anxiety, aggressiveness, and dysphoria in humans.

Depending on the product (derivatives of phenothiazines or thioxanthenes) and dose given (IM), effects can be maintained up to 30 days. Little research has been published on the use of long-acting neuroleptics in exotic animals. Most of the work has taken place in South Africa (12, 13).

6. ADJUVANTS

Some zoo veterinarians also use adjuvants like hyluronidase which act as spreading agent to promote diffusion and increase the absorption rate of the injectable anesthetic (14).

INHALATION ANESTHETICS

To maintain anesthesia after the animal has been immobilized, inhalation anesthetics are commonly used in zoo animal work administered with portable precision-calibrated vaporizers. In the Zurich Zoo, halothane is used for large mammals and isoflurane for critical patients, small mammals, reptiles and birds. Isoflurane provides rapid and smooth induction and emergence from anesthesia, and is an excellent anesthetic for exotic animals, but its costs may be prohibitive for use in larger animals.

MONITORING

Minimal “field” monitoring equipment includes electronic thermometers to supervise hypo- or hyperthermia of the anesthetized animal, and a portable pulse oximeter (Fig. 9). A photodetector clip is attached to the tongue or ear and provides useful information on the respiratory function of the animal. An oxygen supply should be ready when the SpO2 falls below 90%. However, oxygen is many times simply not available under field conditions and it is also not uncommon for animals anesthetized with potent narcotics or alpha2-adrenergic agonists to have SpO2 values that fall markedly below 90%. However, there currently is no data on the pathological effects, if any, of depressed SpO2 in wild animals and we are left to speculate if absolute SpO2 values have any biological significance to the immobilized animal. Nonetheless, the trend of SpO2 values do have justification. That is, if the SpO2 steadily decreases, it can be presumed that the animal is in some sort of respiratory crisis. A venous access should always be included to provide rapid intravenous medication or application of an antagonist.
In unusual situations or when immobilizing particularly critical animals, monitoring cardiac function may be required. Especially in breath-holding reptiles an ECG unit is required to ensure that the patient is still alive! Portable, rechargeable, vital-signs monitors, primarily designed for human emergency use, have been successfully adapted for use on a variety of birds and mammals.

**EMERGENCIES**

Medical emergencies encountered in the immobilization of wild animals in general do not differ from those in human medicine. Respiratory depression, hypo- and hyperthermia, cardiac arrest, and shock are treated like in humans. Special emergency situation in exotic animals include the following:

1. **BLOAT**
   
   It is a common occurrence in ungulates when excess gas resulting from normal fermentation accumulates in the rumen. The rumen enlarges, compressing the diaphragm and lungs, and impairs respiration. Treatment and prevention include correct sternal body position and insertion of a stomach tube to release intestinal gas. If the bloat cannot be relieved, the bloated rumen has to be trocharized in the left flank with a large-bore needle.

2. **VOMITING/ASPIRATION**
   
   Drug-(e.g. xylazine) or stress-induced vomiting often occurs in animals, especially in ruminants, and is harmful because of fatal aspiration pneumonia. Intubation of ruminants is always recommended.

3. **CAPTURE MYOPATHY**

   The effects of sympathetic exhaustion from sustained stress, combined with intense muscular exertion, are the causative factors of various life-threatening syndromes known as capture myopathy (m). Production and buildup of high levels of lactic acid in muscle cells lead to muscle fiber destruction and non-respiratory acidosis. Heart muscle destruction (myocardial necrosis) compromises cardiac function and leads to heart failure. Lactic acid may also cause the death of skeletal muscle fibers, causing them to release K+, Ca++, and myoglobin into the blood. The toxicity of myoglobin causes kidney failure, and K+ and Ca++ alter electric conduction within the heart. In association with high levels of potassium and calcium, epinephrine causes disorder in the heart rhythm. Cardiac arrest may occur as a result of these random, unproductive contractions (ventricular fibrillation). Intracellular enzymes LDH, CPK, and GOT are also released, and the likelihood of capture myopathy is easily confirmed by its presence at increased concentration in the blood.

   A situation with prolonged epinephrine release, as may occur during sustained pursuit or resisting restraint, will result in lack of oxygen in vasoconstricted tissues and loss of responsiveness to epinephrine and vasodilatation. Blood may stagnate and pool in this tissue. Blood pressure will drop, leading to shock and death.

   Capture myopathy may be prevented by reducing capture stress, fear, and exertion. Limit chase or darting time to 2 minutes and refrain from the procedure for 24 hours. Keep visual and auditory stimulation, handling, and restraint of the captured or immobilized animal to a minimum. Provide a stress-free postcapture or postanesthetic environment.

   Dietary vitamin E and selenium may be of value in the prevention of capture myopathy (n).
References

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