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USE OF DISSOCIATIVE ANESTHETICS FOR THE IMMOBILIZATION OF CAPTIVE BEARS: BLOOD GAS, HEMATOLOGY AND BIOCHEMISTRY VALUES[1]

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Abstract: Nineteen bears, representing five species *(Helarctos malayanus, Ursus americanus, Ursus arctos, Tremarctos ornatus, Melursus ursinus)* were immobilized a total of 52 times using either phencyclidine-promazine or tiletamine-zolazepam. Blood gas, hematology, and serum biochemistry values were determined during the immobilizations.

Immobilizations conducted with tiletamine-zolazepam were characterized by rapid induction and recovery times, good muscle relaxation, and relative freedom from convulsions. Bears immobilized with phencyclidine-promazine had longer induction and recovery times and showed convulsive activity in 29% of the trials with that combination.

INTRODUCTION

The dissociative anesthetics, including phencyclidine and tiletamine, are widely used for the immobilization and anesthetization of non-domestic carnivores. They produce profound analgesia, immobility, and in high dosages a state of dissociative or cataleptoid anesthesia. Unlike most general anesthetics, they do not significantly depress cardiovascular or respiratory functions. With their use, the palpebral, corneal, and swallowing reflexes remain intact; the eyes are open; and, muscular tone is increased to varying degrees.

Phencyclidine and tiletamine both exhibit strong tendencies towards convulsive activity when given alone and, consequently, they are commonly given along with a suitable tranquilizer. Promazine is generally given with phencyclidine,[2,4,8] while the diazepinone tranquilizer, zolazepam, is usually given with tiletamine in a 1:1 mixture.[1,2]

In the present report, the use of phencyclidine-promazine and tiletamine-zolazepam in five bear species is described.

MATERIALS AND METHODS

The bears involved in this study are members of the collection of the National Zoological Park in Washington, D.C. Fifty-two immobilizations were conducted with 19 individual bears of five different species. These animals included 1.1 (1 male; 1 female) Malayan sun bears *(Helarctos malayanus),* 2.1 American black bears *(Ursus americanus),* 2.2 European brown bears *(Ursus arctos arctos),* 1.2 Kodiak brown bears *(Ursus arctos middendorffi),* 1.2 spectacled bears *(Tremarctos ornatus),* 1.2 sloth bears *(Melursus ursinus),* and 0.1 Kodiak-polar bear hybrid *(U. arctos middendorffi* × *Thalarctos maritimus).* The European and Kodiak brown bears, and the

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Kodiak-polar hybrid, are discussed as members of a single species, *Ursus arctos*.

Phencyclidine[2] and promazine[3] (PP) were used on thirty-one occasions to immobilize bears; the tiletamine-zolazepam combination[4] (TZ) was used twenty-one times.

The bears ranged in age from 6 months to more than 25 years. They weighed from 11-363 kg. Eighty-eight percent (46) of the immobilizations were conducted in the spring and summer months of March through August. Three of the remaining immobilizations were performed in September through November and three episodes occurred in the winter months of December through February.

The immobilizations were necessitated by a variety of needs including transport, physical examination, contraceptive implantation, and electro-ejaculation. Other procedures performed during the immobilizations included blood collection, dental work, radiographic examinations, and urogenital culturing. All bears were fasted for 24 hours prior to being immobilized.

The drugs were administered to the caged bears with either a projectile syringe fired from a CO_2 pistol,[5] using a 38-50 mm collared needle, or a syringe pole with a 38 mm, 16-G needle. The preferred injection site was a rear leg and the long needles were chosen in attempts to assure penetration through fat tissues and into muscle masses. Induction time was recorded as the length of time between injection and handling of the animal. Anesthesia time was recorded as that period of time during which the animal was tractable. Recovery time was the period of time required from the first purposeful head or limb movements until the bear returned to normal. In many instances, supplemental doses were required to fully immobilize the bears in order to complete the desired procedures.

