EVALUATION OF DEXMEDETOMIDINE WITH TILETAMINE-ZOLAZEPAM FOR SNOW LEOPARD (PANTHERA UNCIA) IMMOBILIZATION

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Evaluation of Dexmedetomidine with Tiletamine-Zolazepam for Snow Leopard (*Panthera uncia*) Immobilization

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ABSTRACT: This study describes two different doses of dexmedetomidine combined with tiletamine-zolazepam (TZ) for anesthesia in snow leopards (*Panthera uncia*). A total of 11 adult snow leopards were anesthetized in Xining City, Qinghai Province, China from November 2019 to June 2023. We recorded the onset time, anesthesia duration, head-up time, and walking time. Vital signs were recorded every 5 min during anesthesia. Arterial blood gas analysis was performed approximately 20 min after the onset of anesthesia by collecting blood from the femoral artery. All results were presented as mean±SD. There were no significant differences in onset time, anesthesia duration, head-up time, and walking time between the two anesthesia protocols. Heart rate, respiratory rate, body temperature, and blood pressure had a gradual decreasing trend, and blood oxygen saturation gradually increased. Our results suggest that using dexmedetomidine at doses of 21.25±1.38 μg/kg to 30.95±1.13 μg/kg combined with TZ at 2.07±0.08 mg/kg to 2.13±0.15 mg/kg can provide safe and effective anesthesia for snow leopards.

Key words: Anesthesia, dexmedetomidine, *Panthera uncia*, snow leopard, tiletamine-zolazepam, wildlife medicine.

INTRODUCTION

There are an estimated 4,678–8,745 snow leopards (*Panthera uncia*) in the wild (McCarthy et al. 2016), and the International Union for Conservation of Nature currently considers snow leopards to be a vulnerable species (McCarthy et al. 2017). As part of the effort to protect snow leopard populations, chemical immobilization is sometimes needed to facilitate physical examination, semen collection, and the placement of satellite collars. Compared with domestic animals, the risks and challenges of anesthetizing wild animals in the field are greater (Arnemo et al. 2006). Capture and anesthesia of wild animals may affect their physiologic functions, behavior, reproductive success, and hunting skills (Laurenson and Caro 1994; Cattet et al. 2008; Neumann et al. 2011; Afonso and Reis 2012). Reported anesthesia protocols for snow leopards include medetomidine and ketamine (Jalanka 1989a); xylazine and ketamine (Jalanka 1989b); and medetomidine and tiletamine-zolazepam (TZ; Johansson et al. 2013). Use of dexmedetomidine and TZ has been reported in snow leopards (Yu et al. 2022); however, the primary aim of that study was to investigate the activity patterns of snow leopards by placing satellite tracking collars on them, without assessing the efficacy of this anesthesia protocol.

Tiletamine-zolazepam is an anesthetic drug combination widely used in felids because of its short induction time and prolonged duration of action (West et al. 2014). It is composed of tiletamine (a dissociative anesthetic that is an *N*-methyl-D-aspartate receptor antagonist) and the benzodiazepine tranquilizer zolazepam (De la Peña and Cheong 2016). Its side effects can include increased salivation, hypothermia, and vomiting (Plumb 2008), and ataxia and involuntary muscle twitching during the recovery process (Kucharski and Kiełbowicz 2021). Ataxia also has been reported in black bears recovering from TZ anesthesia, but this side effect was not seen when dexmedetomidine was used combined with TZ (Coltrane et al. 2015). Dexmedetomidine, an α2 adrenergic receptor agonist, acts by activating both presynaptic and postsynaptic α2 adrenergic receptors within the central nervous system. This mechanism induces the hyperpolarization of adrenergic neurons, initiates inhibitory feedback loops, and diminishes the release of norepinephrine, resulting in antisympathetic effects (Bekker and Sturaitis 2005; Giovannitti et al. 2015). Dexmedetomidine causes sedation and analgesia. It has been widely used in small animal clinical settings, and its application in wildlife has increased (Grimm et al. 2015). It is the active, dextro, enantiomer of the widely used α2 adrenergic receptor agonist medetomidine, which is a racemic mixture of two equal proportions optical isomers, levomedetomidine and dexmedetomidine; the levo enantiomer of medetomidine is considered pharmacologically inactive, and therefore the potency of dexmedetomidine is approximately twice that of medetomidine (Plumb 2008; West et al. 2014). The combination of dexmedetomidine and TZ has been safely, effectively, and reversibly used in wild giant pandas (*Ailuropoda melanoleuca*; Jin et al. 2016), captive Siberian tigers (*Panthera tigris*; Hu et al. 2021), and black bears (*Ursus americanus*; Coltrane et al. 2015).

