

Scott M. McCorquodale and Lester E. Eberhardt
Pacific Northwest Laboratory, P.O. Box 999, Richland, Washington 99352

and

Stephen E. Petron, Department of Zoology
Washington State University, Pullman, Washington 99164-4220

Helicopter Immobilization of Elk in Southcentral Washington

Abstract

Free-ranging elk (*Cervus elaphus*) are commonly immobilized for research or management by rifle-fired darts shot from a helicopter. Compounds used for this purpose have included succinylcholine chloride (succinylcholine), etorphine hydrochloride (etorphine), and xylazine hydrochloride (xylazine). To assess the efficacy of various immobilizing drugs used in helicopter applications, we darted 38 elk from a helicopter on the Arid Lands Ecology Reserve, Washington from 1983 to 1987. We used either succinylcholine, etorphine hydrochloride, or xylazine hydrochloride as primary immobilizants. Unsuccessful immobilizations were most common in elk darted with succinylcholine. Induction times were similar in elk darted with xylazine and etorphine and shortest in elk darted with succinylcholine. Yohimbine was used to reverse xylazine immobilizations. The use of xylazine and yohimbine provides an efficient, cost-effective alternative to etorphine, diprenorphine immobilization and reversal in elk while increasing handler safety. Etorphine appeared to be the best immobilizant when extended pain-producing procedures (such as surgical telemetry implantation) are planned because it induced the longest and deepest anesthesia. When the potential to lose contact with darted animals exists, we believe succinylcholine may be the preferred immobilizant because of rapid, spontaneous recovery.

Introduction

Darting from a helicopter is a common method used to capture elk for research purposes in North America (Jessup 1982), but most published data on immobilizing elk concern darting animals in a trap (Coggins 1975, Amstrup *et al.* 1982, Meuleman *et al.* 1984). An animal's degree of excitation can have a major effect on dosage required for chemical immobilization (Fowler 1978). Elk darted from a helicopter experience elevated muscular and physiological activity prior to injection in comparison to elk darted in a trap. Thus, immobilization data specific to helicopter applications are needed. Although several compounds have been used to immobilize elk from a helicopter (Hebert *et al.* 1982), physiological variation between study populations has complicated a comparison of the efficacy of various compounds and dosages.

Between 1983 and 1987, we used three different compounds to immobilize wild elk from a single population on the Arid Lands Ecology Reserve in south-central Washington using a helicopter. In this paper, we report results of our immobilizing efforts using three traditional compounds (or combinations) and one new combination.

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Methods

Adult elk were darted from a Hughes 500C helicopter using a Palmer Cap-Chur[®] long-range projector (use of trade names does not imply endorsement by the authors or sponsoring agency). Elk were immobilized with either liquid succinylcholine chloride (Sucostrin[®]) (0.09-0.14 mg/kg), a combination of etorphine hydrochloride (M99[®]) and acepromazine maleate (Acepromazine[®]) (0.02-0.04 mg/kg:0.02-0.03 mg/kg), a combination of etorphine and xylazine hydrochloride (Rompun[®]) (0.01-0.02 mg/kg:0.35-0.55 mg/kg), or xylazine alone (1.4-1.5 mg/kg). Etorphine-induced immobilizations were reversed with diprenorphine hydrochloride (M50-50[®]) (2x M99 dose). Xylazine effects were reversed with yohimbine hydrochloride (Antagonil[®]) (0.15-0.20 mg/kg) whether xylazine was administered alone or in conjunct

with etorphine. Succinylcholine-immobilized elk recovered spontaneously.

Failed immobilizations were those in which darted elk did not become recumbent. We could not differentiate dart malfunction from dosage inadequacies. Elk darted with succinylcholine were followed for 30-35 min before the attempt was aborted. Elk darted with etorphine were monitored for approximately 90 min before an attempt was judged to have failed.

Induction times were compared using a Kruskal-Wallis test and non-parametric multiple comparisons (Conover 1971:231).

Costs per immobilized elk were calculated by adding drug costs to helicopter time. Helicopter time was calculated as induction times plus time used monitoring failed immobilizations (following darted elk until attempt was judged to have failed). We used a rate of \$350/hr for helicopter costs. Time required to dart elk was assumed to be the same regardless of compound used and was not included in cost estimates. These costs do not represent the true costs of capturing an elk, since most helicopter time is spent flying to and from study areas and locating target animals. They do, however, represent relative costs associated with each immobilizing compound.

Results and Discussion

Thirty-eight elk were darted from a helicopter (Table 1). Failed immobilizations were most common in elk darted with succinylcholine (N = 24). Three failures were associated with one batch of succinylcholine and may represent degraded drug (100% of attempts with this batch), and one

failure was probably due to a frozen dart. Regardless, the dependability of immobilizations using this compound was lowest. Succinylcholine is known to be degraded by exposure to light and heat (Fowler 1978). Only one failed immobilization occurred using etorphine (N = 11). None of the classic signs associated with etorphine induction were noted in this case, and we suspect dart malfunction. No failed immobilizations were noted in our use of xylazine alone (N = 3).

Induction times were significantly shorter in elk darted with succinylcholine than in elk darted with etorphine or xylazine ($P < 0.01$) (Table 1). Induction times were not significantly different between elk darted with etorphine or xylazine ($P > 0.25$). Elk darted with only xylazine became sedentary within 10 min even though they did not become recumbent for 15-20 min. One elk darted with xylazine became sternally-recumbent within 10 min but was not tractable for 40-60 min. The duration of immobilization averaged 36 min in succinylcholine-immobilized elk. The period of immobilization was controlled by antagonist administration when using etorphine and xylazine.

