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# Succinylcholine Chloride Immobilization of Black Bears

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## INTRODUCTION

Succinylcholine chloride is a potent relaxant of voluntary striated muscle but has little direct effect on smooth muscle. It has no anesthetic or pain-obliterating properties; therefore, immobilized animals remain completely conscious although unable to move. The duration of effect is quite brief because succinylcholine is rapidly destroyed by non-specific cholinesterases in the blood plasma and liver. Immobilization lasts five to 12 minutes in man and horses and somewhat longer in other species, with ruminants generally requiring longest recovery periods (Stowe *et al.* 1958).

Since the discovery of its curariform properties in 1949, succinylcholine has been widely used for immobilization of animals and in human surgical procedures. Several workers have used succinylcholine on bears (Black 1958, Knudsen 1959, Craighead *et al.* 1960, Troyer *et al.* 1961, Hornocker 1962, Mundy 1963, Pearson *et al.* 1968, Jonkel and Cowan 1971 and Mundy and Flook 1973).

Despite its common usage, the disadvantages of this drug and the factors that modify its effects are not well known. Certain of these aspects were investigated in the course of population studies of black bears (*Ursus americanus*) in the Upper Peninsula of Michigan during 1966 through 1968 and in northeastern Minnesota during 1969.

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## METHODS AND MATERIALS

For preliminary studies, three bears which were to be killed were confined in

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pens and used for comparative study of the effects of injection into different tissues and for evaluation of the dose-effect relationship. One of them, a 194 kg animal, was given nine equal doses (117 mg each) over a period of two weeks by means of projectile syringes equipped with 2.5 cm needles. Each dose was injected into a different area of the body, and the time from injection to collapse was noted. Entry points were marked by shaving the areas around them. After the bear was sacrificed, the entry points were dissected to determine the types of tissue into which each dose had been injected. In this way, the relationship between the type of tissue at the point of injection and time to onset of effects were learned.

To determine how responses varied with dosage, the two other bears were given injections that ranged from ineffective dosages (< 0.10 mg/kg) to lethal dosages (>2.0 mg/kg). These were administered intramuscularly at intervals of 24 hours or longer. Effects of each dose were recorded; following sacrifice of the bears, the entry points of the syringes were examined for subdermal tissue damage.

In field studies in Michigan, 191 immobilizations of black bears were accomplished by several methods. A pole-mounted syringe (Black *et al.* 1959) was used to inject 112 box-trapped and two treed bears. A syringe gun was used to inject 73 free-ranging bears (in garbage dumps or campgrounds) and four animals caught in leg-hold traps. Approximately twenty additional free-ranging bears escaped into heavy cover after being darted. Intramuscular injection was intended in all cases.

Doses generally were prepared from crystalline succinylcholine chloride (Anectine, Burroughs, Wellcome and Company) by dissolving 100 mg amounts into one ml of distilled water just prior to use, making a concentration of approximately 90.0 mg/ml. In a few cases, commercial solutions such as Sucostrin (E.R. Squibb and Sons Company, 20 mg/cc) or Quelicin (Abbott Laboratories, 25 mg/cc) were used. These solutions lose potency at a rate of about 3 percent per month at room temperature, so they were carried afield in an ice chest. A dosage of 0.75 mg of succinylcholine per kilogram of estimated bodyweight generally was given after experience showed that lower dosages often were insufficient. Immobilization was prolonged with sodium pentobarbital (Erickson 1957).

Data routinely recorded included sex, date, weight, dose, manner of delivery of drug, undesirable effects, and latent period. The terms *latency* or *latent period* were used to denote the time between injection and immobilization. Bears were considered to be immobilized when they were unable to stand. All bears were observed for at least an hour and then hidden in the brush. Recoveries were confirmed by examining release sites a day or two later.

The hearts of three bears (one from Michigan and two from Minnesota) that died during immobilization were examined macroscopically and compared with the hearts from six bears that were shot. The only data reported from the Minnesota study are mortality data.

## RESULTS

### Penned Animals

The effectiveness of succinylcholine injections in the 194 kg bear mentioned above varied with the vascularity of the tissue at the site of the injection (Table 1). Injections into muscle produced immobilization in approximately two

