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DEVELOPMENT OF RETROBULBAR AND AURICULOPALPEBRAL NERVE BLOCKS IN CALIFORNIA SEA LIONS (*ZALOPHUS CALIFORNIANUS*)

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Abstract: Eye lesions are commonly observed in pinnipeds. Clinical assessment is challenging because animals are often blepharospastic and under inhalant anesthesia the globe rotates ventrally, making observation difficult. Retrobulbar and auriculopalpebral nerve block techniques have been developed in other species to alleviate these difficulties and allow for a more thorough ophthalmic exam. Ocular nerve block techniques were developed for California sea lions (CSLs) (*Zalophus californianus*) using lidocaine hydrochloride 2%. To develop the retrobulbar block, a variety of needle sizes, anatomic approaches, and volumes of methylene blue were injected into the orbits of 10 CSL cadavers. An optimal technique, based on desired distribution of methylene blue dye into periocular muscles and tissues, was determined to be a two-point (ventrolateral and ventromedial) transpalpebral injection with a 20-ga, 1 1/2-inch needle. This technique was then tested using lidocaine on 26 anesthetized animals prior to euthanasia, and on one case with clinical ocular disease. A dose of 4 mg/kg of lidocaine was considered ideal, with positive results and minimal complications. The retrobulbar block had a 76.9% rate of success (using 4 mg/kg of lidocaine), which was defined as the globe returning at least halfway to its central orientation with mydriasis. No systemic adverse effects were noted with this technique. The auriculopalpebral nerve block was also adapted for CSLs from techniques described in dogs, cattle, and horses. Lidocaine was injected (2–3 ml) by subcutaneous infiltration lateral to the orbital rim, where the auriculopalpebral nerve branch courses over the zygomatic arch. This block was used in five blepharospastic animals that were anesthetized for ophthalmic examinations. The auriculopalpebral nerve block was successful in 60% of the cases, which was defined as reduction or elimination of blepharospasm for up to 3 hr. Success appeared to be dependent more on the location of injection rather than on the dose administered.
Key words: Auriculopalpebral nerve block, California sea lion (*Zalophus californianus*), lidocaine, ocular disease, retrobulbar block.

INTRODUCTION

Ophthalmic lesions are common in both captive and wild pinnipeds. Young animals frequently experience corneal ulceration secondary to trauma, and aging animals commonly develop bullous keratopathy, keratitis, or cataracts,[8,9,18] although these conditions can occur at any age. Pinnipeds have a strong blepharospastic response and an ability to retract the globe. In addition, the use of inhalant anesthesia for examinations usually results in ventromedial rotation of the globe, which makes ophthalmic evaluation and subsequent treatment difficult. A retrobulbar block prevents or reverses this rotation by providing extraocular muscle akinesis and analgesia. In addition, a retrobulbar block produces mydriasis, which facilitates full visualization of the interior of the globe.[1,11,21,23] A successful block improves ophthalmic examination and facilitates topical treatment and surgical intervention. In mammals the extraocular muscles responsible for globe movement are separated into pairs: medial and lateral rectus muscles, superior and inferior rectus muscles, and superior and inferior oblique muscles. The oculomotor nerve innervates the medial, dorsal, and ventral rectus muscles and the inferior oblique muscle. The abducens nerve innervates the lateral rectus and the retractor bulbi muscles, and the trochlear nerve innervates the dorsal oblique muscle.[11,27]

The retrobulbar block was first described in humans in 1884, and refined by Atkinson in 1936.[10] The standard Atkinson needle is 1 1/2 inches in length, which places the anesthetic just anterior to the optic foramen, as the distance from the ventrolateral orbital rim to the optic foramen in humans is 4.2–5.4 cm.[2] The technique includes placing the anesthetic agent internal (retrobulbar) or external (peribulbar) to the retrobulbar muscle cone (Fig. 1).[1,25] The intraconal space is a conical