Our results with etorphine suggest that the total dose of additional tranquilizer may be more crucial to optimal immobilizations than the etorphine dose. Given volume restrictions in rifle-fired darts, we found it most effective to reduce etorphine volume while increasing xylazine volume. Four mg of etorphine were quite effective when coupled with 100-150 mg of xylazine. The temptation to assume that a maximum etorphine dose is critical to effective immobilization

TABLE 1. Results of helicopter darting on the Arid Lands Ecology Reserve, Washington, 1983-87. Values given are mean \pm 1 SE (range).

Immobilant	Dose [mg/elk]	No. of Immobilizations		Induction (min)	Duration of Immobilization (min)	Reversal Agent	Time to Recovery (min)
		Succeeded	Failed (%)				
Succinylcholine	24.7 (23-26)	13	11(46)	8.7 \pm 0.6 (5-12)	36.1 \pm 6.1	none	—
Etorphine/ Acepromazine	6.3:4.5 (6-6.8)*	4	1(20)	37.8 \pm 17.7 (12-90)	—	Diprenorphine	6.8 \pm 2.6
Etorphine/ Xylazine	4.2:130 (3-5)	6	0	20.5 \pm 3.1 (10-31)	—	Diprenorphine/ Yohimbine	9.4 \pm 2.8
Xylazine	380 (350-400)	3	0	32.0 \pm 15.4 (14-63)	—	Yohimbine	4.0 \pm 1.2

*One elk required a second dose of 3.0 mg etorphine before it became tractable (total dose = 9.8 mg).

should be avoided. The shorter induction times associated with a liberal dose of xylazine reduced helicopter time and the risks of hyperthermia to etorphine-immobilized elk. Elk darted with etorphine/xylazine also tended to be more tractable than elk darted with etorphine/acepromazine. The heavy xylazine dose is especially favored since a xylazine reversal agent (yohimbine) has become available (application for FDA licensing has recently been submitted).

While our sample of elk darted with xylazine alone was small, results were consistent. Two of the three elk darted were large bulls; thus, this method appears to be promising even when darting large elk. Previously, delayed recovery detracted from the utility of xylazine-alone immobilization in elk. However, the availability of a xylazine antagonist now appears to eliminate this problem. Recovery following administration of yohimbine was dramatic and rapid. Elk typically stood on their initial attempt, and none returned to recumbency. Recovery tended to be more rapid and complete than that reported by Jessup *et al.* (1983) in mule deer (*Odocoileus hemionus*). One elk was seen four hours after immobilization approximately 11 km from the capture site, suggesting that re-narcosis did not occur. We obtained similar results with xylazine/yohimbine and etorphine/diprenorphine. However, drug costs and risks to crew from the immobilizing compound were reduced with xylazine (very low doses of etorphine can be fatal to humans [Parker and Haigh 1982]). The latter can be important since wildlife captures are often conducted in remote places, far from professional medical help.

We did not note any drug-related mortalities when using these compounds, and no post-capture complications were noted in elk immobilized during the study. Xylazine and etorphine appear to have a high Therapeutic Index (lethal dose/effective dose) in elk. Succinylcholine may produce apnea at high doses (Fowler 1978), but we recorded no instances at the doses we used.

The cost per immobilized elk was lowest using xylazine alone (\$106/elk) and etorphine/xylazine (\$153/elk), intermediate in elk darted with succinylcholine (\$199/elk), and highest in elk

darted with etorphine/acepromazine (\$412/elk). Succinylcholine was the most inexpensive compound, but helicopter time associated with failed immobilizations inflated the cost per captured elk.

Based on our limited experience, we believe the use of xylazine and its antagonist, yohimbine, is a promising solution to maximizing immobilization efficiency and drug-related personnel safety, while minimizing the costs associated with darting elk from a helicopter. Etorphine is a useful compound when combined with xylazine, but clearly represents a substantial safety risk to darting crews. Etorphine is favored if surgical procedures are planned, since etorphine produces a more complete analgesia than xylazine. Succinylcholine has utility in helicopter applications when short inductions and downtimes are desired, although the experience is clearly more stressful to elk than immobilization with xylazine or etorphine. Succinylcholine may be particularly useful when darting elk in areas where loss of contact with darted animals is a distinct possibility. The rapid and spontaneous recovery of succinylcholine-immobilized elk would likely minimize the risk of mortality to elk which are darted but escape before they can be handled.

We did not note sex-specific dose differences with xylazine or etorphine. Since it is difficult to estimate weights of elk when they are running in front of a helicopter, it is more practical to load darts by total doses. We suggest a xylazine dose of 400 mg or a combined dose of 4-5 mg etorphine and 100-150 mg xylazine for either sex of adult elk when darting from a helicopter. The antagonists diprenorphine and yohimbine should be administered intravenously for the best effect and to avoid local tissue damage associated with large intramuscular injections. Bull elk seemed to require slightly larger doses of succinylcholine than cows. Our elk were in extremely good condition (average estimated weight = 255 kg). We recommend succinylcholine doses of 23-25 mg for cows and 25-27 mg for bulls in similar condition. Vials from at least 2 different, recent succinylcholine batches should be taken to the field. Loaded succinylcholine darts and spare vials should be kept cool and shielded from light.

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