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Anesthesia of Bears (25-Mar-2002)

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Introduction

Bears are anesthetized for a variety of reasons. In areas that humans and bears cohabit, bears may be anesthetized by wildlife managers for translocation and/or marking. Bears may be anesthetized for research purposes or for medical management of sick bears. This article will discuss the anesthesia of bears. The major focus will be on polar bears (*Ursus maritimus*), brown or grizzly bears (*Ursus arctos*), and black bears (*Ursus americanus*). Spectacled bears (*Tremarctos ornatus*), sun bears (*Ursus malayanus*), asiatic black bears (*Ursus thibetanus*) and sloth bears (*Melurus ursinus*) will be briefly discussed. The first part of the manuscript will focus on considerations for anesthesia of all bear species. The next section will deal with pharmacological considerations. The final section will focus on considerations for individual species.

General Considerations

Bears are not particularly difficult to anesthetize. They are monogastrics and can be prone to vomiting on induction, or regurgitation during anesthesia. It is best to avoid anesthetizing bears that have recently eaten. This is not always possible in management situations, but may be an option in research situations, and should be adhered to with captive animals.
There are obvious human safety concerns inherent in bear anesthesia. These risks extend to the bear, as they may be destroyed in protection of human life. It is important to know the behavior of the target species, and take every possible step to avoid injury to capture personnel and to the bear. With free-ranging bears it is also important to consider other bears in the vicinity, particularly older cubs, consort males, or sow bears if the cub is the target. These animals can pose a threat to the anesthetized bear or to the capture personnel.

Drug Delivery

Drug delivery must be reliable and accurate. Systems that have low impact energy and deliver drugs at a low velocity are preferable when human or bear safety will not be compromised. Captive bears in culvert traps, or small enclosures may be injected with a pole syringe or blow dart. Volume limitations with blow darts necessitate the use of potent drug combinations, or the bear must be small. Large aggressive bears, captured in snares, may be darted via a pneumatic pistol. Paxarms® darts can be used to deliver volumes, up to 6 ml, at a low velocity. It is advisable to dart free-ranging bears from a distance. Cartridge or carbon dioxide powered rifles will facilitate drug delivery in these situations. Potent drugs may be incorporated into a sticky bait, to facilitate capture in zoological settings.
Bears will demonstrate seasonal variation in fat distribution. Black bears and brown bears will deposit a thick layer of fat over the rump in fall. At this time of the year, the shoulder or neck is the preferred location for dart placement. In the spring, these animals can be darted in the rump or hind limb. Polar bears may have a thick layer of fat at any time of the year and the shoulder or neck should be targeted.

Monitoring Anesthesia and Supportive Care

It goes without saying that depth of anesthesia should be closely monitored. Some drug combinations have proven to be unreliable in bears. Xylazine-ketamine and medetomidine-ketamine are unreliable, and sudden recoveries may be encountered. These combinations are best avoided in most situations. Factors that increase the risk of sudden arousal include: loud noise, distress vocalization of cubs is particularly dangerous. Other factors that can induce arousal include: movement of the bear i.e., changing the body position or location of the anesthetized animal, or painful stimuli, such as tooth extraction.
Techniques for monitoring depth of anesthesia will depend on the agent used. Tiletamine-zolazepam {Telazol®, Zoletil® (ZT)} will produce reliable anesthesia with predictable signs of recovery. As anesthesia lightens spontaneous blinking will occur, bears will show chewing movements and paw movement. They will start to lift their head, and may attempt to raise

