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CLINICAL AND CARDIORESPIRATORY EFFECTS OF PROPOFOL IN THE SPOTTED BAMBOO SHARK (*CHYLLOSCYLLIUM PLAGIOSUM*)

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Abstract: Sharks are important exhibit animals in aquariums and zoologic institutions worldwide. Although veterinarians are encountering these species more frequently in these institutions, our knowledge regarding safe restraint and anesthesia is limited. To date there have been only a few anecdotal reports or studies evaluating the effects of tricaine methane sulfonate (MS-222), ketamine hydrochloride, and tiletamine and zolazepam (Telazol) in sharks. The purpose of this study was to evaluate the clinical and cardiorespiratory effects of propofol in spotted bamboo sharks (*Chylloscyllium plagiosum*). Nine wild-caught adult female spotted bamboo sharks (mean weight 2.4 kg ± SD 1.45 kg) were used in this study. Propofol (2.5 mg/kg) was administered over 30 sec via the caudal tail vein. Heart rate, respiratory rate, time to relaxation, escape response, loss of righting reflex, and response to noxious stimuli (fin pinch) were evaluated and recorded at baseline and 5, 10, 15, 30, 45, 60, and 75 min after propofol administration. A surgical plane of anesthesia was achieved when the shark lost its righting reflex, did not respond to noxious painful stimuli, and no longer resisted handling. The righting reflex was lost within 5 min of propofol administration, and a surgical plane of anesthesia was observed in all nine sharks. Heart rate ($P = 0.5$) and respiratory rate ($P = 0.5$) did not change significantly over time. The righting response returned within 60 min in 44% (4/9) of the sharks, 75 min in 22% (2/9) of the sharks, and over 200 min in 33% (3/9) of the sharks. All nine animals recovered uneventfully. Propofol provided a safe anesthetic event for spotted bamboo sharks.

Key words: *Chylloscyllium plagiosum*, cardiorespiratory, escape response, righting reflex, noxious stimuli, relaxation, spotted bamboo shark.

INTRODUCTION

Sharks are important exhibit animals in aquariums and zoologic institutions worldwide. Restraint is often necessary for physical examination, diagnostic evaluation, medical treatment, and/or surgical procedures.[14,15] Manual restraint is often used for simple procedures but may result in dangerous contact for the shark and the handler. Research evaluating the clinical effectiveness of anesthetics in sharks is limited. Tricaine methane sulfonate (MS-222, Fisheries Chemical Division, Redmond, Washington 98052, USA) has been used, but it is expensive and must be used in an immersion bath. It may be difficult to use with larger specimens if there is not space available to completely immerse the animal in the anesthetic solution. Any shark that is anesthetized with MS-222 will require a flow of oxygenated water over the gills.[1] Injectable anesthetics, such as ketamine hydrochloride (Ketaset, Fort Dodge Laboratories, Fort Dodge, Indiana 50501, USA) and tiletamine-zolazepam have also been evaluated; however, they have been found to provide inconsistent anesthesia, have extended recovery periods, and do not provide appropriate visceral analgesia.[16,20]

Propofol (Diprivan, Zeneca Pharmaceuticals, Wilmington, Delaware 19850, USA) is an alkyphenol derivative (2,6-diisopropylphenol), a short-acting hypnotic that is unrelated to other general anesthetic agents. Its mechanism of action is not well understood[8]; however, it has been used in humans and higher vertebrates to perform diagnostic and surgical procedures. The primary advantages associated with propofol anesthesia include rapid induction and metabolism, short duration of effect, and it has noncumulative effects. The disadvantages of propofol include cardiorespiratory depression, it must be administered intravenously, and you cannot reverse the effects of the drug. The negative cardiorespiratory effects identified in higher vertebrates include arterial hypotension, bradycardia, negative inotropism, and apnea.[11,20] Significant respiratory depression is most common with rapid administration or high doses of propofol.[7] Other side effects reported with propofol in higher vertebrates include a reduction in intraocular pressure, in-

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creased appetite, and antiemetic properties.[4] Propofol is a general anesthetic but provides only moderate analgesia during recovery.[17]

Although there have been a number of studies evaluating the clinical value of propofol in domestic pets,[2] birds,[5,13] reptiles,[6] and amphibians, there is very limited information available on its use in aquatic animals,[9,10] i.e., a combined study on mallard ducks (*Anas platyrynchos*) and canvasback ducks (*Aythya valisineria*)[12] and a single study on the common bottlenose dolphin (*Tursiops truncatus*).[17] The purpose of this study was to evaluate the clinical and cardiorespiratory effects of propofol in spotted bamboo sharks (*Chylloscyllium plagiosum*).

