Development of a retrobulbar injection technique for ocular surgery and analgesia in dogs

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Objective—To develop and compare 3 techniques for retrobulbar injection of local anesthetic agents for ocular surgery and analgesia in dogs.

Design—Prospective study.

Animals—17 dogs (including 9 cadavers).

Procedure—Inferior-temporal palpebral (ITP), perimandibular, and combined superior-inferior peribulbar injection techniques were compared by assessing the distribution of latex after injection into the orbits of 5 canine cadavers; magnetic resonance imaging (MRI) evaluation of the distribution of contrast agent after injection in the retrobulbar space of 4 canine cadavers; and assessment of the efficacy and MRI evaluation of the anatomic distribution of injections of a lidocaine-contrast agent mixture in 4 anesthetized, nonrecovery dogs. By use of the preferred technique (ITP), the ocular effects of lidocaine anesthesia were evaluated in 4 dogs; during a 2-week period after treatment, dogs underwent ophthalmic examination, Schirmer tear testing (STT), intraocular pressure (IOP) measurement, and Cochet–Bonnet esthesiometry.

Results—Of the 3 techniques, the ITP technique was the preferred method for retrobulbar administration of anesthetic agent in dogs because it was efficacious (pupil dilation and central rotation of the globe achieved in all eyes), easiest to perform, and provided thorough coverage of the intraconal retrobulbar space without complication. During the 2-week follow-up period, the ITP injection did not significantly affect STT, IOP, or Cochet-Bonnet esthesiometry values in dogs.

Conclusions and Clinical Relevance—In dogs, retrobulbar administration of anesthetic agents via the ITP technique is a potential alternative to systemic administration of neuromuscular blocking agents for ophthalmic surgery and provides the additional benefit of local ocular analgesia. (J Am Vet Med Assoc 2006;229:220–225)

Nondepolarizing neuromuscular-blocking agents are commonly used in veterinary ophthalmologic practice because they are easy to administer systemically in animals and provide the necessary extraocular muscle paralysis for intraocular and corneal surgery. Unfortunately, with NBA administration, it is not possible to adequately eliminate extraocular muscle activity for surgery without inducing major respiratory compromise. Systemic administrations of NBAs induce respiratory muscle paralysis, and thus patients require specific monitoring such as train-of-4 peripheral nerve stimulation to accurately determine the duration of effect. The use of intermittent positive-pressure ventilation is necessary and requires the use of specialized anesthetic equipment and capnometry or arterial blood gas measurement to ensure that adequate ventilation is achieved. Without the ability to appropriately monitor the effects of NBAs in dogs, which is common in many practice settings, hypoventilation will lead to hypercapnia and considerable respiratory acidosis, with potential cardiovascular, neurologic, and metabolic consequences. Additionally, respiratory acidosis induces an increase in choroidal blood flow, resulting in increased IOP and anterior vitreal displacement, both of which can increase the potential for surgical complication. Therefore, there are considerable advantages in preferentially paralyzing the extraocular muscles without impairment of patient ventilation.

Retrobulbar anesthesia provides excellent extraocular muscle akinesis and has the added benefit of providing local analgesia that could reduce the need for perioperative systemic administration of analgesics such as opioids or nonsteroidal anti-inflammatory drugs. Also, without the specific need for a mechanical ventilator and additional monitoring equipment with associated personnel, the overall operative cost may be reduced.

A thorough understanding of the relevant canine ophthalmic and orbital anatomic features as well as consideration of ocular axial length, orbital depth, and orbital axis is required to accurately administer retrobulbar injections. Targets of retrobulbar anesthesia include cranial nerves III, IV, V, and VI and the ciliary ganglion. Options for induction of retrobulbar anesthesia include placing the anesthetic agent internal or external to the retrobulbar muscular cone. In general, injection of an anesthetic agent into the intraconal space will result in the most rapid and consistent effect with the least volume required. In comparison, extraconal injection of an anesthetic agent, although perhaps safer because the needle is not as close to the globe, can have a longer onset of action and typically requires a higher drug volume; moreover, multiple injections are often required, each having its own associated potential complications. Possible complications of retrobulbar anesthesia include retrobulbar hemorrhage, IV injection of the anesthetic, globe perforation, optic nerve damage or other neuropathy, extraocular muscle myopathy, and

ABBREVIATIONS
NBA Nondepolarizing neuromuscular-blocking agent
IOP Intraocular pressure
ITP Inferior-temporal palpebral
MR Magnetic resonance

intrathecal injection (which could induce seizure or cardiorespiratory arrest).