Arterial blood samples for blood gas analysis were collected from the femoral artery within 10 minutes after the immobilized bears were handled. The actual sampling time, relative to injection of the immobilizing drugs, varied with the length of the induction period. The samples were drawn anaerobically with a 1-ml sodium heparinized, plastic disposable syringe and, after thorough mixing, introduced into a pH blood gas analyzer.[6] Values for arterial pH, pCO_2, and pO_2 were recorded at the instrument's temperature of 37 C. If not immediately analyzed, the samples were placed in an ice bath and analyzed within 3 hours. Respiration rate, heart rate, and rectal temperature were measured simultaneous to the arterial sampling. Subsequent arterial samples were collected during the immobilizations and handled in a similar manner.

Values for pCO_2 and pO_2 were corrected to correlate with the bears' rectal temperatures using line charts prepared for humans and dogs.[10] The pH values were corrected for temperature by the addition or subtraction of 0.015 pH units per 1 C difference below or above, respectively, the instrumental temperature of 37 C.[7] These temperature-corrected values were then used to estimate base excess (BE) on an alignment nomogram.[11]

Statistical analysis was carried out using Student's 't' test to evaluate the differences between means; a value of $p < 0.05$ denoted significance.

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[2] Sernylan, Bio-Ceutic Laboratories, Inc., St. Louis, Missouri, USA.

[3] Sparine, Wyeth Laboratories, Inc., Philadelphia, Pennsylvania, USA.

[4] Telazol, Parke-Davis & Company, Ann Arbor, Michigan, USA.

[5] Cap-Chur Gun, Palmer Chemical & Equipment Co., Inc., Douglassville, Georgia, USA.

[6] IL Model 213 pH/Blood Gas Analyzer, Instrumentation Laboratories, Inc., Lexington, Massachusetts, USA.

Blood samples for laboratory analysis were collected from the jugular vein with a plastic disposable syringe. The sample was immediately transferred to 3-ml glass tubes containing ethylenediaminetetraacetic acid (EDTA) for hematologic evaluation, and to 10-ml silicone-coated glass tubes containing no anticoagulant for serum biochemical studies. Total erythrocyte and leukocyte determinations were made with an electronic cell counter.[7] Slides for differential white cell counts were prepared and stained with Wright's stain: 100 cells were counted. Hematocrit values were obtained by the microhematocrit method. Hemoglobin was measured using a cyanomethemoglobin technique.[8] The determined values were then used to calculate the red cell indices: mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), and mean corpuscular hemoglobin concentration (MCHC). Total serum protein was obtained with a refractometer.[9] Serum levels of calcium, phosphorus, glucose, urea nitrogen, uric acid, cholesterol, total bilirubin, alkaline phosphatase, lactic dehydrogenase, and glutamic-oxaloacetic transaminase were measured with an autoanalyzer.[10] Sodium and potassium levels were measured on a flame photometer[11] and chloride concentrations were determined with a chloridimeter.[12]

RESULTS

Phencyclidine-promazine (PP)

Fourteen individual bears representing five species were immobilized a total of 31 times with PP. Dosage and induction time data are presented in Table 1. Mean initial dosages were similar for all species and ranged 1.0-1.4 mg/kg body weight for phencyclidine and 1.2-1.6 mg/kg for promazine. In twenty-two of the immobilization episodes (71%), supplemental doses of both phencyclidine and promazine were necessary to provide the desired levels of sedation. These supplements ranged 19-400% and 15-100% of the original phencyclidine and promazine doses, respectively. Eight of the immobilizations requiring supplements needed more than one additional dose. The total drug dosages given to bears ranged 1.4-1.8 mg/kg for phencyclidine and 1.4-2.0 mg/kg for promazine.