MATERIALS AND METHODS

Animals

The procedures performed in this study were performed with authorization of the Institutional Animal Care and Use Committee at Louisiana State University (procedure # 99-063). Nine wild-caught adult female spotted bamboo sharks were used in the study. The mean weight of the animals used for this study was 2.4 ± 1.45 kg. The sharks were housed communally in an 11,500-L circular tank at the Audubon Institute Aquarium of the Americas (AAOA, 1 Canal Street, New Orleans, Louisiana 70130, USA). Seawater was recirculated (22,000 L/hr) and maintained at 26°C. Water quality parameters including salinity 28–30 ppt, pH 8–8.2, ammonia < 10 ppm, nitrates < 20 ppm, and alkalinity ~300 ppm Ca Carbonate were within normal acceptable limits for this species.[19] For each anesthetic trial, a shark was removed from the communal tank and placed into a plastic tub containing approximately 104 L of seawater. An initial physical examination (time 0) was performed under passive manual restraint, and baseline data were collected, including heart rate (HR), respiratory rate (RR), escape response, loss of righting reflex, and response to noxious stimuli. Heart rates were continuously monitored in all animals via pulse oximetry (SurgiVet, Nelcor Incorporated, Pleasanton, California 71012, USA). A probe was placed through the gill slits and situated lateral and caudal to gill lamellae. A crystal ultrasonic Doppler probe (Jorvet hand-held Doppler, Jorgensen Laboratories, Inc., Loveland, Colorado 80538, USA) was placed under the pectoral girdle to audibly monitor the heart rate. There was a direct correlation between the Doppler and pulse oximetry with regard to heart rate, but O_2 saturation was not assessed. Respiratory rate was measured every 5 min and determined by counting the opening and closing of the gill slits for 1 min.

Following collection of the baseline data, 2.5 mg/kg of propofol was administered intravenously via the caudal tail vein to each shark. The entire drug dose was administered via a 1-ml syringe with a 1.5-inch 20-gauge needle by slow push over a 30-sec period. The clinical and cardiorespiratory parameters were recorded at 5, 10, 15, 30, 45, 60, and 70 min after the propofol was administered. A stage III, surgical plane of anesthesia was achieved when a shark lost its righting reflex, did not respond to noxious stimuli, and no longer resisted handling.[20]

Neurologic function was assessed before propofol administration (time 0) to obtain baseline values for judging response to a noxious stimuli and anesthetic depth. Time to relaxation, movement of the animal, and fin movement were monitored. Analgesia was assessed by response to noxious stimuli (fin pinch).[18] The clinical measurements evaluated in this study were measured using an ordinal scale. For evaluating the righting reflex the shark was placed in dorsal recumbency, released, and the animal's response measured to determine when the animal had lost all ability to right itself. To evaluate the escape response, the shark was grasped and lifted from the water column to observe any resistance or thrashing movements. Finally, the response to noxious stimuli was measured by grasping the caudal fin with a pair of hemostats. We performed the fin pinch to evaluate the deep pain response by looking for body withdrawal and tail-thrashing movements during the anesthesia trial. A lack of fin pinch withdrawal response combined with a lack of fin, body, and tail-thrashing movements would indicate that an acceptable level of anesthesia had been achieved.