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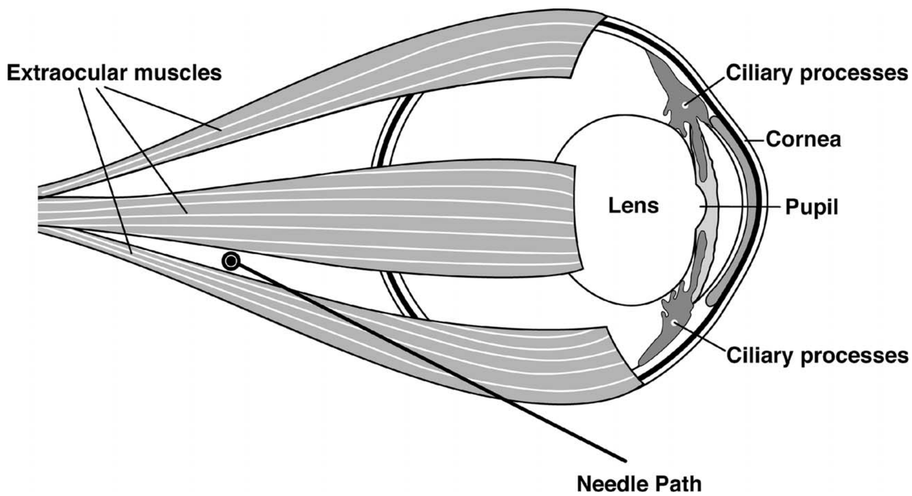

Figure 1. Normal California sea lion eye anatomy. Needle path line indicates the site of needle placement for retrobulbar injection. Illustration by Victoria Saxe.

compartment formed by the retractor bulbi muscle and the four rectus muscles surrounding the optic nerve.[4] For the purposes of this study there is no differentiation between a retrobulbar and peribulbar technique, because there is no evidence of an anatomic structure dividing the intraconal and extraconal space.[4,25] Potential adverse effects of retrobulbar injection include penetration of the globe, orbital hemorrhage, damage to the optic nerve or other neuropathy, dysrhythmias caused by initiation of the oculocardiac reflex, extraocular muscle myopathy, general lidocaine systemic toxicity, injection into the optic nerve meninges, and intravenous injection of the anesthetic drug (which can induce neurologic signs and cardiorespiratory arrest).[1,2,11,19,23–25,27,32]

In dogs, the ventrolateral transpalpebral technique using a single injection site is described as easy to perform and provides thorough distribution of anesthetic agent within the intraconal retrobulbar space with little evidence of complication.[1] In cattle, two common techniques are a four-point retrobulbar block, which is described to be easier because of the anatomy of this species, and the Peterson eye block, which requires more skill because the needle must penetrate through the notch created by the supraorbital process, the zygomatic arch, and the coronoid process, but is safer because it has less risk of damaging the surrounding structures and the globe itself if performed correctly.[11,23,28] In horses, the needle is inserted caudal to the supraorbital process of the frontal bone near the supraorbital foramen.[12]

The globe, conjunctiva, nictitating membrane, and part of the motor function of the eyelids are supplied by the ophthalmic branch of the trigeminal nerve and by the auriculopalpebral nerve, which is a terminal branch of the facial nerve.[11] The auriculopalpebral nerve travels over the zygomatic arch to innervate the orbicularis oculi muscle, responsible for closure of the eyelids.[33] An auriculopalpebral nerve block is commonly performed in horses and cattle to facilitate ophthalmic examination, but it is important to note that the block provides akinesis and anesthesia of the eyelid, but not analgesia.[11,28]

Lidocaine is described as the most commonly used regional block agent, and can be used alone or in combination with synergic drugs. The toxic dose for pinnipeds is still unknown, but this study was guided by the maximum dose described for ruminants (6–10 mg/kg) and dogs (5 mg/kg).[28,30,31]

The purpose of this study was to develop retrobulbar and auriculopalpebral nerve block techniques for California sea lions (CSLs) (*Zalophus californianus*) in order to enhance ocular disease diagnosis and treatment in this species.