In humans, retrobulbar anesthesia is commonly used in ophthalmic surgery. Physician ophthalmologists have not reached a consensus about the optimal approach to achieving local anesthesia for cataract surgery, and method selection is based largely on surgeon preference.1 Complications associated with retrobulbar anesthesia in humans, although potentially severe, are rare.2,3,4 The rate of scleral perforation, the most severe ocular complication, has been reported to be 0.007% after evaluation of 26,857 consecutive injections in humans. In each case of perforation, posterior staphyloma—a rare finding in dogs—was identified as a risk factor. There was no scleral perforation in non-staphylomatous eyes.5 There are few reports6–9 on retrobulbar anesthesia in veterinary species. The purpose of the study reported here was to develop and compare 3 techniques for retrobulbar injection of local anesthetic agents for analgesia and oculary surgery in dogs. Our intent was to develop an ideal retrobulbar injection technique for use in dogs, evaluate its efficacy, and identify any postinjection complications.

Materials and Methods

All dogs were treated in accordance with the tenets of the Association of Research and Vision in Ophthalmology Statement for the Use of Animals in Ophthalmic and Vision Research, and the Animal Care and Use Committee of the University of Wisconsin-Madison approved this research.

Description of techniques—The injection techniques evaluated in the study were the ITP, perimandibular, and combined superior-inferior peribulbar approaches. These techniques were considered intracranal, intra- or extracranal, and extracranial, respectively. In each, the bevel of the needle was directed toward the center of the intracranal space and aspiration was performed prior to injection to confirm extravascular placement. The same person (PJA) performed all injections for all phases of the study.

For the ITP technique, an approximate 20° angle was created by mechanical bending at the midpoint of a 1.5-inch (3.81-cm), 22-gauge spinal needle. The needle was positioned at the inferior orbital rim and inserted through the inferior lid at the junction of its middle and temporal thirds; it was advanced until a slight popping sensation was detected, which indicated piercing of the orbital fascia. The needle was then directed slightly dorsally and nasally toward the apex of the orbit and advanced approximately 1 to 2 cm.

In the perimandibular technique, the same size needle was inserted ventral to the zygomatic process at the level of the lateral canthus. The point of insertion was approximately 0.5 cm cranial to the vertical portion of the ramus of the mandible. The needle was then advanced mediolateral to the ramus in the mediodorsal and caudal direction until it reached the retrobulbar space.10

In the combined superior-inferior peribulbar technique, 2 injections were performed. The same size needle was inserted halfway between the medial and lateral canths of the superior and inferior lids between the orbital rim and globe. The needle was advanced until the tip was just beyond the posterior aspect of the globe.

Technique comparisons (phase 1)—The first part of phase 1 of the study involved injection of latex® into the retrobulbar space of the heads from cadavers of 5 mesocephalic dogs; the dogs had been euthanatized by IV injection of pentobarbital sodium (73 to 123 mg/kg [33 to 56 mg/lb]) as part of an unrelated study. The heads had been removed from the bodies prior to use in this study. Two perimandibular injections (1 right eye and 1 left eye), 4 combined superior-inferior peribulbar injections (1 left eye and 3 right eyes), and 4 ITP injections (3 left eyes and 1 right eye) were performed. The vitreous body of each eye was injected with water by use of a 25-gauge needle to inflate the globe to normal size. Injections were randomly assigned and performed as described. After injections, the skulls were cooled at 2.2°C (36°F) for 24 hours. Lateral orbitotomy with resection of the zygomatic arch was then performed to allow evaluation of latex distribution.

In the second part of phase 1, 4 dogs (mean weight, 12.2 kg [26.9 lb]; range, 9.5 to 16.1 kg [21.0 to 35.5 lb]) that were scheduled for euthanasia as part of unrelated research and for reasons unrelated to this study were assessed as clinically normal via ophthalmic examination performed by the same investigator (EB) and then were humanely euthanatized by IV injection of pentobarbital sodium (73 to 123 mg/kg). Retrobulbar injections with the 2 techniques that resulted in acceptable latex distribution as determined from results of the first part of phase 1 were then performed (2 left eyes and 2 right eyes/technique) with 2 mL of a mixture of 0.1 mL of gadolinium contrast agent (287 mg of gadolinium/mL) and 1.9 mL of 2% lidocaine hydrochloride (38 mg). Magnetic resonance imaging was performed immediately after completion of the injections to evaluate contrast distribution of each technique.