themselves with their forelimbs. Animals with significant head movement generally require a "top-up" of tiletamine-zolazepam or ketamine, unless they are to be left to recover. Top-up doses of tiletamine-zolazepam can significantly prolong recovery, and should only be used if >30 minutes of additional down time is required. Ketamine is a better choice if 5 - 20 minutes of additional time is needed.
With xylazine-ketamine or medetomidine-ketamine, head lifting or limb movement signal that the bear is extremely light and should not be approached or manipulated. Increased intensity of the palpebral reflex or nystagmus are earlier indicators that the bear is light.
With xylazine-zolazepam-tiletamine (XZT) or medetomidine-zolazepam-tiletamine (MZT), head lifting should be absent before the bear is approached. The palpebral reflex can be used to determine depth of anesthesia. Lightly anesthetized bears will begin to breath deeply, and may sigh. They may start to lick, and will develop a spontaneous palpebral. Head lifting or paw movement should be a sign to be extremely cautious, as the bear may soon rouse. The eyes should always be lubricated, and caution must be exercised to avoid corneal abrasions or ulceration. A blindfold should be placed to protect the eyes and decrease visual stimuli (Fig. 1).

Figure 1. Blindfolded black bear. A blindfold and eye lubrication should be used to protect the eyes of anesthetized bears. A blindfold will also help to decrease stimulation of lightly anesthetized bears. - To view this image in full size go to the IVIS website at www.ivis.org . -

Bears are not particularly prone to hypoxemia. Oxygenation under tiletamine-zolazepam is generally good. The addition of an alpha-2 agonist can result in hypoxemia. Oxygenation can be monitored by visualization of the mucous membranes or with a pulse oximeter. The pulse oximeter probe can be placed on the tongue (Fig. 2). This may be difficult in bears lightly anesthetized with ZT, as they tend to chew. A hemoglobin saturation of < 85% is indicative of hypoxemia. We generally supply these animals with supplemental inspired oxygen (Fig. 3).

Figure 2. Grizzly bear with pulse oximeter probe in place. The tongue is the best location for placement of a multi-site pulse oximeter probe. - To view this image in full size go to the IVIS website at www.ivis.org . -

Figure 3. Polar bear receiving supplemental inspired oxygen. An aluminum E or D cylinder and an ambulance-type regulator will greatly facilitate the delivery of supplemental oxygen in the field. - To view this image in full size go to the IVIS website at www.ivis.org . -

Portable equipment is available to facilitate oxygen delivery An ambulance type regulator (Easy Reg®; Precision Medical, Inc. 300 Held Drive, Northampton, PA 18067) and aluminum D-cylinder is lightweight, portable and sturdy. It can provide a 10 l/min flow for up to 30 minutes. An E-cylinder will provide this flow for an hour or more. A nasal catheter is a simple method to provide supplemental inspired oxygen. The catheter should be threaded as far as the medial canthus of the eye. A flow rate of 5 - 10 l/min is required in most bears. Efficacy of oxygen therapy can be monitored with a pulse oximeter. Bears are best positioned in sternal recumbency, but can be positioned in dorsal or lateral recumbency, with few adverse effects.
The cardiovascular system should be closely monitored. Polar bears, black bears, and brown bears anesthetized with ZT commonly have heart rates of 70 - 90 beats/min. Heart rate is slightly lower with XZT and MZT , 50 - 70 beats/min. Bradycardia is common with medetomidine-ketamine, heart rates of 30 - 40 beats/min. are not uncommon in polar bears. The femoral artery is the best location to palpate a pulse, the brachial artery can also be used. Blood can be sampled from the jugular or medial saphenous vein. IV catheters may be placed in the jugular or cephalic vein (Fig. 4).

Figure 4. Grizzly bear, with IV catheter placed in the cephalic vein. - To view this image in full size go to the IVIS website at www.ivis.org . -

Blood pressure can be measured directly, via the femoral artery. In smaller bears oscillometric monitors can be used. The cuff width should be approximately 0.4 times the limb circumference. Mean arterial pressure in polar bears anesthetized with TZ was approximately 150 mmHg [1]. Polar bears anesthetized with MZT are hypertensive (MAP > 200mmHg) [1]. Black bears are also hypertensive with this combination [2].
Rectal temperature should be closely monitored. Rectal temperature tends to decrease over time with TZ and it tends to increase with XZT and MZT. In hot ambient temperatures body temperature can increase to dangerous levels (>41ºC). In these situations the alpha-2 agonist should be antagonized as quickly as possible. When possible, anesthesia should be reversed in free-ranging animals. This is particularly important for sows with cubs, and in areas where high concentrations of bears are present.
Bears may be translocated as part of management procedures. Translocation of bears in cargo nets, by helicopter can result in mortality [3]. Slinging in a cargo net can induce hypertension and hypoxemia [3]. Ideally, these bears should be transported or weighed with their head and neck extended and their body extended in sternal or dorsal recumbency [3]. We have used a stretcher-type sling to facilitate this positioning (Fig. 5). If bears are to be relocated in culvert traps they should be awake before transport. Anesthetized bear can gravitate towards the door of the trap. If the neck is flexed they can loose their airway and suffocate.