Statistical analyses

Heart rate, respiratory rate, escape response, righting reflex, and response to noxious stimuli were evaluated over time using Friedman's nonparametric analysis of repeated data. A significant difference was determined at $P < 0.05$. Where differences were apparent, Rhyne and Steel's method for comparison of related samples to a control (time 0) was used with an experimental error of $\alpha = 0.05$. Data analysis was performed using SAS statistical software (SAS Institute Inc., Carey, North Carolina 27513, USA).

RESULTS

A surgical plane of anesthesia was observed in all nine sharks. Heart rate and respiratory rate were normally distributed for all time intervals (Tables 1

Table 1. Respiratory rates (min^{-1}) for spotted bamboo sharks (n = 9) administered propofol.

Time (min)	Mean	SD	Range
0	40	8.0	31–56
5	46	15.3	18–60
15	41	13.2	24–60
30	41	14.5	21–60
45	40	14.8	22–64
60	41	12.4	24–60
75	39	11.6	26–60

Table 2. Heart rates for spotted bamboo sharks (n = 9) administered propofol.

Time (min)	Mean ± SD (min^{-1})	Range (min^{-1})
0	38 ± 9.0	27–52
5	39 ± 5.1	34–46
15	41 ± 5.7	35–51
30	39 ± 5.0	35–48
45	43 ± 9.4	36–61
60	45 ± 9.2	37–62
75	46 ± 7.0	37–54

and 2). The righting reflex was lost within 5 min of propofol administration in all nine sharks (100%). The righting response returned within 60 min in four (44%) of the sharks and 75 min in two (22%) of the sharks. The remaining three (33%) sharks required over 200 min for a complete return of the righting reflex. All nine (100%) animals recovered uneventfully. There was no significant difference in heart rate (ANOVA: 6.4, $P = 0.5$) or respiratory rate (ANOVA: 6.7, $P = 0.5$) over time. The loss of the righting reflex (ANOVA: 41.8, $P = 0.0001$), escape response (ANOVA: 49.5, $P = 0.0001$), and the response to noxious stimuli (ANOVA: 40.6, $P = 0.0001$) were significantly different from time 0 at the 5- to 30-min intervals postpropofol administration. There was little variation in these parameters at the 45-, 60-, and 75-min measurements ($P > 0.05$), as sharks begin to recover.

DISCUSSION

There is very little information available on the use of anesthesia protocols in sharks. The criteria for an acceptable anesthesia protocol are multifactorial and include rapid induction and recovery, acceptable provision of a surgical plane of anesthesia, ease of administration, and safety. In this study, intravenous propofol provided an effective method for chemical immobilization of captive sharks.

Arterial hypertension, negative inotropism, and bradycardia[4] are commonly reported in higher vertebrates given propofol. Bradycardia was avoided in this study by slow administration of the drug; although blood pressure was not measured in this study, no significant change in heart rate occurred. Although the heart rate and respiratory rate did not decrease over time, neurologic changes associated with propofol administration might be expected. Propofol decreases cerebral blood flow, cerebral metabolic rate, and intracranial pressure.[3,17] These effects, coupled with the finding that autoregulation is maintained after propofol administration, indicate that propofol may have a cerebral protective effect. Future studies to evaluate the neurologic effects of propofol in elasmobranchs are needed.

The effects observed in this study were based on maintaining the sharks at a constant temperature of 26°C. Because sharks are ectotherms, and their metabolic rate is temperature dependent, different effects might be expected at different temperatures. Temperature may have a direct effect on the duration of anesthesia, greater bradycardia, or an extended recovery period.

CONCLUSIONS

Propofol is a reliable and safe anesthetic agent that can be effectively used for the induction and maintenance of anesthesia in normal healthy sharks. The cardiovascular depressant effects of propofol appear to be well tolerated in healthy animals. A favorable recovery profile associated with propofol offers advantages in clinical situations in which rapid recovery is important. When coupled with subjective responses to noxious stimuli, responses during propofol anesthesia provide clear evidence that a satisfactory plane of anesthesia has been achieved in experimental sharks.

Cost is the major disadvantage of propofol when compared to other injectable anesthetic agents. Because propofol does not have marked analgesic effects, and its metabolism is rapid, the use of local anesthetics and postoperative analgesia should be considered.

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