Induction times ranged 10-90 minutes with the longest induction periods seen in animals requiring supplementation of initial PP doses. In those animals which were immobilized by the initial dose alone, the induction times were 10-27 minutes. Anesthesia was available, in most cases, for at least 30 minutes and often lasted up to 2 hours. Recovery from PP was generally prolonged, and the immobilized bears did not usually return to normal until the next day. Prolonged anesthetic effects, as indicated by ataxia or depression on the days following immobilization, were noted twice.

On several occasions, other immobilizing drugs or drug combinations were given to bears which could not be immobilized using PP alone. These other drugs included the tiletamine-zolazepam combination and another dissociative anesthetic, ketamine. On four occasions, halothane was introduced to maintain anesthesia following immobilization with PP. Except for a series of major convulsions in one bear following a

[7] Coulter Counter ZB16, Coulter Diagnostics, Hialeah, Florida, USA.

[8] Hycel Cyanomethemoglobin Determinations, Hycel, Inc., Houston, Texas, USA.

[9] Goldberg Refractometer, American Optical Company, Buffalo, New York, USA.

[10] SMA 12/60, Technicon Instruments Corporation, Chauncey, New York, USA.

[11] IL Model 343 Flame Photometer, Instrumentation Laboratories, Inc., Lexington, Massachusetts, USA.

[12] Chloride Meter 920, Corning Glass Works, Science Products Division, Corning, New York, USA.

ketamine injection, no serious adverse effects were encountered with these subsequent drug administrations.

Severe muscle tremors and/or convulsions were observed in 9 of the 31 immobilizations with PP. On several occasions, diazepam hydrochloride [1] (0.1-0.2 mg/kg IV) was useful in controlling this convulsive activity.

The physiological data and the arterial pH and blood gas values collected during immobilizations with PP are presented in Table 2. Mean respiratory rates during immobilization varied from 10 breaths/minute in the American black bears to 48 breaths/minute in the spectacled bears. Mean pulse rates ranged from 90 beats/minute in the brown bears to 154 beats/minute in the sun bears. Mean rectal temperatures for the five species ranged from 35.6 C in the sun bear to 38.6 C in the spectacled bears. The highest rectal temperature observed during the trials with PP was 40.1 C. That temperature was reached by the same spectacled bear on each of 2 occasions. The lowest temperature seen was a reading of 35.6 C obtained from the sun bear.

There were no significant alterations to the arterial pH or blood gas values of the bears immobilized with PP. Mean pH values, 7.30-7.40, were very near normal. Mean arterial pCO_2 and pO_2 values were also quite close to expected normals with the pCO_2 ranging 28.7 to 42.1 mm Hg and the pO_2 ranging 82.4 to 107.8 mm Hg.

Tiletamine-Zolazepam (TZ)

The tiletamine-zolazepam combination was used a total of 21 times to immobilize 12 individual bears representing 4 species. Mean total TZ doses for these immobilizations ranged 2.8 to 4.7 mg/kg, as shown in Table 1. During 7 immobilization episodes, supplemental doses equalling 29-75% of the original dose were required to permit handling of the bears. On four occasions, at least two supplemental doses of TZ were needed to achieve complete immobilization. Anesthesia was induced within 2 to 12 minutes, considerably faster than with PP, and generally lasted from 15 to 180 minutes. Recoveries took place uneventfully within 2-6 hours of the initial dose administration. In general, the lengths of the anesthesia and recovery periods showed a positive correlation with the administered dose; the higher doses yielded longer anesthesia and recovery times.

Halothane was introduced following TZ immobilization on 4 occasions. No adverse effects or problems were encountered during those episodes. Recovery following halothane and TZ did not differ in length significantly from recovery following TZ alone.

Vomiting in one bear and moderate muscle tremors in another were the only adverse effects noticed with TZ use in these studies.

