Comparison of anesthetic efficacy and adverse effects associated with peribulbar injection of ropivacaine performed with and without ultrasound guidance in dogs

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Objective—To compare the anesthetic efficacy and adverse effects associated with peribulbar injection of ropivacaine (1% solution) performed with and without ultrasound guidance (UG) in dogs.

Animals—15 dogs without ophthalmologic abnormalities.

Procedures—Each dog was sedated and anesthetized. A peribulbar injection of ropivacaine (1% solution; 0.3 mL/kg) was performed with UG in 1 eye and without UG in the contralateral eye (control). For each eye, the intraocular pressure (IOP) immediately after eye centralization and number of punctures were recorded; ophthalmic complications, postinjection corneal sensitivity (determined by Cochet–Bonnet esthesiometry), durations of the sensory and motor blockades (the latter determined as the interval to restoration of the vestibulo-ocular reflex, pupillary light reflex, and conjugate eye movement), and blockade quality were assessed in both eyes following anesthetic recovery.

Results—Needle placement was fully visualized in 8 of the 15 eyes injected with UG. For eyes injected with or without UG, there was no difference with regard to the number of punctures, postinjection corneal sensitivity, and sensory or motor blockade duration and quality; however, restoration of conjugate eye movement occurred later in control eyes. For eyes injected with UG, mean IOP was 18.6 mm Hg, compared with 23.3 mm Hg for control eyes. Incidence of subconjunctival hemorrhage was higher for control eyes; severity of chemosis and hyperemia varied over time within both groups of eyes.

Conclusion and Clinical Relevance—In dogs, peribulbar injection of ropivacaine with UG is feasible in dogs and provides effective sensory and motor blockades similar to those achieved with conventional techniques. (Am J Vet Res 2014;75:1040–1048)

To preserve ocular integrity, ophthalmic procedures require specialized anesthetic and surgical conditions such as application of sophisticated equipment and techniques, patient immobilization, maintenance of cardiovascular and respiratory variables, and provision of an adequate surgical field. To achieve these conditions, intraocular analgesia should result in sensory fiber blockade, ocular extrinsic muscle akinesia, oculocardiac reflex blockade, and reduced IOP, allowing an appropriate postoperative outcome with minimal opioid use.

Peribulbar and retrobulbar blocks are highlighted among the various ophthalmic anesthetic techniques such as intracameral and subtenon anesthesia, topically, infiltrative anesthesia, and anesthesia of the lacrimal, zygomatic, ophthalmic, and auriculopalpebral nerves, because the isolated use of one of these techniques (except the subtenon anesthesia) will provide only the sensorial or motor blockade, and the value of the cannula of Greenbaum used in subtenon anesthesia technique can increase the cost of the procedure, which is high, compared with the cost of peribulbar or retrobulbar blockade.

For a retrobulbar block, the anesthetic agent is administered within the retrobulbar musculature and results in adequate analgesia and globe akinesia; a small drug volume is required and yet the time to onset of effects is short. However, close contact of the needle

ABBREVIATIONS

CEM Conjugate eye movement
IOP Intraocular pressure
PLR Pupillary light reflex
UG Ultrasound guidance
VOR Vestibulo-ocular reflex
with the muscular cone is associated with several risks including intraneural anesthesia of the subarachnoid space, which may induce CNS depression, apnea, and cardiac arrest; IV administration; ocular puncture; and retrobulbar hemorrhage. 9