The objective of our study was to evaluate whether two combinations of dexmedetomidine and TZ could provide a practical and safe anesthesia protocol for snow leopards, and to provide data to support anesthesia in other large wild felids.

MATERIALS AND METHODS

Experimental animals and identification numbers

The study was conducted from November 2019 to June 2023 in Qinghai-Tibet Plateau Wild Zoo and the Qilian Mountain Nature Reserve in Qinghai Province, China, with a mean elevation of 2,261 m. The mean temperature in the zoo enclosures ranged from 10 C to 2 C, whereas the Qilian Mountain Nature Reserve mean temperature ranged from −23 C to 5 C. The animals included seven captive snow leopards housed at Qinghai-Tibet Plateau Wild Zoo, two rescued wild snow leopards, and two wild snow leopards captured in the Qilian Mountain Nature Reserve. The seven captive snow leopards were anesthetized eight times, designated as animals 1, 2, 3, 4, 5a, 5b, 6, and 7; snow leopard 5 was anesthetized twice with 1 mo between anesthetic events, designated as 5a and 5b. Six anesthesia procedures involved semen collection aimed at examining semen quality, and two were for routine physical examinations. The two rescued snow leopards had physical examinations performed at the zoo; these animals were designated as 8 and 9. The two wild snow leopards had physical examinations performed and were fitted with satellite collars; they were designated as 10 and 11. In total, there were seven males and four females, ranging in age from 9 to 21 yr old. The age of the wild snow leopards could not be determined precisely, but based on size and tooth wear they were considered to be adults (Stander 1997).

Anesthesia protocol

For routine examinations of snow leopards, a combination of 20 μg/kg dexmedetomidine (Dexdomitor, 500 μg/mL, ShuoTeng Co., Ltd., Taiwan, China) and 2 mg/kg TZ (Zoletil, 250 mg/vial, Virbac Co., Ltd., Carpentras, France) was administered via intramuscular injection using a 3-mL dart with a 1.5 × 38-mm needle (Dan-Inject ApS, Kolding, Denmark) using a blowpipe (Blow180, Dan-Inject). For snow leopards requiring semen collection, a combination of 30 μg/kg dexmedetomidine and 2 mg/kg TZ was used with the same delivery equipment. Dosages were calculated based on the estimated weight of the snow leopard. Atipamezole (Antisedan, 5 mg/mL, ShuoTeng) at 10 times the dexmedetomidine dose was given intramuscularly to reverse the dexmedetomidine.

Captive and rescued snow leopards (n=9) were confined to their enclosures before anesthesia. Wild snow leopards (n=2) were captured using trap cages (2 × 0.8 × 0.8 m, constructed of 6 × 6-cm welded iron–wire mesh), fasted overnight in the cage, and anesthetized the next day. All animals were fasted for 8 h before anesthesia. The injection site was the muscles of the thigh and shoulder. The injection time was recorded; the time when the animal showed no response to stimuli was defined as the onset time of anesthesia. The body weights of the captive snow leopards were measured using a platform scale (ZF8003, Suzhou Zhengfeng Electronic Technology Co., Ltd., Jiangsu, China); the body weights of the wild snow leopards were measured using a high-precision hanging scale (OCS-L, Hangzhou

Dingxin Technology Co., Ltd., Zhejiang, China). We assessed the depth of anesthesia, heart rate, mucous membrane color of the tongue, and respiratory rate. For wild snow leopards anesthetized in low temperatures, precautions were taken to prevent hypothermia using blankets and hot water in rubber bottles in the groin and axillae. Eye gel (Humigel, Virbac) was applied to the cornea, and animals were blindfolded to protect the eyes from dust and light.

