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## **The Art and Science of Giraffe (*Giraffa camelopardalis*) Immobilization/Anesthesia** ( 9-Jan-2002 )

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### **Summary**

The anesthesia/immobilization of giraffe is a unique specialty due to a combination of problems usually encountered in the procedure resulting in mortality or morbidity to the patient. This paper presents a historical description of the early drugs and methods and documents of the advances made in giraffe anesthesia during the last three decades. Also included are the current suggestions for both standing sedation and anesthesia/immobilization of this unique species. Suggestions include managing the giraffe prior to, during and following an anesthesia/immobilization. The differences between anesthesia/immobilization in captive and free ranging are compared and contrasted, with the true challenge being the free-ranging animal where there is less control of the situation. The current techniques have an improved safety record due to the development of newer and safer drugs, plus the development and use of improved physiological monitoring equipment to help assure the safety of the patient. The studies to develop safe anesthesia are a continuing challenge.

To deliver appropriate health care to species maintained in zoological collections it is necessary for the medical staff to manipulate individuals by physical and/or chemical means. Safe anesthetic protocols are also necessary for many conservation based field studies and translocation programs on free-living individuals, since an adverse anesthesia reaction can curtail such programs.

### **Introduction**

The art and science of anesthesia or immobilization in giraffes remains a challenge [1,2] because the giraffe's unique anatomy and physiology [3] presents inherent problems during anesthesia and/or chemical restraint including:

1. Their large size limits physical control during the critical times of induction and recovery, and limits manipulation once the animal is down;
2. Their characteristic long neck, which if not controlled, acts as a lever arm creating a danger to itself or the support staff. Also a mal-positioned neck leads to airway obstruction and/or cramping of neck muscles, which can produce fatalities;
3. Improper substrate potentates self-induced injury due to slipping during induction and recovery;
4. Their tendency to vomit or regurgitate can lead to fatal aspiration pneumonia and the posterior position of the larynx in the pharynx hampers draining of any fluid (rumen and/or saliva). Vomiting can result from the increased intra-abdominal pressure occurring when the animal impacts the ground since the skin and muscles over the abdomen are very tense. This compact tightness of the skin and muscle may function as a "G Suit" to help prevent the accumulation of interstitial fluid thus preventing peripheral edema [4]. A rumen bolus can on occasion be seen as it progresses up the neck in some giraffes receiving opioids just prior to or during recumbency;
5. Prolonged induction and/or recovery lead to hyperthermia, myopathy and secondary trauma. Other physiological adaptations in the giraffe which can impact on a anesthetic procedure includes an elevated systolic blood pressure [5], small respiratory tidal volume with a large dead space [6] and relative small cardiac output during anesthesia [7].

### **Physical Restraint of Giraffe**

Many may remember the dramatic capture scene of a young giraffe by "The Duke" in the movie "Hatari", which was the accepted method at that time due to the lack of drugs. The practice of physical restraint continues today for minimally

invasive procedures such as blood sampling, rectal examinations, minor hoof trimming and tuberculin testing. The design of the restraint facility varies from a chute [8] or a movable wall to extensive hydraulically controlled squeeze cages. The key to making a restraint procedure work is dependant on the design of the confinement area and the training and conditioning of the giraffe in that facility plus a well-trained staff. The management program should include confining the animals in the cage on a routine basis.

Physical restraint in a confinement chute can be enhanced by the use of sedatives and tranquilizers. The combination of azaperone (250 µg/kg) plus detomidine (15 to 30 µg/kg) given IM produces good tranquilization and moderate analgesia (Citino SB; Meltzer DGA; personal communications). This combination facilitates blood sampling, reproductive examinations, tuberculin testing, joint taps, radiographs, suturing and dystocia corrections. To increase sedation 10 mg of butorphanol IV helped produce deeper sedation in adult animal (Citino SB; personal communication). The detomidine is partially reversed with yohimbine (0.1mg/kg) or atipamezole (0.2 mg/kg) and the butorphanol is reversed with naltrexone (2mg naltrexone/mg of butorphanol).

