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Source: Journal of Wildlife Diseases, 36(4) : 670-675

Published By: Wildlife Disease Association

URL: https://doi.org/10.7589/0090-3558-36.4.670

Journal of Wildlife Diseases, 36(4), 2000, pp. 670–675

ANESTHESIA IN FEMALE WHITE-TAILED DEER USING TELAZOL® AND XYLAZINE

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ABSTRACT: Thirty two free-ranging female white-tailed deer (*Odocoileus virginianus*) were anesthesized with varying Telazol® and xylazine HCl combinations in Front Royal (Virginia, USA) between August 1992 and September 1992. All animals were caught in baited box traps, manually restrained, and hand injected with a combination of Telazol and xylazine administered intramuscularly. Deer received mean ± SE dosages of 2.53 ± 0.16 mg/kg Telazol and 0.69 ± 0.05 mg/kg of xylazine. These dosages achieved a rapid and effective anesthetic plane for short-term procedures such as weighing, blood collection, and translocation. Eight of 32 deer (25%) required an intravenous (i.v.) supplement of ketamine HCl (100 mg) to maintain a safe plane of anesthesia. Ketamine supplementation provided an average of 11.8 ± 2.0 min additional safe handling. Satisfactory reversals were achieved in all deer by administering yohimbine HCl 16 mg i.v. (dose range, 0.22 to 0.48 mg/kg) to all animals.

Key words: Anesthesia, ketamine, *Odocoileus virginianus,* Telazol®, white-tailed deer, xylazine, yohimbine.

INTRODUCTION

Numerous reports have described the use of Telazol®, ketamine HCl and xylazine HCl for anesthetizing cervids (Jessup et al., 1983; Hsu and Shulaw, 1984; Mech et al., 1985; Del Giudice et al., 1989; Schultz et al., 1991; Millspaugh et al., 1995; Wallingford et al., 1996). Telazol, a 1:1 mixture of tiletamine HCl and zolazepam HCl, is desirable as a wildlife anesthetic because it is effective at small volumes, has a wide margin of safety, and produces smooth and rapid anesthetic inductions. However, prolonged and rough recoveries are common when Telazol is used as a sole anesthetic agent (Millspaugh et al., 1995; Lin, 1996). Ketamine, a cyclohexamine, has been used as a sole anesthetic agent in numerous species, but volume restrictions often preclude its use for darting procedures, and ketamine can induce excessive muscle rigidity and violent recoveries (Lin, 1996). Xylazine used alone has a wide margin of safety, but has been associated with prolonged inductions, unreliable immobilizations (especially in stressed or excited animals), and at high dosages, rumen stasis, apnea, and bradycardia (Jacobsen, 1983; Hsu and Shulaw, 1984; Jessup et al., 1985; Wallingford et al., 1996).

Despite the limitations of these drugs as sole anesthetic agents, their use in combination can provide satisfactory anesthesia. For example, xylazine in combination with either Telazol or ketamine reduces the requirement of the primary immobilizing agent, enhances muscle relaxation and duration of effect, and has been associated with faster and smoother inductions and smoother recoveries (Lin, 1996). Ketamine-xylazine (Jessup et al., 1983; Mech et al., 1985; Kreeger et al., 1986; Del Giudice et al., 1989) and Telazol-xylazine (Schultz et al., 1991; Millspaugh et al., 1995) combinations have been reported in several cervid species. Ketamine (4.8 mg/kg, range = 3.3–6.8 mg/kg) in combination with xylazine (1.6 mg/kg, range = 1.1–2.3 mg/kg) was safe and effective for use in white-tailed deer, but resulted in fairly long inductions times ($\bar{x}$ ± SE = 12.1 ± 4.3 min, Kreeger et al., 1986). Telazol (2.5 ± 0.6 mg/kg) and xylazine (0.3 ± 0.1 mg/kg) provided shorter inductions times (4.6 ± 0.8 min) while maintaining a safe plane of anesthesia in trapped Rocky Mountain Elk (*Cervus elophus*; Millspaugh et al., 1995).