In the final part of phase 1, 4 dogs (mean weight, 10.0 kg [22.0 lb]; range, 6.9 to 12.7 kg [15.2 to 27.9 lb]) scheduled for euthanasia as part of unrelated research and assessed as clinically normal via complete ophthalmic examination performed by the same investigator (EB) were premedicated with acepromazine maleate (0.1 mg/kg [0.045 mg/lb], IM) before anesthesia was induced with thiopental sodium (15.0 mg/kg [6.82 mg/lb], IV, to effect); after endotracheal intubation, anesthesia was maintained with isoflurane gas in 100% oxygen. The dogs were mechanically ventilated, and anesthesia was monitored (via ECG, noninvasive assessment of blood pressure, pulse oximetry, and end-tidal capnography). No anesthetic complications occurred. By use of the preferred technique (as determined from results of the first 2 parts of phase 1), injections were performed (4 left eyes and 4 right eyes) with a mixture of 0.1 mL of gadolinium contrast agent (287 mg of gadolinium/mL) and 1.9 mL of 2% lidocaine hydrochloride (38 mg). Magnetic resonance imaging of the skull was performed immediately before and after injection. Evaluation of IOP by applanation tonometry and horizontal pupil diameter, gross evaluation of eye positioning, and assessment of the ease of globe manipulation were all performed before and after injection. After the final examination and without recovery from anesthesia, dogs were humanely euthanatized by IV injection of pentobarbital sodium for reasons unrelated to this study.

Evaluation of injection effects (phase 2)—In phase 2, 4 research Beagles (mean weight, 8.8 kg [19.4 lb]; range, 5.7 to 10.0 kg [12.5 to 22 lb]) received injections of a local anesthetic via the preferred technique that was identified from results of phase 1. Injections were administered in the right eyes of 2 dogs and in the left eyes of 2 dogs; in each dog, the noninjected eye was the control eye for that dog. Prior to injection, all eyes were assessed as clinically normal via ophthalmic examination performed by the same investigator (EB); for each dog, the assessment was made on the basis of results of a Schirmer tear test, fluorescein staining, slit-lamp biomicroscopy, direct and indirect ophthalmoscopy, applanation tonometry, and Cochet-Bonnet esthesiometry. The dogs were anesthetized as described. No anesthetic complications occurred. The retrobulbar needle penetration site was prepared with 23% povidone iodine solution;11 retrobulbar injections were performed with 2 mL of 2% lidocaine hydrochloride.
hydrochloride (40 mg; day 1). The effects of these injections were evaluated during anesthesia as described. For each dog, the same investigator (EB) performed a complete ophthalmic examination (as described) by 8 hours after the injection, then once daily for 5 days and also on days 8 and 15. Ocular motility was also assessed at each examination. Dogs were then transferred to another research study.

**Statistical analysis**—A paired \( t \) test was used to compare immediate pre- and postinjection pupil diameter and IOP. An ANOVA was performed to evaluate STT, IOP, and Cochet-Bonnet esthesiometry values during the 2-week postinjection period of phase 2. A value of \( P < 0.05 \) was considered significant.

**Results**

**Evaluation of techniques**—Results of the first part of phase 1 indicated that the ITP and perimandibular techniques both resulted in adequate distribution of latex in the retrobulbar space with no evidence of direct nerve trauma or globe perforation. Via the ITP technique, latex was present predominantly in the intraconal space, whereas via the perimandibular technique, it was present predominantly in the extraconal space.

Via the combined superior-inferior peribulbar technique, latex was present in the extraconal space with additional deposition under the eyelids, on the zygomatic salivary gland, and in the periorcular areas. Because this technique resulted in less predictable retrobulbar distribution of the injected material and was considered to have some increased risk associated with the need for 2 injections, it was not evaluated further.

In the second part of phase 1, dorsal and sagittal plane MR imaging revealed that intraconal retrobulbar placement of the contrast material was achieved for all injections performed via the ITP technique. In 1 perimandibular injection, no contrast agent was detected within the retrobulbar space. Both techniques resulted in some leakage of contrast material along the fascial plane of the temporalis muscle. In general, the ITP technique resulted in thorough and more consistent retrobulbar distribution of contrast material, compared with that achieved via the perimandibular technique. In addition, the perimandibular technique was more technically challenging, and the administrator had less confidence of exact needle placement at the time of injection. On the basis of these findings, the decision was made to focus only on the ITP technique for the remainder of the study (Figures 1 and 2).