MATERIALS AND METHODS

Measurements and retrobulbar block

In order to standardize needle size needed for the block technique, axial and equatorial diameters were measured at necropsy for CSLs that died or were euthanized while undergoing rehabilitation at The Marine Mammal Center in Sausalito, California, USA. Both male and females ranging from pups to adults were included, and the globes had no evidence of ophthalmic

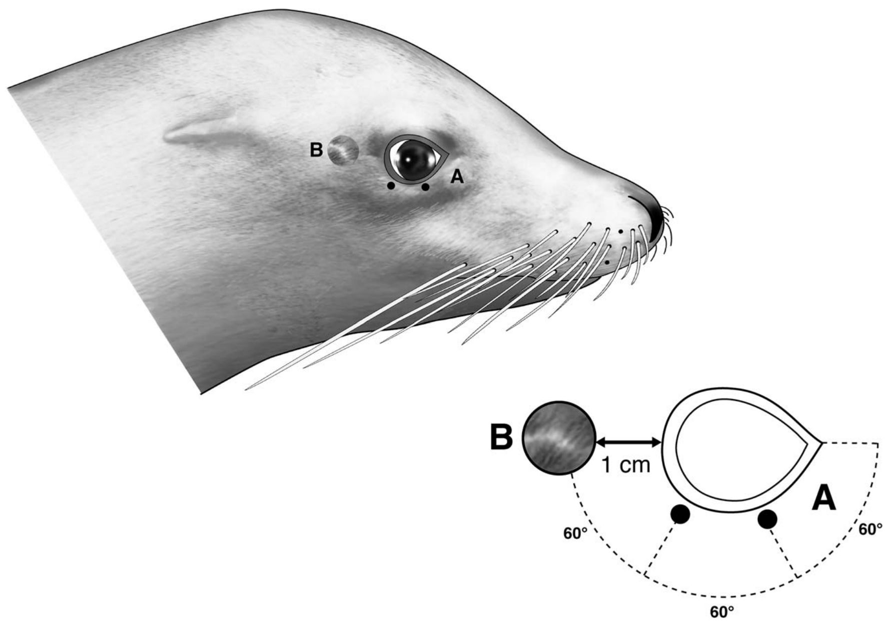

Figure 2. Lateral view of California sea lion head, with (**A**) indicating injection sites for two-point (ventrolateral and ventromedial) transpalpebral retrobulbar block and (**B**) indicating injection site and lidocaine bleb formation for auriculopalpebral nerve block. Illustration by Victoria Saxe.

disease. Linear measurements were performed using calipers for 83 globes from 42 wild CSLs. The axial diameter was measured from the center of the cornea to the optic nerve, and the equatorial diameter was measured from the medial scleral pole, halfway between the cornea and the optic nerve, to the lateral scleral pole. Methylene blue was injected at a variety of sites into 18 orbits, because it spreads easily through adipose tissue[25] and provides a stain to gauge injection dispersion. Following injection, the orbit and all periocular tissues were removed to visualize the site of injection and determine the distribution of dye. The ideal retrobulbar technique in CSLs was determined to be a combination between the ventrolateral transpalpebral technique described in dogs[1,21] and the four-point retrobulbar block commonly used in cattle,[28] based on results from the methylene blue dye distribution tests. The incomplete orbit and slightly dorsal position of the optic nerve suggested that a dorsal approach would be more likely to inject anesthetic directly into the optic nerve than a ventral approach.

Once a technique was identified that demonstrated methylene blue distribution throughout the muscle cone without dying the optic nerve, the retrobulbar block was performed with lidocaine hydrochloride 2% (MWI, Boise, Idaho 83705, USA) on 26 anesthetized animals prior to euthanasia for unrelated illness, and on one anesthetized animal with clinical ocular disease. Twenty-two individuals were anesthetized using previously described protocols[29] with midazolam (ZooPharm, Laramie, Wyoming 82070, USA; 0.1–0.2 mg/kg i.m.), butorphanol (Torbugesic®, Fort Dodge Animal Health, Fort Dodge, Iowa 50501, USA; 0.1–0.2 mg/kg i.m.) and isoflurane inhalant anesthesia (Forane®, Baxter International Inc., Deerfield, Illinois 60015-4625, USA), or isoflurane alone. The remaining five were anesthetized using either tiletamine hydrochloride–zolazepam hydrochloride (Telazol®, Zoetis Inc., Kalamazoo, Michigan 49007, USA; 1 mg/kg i.m.), ketamine (Phoenix, St. Joseph, Missouri 64507, USA; 2.5 mg/kg i.m.), or medetomidine (ZooPharm; 0.03 mg/kg i.m.) prior to isoflurane.[14]