Standardized dosages of combined Telazol and xylazine have also been used in captive white-tailed deer (*Odocoileus virginionus*) (Telazol dose range = 83–250 mg; xylazine dose range = 100–300 mg), but the failure to report body weights precluded expression of drug dosages on a mg/kg basis (Schultz et al., 1991). The present study was designed to test varying dosages of Telazol (dose range = 75–150 mg) and xylazine (dose range = 10–50 mg) for efficacy in achieving rapid, effective, and easily reversible anesthesia in box-trapped white-tailed deer.

MATERIALS AND METHODS

This study was conducted at the Conservation and Research Center (CRC); Front Royal, Virginia, USA; (38°55′N, 77°0′W) between August 1992 and September 1992. Thirty-two adult female white-tailed deer inhabiting a 600 ha forested portion of the CRC were caught in baited box traps, manually restrained and hand-injected with a combination of Telazol (Fort Dodge Laboratories, Inc., Fort Dodge, Iowa, USA) and xylazine HCl (Rompun®, Mobay Corporation, Shawnee, Kansas, USA). Animals captured in box traps overnight were anesthetized between 0800–1100 hr; box traps were reset during mid-afternoon (approximately 1400 hr) and monitored until 1900 hr. Thus, all anesthetic procedures were conducted in the morning (0800–1100 hr) or late afternoon (1600–1900 hr), and only when ambient temperatures fell within prescribed limits (15–37 C).

Following injection, animals were released into box traps until they were safe to handle. The time in minutes from the initial anesthetic injection until the onset of clinical signs (i.e., stumbling, wide-stance gait, standing immobile with head down) was defined as "onset", whereas the time from anesthetic injection to safe handling of animals was defined as "induction". The time from yohimbine administration to when the animal stood was defined as the "up" time, and "procedure" was defined as the time from induction to yohimbine administration. Onset, induction, procedure, and up times were measured on all animals, and physiological data (body weight, heart rate (HR), respiratory rate (RR), oxygen saturation (SpO_2), and rectal temperature (TEMP) were collected within 10 to 20 min of induction from all animals in order to assess cardiopulmonary function as well as depth of anesthesia. Anesthetized deer were suspended in a net attached to a portable spring-loaded scale to measure body weight. Oxygen saturation was measured using a Nellcor pulse oximeter (N-200 Pulse Oximeter, Nellcor Incorporated, Pleasanton, California, USA).

In some cases, animals required supplemental intravenous (i.v.) injections of ketamine HCl (100 mg) to maintain a safe plane of anesthesia. Yohimbine HCl (Sigma Chemical Company, St. Louis, Missouri, USA) doses of 16 mg i.v. were administered to antagonize the effects of xylazine. All drug dosages are listed as mean ± standard error. Because data were not normally distributed, Spearman's rank-order correlations were performed to determine the correspondence between initial anesthetic dosages (Telazol and xylazine, both mg/kg) and onset, induction, and up times. One-way ANOVA of log-transformed anesthetic dosages was used to compare initial Telazol and xylazine dosages in ketamine-supplemented and non-ketamine-supplemented deer. Statistical significance was determined at $P < 0.05$. The JMP statistics program (version 3.1) was used for all statistical tests (SAS Institute, Cary, North Carolina, USA).

This study was originally designed to evaluate specific, predetermined Telazol and xylazine combinations to be administered irrespective of inter-animal differences in body weight. Animals received 1 of 3 Telazol dosages (75, 100, or 150 mg) in combination with 1 of 5 xylazine dosages (10, 20, 30, 40, or 50 mg). However, retrospective evaluation of drug dosages adjusted for body weight (i.e., mg/kg dosages) revealed no statistical differences among presumptive treatment groups. Thus, all anesthetic treatments were combined post-hoc for the purposes of subsequent analysis and discussion.

RESULTS

The 32 deer caught in box traps received mean dosages of 2.53 ± 0.16 mg/kg Telazol and 0.69 ± 0.05 mg/kg of xylazine. Mean onset time was 2.8 ± 0.2 min, with a mean induction time of 5.7 ± 0.6 min. Procedure length was 32.4 ± 1.9 min, and mean up time was 8.5 ± 2.5 min. All deer maintained acceptable cardiopulmonary function and physiological data are listed in Table 1. Eight of the 32 (25 %) deer in this group required an i.v. ketamine (100 mg) supplement; six deer received a single supplement and two deer received two supplements.