The physiological, arterial pH and blood gas data from the TZ-immobilized bears are presented in Table 2. Respiratory rates ranged from a mean of 8 breaths/minute in the American black bears to a mean of 30 breaths/minute in the spectacled bear. Mean pulse rates extended from 87 beats/minute in the spectacled bears to 140 beats/minute in the black bears. Mean rectal temperatures ranged from 37.8 C in the American black bears to 39.0 C in the brown bears.

The mean arterial pH values were slightly lower than normal, ranging from 7.30 in the brown bears to 7.35 in the spectacled bears. Mean arterial pCO_2 and pO_2 values ranged from 30.9 to 42.1 mm Hg and 57.6 to 92.6 mm Hg, respectively. Two brown bears experienced mild cases of respiratory acidosis resulting from decreased respiration rates as indicated by blood gas measures

[1] Injectable Valium, Roche Laboratories, Division of Hoffmann-La Roche, Inc., Nutley, New Jersey, USA.

TABLE 1. Total immobilizing dosages and induction times of bears immobilized with phencyclidine-promazine and tiletamine-zolazepam.

Species	Phencyclidine-Promazine			Tiletamine-Zolazepam	
	Phencyclidine (mg/kg)	Promazine (mg/kg)	Induction time (min)	Tiletamine-Zolazepam[a] (mg/kg)	Induction time (min)
Helarctos malayanus (Malayan sun bear)	1.7 ± 0.4[b]	1.9 ± 0.7	47.0 ± 28.0 2[c]	4.1 ± 0.9	8.7 ± 3.0 3
Tremarctos ornatus (Spectacled bear)	1.8 ± 0.7	2.0 ± 1.0	35.3 ± 22.4 9	2.8 ± 0.5	15.0 ± 0.8 3
Melursus ursinus (Sloth bear)	1.6 ± 0.6	1.8 ± 0.8	33.4 ± 13.9 5	—	—
Ursus americanus (American black bear)	1.4 ± 0.1	1.4 ± 0.1	37.5 ± 36.0 2	4.7 ± 1.8	14.5 ± 12.7 6
Ursus arctos sp. (Brown bears)	1.6 ± 0.7	1.8 ± 0.7	36.9 ± 19.9 13	3.5 ± 1.8	4.0 ± 2.0 9

[a]Tiletamine and zolazepam administered in a 1:1 ratio.
[b]Mean ± S. D.
[c]Sample size.

TABLE 2. Blood gas values and physiological measures of bears immobilized with phencyclidine-promazine (PP and tiletamine-zolazepam (TZ).

Species		No.	pH	pCO_2 (mm Hg)	pO_2 (mm Hg)	BE (mEq/1)	Respiration (breaths/min)	Pulse beats/min)	Temperature (C)
Helarctos malayanus (Malayan sun bear)	(PP)	1	7.31	42.1	103.4	-4.7	12	154	35.6
Tremarctos ornatus (Spectacled bear)	(PP)	6	7.36 ± .02[a]	28.7 ± 5.8	82.4 ± 20.8	-7.8 ± 2.1	48 ± 23	108 ± 22	38.6 ± 0.8
	(TZ)	3	7.35 ± .01	30.9 ± 4.1	82.6 ± 14.7	-7.5 ± 1.3	30 ± 10	87 ± 14	38.6 ± 1.4
Melursus ursinus (Sloth bear)	(PP)	4	7.30 ± .13	32.7 ± 9.1	90.8 ± 16.3	-9.8 ± 4.2	13 ± 6	113 ± 13	38.8 ± 0.3
Ursus americanus (American black bear)	(PP)	2	7.40 ± .03	36.6 ± 10.1	107.8 ± 12.8	-2.0 ± 6.7	10 ± 3	102 ± 48	37.0 ± 0.2
	(TZ)	1	7.32	33.6	57.6	-7.3	8	140	37.8
Ursus arctos sp. (Brown bears)	(PP)	12	7.39 ± .04	29.4 ± 5.6	91.7 ± 19.6	-6.0 ± 3.6	32 ± 25	90 ± 32	38.0 ± 0.9
	(TZ)	6	7.30 ± .08	42.1 ± 12.3	92.6 ± 11.1	-6.2 ± 0.8	26 ± 18	121 ± 37	39.0 ± 1.7

[a]Mean ± S. D.

at about 15 minutes after injection of the TZ. However, subsequent blood gas values from these bears showed a return to normal levels within 30 minutes of the first sample.