TABLE 1. SUMMARY OF NINE IMMOBILIZATION ATTEMPTS USING EQUIPONDERANT DOSES OF SUCCINYLCHOLINE INJECTED INTO DIFFERENT AREAS OF A 194 kg BEAR.*

| Injection number | Date | Site of Injection | Tissue Type | Response |
|---|---|---|---|---|
| 1 | 8-18 | rump | Entry hole not discernable | Latency 8 minutes |
| 2 | 8-21 | left shoulder | muscle | Latency 2 minutes, duration 38 min. |
| 3 | 8-23 | high on rump on midline | 10 cm of fat under skin | No visible effects |
| 4 | 8-24 | high on rump on midline | 10 cm of fat under skin | No visible effects |
| 5 | 8-26 | middle of side near last rib | 2.4 cm of fat under skin and covering 2 cm of muscle covering 7th rib | Latency 13 minutes, duration 73 min. |
| 6 | 8-28 | high on neck | 0.6 cm of skin and 0.9 cm of fat covering muscle | Latency 4 minutes, duration 100 min. |
| 7 | 8-29 | posterior side of upper hind leg | Dart bounced out upon discharging | No visible effects. Blood and drug ran out of entry hole. |
| 8 | 8-30 | side of chest behind shoulder | skin 0.5 cm, fat 1.2 cm, muscle 0.3 cm, fat 3 cm | Latency 8½ minutes, duration 52 min. |
| 9 | 9-1 | upper part of hind leg | 5 to 8 cm of fat | No visible effects. Dart bounced out and exact point of entry could not be found. |

*All injections were of 117 mg. (0.6 mg/kg) and were given by means of projectile syringes equipped with 2.5 cm needles.

minutes (Injection 2, Table 1), but injections of the same dosage into fat resulted in prolonged latent periods (Injections 5, 6 and 8, Table 1) or no visible effect (Injections 3 and 4, Table 1) depending upon the thickness of the fat. One dose (Injection 7, Table 1) that was injected into vascular tissue was washed out of the entry hole by blood, and no visible effects ensued.

Increasing the dosage in the other two penned bears resulted in only slightly and inconsistently reduced latent periods. The median latent period was two minutes and ranged from one to four minutes in 37 of the 40 successful immobilizations. Six injections failed to produce immobilization because they were injected into fat or were otherwise faulty. Two of these failures resulted when blood and drug ran out of holes that remained in the skin after projectile syringes discharged and fell away. In general, it appeared that latency was affected less by dosage than it was by the vascularity of the tissue into which the drug was injected. Peak immobilization and paralysis occurred within fifteen minutes of collapse at all dosages.

Dissection of punctures from projectile syringes revealed pockets in subcutaneous fat. These pockets, which varied in size according to the amount of solution injected, apparently were created by the explosive entry of drugs expelled from syringes by powder charges.

### Wild Bears in the Field

Extensive field studies in Michigan involved 191 immobilizations of 186 wild bears of both sexes representing various age and weight groups. Data from penned bears were not combined with data from wild bears.

### General Reactions to Injections

Most free-ranging bears ran for heavy cover after being struck by projectile syringes. They usually collapsed within $2\frac{1}{2}$ minutes but still were able to move their heads and bite for another minute or so. Respiratory muscles were the last to be affected and the first to recover.

Many bears in box traps already were lying down when succinylcholine chloride took effect. In these animals, transient muscle fasciculation, which often appeared as a wave-like rippling under the skin, and dropping of the head were taken as signs of adequate immobilization. Approximately 76 percent (84 of 111) of the trapped bears were immoblized with initial injections.

During peak immobilization, the thoracic component of respiration often was depressed; and respiration appeared to be accomplished mainly by abdominal movements which appeared to be diaphragmatic. In 21 (11 percent) of the 191 immobilizations, respiration was depressed to the point that artificial respiration was required to prevent death. Spontaneous respiration usually resumed within fifteen minutes of collapse; but in one case, artificial respiration was necessary for 55 minutes.

### Dosage

Dosage data suitable for analysis were obtained from 177 immobilization attempts. Nine attempts involved cubs and will be considered separately (see below). Data from the remaining 168 bears were divided into the following four response groups:

I. Bears not immobilized (n = 27; median dosage 0.55 mg/kg)

II. Bears immobilized and breathing adequately (n = 118; median dosage 0.80 mg/kg)

III. Bears requiring artificial respiration and recovering (n = 14; median dosage 1.0 mg/kg)

IV. Bears that died (n = 9; median dosage 1.2 mg/kg).

Data from males (112) and females (56) were subjected to Duncan's Multiple Range Test which indicated no significant differences in response due to sex.

Application of the same test showed that the dosages of groups I, II and III were significantly different from one another ($P < 0.05$), indicating that response was at least partially dependent upon dosage. Dosage differences between bears that required artificial respiration and recovered (Group III) and those that died (Group IV) were not significant after the datum from one bear accidentally given a triple dose (2.4 mg/kg) was deleted from Group IV. Groups II, III and IV include data from both trapped and free-ranging bears, but Group I includes data only from trapped bears.

