

Observations on Immobilization of Père David's Deer

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SUMMARY

Etorphine and xylazine were found to be a safe and reliable drug combination for the immobilization of Père David's deer, whether excited or unexcited. Excited deer had a longer preimmobilization period, when compared with unexcited deer at comparable dosages. Generally, the acid-base status of Père David's deer during immobilization was not seriously altered. Deer that had been excited and exercised experienced mild respiratory problems; the unexcited, relatively calm deer experienced minimal acidosis. Significantly high pH and P_{O_2} and significantly lower P_{CO_2} and bicarbonate values were found in the excited deer, when compared with the unexcited deer. Rapid physiologic changes occurred after the intravenous administration of the antagonist, diprenorphine.

SUCCINYLCHOLINE CHLORIDE^a alone and a mixture of phencyclidine hydrochloride^b and promazine hydrochloride^c both have proved to be undesirable immobilizing drugs for Père David's deer (*Elaphurus davidianus*) at the National Zoological Park. Other investigators have experienced fatalities with succinylcholine in deer.¹⁰ However, etorphine^d was successfully used to immobilize a Père David's deer at Catskill Game Farm⁵ and on 3 previous occasions at the National Zoological Park. A combination of etorphine and xylazine^e has been used in captive white-tailed deer (*Odocoileus virginianus*),⁹ impala (*Aepyceros melampus*), and eland (*Taurotragus oryx*).² In this study, etorphine, in combination with xylazine, was chosen to immobilize Père David's deer. The clinical and physiologic data were recorded and the methods of drug immobilization were evaluated. The Père David's deer is an endangered species and, because of its value, testing with immobilizing agents was limited.

Materials and Methods

Père David's deer were immobilized under the following conditions: (1) To facilitate relocation, 8 deer were immobilized with a combination of etorphine and xylazine in

a projectile syringe delivered by a powder charge rifle.^f (2) One of the relocated deer was returned for surgery and postoperative treatment. It was confined to a stall and was immobilized 8 times, using various concentrations of etorphine and xylazine administered with a pole syringe.

Drug dosages varied because of estimating the animal's weight before darting. The range of dosage (Table 1) for etorphine was 0.012 mg/kg to 0.021 mg/kg, and the range of dosage for xylazine was 0.23 mg/kg to 0.56 mg/kg. The time required for the deer to lie down or to be manually assisted into recumbency was recorded. The heart rate, respiratory rate, and rectal temperature were recorded when possible.

In our experience, Père David's deer are generally intractable. Their behavior is affected by man's mere presence, as well as by their handling by man. Therefore, the psychologic status of each deer was evaluated before and during immobilization. Each deer was classified into either an "excited" or "unexcited" group—excited if there was evidence of continual autonomic stimulation before and after darting and before immobilization, and unexcited if the deer remained relatively calm.

The unexcited group was generally unaware of the darting procedures and was minimally exercised. This group included 3 transported deer and 1 deer that was immobilized on 8 occasions while confined in a stall.

Deer in the excited group were continually active for a minimum of 10 minutes prior to darting. This activity continued after darting and before immobilization occurred. Excitement was due to several reasons. Occasional difficulty was encountered in the darting procedure. Sometimes 2 deer were immobilized in 1 day. The activity involved in handling the first deer often resulted in excitement of the deer immobilized later.

During immobilization, the deer were maintained in sternal recumbency, with the head elevated.

Arterial blood for pH and blood gas determinations was collected anaerobically in 1-ml heparinized^g disposable syringes from a catheter^h placed in the superficial plantar metatarsal artery or from the femoral artery. The arterial sample was placed on ice immediately after mixing. Venous blood samples were collected in disposable syringes and transferred into 3-ml heparinized glass tubes for the hematologic examination.

The pH, P_{CO_2} , and P_{O_2} were determined within 3 hours at 37 C on a pH/blood analyzer.ⁱ The bicarbonate concentration was estimated by use of a pH/blood gas slide rule.^j

To terminate immobilization, diprenorphine^k was given intravenously at a dosage twice that of etorphine.

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Supported by Grant No. 450116, Smithsonian Research Foundation.

^a Sucostrin, E. R. Squibb & Sons, Inc, New York, NY.

^b Sernylan, Bio-Ceutic Laboratories, Inc, St Joseph, Mo.

^c Sparine, Wyeth Laboratories, Inc, Philadelphia, Pa.

^d M99, American Cyanamid Company, Agricultural Division, Princeton, NJ.

^e Rompun, Chemagro Division, Baychem Corporation, Animal Health Department, Kansas City, Mo.

^f Cap-Chur Gun, Palmer Chemical and Equipment Company, Inc, Douglasville, Ga.