TABLE 1. Drug dosages, effects and physiological parameters of anesthetized female white-tailed deer.

Animal number	Telazol® (mg)	Telazol (mg/kg)	Xylazine (mg)	Xylazine (mg/kg)	T : X[a]	Weight (kg)	Ketamine supplement[b]	Yohimbine (mg)	Yohimbine (mg/kg)	Onset (min)	Induction (min)	Procedure (min)	Up (min)	TEMP (C)	HR (b/min)[d]	RR (b/min)[e]	SpO_2 (%)
1	75	1.46	10	0.19	7.50	51.5	+, +	16	0.31	5	9	35	2	37.1	110	24	93
2	75	1.47	10	0.20	7.50	51.0	+	16	0.31	2	14	36	7	37.0	86	32	97
3	75	1.70	20	0.45	3.75	44.0		16	0.36	2	4	57	2	37.6	64	18	94
4	75	1.60	20	0.43	3.75	47.0		16	0.34	4	7	30	2	37.0	75	12	86
5	75	1.81	30	0.72	2.50	41.5		16	0.39	4	6	20	5	35.8	41	16	95
6	75	1.70	30	0.68	2.50	44.0		16	0.36	2	6	25	6	36.6	51	16	90
7	75	1.46	40	0.78	1.88	51.5		16	0.31	—[c]	4	21	4	37.4	88	16	97
8	75	1.53	40	0.82	1.88	46.0	+	16	0.33	2	5	45	7	38.3	64	12	92
9	75	1.85	50	1.23	1.50	40.5		16	0.40	3	4	40	7	38.0	60	16	90
10	75	1.52	50	1.01	1.50	49.5		16	0.32	—[c]	5	24	8	37.2	65	12	98
11	100	2.41	10	0.24	10.0	41.5	+	16	0.39	2	5	27	5	37.1	89	12	99
12	100	2.47	10	0.25	10.0	40.5	+, +	16	0.40	3	4	30	4	40.0	93	20	89
13	100	2.90	20	0.58	5.00	34.5	+	16	0.46	3	5	50	1	40.8	86	24	86
14	100	1.72	20	0.34	5.00	58.0		16	0.28	3	8	29	1	39.3	86	18	95
15	100	2.00	30	0.60	3.33	50.0	+	16	0.32	5	18	20	10	37.6	67	8	84
16	100	2.78	30	0.83	3.33	36.0		16	0.44	2	4	30	3	38.2	100	40	85
17	100	2.63	30	0.80	3.33	37.5		16	0.43	2	6	43	—[c]	37.3	48	16	85
18	100	2.00	30	0.60	3.33	50.0	+	16	0.40	6	8	—[c]	1	—[c]	—[c]	—[c]	—[c]
19	100	2.24	40	1.10	2.50	36.5		16	0.44	—[c]	4	25	11	36.9	77	19	84
20	100	2.22	40	0.89	2.50	45.0		20	0.36	2	4	24	55	38.1	80	16	81
21	100	2.27	50	1.14	2.00	44.0		16	0.36	2	7	38	54	36.9	64	20	87
22	100	3.96	50	0.98	2.00	51.0	+	16	0.31	2	4	40	12	39.6	96	16	88
23	150	3.66	10	0.24	15.0	41.0		16	0.39	—[c]	4	30	3	39.0	77	12	93
24	150	4.55	10	0.30	15.0	33.0		16	0.48	3	5	21	3	35.8	72	16	100
25	150	4.23	20	0.56	7.50	35.5		16	0.45	2	9	34	4	40.3	96	54	96
26	150	3.85	20	0.51	7.50	39.0		16	0.41	2	3	28	22	38.8	100	30	90
27	150	3.66	30	0.73	5.00	41.0		16	0.39	4	4	20	7	38.2	90	12	88
28	150	3.06	30	0.61	5.00	49.0		16	0.33	2	3	44	—[c]	36.3	76	16	75
29	150	3.75	40	1.00	3.75	40.0		16	0.40	3	3	20	—[c]	37.4	72	8	83
30	150	3.70	40	0.99	3.75	40.5		16	0.40	2	4	48	4	38.9	80	16	81
31	150	2.83	50	0.94	3.00	33.0		16	0.30	2	4	25	5	37.7	90	16	70
32	150	3.37	50	1.12	3.00	44.5		16	0.36	3	4	45	2	39.2	76	12	86
Mean		2.53		0.69		44.0			0.38	2.80	5.70	32.4	8.50	37.90	80.8	18.5	88.9
± SE		0.16		0.05		1.2			0.01	0.02	0.06	1.9	0.25	0.22	2.8	1.7	1.1