### **Chemical Immobilization**

There are situations where more complete control of the giraffe than provided by physical confinement is required to perform the planned procedure safely. In the historical review of the correspondence and records at the National Zoological Park, Washington D.C. Dr Clinton Gray used succinylcholine to immobilize a giraffe in the 1960's. A dose of succinylcholine was selected and given; if no response was noted within an hour then an increased dose was administered. This process was repeated until the animal became paralyzed and recumbent, but not anesthetized. The hope was that the dose was not high enough to paralyze respiratory muscles and that the cholinesterase would soon reverse the effect of the drug. In this one case 45 mg of succinylcholine caused an adult male giraffe to become recumbent in 17 min and it remained down for 21 min. Reports by others, during this time period, found that 10 mg of succinylcholine were effective in adult female giraffes. This shows the marked variation in dosages of succinylcholine encountered.

### **Anesthesia of Captive Giraffes**

The prerequisites to giraffe anesthesia are critical to success [1,2,9]. The patient should be fasted for 48 to 72 hr and water withheld for 24 to 48 hr to minimize the possibility of regurgitation. This length of time may be modified if the weather is extremely hot or if the animal is aged. The site for the procedure should have smooth solid walls and sound footing. A catwalk allowing access to the animal's head during the procedure is ideal. An experienced staff to assist patient monitoring and support is mandatory. Procedural complications can occur even in captive situations where the anesthetist has control of food and water intake with the animal confined and physical means such as ropes and squeeze cages can supplement the anesthetic drugs. In free-ranging giraffes the situation takes on other challenges since there is minimal control of the above variables [10-12].

Perhaps the hardest thing to do is back off from a procedure, whether it be with physical restraint or an anesthesia. Many procedures involving giraffe require extensive coordination to make sure that people and equipment are ready. Unless conducting an emergency procedure, if something is not going right or if there is a factor that can be changed to enhance the success of the procedure, it should be stopped and rescheduled.

There are standardized procedures for handling an immobilized/anesthetized giraffe in lateral recumbency irrespective of the drugs used [9,11]. The neck of the recumbent giraffe must be extended to insure a patent airway. The neck is supported with the head maintained above the rumen and the nose pointed down to facilitate gravity-assisted drainage of any rumen or pharyngeal fluids. The animal is blindfolded and earplugs are used. Supporting and positioning the neck can be aided by a long board or ladder placed under the entire length of the neck to keep it straight. The angle of the neck is altered every 10 - 15 min to minimize the muscle spasms that occasionally occur. During the post-recovery period a muscle spasm in a giraffe's neck is life-threatening. Because of the mortality associated with secondary aspiration pneumonia, it is tempting to consider inserting an endotracheal tube in the giraffe. In most cases this would be of little use since most of the vomiting/regurgitation occurs when the animal initially falls. A second problem is access to the larynx because the mouth can be opened only 5 - 10 cm and direct visualization is extremely difficult without a flexible endoscope. Thirdly, stimulating the posterior pharyngeal area during intubation can cause vomiting and nasal intubation approaches have not been successful. The size of the giraffe is a major factor in the success of the anesthetic procedure with the smaller animals usually having a better success rate than the very large adults [13,14]. This may be due to a combination of factors including the ease of handling the smaller animal and the ability to restrain them easier, therefore using less amount of drugs. Further studies are required to develop safer methods for the huge adult males.

Monitoring a recumbent giraffe is critical for patient safety and should include [9,11] evaluation of the respiratory function, since respiratory failure usually occurs first, which is rapidly followed by a cascading of events including cardiac depression and death. After a giraffe goes down, respiratory movements are checked and the head and neck extended and

elevated to ensure a patent airway. Feeling the amount of air moved on exhalation is an estimate of the tidal volume. End tidal CO<sub>2</sub> is also an accurate measure of respiratory function using the portable battery operated capnograph in most species, but may be altered in giraffe due to the large respiratory dead space and tachypnea. The CO<sub>2</sub> sensor can be attached to a small tracheal tube inserted in one nostril to obtain a reading. Cardiac function is evaluated by auscultation of the chest and palpation of the auricular or mandibular arteries. The use of pulse oximetry is very useful, but may not function properly in some animals and especially when an  $\alpha$ 2-agonist (medetomidine) is part of anesthetic cocktail [11]. The sensor can be placed on the ear after the hair plucked and external epidermis is scraped away. The tongue may also be used and a reflectance transducer may work on the nasal septum. The author has experienced a couple of cases where, at some point during the procedure, the heart could not be auscultated, this is a cause of concern (to say the least), but the animal maintained a good respiration and the contraction of the heart could be felt on the chest wall. This phenomenon needs further study. Further evaluation of the cardiovascular function can be obtained by measuring blood pressure. Indirect systolic blood pressure is measured using a blood pressure cuff, of the appropriate diameter, placed above the carpus and a standard sphygmomanometer [11]. The cuff is inflated to 250 mm Hg and the pressure reduced slowly to the point the sphygmomanometer needle deflections are synchronized with the heart rate. This point is systolic pressure. Rectal temperature is monitored since hyperthermia can be a problem that needs immediate treatment by cooling with water and shortening the down time. The depth of anesthesia can be evaluated by the animal's reaction to various stimuli from blood sampling, hoof trimming or minor surgery. If the anesthesia is inadequate the giraffe may respond by movement or an increase in heart rate [11].