Figure 5. Grizzly bear, being weighed in a sling. The sling will maintain dorsal recumbency and head and neck extension. It is suitable for short translocation flights. - To view this image in full size go to the IVIS website at www.ivis.org . -

Pharmacological Considerations
The following section deals with combinations that can be used to anesthetize bears. Mean dosages of these combinations can be found in the species specific section.Table 1 is a list of drug dosages that are currently recommended for bears.

Table 1. Dosage of Selected Immobilizing Agents Used in Ursids.

	Tiletamine-zolazepam (mg/kg)	**Medetomidine** (µg/kg) + **Tiletamine-zolazepam** (mg/kg)	**Xylazine** (mg/kg) + **Tiletamine-zolazepam** (mg/kg)	**Xylazine**(mg/kg) + **ketamine** (mg/kg)	Oral **carfentanil** (µg/kg)
Polar Bear (*Ursus maratimus*)	8 - 10	75(m) + 2.2(tz)	2(x) + 3(tz)	NRec	NRep
Brown Bear (*Ursus arctos*)	7 - 10	35(m) + 4.8(tz)	2(x) + 3(tz)	NRec	8
Black Bear (*Ursus americanus*)	4 - 6	52(m) + 1.7(tz)	2(x) + 3(tz)	2(x) + 4(k)	6.8 - 18
Spectacled Bear (*Tremarctos ornatus*)	3.2 - 11.1	NRep	NRep	NRep	NRep
Sun Bear (*Melursus ursinus*)	4 - 5.5	NRep	NRep	NRep	NRep
Asiatic Black Bear (*Ursus thibetanus*)	2.8 - 4.4	NRep	NRep	NRep	NRep
Sloth Bear (*Melursus ursinus*)	5.5 - 6.6	NRep	NRep	1.4 - 2.4(x) + 5.8 - 9.7 (k)	NRep

- NRep = not reported in this species
- NRec = not recommended in this species

Xylazine-ketamine - Prior to the release of Telazol®, xylazine-ketamine combinations were the drugs of choice for bear immobilization. This combination may still be suitable for short procedures in small bears, but the risk of sudden arousal limits its utility in larger, more aggressive bears. Risks to the animal include convulsions, and hyperthermia. Xylazine can be

antagonized with yohimbine, but since a high dose of ketamine is required, adverse effects of the ketamine (ridgidity, convulsions, hyperthermia) are unmasked. [4].

Zolazepam-tiletamine (Telazol®, Zoletil®) - This combination will produce reliable anesthesia in bears. Recovery is slow, smooth and reliable. Bears will generally develop chewing motions a brisk palpebral and licking as the plane of anesthesia lightens. They will develop paw movement and start to lift their head in lighter planes of anesthesia, at this point procedures should be terminated or additional telazol or ketamine should be administered. Sudden recoveries are not a problem. Zolazepam-tiletamine produces minimal adverse effects on the respiratory or cardiovascular systems; therefore, it has a high margin of safety [1]. The major disadvantages of zolazepam-tiletamine are lack of analgesia [1] and lack of reversability [1,5]. Recovery can be prolonged, particularly in large bears, if repeated doses are administered. We typically reconstitute telazol with 1.8 ml of diluent. This will result in a volume of 2.2 ml and a concentration of 227 mg/ml.