^g Sodium heparin, 1,000 USP units/ml, Riker Laboratories, Inc, Northridge, Ca, and Wolins Pharmacal Corporation, Melville, NY.

^h Inside needle catheter No. 8 needle, 17G × 2, C. R. Bard, Inc, Murray Hill, NJ.

ⁱ IL 213 pH/blood analyzer, Instrumentation Laboratory, Inc, Lexington, Ma.

^j pH-Blood Gas Calculator, Instrumentation Laboratory, Inc, Lexington, Ma.

^k M50-50, antagonist for etorphine, American Cyanamid Company, Agricultural Division, Princeton, NJ.

TABLE 1—Observational Data, Vital Statistics, and Dosages of Immobilizing Drugs Used on Père David's Deer

Deer No.	Preimmobilization period (time, in minutes, from darting to recumbency)	Respiratory rate (min)	Heart rate (min)	Body wt (kg)	Dosage of etorphine (mg/kg)	Dosage of xylazine (mg/kg)
EXCITED GROUP						
1	8	28	88	117	0.017	0.51
2	25	92	80	107	0.021	0.56
3	9	44	68	132	0.017	0.46
4	16	64	120			
5	8	60	104	156	0.018	0.45
UNEXCITED GROUP						
6	10	44	64	162	0.012	0.31
7	9.5	8	56	143	0.019	0.42
8	4	12	56	124	0.020	0.41
1						
3/18	3	4	44	107*	0.019	0.47
3/25	8	6	55	107*	0.012	0.28
3/31	6	6	72	107*	0.012	0.28
4/8	9.5	12	68	107*	0.012	0.23
4/15	7	6	107*	107*	0.012	0.23
4/24	7	4	56	104	0.012	0.29
5/1	7.5	4	52	104*	0.012	0.29
5/12	6.5	9	64	104*	0.012	0.29

* Estimated.

The dosages of etorphine and xylazine (Table 1) independently may be considered small, but in combination, resulted in adequate immobilization. Generally, the excited deer were given larger dosages of etorphine and xylazine.

Within 2 to 5 minutes after the injection of etorphine and xylazine, all deer appeared glassy-eyed; they salivated and their tongues protruded. Bloating or regurgitation was not observed. Some of the deer goose-stepped, which delayed the immobilization and caused hyperthermia.

TABLE 2—pH and Blood Gas Data of the First Arterial Blood Sample from Immobilized Père David's Deer

Deer No.	Time of obtaining sample (minutes after injection)	pH	P _{CO₂} (mm Hg)	P _{O₂} (mm Hg)	Bicarbonate (mEq/L)
EXCITED GROUP					
1	10	7.30	14	98	7
2	36½	7.61	7	109	7
3	12	7.47	12	96	8
4	39	7.72	7	106	8
5	9	7.20	19	98	7
UNEXCITED GROUP					
6	25	7.47	28	54	20
7	28½	7.39	45	41	26
8	5	7.36	38	91	20
1					
3/18	23	7.38	44	56	25
3/25	14	7.37	39	35	22
3/31	21	7.22	52	40	20
4/8	12	7.32	33	58	17
4/15	12	7.14	43	52	14
4/24	18	7.35	48	28	25
5/1	12½	7.34	47	31	24
5/12	10	7.30	40	42	19

In our experience, if the goose-stepping was excessive (lasting longer than 3 to 4 minutes), it was best to stop the pacing. After a pacing deer was held still, recumbency was fairly rapid, and immobilization was satisfactory for most procedures. This was done for 6 of the deer.

Within 3 minutes after the diprenorphine was administered, each deer made a prompt, partial recovery, which enabled us to lead it into the transport crate. All deer became recumbent again in 5 to 10 minutes, and the recumbency persisted for about 1½ to 3 hours. The second recumbency after the reversal of the effect of etorphine was attributed to the continual effect of xylazine.

The pH and blood gas data of the excited and unexcited deer are listed (Table 2). In a statistical comparison of the

data between the excited and unexcited deer (Table 3), student's *t* test was used.⁹ The excited deer had significantly higher heart rates, respiratory rates, and P_{O₂} values. The excited deer also took a significantly longer time to reach recumbency after darting (preimmobilization period), even though the drug dosages were higher. The P_{CO₂} and bicarbonate values were significantly lower in the excited deer. The rectal temperatures of the excited deer were significantly higher (Tables 4 and 5). Inasmuch as pH, P_{CO₂}, and P_{O₂} are temperature-dependent and measurements were determined at 37 C, these quantities should be adjusted to the body temperature of the animal. Unfortunately, temperature data was not obtained on all deer.