Monitoring

We monitored vital signs using an electronic monitor (VS-600, Shenzhen Mindray Bio-Medical Electronics Co., Ltd., Shenzhen, China) and used a Doppler blood pressure monitor (811-B, Shanghai Yuyan Scientific Instrument Co., Ltd., Shanghai, China) to monitor blood pressure. A portable pulse oximeter (H2-100K1, Xuzhou Mingsheng Electronic Technology Co., Ltd., Xuzhou, China) was attached to the snow leopard's tongue to monitor the heart rate and blood oxygen saturation (SpO_2). Rectal temperature was assessed using a digital thermometer. The vital signs were recorded every 5 min. Approximately 20 min after the onset of anesthesia, an arterial blood sample was collected from the femoral artery using a heparinized 1-mL syringe with a 22-gauge needle. The sample was analyzed within 10 min using a blood gas analyzer (i15VET, Shenzhen Mindray) to determine pH, partial pressure of carbon dioxide (PCO_2), partial pressure of oxygen (PO_2), and lactate. Snow leopards 10 and 11 in the 20Dex group, anesthetized in the field, were monitored using a Doppler blood pressure monitor. Their body temperature and blood pressure data were not included in the statistical analysis but are provided for completeness of data. After all procedures had been completed, atipamezole was administered via intramuscular injection. Captive snow leopards were transported back to their enclosures, and wild snow leopards were released into a flat, open area. Observation of the wild snow leopards was conducted from a safe distance until they left the site. The anesthesia duration was defined as the time from the onset of anesthesia to when the snow leopard raised its head. The time when the snow leopard raised its head after receiving the reversal agent was defined as the head-up time, and the time when the snow leopard could walk steadily was defined as the walking time.

TABLE 1. Basic characteristics of snow leopards (*Panthera uncia*) anesthetized with dexmedetomidine and tiletamine-zolazepam in Qinghai Province, China, November 2019 to June 2023, including their age, sex, weight, whether they were captive or free-living, reason for anesthesia (operation) and dexmedetomidine dose group (20 μg/kg [20Dex] or 30 μg/kg [30Dex]).

No.	Group	Source	Sex	Age (yr)	Weight	Operation[a]
1	30Dex	Captive	M	9	37.2	PE, SC
2	30Dex	Captive	M	21	64.5	PE, SC
3	30Dex	Captive	M	11	43.6	PE, SC
4	30Dex	Captive	M	14	39.1	PE, SC
5[b]	30Dex	Captive	M	15	38.9	PE, SC
5[b]	30Dex	Captive	M	15	40.2	SC
6	20Dex	Captive	F	12	32.6	PE
7	20Dex	Captive	M	17	34.5	PE
8	20Dex	Wild	M	Adult	43.8	PE
9	20Dex	Wild	M	Adult	42.5	PE
10	20Dex	Wild	F	Adult	35.6	PE, SCP
11	20Dex	Wild	F	Adult	36.3	PE, SCP

[a] PE = physical examination; SC = semen collection; SCP = satellite collar placement.
[b] The same snow leopard undergoing anesthesia twice, with an interval of 1 mo.

Data organization and analysis

We organized and analyzed the recorded data using Microsoft Excel (Microsoft Corporation, Redmond, Washington) and StataMP 16.0 statistical software (StataCorp LLC, College Station, Texas) respectively. We used *t*-tests to assess differences between the mean values of the two groups of snow leopards for anesthesia onset time, anesthesia duration, head-up time, walking time, and blood gas data. We used nonparametric Mann-Whitney *U* tests to assess trends in differences between other continuous physiologic measurements. We used random-effects generalized least squares regression analysis to fit trend lines and illustrate changes over time. We calculated mean±SD for each data type and determined statistical significance as $P<0.05$.

RESULTS

Group and drug doses

We assigned snow leopards that did not require semen collection procedures to the 20Dex group, and those that required semen collection to the 30Dex group (Table 1). The

TABLE 2. Induction, duration of anesthesia, and recovery time of 11 snow leopards (*Panthera uncia*) anesthetized with two anesthesia protocols in Qinghai Province, China, November 2019 to June 2023. All snow leopards received an estimated 2 mg/kg tiletamine-zolazepam (TZ), plus either 20 μg/kg (20Dex) or 30 μg/kg (30Dex) dexmedetomidine by remote injection, with actual dosages calculated once body weight was known.