When an antagonist is used to reverse anesthetic drugs there are several procedures to follow [1,9-11]. After the administration of the antagonist, the head of the giraffe is supported in an elevated position with the nose pointed downward. Two people are usually used to support the head and neck and prevent the animal from rising too soon before it is adequately recovered. The earplugs are removed and the timing of the removal of the blindfold is after the animal begins to respond. To assist the recovering giraffe, a rope held by a minimum of three people on each end, is placed around the animal's shoulders so that as the animal attempts to stand, pulling on the rope helps the giraffe into a sternal position. When the giraffe appears to have recovered sufficient strength and is resisting the head restraint by lifting one person off the ground, then the head is manually elevated as the rope is pulled to assist the giraffe to a sternal position. Once the animal stands, the rope is released, and the giraffe walks over it. The interval from administering an antagonist until the animal is standing can vary from 10 - 20 min depending on the drugs used and the administration route of the antagonists. Subjective supportive therapy given prior to the antagonist includes 500 mg of a nonsteroidal anti-inflammatory drug (Banamine) plus 1,000 mg of a muscle relaxant (Robaxin).

In the decade of the late 1960's and early 1970's xylazine and etorphine became more widely used in other hoofstock species and some initial trials were conducted on giraffes [15,17]. Giraffes were found to be very sensitive to the  $\alpha$ 2-agonist and when used alone there was sedation accompanied by considerable ataxia, causing the giraffe to be a danger to itself and people working with it [1] since the animal can see and react defensively against capture personal or stumble and collapse unexpectedly. Initially a high dose of xylazine was tried causing recumbency but the recovery period was prolonged since  $\alpha$ 2-antagonists (yohimbine and atipamezole) were not yet available.

The major problems encountered when using opioids (etorphine and carfentanil) in giraffes are [12]:

1. Vomiting or passive regurgitation leading to fatal aspiration pneumonia;
2. Marked respiratory and cardiac depression;
3. Self-induced trauma during the onset of recumbency with the animal falling without control and;
4. Prolonged induction and/or stormy recovery resulting in secondary self-induced trauma, marked hyperthermia and/or capture myopathy [17]. The historical high morbidity and mortality (>10%) encountered with previous field anesthetic procedures utilizing opioids has resulted in a hesitancy to anesthetize this species [1].

In a captive situation, a staged anesthetic protocol using a combination of xylazine and etorphine given over time has been successful especially when analgesia is indicated [1,2,9]. This approach causes less respiratory depression because subsequent drug dosages can be adjusted depending on the individual patient's reaction. Ideally, the giraffe should be confined to a squeeze cage during anesthetic administration, which is designed to prevent the sedated giraffe from putting pressure on the trachea as it leans or pushes forward and obstruct its trachea which compromises breathing leading to collapse.

Initial sedation is accomplished by giving xylazine. Giraffes are sensitive to this drug and require 70 - 100 mg/adult or 30 - 40 mg/yearling. Atropine (7 - 8 mg/adult and 2 - 3 mg/yearling) is given simultaneously to prevent xylazine-induced bradycardia and atropine is reported to have a synergistic sedative effect when used with xylazine [18]. Five to 10 min

after xylazine administration, signs of sedation are usually evident including stargazing, slight ataxia and protrusion of the tongue with slight salivation. Manipulation at this time is contraindicated as most animals react defensively and may trip or stumble while attempting to escape and even when they appear sedated they are able to strike out effectively at ground staff. About 15 - 20 min after the xylazine, a narcotizing dose of etorphine (1.5 - 2.5 mg/adult and 0.5 - 1.25/yearling) is administered. This dose may be adequate to induce recumbency within 15 - 20 min. Ideally a head halter, placed when the animal is narcotized, is used to help control the animal's head to prevent it from tumbling over backwards and assist the animal to the ground. Minor procedures (e.g., blood sampling, tuberculin testing) can be performed on the standing narcotized animal with etorphine and xylazine antagonists given IV before the animal falls. If the narcotizing dose of etorphine does not put the giraffe down there are several alternatives;