As an alternative to the retrobulbar technique, peribulbar injection of anesthetic agents has been suggested. In a peribulbar block, the needle is introduced parallel to the orbital wall or floor and, unlike the retrobulbar block, the anesthetic agent is delivered external to the muscular cone. Thus, a peribulbar block is considered a safer method10 because it reduces the risk of injury to the orbital structures such as the optic nerve and blood vessels. 8 The peribulbar technique can be performed by double puncture at the orbit upper and lower corners,11,12,16 or by a single puncture at the inferotemporal or superonasal corner.12,13 The needle puncture in the inferotemporal aspect is performed at a point situated on the border of the zygomatic arch at the junction between the lateral third and the medial two-thirds; a puncture in the superonasal corner is performed between the medial third and the lateral two-thirds. 9,11 Results of several human14–17 and 2 animal12,13 studies suggest that a single-puncture technique yields adequate drug distribution with a low incidence of ophthalmic complications. 12 However, this technique usually requires a large volume of anesthetic agent as well as additional punctures when analgesia and akinesia were not adequate, which may increase the incidence of complications such as retrobulbar hematoma as well as scleral or ocular perforation. 8,12,13 Ultrasound guidance during administration of an anesthetic agent enables real-time visualization of the needle and drug dispersion, thereby improving the quality and safety of the procedure. 18 Widely used in human medicine20–23 and promisingly useful in veterinary medicine for patients requiring local anesthesia,24–31 anesthetic drug delivery with UG has advantages over anesthetic drug delivery without UG. The benefits include reduced volume of anesthetic agent, improved therapeutic efficacy;32,33 and visual confirmation of drug deposition.31–33 To our knowledge, the use of ultrasonography during administration of ophthalmic anesthetic blocks has been rarely explored, with only a few reports31–33,34 of human studies and 1 report35 of a study evaluating retrobulbar administration in equine cadavers. We are not aware of any studies of the efficacy and safety of anesthetic agents injected with UG for ocular anesthesia in live animals. On the basis of published data, use of UG during anesthetic agent administration to establish a peribulbar block could be a viable technique in dogs. Therefore, the purpose of the study reported here was to compare the anesthetic efficacy and adverse effects associated with peribulbar injection of ropivacaine (1% solution) performed with and without UG in dogs.

Materials and Methods

Animals—Fifteen adult dogs (30 eyes evaluated) owned by the university experimental kennel and of multiple breeds, both sexes, and various weights each underwent an ophthalmic examination. The evaluations were performed in a specific sequence, as follows:

Experimental procedures—Prior to each experiment, food and water were withheld from each dog for 12 and 2 hours, respectively. For sedation, acepromazine maleate was administered IM (0.05 mg/kg). After an interval of 20 minutes, a catheter was placed in a cephalic vein to enable IV administration of lactated Ringer’s solution (administration rate, 8 mL/kg/h). Anesthesia was induced with propofol (5 mg/kg, IV) and maintained via inhalation of isoflurane in oxygen. Throughout the period that the dogs were anesthetized with isoflurane, heart and respiratory rates; esophageal temperature; systolic, diastolic, and mean arterial blood pressures; oxygen saturation as measured by pulse oximetry; and fractions of inspired isoflurane and expired carbon dioxide were measured every 5 minutes with a multiparameter monitor. 8

For each dog, the 2 eyelids (upper and lower) were shaved, and the puncture site was aseptically prepared by delicately applying topical iodine solution with a sterile gauze. Each dog was first positioned in right recumbency for the peribulbar blockade with UG
and thereafter in left lateral recumbency for peribulbar blockade without UG. Once the dog was stable under general anesthesia, the peribulbar block was performed with UG via a single lower puncture site. Instead of a transcorneal technique, a trans-eyelid ultrasound technique was used to decrease the risk of corneal injury.35 The transducer was positioned sagittally on the upper eyelid near the optical axis and angled 80° to 90° relative to the globe to allow visualization of the eye, bulbar musculature, and optic nerve.

The transducer was then angled at 45° to 60° relative to the upper eyelid, remaining contralateral to the puncture point at the infraorbital floor and with the transducer orientation marker facing the puncture site (Figure 1); with this transducer orientation, the globe, ocular muscles, and optic nerve were simultaneously observed. Once the acoustic window was established, the needle was introduced through the skin within the lateral third of the lower orbital margin and aligned lengthwise to the ultrasound beam, which allowed visual confirmation of the needle’s real-time peribulbar location. In this moment, a syringe with ropivacaine (1% solution; 0.3 mL/kg) was connected to the needle and the drug was administered and visualized during its deposition; the orbit was then gently compressed for 2 minutes.

The dog was then positioned in lateral recumbency on the other side of the body, and the axial length of that contralateral eye was measured; its extension was marked directly on the needle shank with a pen to avoid excessive insertion into the socket. The globe was anesthetized via injection of the same volume of ropivacaine used previously but drug administration occurred without UG (control eyes). The injection was performed solely on the basis of the peribulbar block anatomic landmarks, with the needle introduced into the skin at the lower orbital margin between the lateral third and medial two-thirds. Once the drug was administered, the site was gently compressed for 2 minutes, the dog was kept in sternal recumbency for 20 minutes, and after this time, the anesthetic vaporization was completed.