Parameter	20Dex			30Dex		
	Mean±SD	Range	*n*	Mean±SD	Range	*n*
Dexmedetomidine (μg/kg)	21.25±1.38	19.7–23.5	6	30.95±1.13	29.9–33.1	6
TZ (mg/kg)	2.13±0.15	2.0–2.4	6	2.07±0.08	2.0–2.2	6
Onset time[a] (min)	9.5±2.3	7–13	6	9.0±2.5	7–14	6
Anesthesia duration[b] (min)	81.5±25.1	65–130	6	87.3±9.9	70–97	6
Head-up time[c] (min)	13.0±5.8	6–20	5	11.8±3.8	8–18	5
Walking time[d] (min)	24.0±10.7	11–38	5	17.8±5.3	13–26	5

[a] The onset time was when there is no response to stimulation after the administration of drugs.
[b] The anesthesia duration was from the onset of anesthesia until the animal lifted its head.
[c] The head-up time was from the moment the animal received the antagonist injection until it lifted its head.
[d] The walking time was from the administration of the antagonist injection until the animal exhibited stable walking.

actual drug dosages were calculated based on the actual body weight and volume of administration (Table 2). The mean dose of dexmedetomidine in the 20Dex group was 21.25±1.38 μg/kg (19.7–23.5 μg/kg), and the mean dose of TZ was 2.13±0.15 mg/kg (2.0–2.4 mg/kg). In the 30Dex group, the mean dose of dexmedetomidine was 30.95±1.13 μg/kg (29.9–33.1 μg/kg), and the mean dose of TZ was 2.07±0.08 mg/kg (2.0–2.2 mg/kg).

Induction, duration of anesthesia, and recovery

Both groups of animals exhibited relatively smooth induction periods, characterized by reduced activity and subdued demeanor. In both anesthesia protocols, 15 min after injection of anesthetic drugs all animals were unresponsive to stimuli. We did not observe excessive salivation during anesthesia, but one snow leopard (9) vomited during the procedure. After the antagonists were administered, no involuntary muscle twitching was observed in any animals during the recovery period, although most animals initially displayed instability when attempting to stand during recovery. All animals were able to recover to a normal state during subsequent observations. There were no significant differences in the onset time, anesthesia duration, head-up time, or walking time between the 20Dex group and the 30Dex group (Table 2). Snow leopard 9 in the 20Dex group showed the longest anesthesia duration (130 min), head-up time (20 min) and walking time (38 min). Snow leopard 11 in the 20Dex group and snow leopard 1 in the 30Dex group exhibited signs of recovery before receiving the antagonist, and head-up time and walking time were not recorded. Snow leopard 2 in the 30Dex group had the longest onset time (14 min).

Physiologic responses

The mean and SD of the physiologic responses in both groups of snow leopards are summarized in Table 3. There were no significant differences in SpO_2 and body temperature between the 20Dex and 30Dex groups, but we observed significant differences in respiratory rate ($P < 0.001$) and heart rate ($P < 0.001$). The mean respiratory rate in the 20Dex group was 24.6±2.8 breaths per minute (brpm), and the mean heart rate was 90.6±5.7 beats per minute (bpm), whereas in the 30Dex group, the mean respiratory rate was 28.1±3.6 brpm, and the mean heart rate was 80.7±4.4 bpm. The trends in physiologic responses of the two groups of snow leopards are shown in Figures 1 and 2. All snow leopards exhibited a slight increase in body temperature during the early stages of anesthesia, followed by a downward trend, with body temperatures

TABLE 3. Vital signs of 11 snow leopards (*Panthera uncia*) anesthetized with two anesthesia protocols, an estimated tiletamine-zolazepam (TZ) 2 mg/kg, plus either 30 μg/k or 30 μg/kg dexmedetomidine, in Qinghai Province, China, November 2019 to June 2023.

	20Dex			30Dex		
Parameter[a]	Mean±SD	Range	*n*	Mean±SD	Range	*n*
HR (bpm)	90.6±5.7*	80–102	69	80.7±4.4	70–90	77
SpO_2 (%)	94.0±1.4	90–96	68	94.4±1.5	91–98	74
RR (brpm)	24.6±2.8*	20–32	66	28.1±3.6	18–38	75
T (C)	37.87±0.19	37.5–38.3	43	37.78±0.30	36.9–38.2	73
SAP (mm Hg)	161.0±11.2	140–185	39	157.1±27.4	108–221	64
DAP (mm Hg)	110.3±14.3*	84–134	39	102.6±15.4	73–130	64
MAP (mm Hg)	126.3±10.1	110–151	39	125.0±14.8	92–150	64
pH	7.418±0.047	7.33–7.46	6	7.385±0.046	7.31–7.45	6
$PaCO_2$ (mm Hg)	33.7±2.7	30–38	6	33.7±3.4	30–38	6
PaO_2 (mm Hg)	73.3±3.1	69–78	6	73.2±4.6	67–78	6
Lac (mmol/L)	1.35±0.10	1.2–1.5	6	1.13±0.21	0.9–1.4	6