As Telazol and xylazine dosages increased, induction times decreased (Telazol, $r_s = -0.424$, $P = 0.02$; xylazine, $r_s = -0.466$, $P = 0.009$). Although there was no significant correlation between initial Telazol dosage and up time, up times were extended as xylazine dosages increased ($r_s = 0.408$, $P = 0.025$). Up times were also significantly correlated to yohimbine dosages ($r_s = -0.403$, $P = 0.027$). Initial xylazine (0.50 ± 0.01 mg/kg; $F = 6.81$, degrees of freedom (df) = 31, $P = 0.014$), but not Telazol (2.02 ± 0.17 mg/kg; $F = 2.35$, df = 31, $P = 0.135$), dosages were significantly lower in ketamine-supplemented deer compared to non-ketamine-supplemented animals (Telazol, 2.72 ± 0.19 mg/kg; xylazine, 0.76 ± 0.06 mg/kg). Procedure length was not extended significantly ($F = 0.91$, df = 29, $P = 0.347$) in ketamine-supplemented deer (35.4 ± 3.6 min) compared to non-ketamine-supplemented deer (31.3 ± 2.1 min).

DISCUSSION

The mean Telazol, xylazine, and yohimbine dosages used in this study provided safe, rapid and effective anesthesia for short-term procedures with successful reversal in female, box-trapped white-tailed deer. The relatively rapid onset and induction times recorded in the present study may have been related to factors including sex, age, and capture technique. All deer in this study were female, and ages were not determined. However, the capture technique, along with the resultant demeanor of the deer, is likely to have a large impact on the dosages of anesthetic agent required, as well as the rate of induction. In general, box-trapped deer were fairly quiet and calm prior to anesthetic administration and calmed down quickly after their release back into the box trap. In contrast, darted animals often become alarmed or excited during darting procedures, which can result in increased induction times, and may require higher dosages of anesthetic agents to achieve similar results. For example, alarmed black-tailed deer required about twice as much xylazine as calm deer to achieve similar results (Jacobsen, 1983), and excited mule deer required increased anesthetic dosages to achieve satisfactory anesthesia (Del Giudice et al., 1989).

In the present study, at low dosages, Telazol generally provided rapid and smooth anesthetic inductions, and satisfactory reversals. Marginally increased Telazol dosages hastened induction without prolonging up times. However, as Telazol dosages approached 4.5 mg/kg, little improvement in induction times was noted, and a non-significant trend towards longer recovery times was observed. This result was expected since increased Telazol dosages have been associated with prolonged recoveries in several species (Van Heerden et al., 1991; Lin, 1996). Thus, the authors recommend dosages of Telazol less than, or equal to, 4.5 mg/kg for use in box-trapped white-tailed deer.

Although it was not possible to identify an optimal dosage for xylazine, no adverse physiological side effects were noted at the range of dosages employed in the present study (0.19 to 1.23 mg/kg). Increased xylazine dosages were associated with decreased induction times and slightly prolonged recoveries. The decrease in induction times was anticipated, but xylazine dosages were not expected to effect up times. This increase in up times is most likely due to incomplete antagonism of xylazine by sub-optimal yohimbine dosages

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[a] T : X = Telazol to Xylazine ratio.
[b] + = received intravenous Ketamine supplement, blank indicates did not receive Ketamine supplement.
[c] — = not recorded.
[d] Beats per minute.
[e] Breaths per minute.

since the prolonged up times were also significantly related to decreasing yohimbine dosages. Indeed, there are several reports of much higher dosages of xylazine being used without ill effect (Schultz et al., 1991; Millspaugh et al., 1995). Xylazine dosages up to 0.3 mg/kg, used in combination with 2.5 mg/kg Telazol were reported to be safe and effective in Rocky Mountain Elk (Millspaugh et al., 1995), and no negative side effects were reported following absolute doses of 100 and 200 mg xylazine in combination with varying amounts of Telazol in white-tailed deer (Schultz et al., 1991). Xylazine doses as high as 2.8 mg/kg were associated with respiratory depression and bradycardia in white-tailed deer (Hsu and Shulaw, 1984), but dosages up to 8 mg/kg did not cause mortality in captive white-tailed deer (Roughton, 1975). In summary, xylazine appears to have a wide margin of safety with anesthetic effects that are dose-dependent. Further studies will be needed to determine optimal dosages of xylazine in white-tailed deer under a variety of capture conditions.