Data collection—For both eyes in each dog, the number of punctures and the IOP immediately after eye centralization were recorded; for eyes injected with UG, the quality of needle visualization was assessed. Once the dog was completely awake (approx 30 minutes after the cessation of isoflurane administration), corneal and motor block durations and the incidence of opthalmic complications were also determined. Each dog was evaluated every 30 minutes until the basal esthesiometric value return to baseline and ocular movement returned and normalized. All dogs were evaluated by the same evaluators (FBP, JZF) who were unaware which eye was blocked with UG or not.

To assess the sensory blockade, corneal sensitivity was assessed with a Cochet–Bonnet esthesiometer; the filament length that induced a positive response indicated by a positive corneal reflex, globe retraction, or third eyelid protrusion in 2 of 3 consecutive assessments was recorded. A 4-cm-long filament was used initially, and the length was reduced in 0.5-cm increments for subsequent assessments until a positive response was elicited. To quantify the duration of the sensory blockade, the interval from the first evaluation after drug administration to when the esthesiometric value returned to the basal value was determined. The intensity of the motor blockade was considered absent, partial, or full on the basis of assessment of each of the cephalic movements: VOR (motor blockade indicated by absence of or decrease in lateral nystagmus during cranial rotation), PLR (motor blockade indicated by mydriasis unresponsive or poorly responsive to light), and CEM (motor blockade indicated by absence of or decreased visual accommodation during cranial movement). The interval during which each cephalic movement was not normal was recorded individually. Overall motor blockade duration was the time needed for the motor blockades to become absent as determined on the basis of the VOR, PLR, and CEM.

Each dog’s eyes were assessed for ophthalmic complications. Hyperemia, chemosis, subconjunctival hemorrhage, ophthalmic pruritus, tearing, and discharge were classified as absent, light, moderate, or intense; the behavior of these complications over the time was assessed. For statistical analysis, the severities of the ocular complications detected at 30, 60, 180, and 300 minutes after injection of the anesthetic agent and the last moment evaluated were also used. However, because the timing of that last evaluation differed among individuals, the final evaluation time point was not the same for all dogs.

Statistical analysis—Data that were not normally distributed or had a high variation coefficient were compared with the Wilcoxon test; normally distributed data were compared with a paired t test. Comparisons over time within each group of eyes were analyzed with the Friedman test, followed by the Dunn test for multiple comparisons. Comparisons over time between the groups of eyes were performed with the Wilcoxon signed rank test. The data were analyzed with computer software; a value of P < 0.05 was considered significant.

Results

Fifteen dogs were selected and included in the study. There were 8 females and 7 males of various breeds, including Beagle (n = 8), Labrador Retriever (1), Golden Retriever (1) and mixed-breed dogs (5). The mean ± SD weight was 13.5 ± 10.9 kg (median, 8.3 kg). During anesthesia, all dogs maintained mean arterial blood pressure (63.2 ± 5.4 mm Hg) within reference range, and fraction of expired carbon dioxide was 40.5 ± 5.6 mm Hg.

The peribulbar block was successfully performed in both eyes of all dogs. To correctly execute the injection with UG, an adequate acoustic window allowing real-time visualization of the needle, globe, and musculature was required. The needle was appropriately positioned in the peribulbar region of the 15 eyes. In 8 of the 15 eyes, complete ultrasonographically visible of the needle was achieved; the needle shank and tip were partially visible in images obtained from 7 eyes. The needle tip only was ultrasonographically visible for 3 eyes. Tissue distortion or the needle shank alone was not observed in the images for any of the 15 eyes.
The ropivacaine deposition was completely visualized in real time in all 15 eyes, and both the hypoechoic and anechoic aspects were visible as circular or oval shapes (Figure 2). After peribulbar injection of ropivacaine with UG, centering of the pupil was visible (Figure 3).

Of the variables assessed, only data for the IOP measurements were normally distributed, and are reported as mean ± SD. All other data were not normally distributed, and were compared by means of the Wilcoxon test; these data are reported as median and range as well as mean ± SD.

Figure 2—Representative real-time ultrasonographic image of the dispersion (area outlined by yellow dots) of 1% ropivacaine solution after peribulbar administration with UG in an isoflurane-anesthetized dog. In this image, the needle (arrow), globe (G), and optic nerve (ON) are visible.

Figure 3—Photographs illustrating ocular rotation (right eye) before peribulbar injection of 1% ropivacaine solution (A) and the visible centering of the pupil (left eye) after peribulbar injection of ropivacaine with UG (B) in an isoflurane-anesthetized dog.