The skin surrounding the injection site was prepared with povidone iodine solution (Betadine®, Purdue Pharma LP, Stamford, Connecticut 06901-3431, USA) diluted 1 : 50 in sterile saline (0.9% NaCl).[26] Each individual was placed in lateral recumbency to more easily approach the injection site. A two-point transpalpebral retrobulbar block was performed (Fig. 2A), administering ventrolateral and ventromedial injections in a 1 : 1 proportion, using a 20-ga, 1 1/2-inch needle. Lidocaine doses ranging from 1.4 to 10 mg/kg (2.6–38 mL) were used, with an optimal dose of 4 mg/kg selected based on clinical response. The 4 mg/kg dose was evaluated in 14 animals.

Figure 3. Globe ventrally rotated secondary to inhalant anesthesia.

The ventromedial injection was performed approximately one-third of the distance between the medial and lateral canthi (Fig. 2A). The entire needle was inserted, with the hub of the needle extending just deep to the orbital bone. In order to ensure that the globe had not been inadvertently penetrated, the needle was gently moved several millimeters dorsoventrally or lateromedially, with absence of globe movement confirming needle placement in the periocular space. The syringe was aspirated to ensure that the needle tip was not in a vascular space, and half of the total volume of lidocaine hydrochloride 2% was administered slowly. A visible mechanical exophthalmia was noted following injection. The same technique was performed in the ventrolateral orbit, approximately two-thirds of the distance between the medial and lateral canthi (Fig. 2A), where the remaining half of the injection was administered. Photographs of globe position were taken of the injected eye and the contralateral eye prior to injection (Fig. 3) and 10 min following injection (Fig. 4). Return of the globe to a central position and presence of mydriasis were evaluated to measure the efficacy of the block.

Auriculopalpebral nerve block

An auriculopalpebral nerve block was developed for CSLs by adapting the techniques used commonly in dogs, cattle, and horses[11,22,28,30,33] and modified because of the anatomical differences between species. Five animals with a history of unilateral blepharospasm were anesthetized for ophthalmic evaluation with a combination of midazolam, butorphanol, medetomidine, and inhalant isoflurane, or isoflurane alone. The skin surrounding the injection site was prepared as

Figure 4. Positive retrobulbar block, 10 min post-injection. Note the central position of the globe as well as mydriasis.

described for the retrobulbar block. Each patient was positioned in lateral recumbency and a 22-ga, 3/4-inch needle was inserted 1 cm caudal to the lateral orbital rim (Fig. 2B), where the auriculopalpebral nerve, which is not palpable in this species, courses over the zygomatic arch (Fig. 5). Lidocaine was injected subcutaneously and a bleb was noted, using doses between 0.2 and 1.2 mg/kg (2–3 mL).

RESULTS

Globe measurements

Eighty-three eye globes were measured. The mean axial diameter was 3.5 ± 0.5 cm and the mean equatorial diameter was 3.6 ± 0.6 cm.

Retrobulbar block

The retrobulbar block was performed on 27 eyes with varying doses and techniques (Table 1). A two-point transpalpebral block using 4 mg/kg of lidocaine proved to be the technique that was most effective, with the least amount of mechanical displacement of the eye. This technique was performed on 14 eyes. Success was achieved in 76.9% of cases, with a positive block defined as return of the globe to at least halfway towards the original, central position, and with mydriasis observed. No systemic complications occurred during any of the procedures. All animals exhibited stable cardiovascular parameters while under anesthesia until the euthanasia solution was injected, at least 10 min after performing the block. Postmortem examination of the globes

Figure 5. Lateral view of a California sea lion skull indicating the auriculopalpebral nerve block site (black circle) over the zygomatic arch.

found no evidence of any signs of globe perforation or of laceration of the optic nerve or periocular muscles. In one animal, blood was aspirated prior to injection into the ventromedial site. The needle was redirected and the two-point block was performed, but no response was seen after 10 min. At necropsy mild periorbital hemorrhage was observed. No periorbital hemorrhage was noted in any other cases. The final retrobulbar block in this study was performed during anesthesia, not followed by euthanasia, and appeared to last at least 40 min. This animal had a normal recovery after the procedure and no complications were noted.