[a] HR= heart rate; bpm = beats per minute; SpO_2 = blood oxygen saturation; RR = respiratory rate; brpm = breaths per minute; T = body temperature; SAP = systolic arterial pressure; DAP = diastolic arterial pressure; MAP = mean arterial pressure;. $PaCO_2$ = partial pressure of arterial blood carbon dioxide; PaO_2 = arterial partial pressure of oxygen; Lac = lactic acid.
* Values differ significantly.

stabilizing in the later stages of anesthesia. The respiratory and heart rates showed a slight decreasing trend, with no obvious respiratory abnormalities, whereas SpO_2 showed a gradual upward trend. During the early stages of anesthesia, most animals showed a slight increase in blood pressure, followed by a gradual decrease, and a tendency to rise just before awakening. Snow leopard 1 exhibited the highest blood pressure (180–221 mm Hg). There were significant differences in diastolic blood pressure ($P<0.05$) between the 20Dex group (110.3±14.3 mm Hg) and the 30Dex group (102.6±15.4 mm Hg), although there were no significant differences in systolic or mean blood pressure between the two groups. There were no significant differences in arterial blood pH, PCO_2, PO_2, or lactate between the 20Dex and 30Dex groups.

Among the 12 anesthesia procedures conducted, snow leopard 9, which had received 2.4 mg/kg TZ, showed vomiting postadministration. The incident did not result in aspiration.

DISCUSSION

In our study on the use of combined dexmedetomidine and TZ, dexmedetomidine doses ranging from 21.25±1.38 μg/kg to 30.95±1.13 μg/kg, with TZ at 2.07±0.08 mg/kg to 2.13±0.15 mg/kg, provided stable anesthesia in snow leopards. Throughout the anesthesia procedure, the vital signs of the snow leopards remained stable. Higher dosages of TZ may induce anesthesia-related complications, such as vomiting (Plumb 2008; Nájera et al. 2017); this occurred in one animal in our study that had received a relatively high dose of TZ.

Induction, duration, and recovery

Smooth induction was observed in both groups of snow leopards, potentially because of the sedative and muscle-relaxing properties of dexmedetomidine (Plumb 2008). When using medetomidine and TZ to anesthetize snow leopards, onset time has been reported as 10±4 min (Johansson et al. 2013). The shorter onset time of both anesthesia protocols in this study was probably because dexmedetomidine is twice as potent as medetomidine (Plumb 2008; Kreeger and Arnemo 2018). The lack of significant variation in anesthesia duration between the two groups indicates that the 30 μg/kg dexmedetomidine protocol did not effectively extend the duration of anesthesia compared with the