For eyes that received a ropivacaine injection with UG, sensory block duration, the value of corneal esthesiometry obtained in the first assessment after administration of the anesthetic agent, and the mean number of punctures did not differ from findings for eyes that received a ropivacaine injection without UG (Table 1). For eyes injected with and without UG, the intervals during which the VOR, PLR, and CEM were absent and the intervals during which the VOR, PLR, and CEM were decreased did not differ significantly (Table 2). There was no difference in the intervals to restoration of the VOR and PLR; however, the interval to restoration of the CEM differed significantly between the groups of eyes. There was no difference in the overall duration of motor block between the groups of eyes.

The mean basal IOP was 18.8 ± 3.5 mm Hg in the eyes that were subsequently injected without UG and 19.6 ± 4.2 mm Hg in the eyes that were subsequently injected with UG. After ropivacaine injection, mean IOP immediately after eye centralization differed significantly (P < 0.05) between the 2 groups of eyes (23.3 ± 5.2 mm Hg in the control eyes vs 18.6 ± 5.4 mm Hg in the eyes injected with UG). The mean IOP immediately after eye centralization differed significantly (P < 0.05) from the basal value for the control eyes.

The dogs’ eyes were assessed for development of hyperemia, chemosis, subconjunctival hemorrhage, ophthalmic pruritus, tearing, and discharge (all of which were classified as absent, light, moderate, or intense) at 30, 60, 180, and 300 minutes after injection of the anesthetic agent and at the final evaluation (Table 3). In the eyes that received a ropivacaine injection with UG, chemosis was evident in all dogs 30 minutes after administration of the anesthetic agent. However, the classification assigned to this complication decreased over time and differed significantly at 60 and 300 minutes and at the final assessment after administration of the anesthetic agent; the severity at 60 minutes after injection of ropivacaine also differed from that at 300 minutes and at the final evaluation. Among eyes that received ropivacaine injection, that of only 1 dog did not develop chemosis at 30 minutes after administration of the anesthetic agent; this finding differed with changes identified at 60, 180, and 300 minutes and at

<table>
<thead>
<tr>
<th>Variable</th>
<th>With UG</th>
<th>Without UG</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of punctures</td>
<td>1 (1–3)</td>
<td>1 (1–6)</td>
</tr>
<tr>
<td>Duration of sensory blockade (min)</td>
<td>383 (212–732)</td>
<td>383 (157–485)</td>
</tr>
<tr>
<td>Basal esthesiometric value (cm)</td>
<td>1.6 (2.0–2.5)</td>
<td>1.4 ± 0.57</td>
</tr>
<tr>
<td>Postinjection esthesiometric value (cm)</td>
<td>0.066 ± 0.25</td>
<td>0.033 ± 0.12</td>
</tr>
</tbody>
</table>

Basal (pretreatment) corneal sensitivity testing of each dog was performed by use of a Cochet-Bonnet esthesiometer (pretreatment esthesiometric value [baseline]). Each dog underwent inhalation anesthesia with isoflurane and was administered a peribulbar injection of ropivacaine bilaterally (injection performed with UG for 1 eye and without UG for the other eye). A trans-eyelid ultrasonographic technique was used to decrease the risk of corneal injury, compared with the risk associated with a transcorneal technique. Number of punctures required to perform each injection was recorded. On completion of study evaluations, each dog was assessed for recovery from anesthesia. A trans-eyelid ultrasonographic technique was used to decrease the risk of corneal injury, compared with the risk associated with a transcorneal technique. Number of punctures required to perform each injection was recorded. On completion of study evaluations, each dog was assessed for recovery from anesthesia.

Table 1—Data obtained for 15 dogs that received a peribulbar injection of ropivacaine (1% solution; 0.3 mL/kg) with UG in 1 eye and without UG in the contralateral eye (control).
Table 2—Duration of ocular motor blockade (determined on the basis of full or partial blockade of the VOR, PLR, and CEM) in the 15 dogs in Table 1 that received a peribulbar injection of ropivacaine (1% solution; 0.3 mL/kg) with UG in 1 eye and without UG in the contralateral eye (control).