1. A second dose of etorphine, 0.5 - 1 mg, may be required.
2. Physically bring the giraffe down by casting it. This can be used before or after the supplemental anesthetic. To bring a giraffe off its feet, several techniques are effective. Physical restraint to prevent pacing for a few minutes sometimes is followed by collapse. A second casting method is to halter the animal and physically turn it in a tight circle so it stumbles and collapses. This approach can be facilitated by tripping the animal with a rope around one front foot as it is turned. Casting a giraffe down can prevent the need for more etorphine, and thus alleviate the concern over depressed respiration.
3. A standing narcotized giraffe can be given 5% glycerol glycolate IV to induce recumbency and also negates the use of additional etorphine if there is good access to the jugular vein by the means of a catwalk. Once a giraffe is down the anesthesia seems to deepen. If further sedation and/or relaxation is required supplemental 5% glycerol glycolate IV, a muscle relaxant, can be given to enhance muscle relaxation and to avoid supplemental etorphine [7]. Glycerol glycolate is administered by a continuous IV infusion, and the rate is adjusted according to the level of muscle relaxation/sedation desired.

During a 30 - 40 min procedure 30 - 50 gm of glycerol glycolate may be required and can be given up to the time of anesthesia reversal since its effect is short lived and no after effects have been recognized following the reversal of xylazine and etorphine or carfentanil. This drug produces muscle relaxation and only moderate analgesia; therefore, concurrent anesthetic drugs are required to ensure adequate analgesia during painful manipulations.

Naltrexone is given IV to reverse the etorphine (100 mg of naltrexone/mg of etorphine used), plus an additional IM dosage of naltrexone (25 mg/mg of etorphine used). To reverse the xylazine atipamezole is used at 50 to 100 mg/ animals with 1/4 given IV and 3/4 IM. Additionally, doxapram hydrochloride (200 mg) or yohimbine (75 mg) can be given IV or IM to help antagonize xylazine in adults.

An anesthetic protocol using xylazine, carfentanil and atropine has been successful for field immobilization of free-ranging giraffes [10]. The doses of the carfentanil and xylazine were higher than required for captive individuals (8 mg carfentanil, 100 to 150 mg xylazine, with 10 mg of atropine/adult). When the giraffes were pacing in a narcotized condition they were cast so that additional drugs would not be required. The casting technique was to position a large-diameter (6 cm) rope in the animal's path and lift the rope to shoulder height as the giraffe reached it. The rope was then crossed behind the animal thus confining the legs. This controlled the pacing and brought the animal down. The head and the neck were rapidly elevated in an attempt to minimize regurgitation. The down times ranged from 5 to 28 min with an average of 11 min. These animals were supplemented with 5% glycerol guaiacolate IV to facilitate electroejaculation. In this study 1 of 8 animals died and the necropsy of this male showed serous atrophy of fat and liver cirrhosis. The reversal procedure was the same as used with the etorphine and xylazine. Diprenorphine was used to reverse the carfentanil at twice the carfentanil dosage IV plus an IM dose equal to the carfentanil dose. The xylazine was reversed using doxapram IV (400 mg) plus yohimbine IV (75 mg) and 4-aminopyridine IV (180 mg). The use of 4-aminopyridine is no longer recommended for reversing xylazine since it appears less effective and can produce undesirable neurological stimulation.

The use of etorphine (M99) alone has been used successfully for many years for giraffe capture [19]. This protocol uses high doses (6 to 10 mg/adult) for rapid induction and standing narcotization. Once the giraffe is restrained and hooded, the etorphine antagonist is administered quickly to minimize the respiratory depression seen with high dose of etorphine, and the giraffe is loaded on a trailer. This method is for capture only and requires a well-trained support crew to load the giraffe before severe hyperthermia and hypoxia develop.

Another protocol to capture free-ranging giraffes used a combination of fentanyl citrate (0.1 to 1.5 mg/kg), azaperone (0.2 to 0.3 µg/kg) and 35 to 50 mg of hyoscine/animal [12]. This produced signs of ataxia at an average of 5 to 7 min and after waiting for the drugs to have maximal effect the giraffes were cast with ropes. Mortality in this study was 10% due to

narcotic hyperactivity and hyperthermia.