The need for ketamine supplementation was related to the initial xylazine dosages. Initial xylazine dosages in non-ketamine supplemented deer were higher than the xylazine dosages in deer that required anesthetic supplements. This finding was expected, since xylazine produces dose-related analgesia and sedation. Therefore, lower dosages were expected to have less effect. Ketamine also produces dose-related analgesia, and intravenous doses of 0.1 to 2.0 mg/kg can extend unconsciousness from 1.5 to 10 minutes; recovery is achieved through rapid redistribution in tissues (Lin, 1996). In this study, a 100-mg intravenous bolus (dose range = 1.62 mg/mg to 3.39 mg/kg) successfully prolonged anesthesia by an additional 11.8 ± 2.0 min. Rapid onset, profound effect, relatively short duration of action and rapid recovery made intravenous ketamine a suitable anesthetic supplement to Telazol/zylazine anesthesia in white-tailed deer.

Yohimbine, an alpha 2 adrenergic receptor antagonist, has been used in numerous anesthetic protocols to reverse the effects of xylazine (Jessup et al., 1983; Hsu and Shulaw, 1984; MacKintosh and Van Reenen, 1984; Jessup et al., 1985; Mech et al., 1985; Schultz et al., 1991; Millspaugh et al., 1995; Wallingford et al., 1996). Although yohimbine can be given both intravenously or intramuscularly, the intravenous route tends to provide a more rapid recovery; treatment efficacy varies with dosage (MacKintosh and Van Reenan, 1984; Lin, 1996). The recommended dose for most mammals is 0.125 mg/kg, however higher dosages are safe and have been reported to be more effective in reversing xylazine sedation in white-tailed deer (Mech et al., 1985; Kreeger et al., 1987). For example, in one study 0.125 mg/kg yohimbine was administered to white-tailed deer to antagonize the effects of xylazine, but several animals demonstrated residual sedation (Kreeger et al., 1987). Such residual sedation was not noted in xylazine-sedated white-tailed deer that received 2–3 times the recommended yohimbine dosage (range = 0.25 to 0.53 mg/kg; Mech et al., 1985). Absolute yohimbine dosages as high as 48 mg have been used in white-tailed deer without negative effects (Schultz et al., 1991). In the present study, increased yohimbine dosages (range = 0.22 to 0.48 mg/kg) were correlated to more rapid recoveries providing further evidence of greater efficacy of yohimbine at higher than recommended dosages.

Telazol : xylazine ratios in this study ranged from 1.5:1 to 15:1 and an optimal ratio was not identified. However, Telazol dosages up to 4.5 mg/kg were highly effective for achieving rapid and smooth induction without prolonged recoveries. Future studies are needed to determine optimal xylazine dosages, and to determine if increased xylazine (relative to Telazol) provides for superior anesthesia. The highest xylazine dosage used in this study (1.23 mg/kg) was not associated with any ad-

verse physiological side effects. Other studies have reported the safe use of higher dosages of xylazine in white-tailed deer up to 2.8 mg/kg when respiratory depression was noted (Hsu and Shulaw, 1984). Thus, we speculate that optimal xylazine dosages would likely be greater than 1.23 mg/kg and probably less than 2.8 mg/kg. Therefore, optimal Telazol : xylazine ratios are likely to be less than 4.5:1.23 (3.4:1) and most likely greater than 4.5:2.8 (1.6:1). These figures are consistent with another white-tailed deer study that recommended Telazol : xylazine ratios in the range of 1:1 to 2:1.

ACKNOWLEDGMENTS

The authors would like to thank N. Wielebnowski for her assistance with statistical analysis.

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Received for publication 12 November 1999.