<table>
<thead>
<tr>
<th>Variable</th>
<th>With UG</th>
<th>Without UG</th>
</tr>
</thead>
<tbody>
<tr>
<td>VOR</td>
<td>Med (min)</td>
<td>Mean ± SD</td>
</tr>
<tr>
<td>Full blockade</td>
<td>33 (0–70)</td>
<td>26.3 ± 21.8</td>
</tr>
<tr>
<td>Partial blockade</td>
<td>15 (0–60)</td>
<td>26.7 ± 23.5</td>
</tr>
<tr>
<td>Overall blockade</td>
<td>40 (0–160)</td>
<td>53.8 ± 40.2</td>
</tr>
<tr>
<td>PLR</td>
<td>Med (min)</td>
<td>348 (98–630)</td>
</tr>
<tr>
<td>Full blockade</td>
<td>30 (0–90)</td>
<td>42 ± 31.7</td>
</tr>
<tr>
<td>Partial blockade</td>
<td>15 (0–60)</td>
<td>25.3 ± 21.3</td>
</tr>
<tr>
<td>Overall blockade</td>
<td>43 (0–98)</td>
<td>52.3 ± 27.7</td>
</tr>
</tbody>
</table>

Table 3—Number of eyes with ophthalmic complications at various time points in the 15 dogs in Table 1 that received a peribulbar injection of ropivacaine (1% solution; 0.3 mL/kg) with UG in 1 eye and without UG in the contralateral eye (control).

<table>
<thead>
<tr>
<th>Complication and severity</th>
<th>With UG</th>
<th>Without UG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hyperemia</td>
<td>Med (min)</td>
<td>12</td>
</tr>
<tr>
<td>Absent</td>
<td>4 4 3 4 4</td>
<td>5 5 3 4 4</td>
</tr>
<tr>
<td>Light</td>
<td>4 5 3 5 6</td>
<td>5 6 3 4 6</td>
</tr>
<tr>
<td>Moderate</td>
<td>7 6 8 5 6</td>
<td>5 4 7 7 5</td>
</tr>
<tr>
<td>Intense</td>
<td>0 0 1 0 0</td>
<td>0 0 2 0 0</td>
</tr>
<tr>
<td>Chemosis</td>
<td>Med (min)</td>
<td>15</td>
</tr>
<tr>
<td>Absent</td>
<td>0 0 0 4 6</td>
<td>2 1 1 3 6</td>
</tr>
<tr>
<td>Light</td>
<td>2 2 8 9 1</td>
<td>2 2 8 10 8</td>
</tr>
<tr>
<td>Moderate</td>
<td>8 7 7 2 1</td>
<td>7 6 6 2 1</td>
</tr>
<tr>
<td>Intense</td>
<td>5 6 0 0 0</td>
<td>4 6 0 0 0</td>
</tr>
<tr>
<td>Subconjunctival hemorrhage</td>
<td>Med (min)</td>
<td>3</td>
</tr>
<tr>
<td>Absent</td>
<td>13 13 14 13 13</td>
<td>9 8 8 9 8</td>
</tr>
<tr>
<td>Light</td>
<td>2 2 1 2 2</td>
<td>3 4 3 5 4</td>
</tr>
<tr>
<td>Moderate</td>
<td>0 0 0 0 0</td>
<td>1 0 3 2 2</td>
</tr>
<tr>
<td>Intense</td>
<td>0 0 0 0 0</td>
<td>2 3 1 0 0</td>
</tr>
<tr>
<td>Ophthalmic pruritus</td>
<td>Med (min)</td>
<td>1</td>
</tr>
<tr>
<td>Absent</td>
<td>15 15 14 15 15</td>
<td>15 15 14 15 15</td>
</tr>
<tr>
<td>Light</td>
<td>0 0 1 0 0</td>
<td>0 0 1 0 0</td>
</tr>
<tr>
<td>Moderate</td>
<td>0 0 0 0 0</td>
<td>0 0 0 0 0</td>
</tr>
<tr>
<td>Intense</td>
<td>0 0 0 0 0</td>
<td>0 0 0 0 0</td>
</tr>
<tr>
<td>Tearing</td>
<td>Med (min)</td>
<td>1</td>
</tr>
<tr>
<td>Absent</td>
<td>14 14 14 15 15</td>
<td>15 15 13 15 15</td>
</tr>
<tr>
<td>Light</td>
<td>1 1 1 0 0</td>
<td>0 0 2 0 0</td>
</tr>
<tr>
<td>Moderate</td>
<td>0 0 0 0 0</td>
<td>0 0 0 0 0</td>
</tr>
<tr>
<td>Intense</td>
<td>0 0 0 0 0</td>
<td>0 0 0 0 0</td>
</tr>
<tr>
<td>Discharge</td>
<td>Med (min)</td>
<td>3</td>
</tr>
<tr>
<td>Absent</td>
<td>15 14 14 15 15</td>
<td>14 14 14 15 15</td>
</tr>
<tr>
<td>Light</td>
<td>0 1 1 0 0</td>
<td>1 1 1 0 0</td>
</tr>
<tr>
<td>Moderate</td>
<td>0 0 0 0 0</td>
<td>0 0 0 0 0</td>
</tr>
<tr>
<td>Intense</td>
<td>0 0 0 0 0</td>
<td>0 0 0 0 0</td>
</tr>
</tbody>
</table>