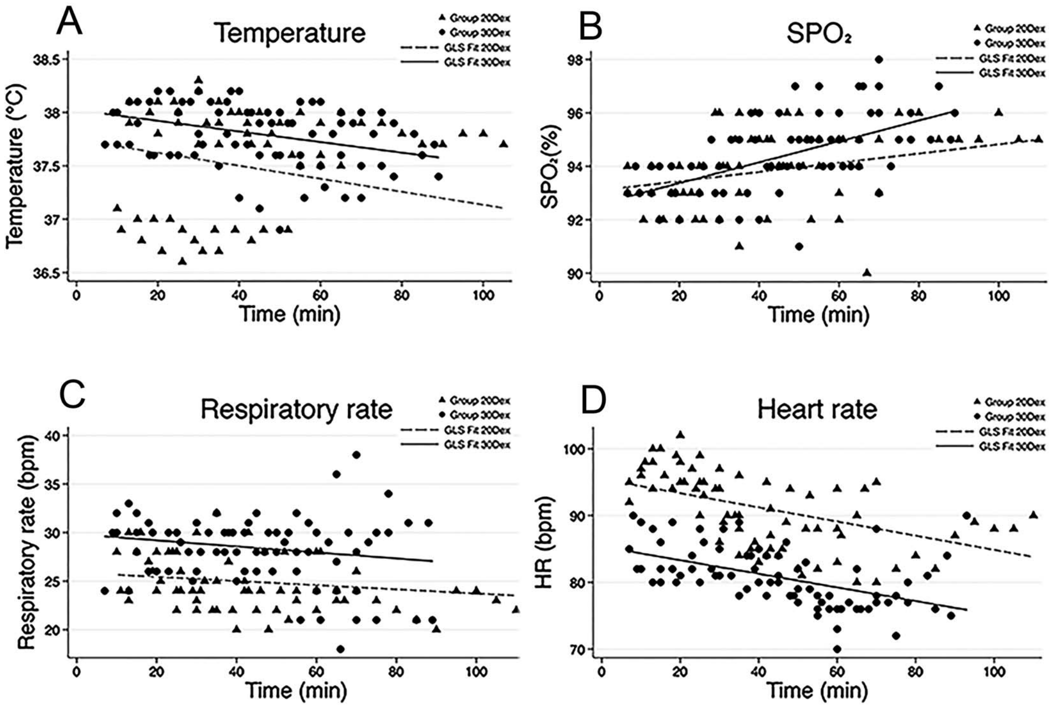

FIGURE 1. Trends in vital signs for snow leopards (*Panthera uncia*) during anesthesia using an estimated 2 mg/kg tiletamine-zolazepam, plus either 20 μg/kg (20Dex group) or 30 μg/kg (30Dex group) dexmedetomidine, delivered by remote injection, in Qinghai Province, China, November 2019 to June 2023. (A) Body temperature; (B) SPO_2; (C) respiratory rate; (D) heart rate. The fitted line was determined through random-effects generalized least squares regression analysis. GLS Fit 20Dex = the random-effects generalized least squares regression fitted line for the 20Dex group; GLS Fit 30Dex = the random-effects generalized least squares regression fitted line for the 30Dex group.

20 μg/kg dexmedetomidine protocol. Throughout the entire anesthesia process, most animals did not exhibit any notable abnormal behaviors. The prolonged anesthesia maintenance time (130 min) of snow leopard 9 may be related the dosage of TZ administered, which at 2.4 mg/kg was the highest among the 11 animals. Elevated TZ dosages are associated with extended duration of anesthesia (Plumb 2008; Nájera et al. 2017).

Recovery is a crucial phase of anesthesia, and smooth recovery is highly desirable (Kreeger and Arnemo 2018). Because most snow leopards in this study received antagonists immediately after the procedures, their recovery times, as indicated by elevation of their heads and resumption of ambulation, were shorter compared with natural recovery. The anesthetic dosages used for the two snow leopards that recovered spontaneously, after 93 and 65 min respectively, were not the lowest used (snow leopard 1, 33.1 μg/kg dexmedetomidine + 2.2 mg/kg TZ; snow leopard 11, 22.0 μg/kg dexmedetomidine + 2.2 mg/kg TZ), suggesting that their spontaneous recovery may be due to individual differences. The head-up and walking times did not significantly differ between the two anesthesia protocols in this study. Compared with the study by Johansson et al. (2013), using medetomidine at 20±0.4 μg/kg and TZ at 2.17±0.45 mg/kg and atipamezole at five times the dosage of medetomidine for antagonism, our head-up and walking time were longer, probably because dexmedetomidine has a higher potency compared with medetomidine (Plumb 2008; Kreeger and Arnemo 2018).