In the last part of phase 1, the onset of action of the ITP retrobulbar injection was \(< 1\) minute in all eyes and was made evident by a large increase in pupil diameter and central rotation of the globe. After injec-

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**Figure 1**—Photograph (rostral view) to illustrate the needle placement required for retrobulbar injection performed via the ITP technique in an anesthetized dog.

**Figure 2**—Photograph of a frozen canine skull that has been sectioned through an eye and orbit to illustrate the approximate path of needle placement required for retrobulbar injection performed via the ITP technique. Notice that the tip of the needle terminates in the intraconal fat.

**Figure 3**—Photographs of the left eye of a clinically normal anesthetized dog immediately before (A) and after (B) ITP injection of a mixture of anesthetic and contrast agents. Following ITP injection, notice the pupil dilation, central globe positioning, and mild exophthalmia; there is no gross evidence of injection-associated complications. An absence of globe proptosis indicates a lack of clinically important retrobulbar hemorrhage. The irregular surface and reflectivity of the cornea is a result of general anesthesia and repeated tonometry measurements.
tion, pupil diameter increased significantly from a mean value of 2.9 mm before injection to a mean value of 11.0 mm after injection (Figure 3). All eyes became mildly exophthalmic without proptosis. After injection, there was no evidence that any globe had been injured in any way as a result of the ITP procedure. Finally, mean pre- and postinjection values of IOP for the dogs in this part of the study were not significantly different: mean preinjection values were 13 mm Hg in left eyes and 12 mm Hg in right eyes, and mean postinjection values were 12 mm Hg in left eyes and 14 mm Hg in right eyes.

On T1-weighted fat-suppression MR sequences obtained after ITP injection, it was possible to visualize the contrast material without interference from the orbital fat (Figure 4). In dorsal plane MR images, distribution of contrast material was detected in the
retrobulbar space, which indicated that intraconal placement of the contrast agent was achieved. There was no evidence of intraocular or intrathecal injection.

In sagittal plane MR images obtained before the ITP injection, the position of the lens was ventral to the palpebral opening, which was consistent with the clinical observation of anesthesia-induced ventral rotation of the globe (Figure 5). After injection, MR imaging revealed retrobulbar placement of contrast material, mild exophthalmia, and central rotation of the globe, indicated by positioning of the lens at the level of the palpebral opening. There was no evidence of intraocular or intrathecal injection, notable proptosis, or retrobulbar hemorrhage in any images.

**Evaluation of injection effects**—In phase 2, each of the 4 dogs had significant pupil dilation immediately after ITP injection of contrast material at all time points during anesthesia; before and after the injection, mean pupil diameter was 3.1 and 9.5 mm, respectively. The mean duration of anesthesia was 122.3 minutes (range, 115 to 128 minutes). In 1 dog in which pupil dilation was not as marked as in the others, a second injection of 1 mL of lidocaine hydrochloride was administered. This resulted in further pupil dilation, although the degree of dilation was not as dramatic as that detected in the other dogs.

There was no immediate evidence of complications secondary to the ITP injections. At all time points during anesthesia, there was no significant difference in IOP values between injected and control eyes either before (mean IOP value, 17 and 19 mm Hg, respectively) or after (mean IOP value, 21 and 22 mm Hg, respectively) injection. After uneventful recovery from anesthesia, each dog underwent complete ophthalmic examinations that were performed by the same investigator (EB) at intervals (as described) during a 2-week period. Findings of all postinjection ophthalmic examinations were considered normal with the exception of the following: mild conjunctival hyperemia for 24 hours after injection in all dogs; a single superficial, axial, pinpoint corneal erosion in 1 dog that healed without treatment within 24 hours; and subtle exophthalmia in 3 of 4 dogs that resolved by the 48-hour examination. Ocular motility was assessed as normal at all time points. Similarly, IOP values and results of Schirmer tear tests and Cochet-Bonnet esthesiometry were within reference ranges; there were no significant differences in those values between injected and control eyes at any point during the 2-week period.