TABLE 3—Comparison of pH and Blood Gas Data of the Excited and Unexcited Père David's Deer

Factor	Excited deer (mean ± SE)	Unexcited deer (mean ± SE)	Significance of difference (P value)
	n = 5	n = 11	
Preimmobilization period (time, in minutes, from darting to recumbency)	13 ± 3.3	7.1 ± 0.67	0.01
Respiratory rate (min)	58 ± 11	11 ± 3.5	0.01
Heart rate (min)	92 ± 9.1	59 ± 2.6 (n = 10)	0.01
pH	7.46 ± 0.09	7.33 ± 0.03	(not significant)
P _{CO₂} (mm Hg)	11.8 ± 2.27	41.6 ± 2.09	0.01
P _{O₂} (mm Hg)	101 ± 2.56	48 ± 5.28	0.01
Bicarbonate (mEq/L)	7.4 ± 0.24	21 ± 1.12	0.01

The pH is inversely proportional to temperature. For each degree Centigrade change in temperature, the pH of whole blood changes 0.015 pH units.¹² The blood gas measurements were temperature corrected according to a published chart.¹³ The temperature-corrected pH and blood gas information (Table 4) is from the first arterial blood sample collected after recumbency. The pH and blood gas temperature corrected data of excited and unexcited Père David's deer are compared (Table 5). The differences in nontemperature-corrected and the temperature-corrected data were not significant except for pH. The difference in pH between the excited and unexcited deer became significant in the temperature-corrected data (Table 5).

Rapid changes in the acid-base balance of all the deer were observed following the intravenous administration of antagonist. The results of serial physiologic sampling on a Père David's deer throughout immobilization and after antagonist administration are depicted (Fig 1).

TABLE 4—pH and Blood Gas Temperature-Corrected Data of the First Arterial Blood Sample from the Immobilized Père David's Deer

Deer No.	Time of obtaining sample (minutes after injection)	Rectal temperature (C)	pH	P _{CO₂} (mm Hg)	P _{O₂} (mm Hg)	Bicarbonate (mEq/L)	Hemoglobin (g/dl)	A factor* (P _{CO₂} -40)	B factor* (base excess - 2)
EXCITED GROUP									
2	36.5	43.3	7.52	9	171	7	15.0	- 31	- 13
3	12	42.8	7.38	15	145	9	12.4	- 25	- 14
4	39	40.6	7.60	8	137	8	16.4	- 32	- 10
UNEXCITED GROUP									
1									
4/8	12	39.2	7.29	36	68	17	11.2	- 4	- 9
4/15	12	39.7	7.10	48	63	14	13.6	8	- 15
4/24	18	40.5	7.30	56	36	26	11.2	16	0
5/1	12.5	39.4	7.30	52	37	25	13.0	12	- 2
5/12	10	39.4	7.26	44	50	19	14.4	4	- 8

* The A factor is known as the acid or respiratory factor; the B factor refers to the base or metabolic factor.^{1,11}

TABLE 5—Comparison of pH and Blood Gas Temperature-Corrected Data of the Excited and Unexcited Père David's Deer

Factor	Excited deer (mean ± SE)	Unexcited deer (mean ± SE)	Significance of difference (P value)
	n = 3	n = 5	
Rectal temperature (C)	42.2 ± 0.83	39.6 ± 0.23	< 0.01
pH	7.50 ± 0.06	7.25 ± 0.04	< 0.01
P _{CO₂} (mm Hg)	11 ± 2.2	47 ± 3.4	< 0.01
P _{O₂} (mm Hg)	151 ± 10.3	51 ± 6.5	< 0.01
Bicarbonate (mEq/L)	8.0 ± 0.58	20 ± 2.3	< 0.01

Discussion

The A and B factors (Table 4) of the deer are used to evaluate the acid-base status, according to the Siggaard-Andersen nomogram for human blood.¹ It may be noted that the Siggaard-Andersen nomogram has been used to assess the acid-base data of sheep and cattle blood.⁷ Therefore, we are using the same nomogram to evaluate the acid-base status of the Père David's deer. The A and B factors were calculated as follows:

A factor for arterial blood = P_{CO₂} - 40

B factor for arterial blood = Base excess - 2

Base excess is calculated, using the Siggaard-Andersen alignment nomogram.¹¹ The acid-base state approaches normal as the A and B factors approach zero. If the change in A is greater than the change in B, a respiratory problem exists; if B is greater than A, a metabolic problem exists.

Some of the excited deer (Table 4) experienced relatively mild respiratory acidosis and other excited deer experienced mild respiratory alkalosis. All of the deer were hyperventilating because of the excitement experienced in the immobilization process and during the immobilizing periods. Although they had increased, shallow respiration, the respiratory problem probably existed because of diminished tidal volume.

The unexcited deer experienced minimal metabolic acidosis and respiratory acidosis. Etorphine and xylazine are respiratory depressants. Hypoxia developed in the unexcited deer (Table 2).