Each dog's eyes were assessed for ophthalmic complications; hyperemia, chemosis, subconjunctival hemorrhage, ophthalmic pruritus, tearing, and discharge were classified as absent, light, moderate, or intense. The severity of the ocular complications was recorded at 30, 60, 180, and 300 minutes after injection of the anesthetic agent and at the last moment evaluated. However, because the timing of that last evaluation differed among individuals, the final evaluation time point was not the same for all dogs. The number of complications does not add up to the total number because statistical analyses were only performed with the values obtained at 30, 60, 180, and 300 minutes after injection; these time points were chosen because they were associated with a greater number of variations. Only the incidence of subconjunctival hemorrhage differed significantly ($P = 0.031$) between the 2 groups of eyes, with a higher incidence in the control group.

To assess motor blockade after peribulbar injection of ropivacaine in each eye, the intervals during which the VOR, PLR, and CEM were absent (full blockade) or decreased (partial blockade) were recorded. For the VOR, this was indicated by absence of or decrease in lateral nystagmus during cranial rotation. For the PLR, this was indicated by mydriasis that was unresponsive or poorly responsive to light. For CEM, this was indicated by absence of or decrease in visual accommodation during cranial movement. Overall duration of motor blockade was calculated as the interval from the first assessment with the dog completely awake (approx 30 minutes after general anesthetic recovery) to the last assessment when eye movement returned and was normalized.

*For this variable, values differ significantly (Wilcoxon test, $P < 0.02$) between groups*
to the low magnitude of severity difference on the basis of the Dunn multiple comparison test, the intragroup variation over time could not be determined. Only the incidence of subconjunctival hemorrhage (Figure 4) differed significantly ($P = 0.031$) between the 2 groups of eyes, with a higher incidence in the control group.

In 3 large dogs, (1 Labrador Retriever, 1 Golden Retriever, and 1 mixed-breed dog), the ultrasonographic images were poor quality in both eyes, and eyeballs were somewhat retracted after the beginning of inhalation anesthesia; however, these facts did not prevent the completion of the blocks and did not necessitate removal of the images from the study. The tear production was not measured after ropivacaine injection performed with UG and without UG but was visibly decreased during the measurement of the IOP, sensory evaluations, and assessment of ophthalmic complications in both eyes in all dogs.

Punctate superficial ulcers were found in 2 of these dogs in both eyes, in the central part of the cornea at the final assessments, though no signs of discomfort were observed. The dogs were administered topical anti-inflammatory eye drops$^6$ and an antimicrobial ophthalmic solution$^9$ every 6 hours as long as was necessary; however, the corneas were healed after 3 days.

**Discussion**

Ultrasound-guided administration of local anesthetic agents has received great notoriety in human and veterinary medicine.$^{19}$ However, few studies$^{29}$ have compared the clinical outcomes of these techniques with those of anesthetic blocks applied on the basis of anatomic landmarks in live animals.$^{19,30}$ Thus, the present study has provided pioneering results through comparison of data obtained following peribulbar injection of ropivacaine (1% solution) performed with and without UG in dogs.

Successful peribulbar injection of an anesthetic agent with UG depends on upper trans-eyelid positioning of the transducer, visualization of the needle and agent with UG depends on upper trans-eyelid positioning of the needle but was visibly decreased during the measurement of the IOP, sensory evaluations, and assessment of ophthalmic complications in both eyes in all dogs.