Auriculopalpebral nerve block

In this study five animals received an auriculopalpebral nerve block, and three out of five cases (60%) were considered positive (Table 2). A positive block was defined as the absence of the blink reflex when compared with the contralateral eye while recovering from anesthesia, and elimination of blepharospasm. Blepharospasm was eliminated for up to 3 hr (median = 1.7 hr). During this time, incomplete akinesis of the lids was noted, as animals were able to blink but were not blepharospastic. No ocular lubricant was used in the eyes with any of the blocks. No complications were noted with the auriculopalpebral block.

DISCUSSION

To the authors' knowledge, this is the first study to describe retrobulbar and auriculopalpebral nerve blocks in CSLs. The pinniped globe structure has been described in detail,[17] but globe measurements have not been reported. Globe measurements varied by only a few millimeters across age classes and sexes. In other mammals, such as horses and the Asian elephant (*Elephas maximus*), globe diameters remain largely static after the first several years of life, even though the body size may increase substantially.[3,13] Although necropsies were performed as soon after death as was possible, the measurements may be smaller because of postmortem shrinking of the globe. Measuring globe diameters in a variety of age classes showed that the location of the optic nerve, and therefore the depth of injection, does not vary substantially with the size of the animal. This allowed for development of a retrobulbar technique that can be used on a majority of CSL patients, regardless of their age, sex, and body condition.

The retrobulbar technique described in this study produces mydriasis, and allows the globe to return roughly halfway back to a central position, after deviation of 90° under gas anesthesia. These allow the cornea, anterior chamber, and posterior chamber to be accessible for ophthalmologic examination and treatment. The anesthesia and analgesia produced by the retrobulbar block also help improve recovery after surgery and traumatic procedures.[21] Although the block was successful in only 76.9% of cases, reports in humans show that the efficacy of local anesthetic procedures required knowledge of the regional anatomy, and success rates increase as operators become more proficient,[7,16] which occurred during the course of this study. Including ultrasonographic guidance to ensure the accuracy of the anesthetic drug deposit site could improve the success and safety of the technique, as it has been proven in horses, dogs, and humans.[5,6,20,32]

When using lidocaine doses higher than 4 mg/kg, especially in larger adult animals, a marked

Table 1. California sea lions receiving retrobulbar blocks with lidocaine hydrochloride 2%, including technique, volume, and clinical result.[a]

Patient No.	Volume injected (ml)	Weight (kg)	Dose (mg/kg)	Location of injection	Drug	Results
CSL-11188	5	71	1.4	VL	Telazol	(–)
CSL-11220	10	80	2.5	VL	Mid + But/Iso	(+)
CSL-11165	8	64	2.5	VL	Mid + Ket/Iso	(–)
CSL-11257	7	88	1.6	VL	Mid + Ket/Iso	(–)
CSL-11288	7	14	10	VM + VL	Iso	(+)
CSL-11240	14	47	6	VM + VL	Mid + But/Iso	(–)
CSL-11240	24	80	6	VM + VL	Mid + But/Iso	(+)
CSL-11299	20	57	7	VM + VL	Mid + But/Iso	(–)
CSL-11299	15	43	7	VM + VL	Mid + But/Iso	(–)
CSL-11281	34	136	5	VM + VL	Mid + But/Iso	(–)
CSL-11303	19	95	4	VL	Mid + But/Iso	(–)
CSL-11339	12	48	5	VM + VL	Mid + But/Iso	(+)
CSL-11359	5	25	4	VM + VL	Mid + But/Iso	(–)
CSL-11340	2.6	13	4	VM + VL	Mid + But/Iso	(+)
CSL-11371	7.5	38	4	VM + VL	Mid + But/Iso	(+)
CSL-11297	8	27	6	VM + VL	Mid + But/Iso	(–)
CSL-11370	14	70	4	VM + VL	Iso	(+)
CSL-11282	9	45	4	VM + VL	Iso	(+)
CSL-11309	16	107	3	VM + VL	Iso	(–)
CSL-11384	2.8	14	4	VM + VL	Iso	(+)
CSL-11318	16	80	4	VM + VL	Mid + But/Iso	(–)
CSL-11388	11.6	58	4	VM + VL	Iso	(+)
CSL-11404	9.3	47	4	VM + VL	Iso	(+)
CSL-11408	11.2	56	4	VM + VL	Mid + But + Medet/Iso	(–)
CSL-11420	6	30	4	VM + VL	Mid + But/Iso	(+)
CSL-11414	38	190	4	VM + VL	Mid + But + Medet/Iso	(+)
CSL-11441	6.6	33	4	VM + VL	Mid + But/Iso	(+)