In an effort develop a safer anesthetic protocols for both captive and free-living giraffes, we investigated the use of a medetomidine and ketamine combination because of the reported success of this combination in numerous other hoofstock species [20,21].

Medetomidine (MED) is an imidazole-based compound with potent selective and highly specific agonist activity at both the pre and post synaptic  $\alpha_2$ -adrenoreceptors [22,23]. It has an  $\alpha_2$  binding affinity of 10 times that of xylazine [20,23]. Medetomidine is a potent sedative and analgesic and has anxiolytic properties [20,23] and at high doses produces hypnotic or anesthetic effects [20,23]. Medetomidine is commonly combined with ketamine (KET) in a wide range of non-domestic species for reliable anesthesia, especially cervids [20,21]. This combination has also been used in controlled zoo environments to immobilize giraffes [14]. Medetomidine is effectively antagonized by atipamezole (ATP), a highly potent, selective and competitive  $\alpha_2$ -adrenoceptor antagonist [20,23].

A combination of medetomidine (MED) and ketamine (KET), with and without hyaluronidase, was used to immobilize 23 free-ranging giraffes by remote injection [11]. Hyaluronidase is a common addition to anesthetic drug combinations for field immobilizations. Hyaluronidase hydrolyzes hyaluronic acid and thus speeds adsorption of the anesthetic drugs with a resultant decrease in the down time [24,25]. In this study we observed no decreased down time with its use, probably due to the inherent rapid action of both medetomidine and ketamine. The dosages of the medetomidine and ketamine were correlated to the giraffe's shoulder height (SH). Sixteen giraffes became recumbent unassisted, 3 required physical casting prior to data collection and 4 were physically cast to recumbency, but remained too alert and active for safe and meaningful data collection. Physiological data were collected on 19 animals. In calm animals, MED and KET immobilization (150  $\mu$ g MED plus 3 mg KET/cm of SH) provided a rapid and relatively uneventful induction. Initial signs with ataxia were noted at average = 1:46  $\pm$  0:36 (average = min:sec  $\pm$  standard deviation) and progressed with the animal sitting prior to lateral recumbency at average = 6:34  $\pm$  3:42.

After 30 min of data collection, atipamezole administration IM resulted in a rapid and complete reversal of the immobilization. With dosages used in this study, there appeared to be no relationship between the drug dosages to induction time, but an inverse relationship was observed to the level of excitement with the quality of the immobilization. The more excited the giraffe prior to and after darting, the more physical restraint was required, with the 4 most excited giraffes being unmanageable even though a higher dose of medetomidine and ketamine were used. The combination of MED and KET is a preferred alternative to the use of opioids in giraffes for immobilization, although it does not produce adequate analgesia for major manipulative procedures at these doses, and works best on calm animals.

The giraffes, which did not become recumbent, were also on the average larger. This may indicate that the correlation to shoulder height may not be appropriate in the larger giraffes. Physiological monitoring of the giraffe found elevated respiration rates with:

1. Initial mild acidosis average = pH 7.264  $\pm$  0.050 which improved after 30 min to average = pH 7.341  $\pm$  0.055,
2. Hypoxia;
3. Values for Pa CO<sub>2</sub> and end-tidal CO<sub>2</sub> remained within normal ranges. All giraffes were hypertensive with normal heart rates and a slight increase in rectal temperatures occurred. There was no regurgitation or excessive salivation. At the dose levels used analgesia was judged inadequate for painful procedures. Atipamezole administered IM average = 340  $\pm$  20  $\mu$ g/cm of SH resulted in a rapid and smooth recovery.

Additional trials must still be conducted to further improve anesthesia safety in giraffes. Preliminary studies using A3080, medetomidine and ketamine were of limited success due to rapid onset of the A3080 compared to the medetomidine, which resulted in a narcotized giraffe that fell, and several giraffes vomited. There seemed to be a strong additive effect of the medetomidine and the opioids. Planned studies are to use carfentanil and medetomidine with ketamine. With this drug combination it is hoped that the medetomidine will act more rapidly than the carfentanil and the giraffe will become recumbent in a controlled manner with the carfentanil acting next to give the needed control and analgesia.

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