Medetomidine-ketamine - The major advantages of medetomidine-ketamine over xylazine-ketamine are that small volumes are required, and since a low dose of ketamine is used, reversal of medetomidine will not result in rigidity or convulsions. This combination may be useful for small bears, but should not be used in larger potentially aggressive bears. Sudden recoveries have occurred in brown bears [6]. The authors have encountered sudden recoveries in polar bears [5]. This combination should only be used by experienced personnel, for short procedures, and depth of anesthesia should be closely monitored.

Medetomidine-zolazepam-tiletamine (MZT) - This is a very useful combination, it can be delivered in small volumes, this increases its utility in large polar or brown bears. MZT provides better analgesia than zolazepam-tiletamine alone [1]. The major advantage of this combination is that it is readily and rapidly reversible with atipamezole. The major disadvantages of MZT are hypertension and hypoxemia [1,2]. Hypoxemia can be offset by the provision of supplemental oxygen. MZT has been used in black bears [2] polar bears [1] and brown bears [7]. We prepare MZT by adding 2.5 ml of 6mg/ml medetomidine to 500 mg of telazol. The resulting solution contains 5.2 mg/ml of medetomidine, 86.2 mg/ml of tiletamine and 86.2 mg/ml of zolazepam [2]. We have used atipamezole at 3 - 4 times the medetomidine dose, for reversal. We have often split this dose half IV and half IM. This is probably not advisable as recovery can be extremely rapid. IV administration of atipamezole should be reserved for emergency situations.

Xylazine-zolazepam-tiletamine (XZT) - This combination has many of the same characteristics as MZT. It provides analgesia and can be delivered at approximately half the volume of telazol. XZT produces hypertension and hypoxemia. Hypoxemia is generally not severe and responds well to supplemental inspired oxygen. XZT will produce effective immobilization. It is important to note that quality of anesthesia is different to telazol alone, and head lifting or limb movement may immediately precede arousal. This combination is potentially reversible with yohimbine or atipamezole (tolazoline appears to be ineffective). Our current experience is that although recovery is not rapid, as with medetomidine-ketamine or MZT, it is still faster than telazol alone. The longer recovery is probably a result of the higher telazol requirement with this mixture, compared to MZT. We generally use 0.1 - 0.2 mg/kg of yohimbine to antagonize the xylazine component of this mixture. This mixture can be prepared by adding 3.3 ml of 100 mg/ml xylazine to 500 mg of telazol powder. The resulting solution contains 88 mg/ml of xylazine, 66 mg/ml of tiletamine and 66 mg/ml of zolazepam.

Oral carfentanil - Carfentanil has been used orally in captive bears. The drug is mixed in honey. The sticky base will coat the mouth and allow for sublingual absorption. This method may be preferable in captive bears, when injection is not desired [8]. In black bears oral carfentanil produced effective immobilization that was accompanied by rigidity and muscle tremors [9]. Diazepam was administered at a dose of 25 mg IV, to treat these tremors [9]. Bears immobilized with oral carfentanil were hypoxemic. The hypoxemia was readily treated with supplemental inspired oxygen [9]. Oral carfentanil has also been used as part of a balanced anesthetic technique in a brown bear [8].

Species Specific Concerns

Polar Bears - Polar bears can have substantial fat deposits throughout the year. The shoulder and neck are the best sites for drug delivery. Male polar bears can be large and heavy. Body weights >500 kg are not uncommon. Potent drug combinations are required to keep drug volume and dart size to a minimum. Animals should be positioned carefully to avoid excessive pressure on limbs that could result in compartment syndrome. Polar bears enter a hypometabolic state during the summer. At this time of the year animals are fasting and body temperature is decreased (34 - 35ºC). Immobilizing drug requirements may also be decreased at this time of the year. In areas where large numbers of polar bears congregate, reversible anesthetic protocols should be considered. This will decrease the risk of predation from other bears. Reversible protocols should also be

considered for mother bears with cubs.