[a] VL indicates ventrolateral; VM, ventromedial; Mid, midazolam; But, butorphanol; Iso, isoflurane; Ket, ketamine; Medet, medetomidine; (–), negative; (+), positive.

mechanical exophthalmia was observed, and the block was usually unsuccessful. This has the potential for not only chemical toxicity, but also mechanical compression or elongation of sensitive tissues like the optic nerve. An alternative could include the use of a higher concentration of lidocaine or a combination with synergic drugs such as bupivacaine and hyaluronidase.[15] Further studies are also needed to evaluate the mechanical effect of lidocaine when compared with saline injections in the retrobulbar space. Lidocaine doses lower than 4 mg/kg did not produce a successful retrobulbar block. Lidocaine was selected because it is one of the most easily accessible local anesthetics, and because of its rapid onset of action for evaluation of the cases prior to euthanasia in this study. The duration of action of the retrobulbar block was evaluated in

Table 2. California sea lions receiving auriculopalpebral nerve blocks with lidocaine hydrochloride 2%, including technique, volume, and clinical result.[a]

Field No.	Volume injected (ml)	Weight (kg)	Dose (mg/kg)	Location of injection	Drug	Results	Duration (hr)
CSL-11210	3	60	1	E	Iso	(–)	—
CSL-11225	2	100	0.4	OR	Mid + But/Iso	(+)	3
CSL-11213	2	36	1.1	EC	Iso	(–)	—
CSL-11389	2	200	0.2	OR	Mid + But + Medet/Iso	(+)	1
CSL-11441	2	33	1.2	OR	Mid + But/Iso	(+)	1

[a] E indicates 1 cm rostral from ear; OR, 1 cm caudal of lateral orbital rim; EC, 1 cm caudal of lateral eye canthus; Iso, isoflurane; Mid, midazolam; But, butorphanol; Medet, medetomidine; (–), negative; (+), positive.

only one clinical case, and the effects persisted up to 40 min. Further studies are needed to determine the ideal anesthetic and total duration of action of retrobulbar blocks in CSLs.

Concurrent medical issues can make certain animals poor anesthetic candidates, so the akinesis generated by the auriculopalpebral nerve block may allow the clinician to observe central corneal lesions and apply topical treatment under sedation, rather than general anesthesia. Both retrobulbar and auriculopalpebral nerve blocks diminish the blink response, so artificial tear ointment should be applied after the examination.[11,33] In this study, animals that received the auriculopalpebral block were capable of gently closing their eyes, and there were no subjectively observed differences in tearing noted between the treated eye and the contralateral eye. With the wide range of doses used (0.2–1.2 mg/kg), it was apparent that the positive effect was not dose dependent, but rather the site of injection—and using an immobile landmark like the orbital rim, instead of a mobile landmark like the lateral canthus—was the most important variable influencing the success of the auriculopalpebral block.

Although a small number of cases were included in this study, these results establish a baseline for further refinement of these local anesthetic techniques in this species. Assessing and treating ocular disease can often be very difficult in pinnipeds. These nerve block techniques give marine mammal veterinarians and veterinary ophthalmologists additional tools for treating CSLs with ocular disease. With practice, the retrobulbar and auriculopalpebral nerve blocks should provide suitable access to the globe to facilitate assessment of ocular structures.

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