Laboratory Data

The hematology and serum biochemistry data of the blood of bears immobilized in this study are given in Tables 3 and 4. The data collected from bears immobilized with either PP or TZ did not differ significantly from one another and, consequently, all values were pooled together and presented as collective means. The data are tabulated by species; significant differences were not found within the data relative to differences in age, sex, or season of collection for the bears studied.

DISCUSSION

Phencyclidine and tiletamine have received widespread use as immobilants of nondomestic carnivores. In this study, their use in combination with suitable tranquilizers was found satisfactory for the immobilization and anesthetization of captive bears.

The procedures used for immobilizing free-ranging wild animals are often quite different from those used for immobilizing the same species in a captive situation. In general, higher drug dosages are used for free-ranging animals in order to achieve more rapid inductions. In a captive situation, as at the National Zoological Park, it is considered desirable to give immobilizing drugs through low initial doses followed by supplemental doses, if required, until the desired effects are obtained. This technique minimizes potentially adverse side effects, such as convulsive activity and respiratory depression which accompany many immobilizing drugs at high doses. It is interesting that, on several occasions, the low initial doses were sufficient enough to produce the desired effects without the need for additional doses. The use of multiple doses to reach

TABLE 3. Hematological values of bears immobilized with phencyclidine-promazine or tiletamine-zolazepam.

Species	No.	Hct (%)	Hgb (g/dl)	RBC (10^6/mm^3)	WBC (10^3/mm^3)	Differential (10^3/mm^3)						MCV (μ^3)	MCH ($\mu\mu$g)	MCHC (%)	TP (g/dl)
						Segs	Non-Segs	Lymphs	Monos	Eos	Basos				
Helarctos malayanus	3	36.7[a]	13.0	5.05	10.14	7.70	0.0	1.92	.47	0.0	.06	73.5	25.8	35.5	8.2
(Malayan sun bear)		2.1	0.0	.35	1.54	1.03	0.0	.15	.28	0.0	.08	10.6	1.3	2.0	0.6
Tremarctos ornatus	9	42.6	15.4	8.43	6.32	4.26	0.0	1.85	.02	.11	.09	50.4	18.2	36.1	9.0
(Spectacled bear)		3.8	1.7	.71	1.97	1.64	0.0	.82	.03	.10	.06	2.8	0.7	1.5	0.6
Melursus ursinus	3	44.3	15.9	6.14	12.02	9.14	0.0	1.32	.14	1.26	.16	72.7	26.3	36.0	7.9
(Sloth bear)		2.9	1.3	.64	3.14	.94	0.0	1.15	.16	.94	.27	2.9	0.6	1.0	0.2
Ursus americanus	5	38.6	13.6	6.38	11.48	9.59	0.0	1.63	.03	.15	.09	61.2	21.4	35.0	7.2
(American black bear)		8.0	3.7	1.68	4.14	4.65	0.0	.72	.06	.11	.13	3.4	0.5	2.3	0.6
Ursus arctos sp.	19	42.2	15.2	6.32	8.79	7.25	0.0	1.24	.20	.24	.01	66.8	24.2	36.0	8.0
(Brown bear)		4.8	1.7	.56	4.05	3.54	0.1	.57	.23	.29	.02	5.8	1.8	1.9	0.7

[a]Mean ± S. D.

TABLE 4. Serum biochemistry values of bears immobilized with phencyclidine-promazine or tiletamine-zolazepam.