Drug Choices Include:

- 8 - 10 mg/kg of zolazepam-tiletamine, this will produce reliable immobilization, but can also result in prolonged recoveries. Volume requirements are high, this can produce excessive tissue trauma, and will necessitate the use of large darts.
- 2mg/kg of xylazine + 3 mg/kg of zolazepam-tiletamine. This mixture can be delivered at approximately half the volume of zolazepam-tiletamine alone. It is potentially reversible with yohimbine or atipamezole. Reversal of this mixture is not reliable. This is probably due to residual zolazepam-tiletamine sedation. Animals immobilized with this mixture will benefit from supplemental inspired oxygen.
- 75 µg/kg of medetomidine + 2.2 mg/kg of zolazepam-tiletamine will produce reliable immobilization. This combination will produce rapid onset of immobilization, it can be delivered in a small volume and it is readily reversible with atipamezole, administered at four times the medetomidine dose. Animals will benefit from supplemental inspired oxygen [1].

Brown Bears - A variety of techniques can be used to anesthetize brown bears. Drug combinations should be reliable, and potent. In some parts of their range brown bears can grow very large, and potent drug combinations will decrease tissue trauma. Brown bears enter a hypometabolic state in the winter. Drug requirements may be decreased at this time. Zolazepam-tiletamine is routinely used for management of brown bears in North America. Reversible combinations are desirable in certain situations, particularly in free-ranging sows with cubs.

Drug Choices Include:

- 7 - 9 mg/kg of zolazepam-tiletamine, this will produce reliable immobilization, but can also result in prolonged recoveries. Volume requirements are high, this can produce excessive tissue trauma, and will necessitate the use of large darts.
- 2mg/kg of xylazine + 3 mg/kg of zolazepam-tiletamine alone. It is potentially reversible with yohimbine or atipamezole. Reversal of this mixture is not reliable. This is probably due to residual zolazepam-tiletamine induced sedation. Animals immobilized with this mixture will benefit from supplemental inspired oxygen.
- Medetomidine + zolazepam-tiletamine (MZT) will produce reliable immobilization. This combination will produce rapid onset of immobilization, it can be delivered in a small volume and it is readily reversible with atipamezole, administered at 5 times the medetomidine dose. MZT has been used in Scandanavian brown bears [7]. The dosage ranged from 35 µg/kg of medetomidine + 4.8 mg/kg of zolazepam-tiletamine in yearlings to 20 µg/kg of medetomidine + 4.7 mg/kg of zolazepam-tiletamine in adult males.
- Oral carfentanil has been used at a dose of 8 µg/kg in a captive brown bear. This dose induced deep sedation, sufficient for intubation. The bear also received 0.02 mg/kg of atropine IM. Naltrexone was administered at a dose of 0.42 mg/kg IM and IV to speed recovery [8].

Black Bears - Generally these bears have a more placid nature than brown bears, dose requirements are lower with zolazepam-tiletamine. A variety of drugging techniques can be used. Black bears are frequently immobilized for management purposes in North America. The bear may be snared or captured in a culvert trap prior to drug administration. Physical capture of the bear will facilitate drug administration and limit mobility on induction. Free-ranging bears are often treed prior to drug administration. This will also facilitate drug administration and decrease mobility on induction. Ideally, a coniferous tree (not too tall) should be picked, as the boughs will help to break the bear's fall on induction. Air filled bags or mattresses can be placed at the base of the tree to soften the landing. Bears that remain in the tree, after induction, may need to be placed in a sling and lowered with ropes.

Drug Choices Include:

- 4 - 6 mg/kg of zolazepam-tiletamine. This combination will produce reliable immobilization, and can be delivered at a relatively low volume in most bears.
- 2mg/kg of xylazine + 3 mg/kg of zolazepam-tiletamine. We have used this combination in black bears. The dose we have used is similar to a brown bear or polar bear dose. The dose could possibly be lowered. Further work is needed to determine an appropriate dose for this species.