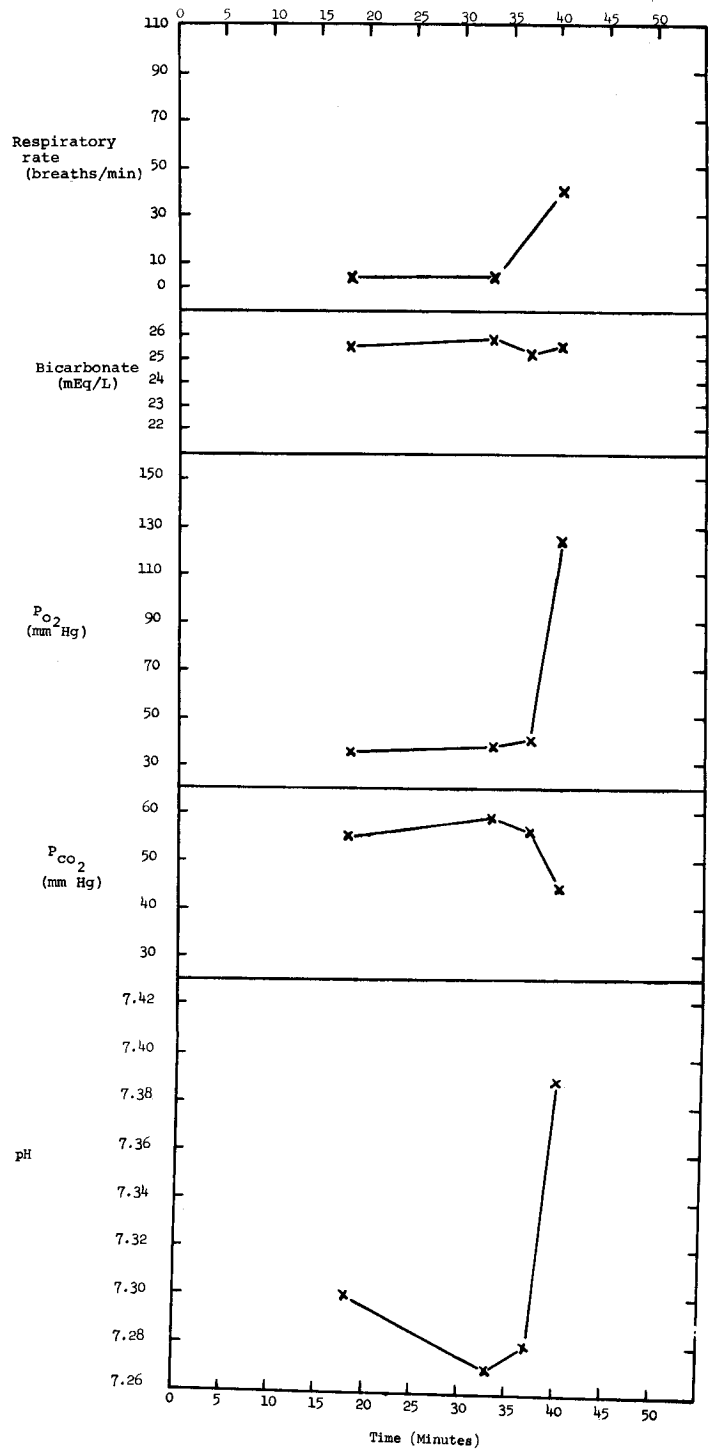


Fig 1—pH, blood gases, and respiration data of unexcited Père David's deer (No. 1) immobilized with the combination of etorphine and xylazine and immediately following antagonist administration. The antagonist was given at 38 minutes.

Two other studies of pH and blood gas measurements have been obtained from physically restrained zebra (*Equus burchelli*) and blesbok (*Damaliscus dorcas phillipsi*) after forced exercise.^{3,4} In these studies, severe metabolic acidosis contributed to postcapture myopathy and to other postcapture problems, including death. This acidosis proved fatal in the zebra if they were not treated intravenously with sodium bicarbonate solution. Metabolic acidosis with respiratory compensation occurred in the blesbok.

Excited deer had significantly lower P_{CO_2} and bicarbonate and higher P_{O_2} and pH values (Table 5). Therefore, blood pH and blood gas changes also appear to be related to the state of excitement and activity in the animal prior to and during the time of immobilization and are not simply a function of the immobilizing agent or dosage.

The pH and blood gas values of white-tailed deer immobilized with etorphine and xylazine remain fairly constant throughout the period of immobilization,⁹ which is what we found for an unexcited Père David's deer. However, rapid changes in the acid-base status occurred after administration of the antagonist. The respiration increased immediately and the A and B factors decreased, indicating a smaller deviation from normal pH and blood gas status.

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