**Discussion**

To our knowledge, this is the first study to evaluate orbital distribution of injectant, local anesthetic efficacy, and postinjection complications of retrobulbar anesthesia in dogs. Although the other techniques evaluated in phase 1 may be suitable for use under some conditions in dogs, the ITP injection was the preferred technique for retrobulbar anesthesia in our experience because it was easier to perform and provided thorough distribution of anesthetic agent within the intraconal retrobulbar space without evidence of complication.

In phase 2 of the study reported here, complete ophthalmic examinations were used to determine whether there were any long-term complications associated with application of the ITP technique in dogs. Cranial nerves II, III, IV, V, and VI and the ciliary ganglion were unaffected after the 2-week postinjection period. During the 2-week period after treatment, there was no significant difference in aqueous tear film production or aqueous humor production or outflow as determined by comparison of pre- and postinjection Schirmer tear test or IOP values, respectively. Retrobulbar myoneuropathy (a rare complication that has been associated with ITP injection in some humans) did not develop in the dogs of the present study because ocular motility remained normal throughout the 2-week follow-up period.

Cochet-Bonnet esthesiometry was used to measure corneal touch threshold (corneal sensitivity). The instrument consists of a nylon filament, which can be adjusted in length from 0 to 6 cm. The force exerted by the nylon when the filament contacts the cornea is inversely proportional to its length. Among the phase 2 study dogs, there was no significant difference in corneal touch thresholds between injected and control eyes, indicating that the functional integrity of the ophthalmic branch of the fifth cranial nerve was unaffected by the procedure.

Finally, the mild amount of conjunctival hyperemia detected in all dogs after the procedure in phase 2 was likely the result of the use of tissue forceps on the conjunctiva to assess ease of globe movement. The superficial corneal erosion identified in 1 dog was very mild and resolved in < 24 hours without treatment. On the basis of the results of the remainder of the ophthalmic examination in that dog, it appears that the erosion was most likely related to exposure or mild trauma during anesthesia. To our knowledge, corneal erosion or ulceration has not been described as a complication of retrobulbar injection in humans.

Results of other research\(^2\) in dogs suggests that IOP values increase after retrobulbar injection; to avoid such an increase in IOP, those authors recommended injection of the agent in small increments. However, in a subsequent report,\(^1\) another author disagreed with this recommendation. A subsequent study\(^3\) revealed that 2 to 3 mL of injectant adequately filled the orbital cone, and exceeding this volume increased the prevalence of leakage from the intraconal space; however, IOP was not evaluated in that study. The 2-mL volume administered to dogs in the present study adequately filled the intraconal space without an increase in IOP or other complications and resulted in a favorable clinical effect.

Many complications can occur with retrobulbar injections, such as globe perforation, extensive retrobulbar hemorrhage, or the development of myoneuropathy that results in abnormalities in globe movement or position. In the dogs used in our study, gross ocular evaluation, MR imaging of the skull, and follow-up ophthalmic examination did not reveal any complications associated with injections administered via the ITP technique. The potential risks of retrobulbar anesthesia may be less than the effects of inappropriate ventilation secondary to the use of NBAs without adequate...
monitoring or surgical procedures performed on eyes that are not centrally rotated and paralyzed.

The mild exophthalmos induced by retrobulbar injection may aid intracapsular lens extraction during the surgical management of anterior lens luxation; the space-occupying effect of the injection may result in an associated anterior vitreal displacement, which may help by maintaining the lens in an anterior position. For the same reason, this phenomenon may complicate phacoemulsification. However, retrobulbar injections are extensively used by physician ophthalmologists, and the human medical literature does not include vitreal displacement as an important complication. Further studies are needed to evaluate the effect of retrobulbar injection in dogs undergoing phacoemulsification and intracapsular lens extraction.

In the dogs used in our study, retrobulbar injections with lidocaine induced changes that are favorable for ophthalmic surgery such as pupil dilation, central rotation of the eye, and inhibition of globe movement and had no significant effects on IOP. At the anesthetic dose used in the present study, the duration of effect (approx 2 hours) appears to be sufficient for most ocular surgical procedures. More information regarding the consistency of the ITP technique will become available over time as it is used clinically. The addition of longer-acting anesthetics (such as bupivacaine hydrochloride) to the lidocaine injectant may increase the duration of retrobulbar analgesia, which could be useful for a procedure such as enucleation. Results of the present study suggest that retrobulbar anesthesia may be a potential alternative to the use of NBAs in ophthalmic surgery with provision of the additional benefit of local analgesia. Further studies are warranted to evaluate this technique in clinical patients.

References