Data for the 168 bears were used to construct dose-response curves (Marsh 1951) in which dosages were plotted against percentages of animals that were immobilized (Curve A, Fig. 1) or that died or experienced prolonged respiratory paralysis (Curve B, Fig. 1). (Death from apnea was prevented by artificial respiration, and 14 of the 23 animals comprising Curve B were revived.) The 20 free-ranging bears that escaped were not considered in construction of the dose-response curves; hence, the percentages indicated in Curve A should be regarded as maxima and actually could be as much as 9 percent lower if all of the 20 failed to become immobilized. Similarly, Curve B would be too low if

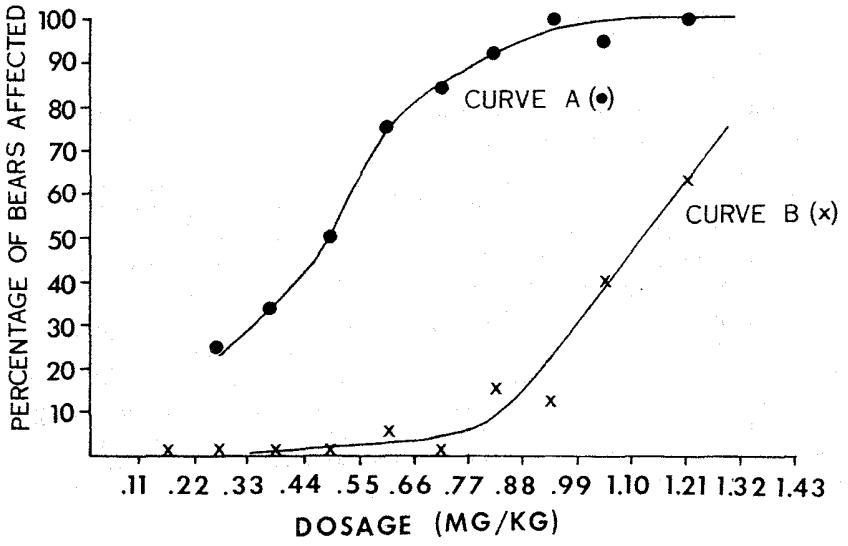


Fig. 1 Dose-response relationship of 168 wild bears to succinylcholine chloride. Curve A shows percentage of animals immobilized at each dosage. Curve B shows percentage that required artificial respiration or died at each dosage. A concentration of 90 mg/cc was used in most cases.

TABLE 2. RELATIONSHIP BETWEEN SUCCINYLCHOLINE DOSAGE AND NUMBER OF SUCCESSFUL IMMOBILIZATIONS WITH LATENCY LESS THAN 1 AND LESS THAN 2.5 MINUTES.

| Mg/kg | Number of Immobilizations | Number with latency less than 2.5 minutes | Number with latency less than 1 minute |
|---|---|---|---|
| 0.33 | 10 | 2 (20%) | 1 (10%) |
| 0.50 | 15 | 6 (40%) | 2 (12%) |
| 0.66 | 31 | 18 (60%) | 4 (13%) |
| 0.75 | 32 | 29 (90%) | 14 (45%) |
| 0.9 | 30 | 28 (92%) | 12 (40%) |
| 1.0 | 22 | 17 (80%) | 11 (50%) |
| 1.1 | 9 | 8 (88%) | 6 (67%) |
| 1.2 | 3 | 3 (100%) | 2 (67%) |
| 1.3 | 4 | 4 (100%) | 4 (100%) |

TABLE 3. RESULTS OF ADMINISTERING SUCCINYLCHOLINE CHLORIDE TO BLACK BEAR CUBS

| Date | Sex | Weight in kg | Dose (mg) | Mg/kg | Response |
|---|---|---|---|---|---|
| 6/29 | male | 7 | 18 | 2.6 | slightly ataxic |
| 6/29 | female | 7 | 18 | 2.6 | slightly ataxic |
| 7/28 | female | 9 | 18 | 2.0 | required artificial respiration for 6 min. |
| 7/28 | female | 9 | 14 | 1.6 | no effect |
| 8/9 | male | 10 | 10 | 1.0 | immobilized in 3 minutes |
| 8/9 | male | 11 | 12 | 1.1 | no effect |
| 8/12 | male | 14 | 4 | 0.3 | no effect |
| 8/14 | female | 11 | 18 | 1.6 | immobilized in 15 min.—injected into body cavity. |
| 8/14 | male | 14 | 18 | 1.3 | immobilized in 85 seconds |

any of the 20 bears died. However, bears that were able to run long enough to move beyond the area in which search efforts were concentrated probably did not die because long latent periods generally were associated with an absence of undesirable effects (see below).

Figure 1 indicates that respiratory paralysis and cardiac arrest were uncommon at dosages less than 0.75 mg/kg but were common among bears that received higher dosages. At a dosage of 1.1 mg/kg, approximately half of the animals required artificial respiration or died.