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Successful peribulbar injection of an anesthetic agent with UG depends on upper trans-eyelid positioning of the transducer, visualization of the needle and orbital structures, and real-time observation of the drug dispersion. The few published reports$^{19,31,32}$ of ophthalmic blocks applied with UG describe the importance of these criteria to ensure a positive clinical outcome.

Although we decided to use a high fixed volume of ropivacaine to ensure that the techniques were not affected by low drug volumes (given that the local structures [extraocular muscles, fat, and blood vessels] could alter its dispersion into the intraconal$^{19}$ region), benefits provided by local blocks administered with UG, such as reducing the volume and latency of the anesthetic agent$^{29,33,38}$ were not evaluated. However, other advantageous features related to the blocks administered with UG were observed including increased safety for the patient, visual confirmation of drug deposition, objective technical accuracy, and increased efficiency for difficult blocks.$^{19,25,26,30}$

The lack of significant differences in sensory and motor blockade duration in the eyes anesthetized with or without UG was due to the use of ropivacaine in the same concentration (1%) and volume (0.3 mL/kg). In the dogs’ eyes evaluated in the present study, the sensory blockade duration was longer than the motor blockade duration (attributed to the higher affinity of $\alpha$ and $\delta$ sensory fibers for ropivacaine, compared with that of motor fibers$^{37}$). This finding was similar to a previously reported sensory blockade duration of 360 minutes in dogs that received local anesthesia of 1% ropivacaine solution.$^{38}$ However, these data differ from that reported by Oliva et al,$^{11}$ who recorded a 272-minute sensory blockade duration in dogs administered a less concentrated ropivacaine formulation (0.75%) via peribulbar injection. Vasquez et al$^{40}$ observed a greater efficacy of 1% ropivacaine solution, compared with that of 0.75% ropivacaine solution, after periconal injection in humans. Lidocaine administration by sub-Tenonian peribulbar injection in dogs undergoing phacoemulsification provided analgesia of approximately 88 minutes’ duration in another report.$^5$ Results of these studies confirm that ropivacaine has a long duration of action, compared with other local anesthetic agents and may reduce the pre- and postoperative opioid analgesic requirement and consequently, reduce the opioid-associated adverse effects (eg, sedation, urinary retention, vomiting, and body temperature changes$^{40}$).

Esthesiometric values between 0 and 0.5 cm indicate corneal insensitivity in dogs$^{11}$; the values for the dogs’ eyes evaluated in the present study were within this range, thereby confirming the effectiveness of the injection techniques. The esthesiometric values were unlikely to have been influenced by anesthesia. The assessment was performed approximately 30 minutes after recovery from anesthesia (when the dogs were conscious) and the esthesiometric response remained absent for hours, gradually returning to basal status in nearly all dogs. These findings all confirm the establishment of an effective sensory blockade.

The motor blockade of the PLR was the most intense and lasting motor effect in both eyes in all dogs in the present study, which differs from the findings of a study by Klaumann$^e$ in which a partial total motor blockade of the PLR was detected in approximately 60% of 15 dogs at 55 minutes after peribulbar injection of 1% ropivacaine solution and partial motor blockade in 40% of the dogs at 100 minutes; the difference between the values in intensity and duration of motor blockade in this study and in that by Klaumann$^e$ can be explained by the low volume (0.1 mL/kg) of anesthetic agent used in the latter, and also by the administration of the total volume of ropivacaine between 2 points of puncture (lateral corner and nasomedial aspect), which exposed the parasympathetic nerve fibers to a lower amount of anesthetic agent.
The high-quality mydriasis induced by techniques in the present study eliminated the need for intraoperative administration of mydriatic eye drops, which requires comparatively more time to achieve the desired effect. Pupillary dilation induced by mydriatics eye drops often dissipates during surgery and is limited when uveitis is present.13

In the present study, the duration of the motor blockade achieved by peribulbar injection of ropivacaine was short, and the blockade was predominantly partial of the VOR and CEM reflexes. Oliva et al11 detected a motor blockade of 133 minutes' duration after peribulbar injection of ropivacaine 0.75% in dogs undergoing laccetomy, but the method of assessment was period intraoperative measurement of the ocular rotation by a goniometer, which differed from the evaluation method used in the present study. Klauumann reported partial motor blockade of the VOR in 9 of 15 dogs only at 100 minutes after peribulbar injection of 1% ropivacaine solution. In the present study, the difference in CEM between eyes that were injected with or without UG was 3.4 minutes, which was not considered clinically relevant. Eye centralization can also be achieved through neuromuscular blockade, but those neuromuscular agents are associated with respiratory muscle paralysis and require controlled ventilation as well as adequate patient monitoring.4,43

In humans, IOP increases in response to extraocular muscle pressure, intraocular content changes, systemic hypertension, medications, and hypercapnia. All dogs of the present study maintained mean arterial blood pressure (63.2 ± 5.4 mm Hg) within reference range, and fraction of expired carbon dioxide was 40.5 ± 5.6 mm Hg; the drugs administered are known to reduce or maintain IOP, and a change in intraocular fluid volume was unlikely because no intraocular drug administration was evident.