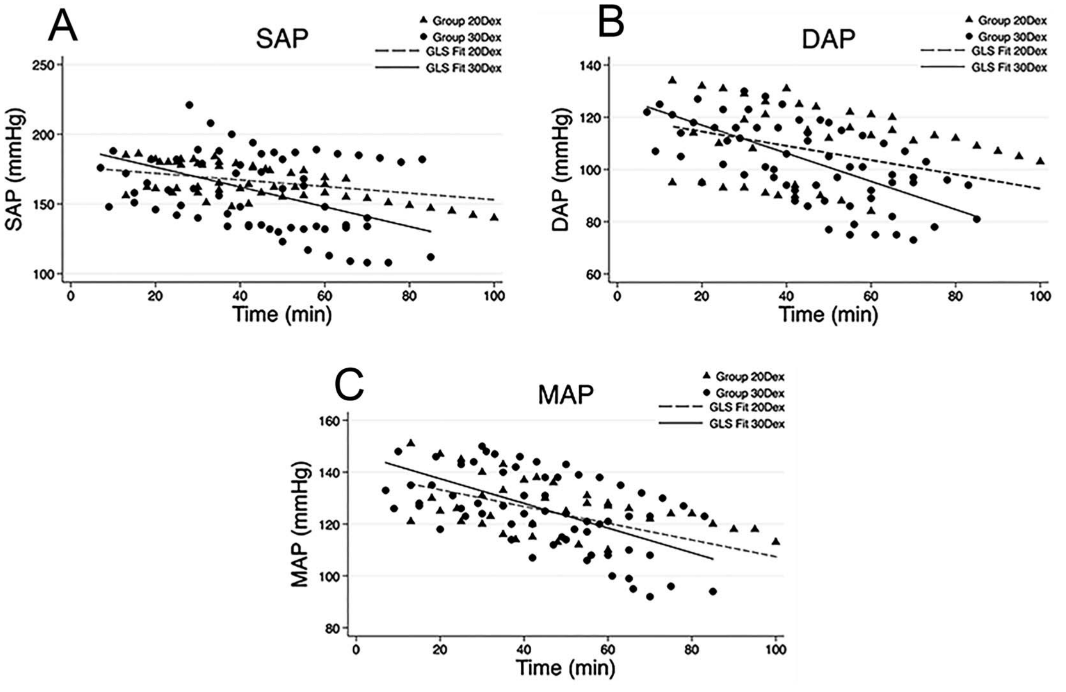

FIGURE 2. Trends in blood pressure of snow leopards (*Panthera uncia*) during anesthesia using an estimated 2 mg/kg tiletamine-zolazepam, plus either 20 µg/kg (20Dex group) or 30 µg/kg (30Dex group) dexmedetomidine, delivered by remote injection, in Qinghai Province, China, November 2019 to June 2023. (A) Systolic arterial pressure (SAP); (B) diastolic arterial pressure (DAP); (C) mean arterial pressure (MAP). The fitted line was determined through random-effects generalized least squares regression analysis. GLS Fit 20Dex = the random-effects generalized least squares regression fitted line for the 20Dex group; GLS Fit 30Dex = the random-effects generalized least squares regression fitted line for the 30Dex group.

Physiologic response

Physiologic monitoring is an important part of wildlife anesthesia; however, baseline vital sign data for snow leopards in a resting state have not been reported. In our study, all snow leopards exhibited an initial increase in temperature, heart rate, and respiratory rate shortly after reaching a stable anesthesia state, probably induced by capture stress. Subsequently, these vital signs showed a gradual decline, possibly due to dexmedetomidine-induced bradycardia and respiratory depression, as well as the hypothermic effect of TZ (Plumb 2008). Significant differences in heart rate and respiratory rate between the two groups might be attributable to different dosages of TZ (20Dex group: 2.13±0.15 mg/kg; 30Dex group: 2.07±0.08 mg/kg), as higher TZ dosages can lead to an increase in heart rate and a decrease in respiratory rate (Forsyth 1995; Ebert et al. 2000). Trends in recorded respiratory rate, heart rate, body temperature, and SpO_2 in this study were consistent with those reported by Johansson et al. (2013) in snow leopards anesthetized with medetomidine plus TZ. Lower arterial partial pressure of oxygen might be attributable to the high altitude of the region (Janecka et al. 2015). Elevated lactate levels in some snow leopards might be associated with precapture activity or struggling before anesthesia (Curro et al. 2004).

We also documented changes in blood pressure. The principles and values of blood pressure measurement using Doppler (which we used on the two free-living snow leopards) and oscillometric methods used on the other individuals may differ, but both methods showed a gradual decline in blood pressure. The initial increase in blood pressure during early anesthesia may be attributable to the stimulation of α2 receptors in vascular smooth muscle by dexmedetomidine, leading to vasoconstriction (Ebert et al. 2000). Subsequently, the slow decline may be due to inhibition of central sympathetic outflow and stimulation of presynaptic α2 receptors, resulting in decreased release of norepinephrine and subsequent blood pressure reduction (Afonso and Reis 2012). Snow leopard 1 exhibited hypertension (180–221 mm Hg) during the early stages, possibly because of the higher dosage of dexmedetomidine administered (33 μg/kg), which might have induced notable vasoconstriction (Ebert et al. 2000).

In our study, endotracheal intubation was not performed during anesthesia. Additionally, because of equipment limitations, continuous blood gas data could not be collected from the snow leopards. Future research efforts should aim to address these limitations, endeavoring to gather more comprehensive anesthesia data to enhance the understanding and refinement of anesthesia protocols for wild felids like snow leopards.

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