Species	No.	Ca (mg/dl)	Phos (mg/dl)	Gluc (mg/dl)	BUN (mg/dl)	Uric Acid (mg/dl)	Chol (mg/dl)	Total Bili (mg/dl)	Alk Phos (U/l)	LDH (U/l)	SGOT (U/l)	Na+ (mEq/l)	K+ (mEq/l)	Cl- (mEq/l)
Helarctos malayanus	2	10.0[a]	6.0	92	11.5	1.4	254	0.1	47	432	46	—	—	—
(Malayan sun bear)		1.6	1.3	50	3.5	0.4	69	0.0	4	33	4			
Tremarctos ornatus	8	10.2	4.5	102	12.8	1.5	365	0.1	40	324	46	140.0	4.0	103.2
(Spectacled bear)		0.6	0.9	57	6.3	0.4	81	0.0	16	72	14	1.9	0.2	1.5
Melursus ursinus	3	9.6	5.3	91	18.3	1.4	248	0.1	30	577	125	145.7	4.2	109.7
(Sloth bear)		0.8	1.4	10	4.0	0.2	35	0.1	12	155	14	1.5	0.0	1.5
Ursus americanus	5	9.6	6.7	103	24.6	1.5	271	0.5	22	447	98	136.6	4.2	102.8
(American black bear)		0.4	1.7	51	9.1	0.4	69	0.3	10	252	14	5.6	0.3	2.8
Ursus arctos sp.	14	10.0	4.8	92	12.3	1.3	317	0.2	56	648	140	139.8	4.4	103.7
(Brown bear)		0.6	1.3	30	3.4	0.3	81	0.1	37	290	70	5.0	1.1	4.6

[a]Mean ± S. D.

a desired level of sedation results in prolonged induction periods but, in our experience, does not appear to markedly alter recovery times.

The use of supplemental doses also results in a total immobilizing dose which may be higher than would have been necessary if the drug had been given in a single administration. This arises from the concurrent metabolism and elimination of early doses while the later doses are undergoing absorption. Consequently, if the immobilizing agent is to be given in one injection, it may not be necessary to give our total cumulative dosages.

The dosages of PP used in the present study were similar to those reported by other investigators working with this combination in bears.[8] They were slightly lower, however, than those used by individuals immobilizing bears with phencyclidine alone.[4,5] Convulsions and muscle fasciculations, problems frequently encountered when using phencyclidine alone, were present in almost one-third of the trials involving the PP combination. Thus, the present study indicates that promazine, in doses similar to phencyclidine, does not completely eliminate this adverse side effect of the latter.

TZ proved to be a satisfactory and highly desirable drug combination for the immobilization of bears. Throughout this study, its use was characterized by rapid inductions, smooth recoveries, adequate muscle relaxation for most procedures, and little alteration to acid-base status. TZ-immobilized bears were free of the convulsive activity usually associated with tiletamine alone and observed in the PP-immobilized bears in the present study.

The low pH and negative base excess values seen during this study indicate that bears experience a metabolic acidosis during immobilization with phencyclidine and tiletamine. However, some respiratory compensation for this acidosis is indicated by the lower than normal pCO_2 values and the higher than expected pO_2 values. This respiratory compensation precludes significant alterations to the bears' acid base balance that would result from an uncompensated metabolic acidosis. Subsequent arterial samples obtained during the immobilizations were similar to the initial samples. Compensated metabolic acidosis, similar to that in the present study, has been described in lions that were immobilized with drug combinations involving dissociative agents.[2]

The hematology data in this study were similar, in all species, to those values reported by Seal *et al.*[9] and Pearson and Halloran[6] after seasonal influences have been considered. Most of the serum biochemistry results from the brown and black bears of the present study are in close agreement with the data of other investigators using dissociative agents for the immobilization of these species.[3] The present study did have considerably lower LDH values for the brown and black bears compared to those reported by Halloran and Pearson[3] who used the same testing procedure (SMA-12). Values from other species were not available in the literature for comparison.

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