In humans, IOP may transiently increase immediately following the peribulbar injection because of the pressure exerted on the globe by the physical volume of drug injected, which increases intraorbital pressure.48 Differences in IOP found between the groups may be due to the large volume of injected anesthetic agent and of the inadequate extrinsic muscle relaxation in some animals. Ideally, IOP should be evaluated serially during the period of blockade to determine whether any increase is transitory and related to the high drug volume or related to high latency of the block because the peribulbar technique is subject to inaccurate needle positioning when performed without UG. Luyet et al13 observed the real-time dispersion of lidocaine after performing a peribulbar block without UG in humans and found erroneous intracameral dispersion in 61 of 100 subjects. In the dogs' eyes that received ropivacaine injection with UG, IOP was unchanged after the procedure, because of the ability of ropivacaine to reduce IOP; this ability may assist in balancing the IOP when large volumes of anesthetic agents are administered, increasing suspicions that the technique of peribulbar injection without UG directly influences IOP value as a result of inappropriate placement of the needle.

Ophthalmic complications may be associated with peribulbar injections of local anesthetic agents and include pruritus, blepharospasm, chemosis, and subconjunctival hemorrhage; administration of retrobulbar blocks may cause hyperemia and corneal ulceration.3 In the present study, subconjunctival hemorrhage was less common and less intense in the dogs' eyes that received the ropivacaine injection with UG, compared with findings for eyes that received the ropivacaine injection without UG, likely because of more accurate orientation of the needle path. Chemosis is caused by drug dispersion in the anterior orbit and decreases over time as the anesthetic agent is absorbed. Accola et al18 reported that hyperemia was associated with excessive conjunctival manipulation during motor blockade assessment after performing a retrobulbar block in dogs. In the present study, sensory evaluation was frequently only possible by forcing the eyelids open manually, causing excessive conjunctival manipulation. Abnormal lacrimal production and eyelid akinesia may cause hyperemia, ocular discharge, and corneal ulceration in dogs; although these complications were not assessed during the postinjection period in the present study, they were observed in some dogs, confirming the potential risk of ophthalmic complications.

The lower-quality definition of images obtained for 3 large dogs in the present study may be attributable to bulbar retraction caused by propofol- and isoflurane-induced muscle relaxation.45 According to Spaulding,11 ocular ultrasonography is more difficult in large dogs because of globe retraction; however, this does not contraindicate the use of UG during administration of ocular anesthetic blocks.

A limitation of the present study was that the tear film in each eye was not evaluated after the injection had been administered. However, tear production was visibly decreased during the measurement of the IOP, sensory evaluations, and assessment of ophthalmic complications in both eyes in all dogs. Yasui et al53 demonstrated a relationship between lacrimal gland vasodilation (induced by electrical corneal stimulation) and tear production in cats, which was mediated by the ophthalmic nerve via the parasympathetic pathway. The vasoconstrictive effect of ropivacaine may reduce lacrimal gland perfusion, which, when combined with an efficient sensory block (ophthalmic nerve block), may explain the decreased tear film in the study dogs. The anesthetic blockade of lacrimal gland innervation cannot be ruled out because of the dorsolateral location of the gland within the orbit.

Results of the present study indicated that peribulbar injection of anesthetic agents can be performed effectively with UG in dogs. Use of upper trans-eyelid transducer positioning allowed real-time needle visualization and anesthetic agent dispersion. The quality and duration of the sensory and motor blockades were very similar to those obtained by the conventional peribulbar injection technique (without UG). However, the eyes of the dogs that received peribulbar injection performance with UG, the IOP remained stable and the incidence of subconjunctival hemorrhage was lower, highlighting the need for further studies to assess the potential clinical usefulness of this anesthetic technique.
References


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