- 52 µg/kg of medetomidine + 1.7 mg/kg of zolazepam-tiletamine will produce reliable immobilization. This combination will produce rapid onset of immobilization, it can be delivered in a small volume and it is readily reversible with atipamezole, administered at four times the medetomidine dose. Animals will benefit from supplemental inspired oxygen [2].
- 4mg/kg of ketamine + 2 mg/kg of xylazine. This combination can be used in black bears. It is important to monitor the bear closely for signs of arousal. Rapid nystagmus and brisk tongue withdrawl are signs of light anesthesia. An IV top up of xylazine-ketamine at one third of the original dose may be considered, or procedures may be terminated.
- Oral carfentanil has been used in captive black bears. A dose of 6.8 - 18 µg/kg was administered in honey. Bears demonstrated muscle rigidity that was readily treated with diazepam (10 - 25 mg IV). Bears also developed hypoxemia that resolved with 5 l/min of supplemental oxygen [9].

Sloth Bears, Sun Bears, Asiatic Black Bears and Spectacled Bears - These species are grouped at the end of the section because there is a paucity of information, in the literature, about anesthesia of these animals. It is very probable that xylazine + zolazepam-tiletamine and medetomidine + zolazepam-tiletamine or oral carfentanil will be as effective in these species as in other bear species. zolazepam-tiletamine has been used in sun bears at a dose of 4.0 - 5.5 mg/kg, in sloth bears at a dose of 5.5 - 6.6 mg/kg, in Asiatic black bears at a dose of 2.8 - 4.4 mg/kg and in spectacled bears at a dose of 3.2 - 11.1 mg/kg [10]. Sloth bears have been anesthetized with 1.4 - 2.4 mg/kg of xylazine, combined with 5.8 - 9.7 mg/kg of ketamine [11]. Sun bears have been anesthetized with 60 - 80 µg/kg of medetomidine + 2 - 3 mg/kg of ketamine [6].

References

1. Caulkett NA, Cattet MRL, Caulkett JM, et al. Comparative Physiologic Effects of Telazol, Medetomidine-Ketamine, and Medetomidine-Telazol in Captive Polar Bears (*Ursus maritimus*). J Zoo and Wildl Med 1999; 30: 504-509.
2. Caulkett NA and Cattet MRL. Physiological Effects of Medetomidine-Zolazepam-Tiletamine Immobilization in Black Bears (*Ursus americanus*). J Wildl Dis 1997; 33: 618-622.
3. Cattet MRL, Caulkett NA, Streib KA, et al. Cardiopulmonary Response of Anesthetized Polar Bears to Suspension by Net and Sling. J Wildl Dis 1999; 35: 548-556.
4. Ramsay MA, Stirling L, Knudsen IØ, et al. Use of yohimbine hydrochloride to reverse immobilization of polar bears by ketamine hydrochloride and xylazine hydrochloride. J Wildl Dis 1985; 21: 396-400.
5. Cattet MRL, Caulkett NA, Polischuk SC, et al. Anesthesia of polar bears with zolazepam-tiletamine, medetomidine-ketamine, and medetomidine-zolazepam-tiletamine. J Zoo Wildl Med 1999; 30: 354-360.
6. Jalanka HH and Roeken BO. The use of medetomidine, medetomidine-ketamine combinations, and atipamezole in nondomestic mammals: A review. J Zoo Wildl Med 1990; 21: 259-282.
7. Arnemo JO, Brunberg S, Ahlqvist P, et al. Reversible immobilization and anesthesia of free-ranging brown bears (*Ursus arctos*) with medetomidine-tiletamine-zolazepam and atipamezole: A review of 575 captures. In: Proceedings of the Annu Meet Am Assoc Zoo Vet 2001.
8. Mama KR, Steffey EP and Withrow SJ. Use of orally administered carfentanil prior to isoflurane-induced anesthesia in a Kodiak brown bear. J Am Vet Med Assoc 2000; 217: 546-549.
9. Ramsay EC, Sleeman JM and Clyde VL. Immobilization of black bears (*Ursus Americanus*) with orally administered carfentanil citrate. J Wildl Dis 1995; 31:391-393.
10. Schobert E. Telazol use in wild and exotic animals. Vet Med 1987; 82:1080-1088.
11. Page CD. Sloth Bear Immobilization with a ketamine-xylazine combination: Reversal with yohimbine. J Am Vet Med Assoc 1986; 189:1050-1051.