Intraocular pressure measurements with the Tono-Pen XL® and Perkins® applanation tonometers in horses and cattle

Pressão intraocular medida com os tonômetros de aplanação Tono-Pen XL® e Perkins® em equinos e bovinos

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ABSTRACT

The objective of this study was to compare the accuracy between two applanation tonometers, Tono-Pen XL® and Perkins®, in horses and cattle. The eyes of 20 horses and 20 cattle conscious and healthy were evaluated for the in vivo study and both eyes of 5 horses and 5 cattle were used as controls for the postmortem study. In conscious animals, the tonometry was performed with auriculopalpebral nerve block and then topical anesthesia for both tonometers and 1% fluorescein eye drops only for the Perkins tonometer. Readings of intraocular pressure (IOP) in the postmortem study were taken using manometry and tonometry by Tono-Pen XL® and Perkins®. The correlation coefficient ($r^2$) between manometry and applanation tonometers Tono-Pen XL® and Perkins®, in horses, were 0.845 and 0.989, respectively, and in cattle, were 0.772 and 0.988, respectively. The mean IOP values in conscious horses with Tono-Pen XL® and Perkins® were 20.1±3.9mmHg and 20.9±3.2mmHg, respectively, and in conscious cattle, these values were 17.2±2.4mmHg and 17.9±1.4mmHg, respectively. There was a strong correlation between the IOP values obtained by direct ocular manometry and the Tono-Pen XL® and Perkins® tonometers in horses and cattle. There was no statistically significant difference between the mean IOPs obtained with both tonometers in conscious animals; however, there was a difference between the minimum values, which were on average 2–3 mmHg lower with the Tono-Pen XL® tonometer than with the Perkins® tonometer, which justifies a table of normal values differentiated for each tonometer.

Key words: applanation tonometer, cattle, horses, Perkins tonometer, Tono-Pen XL tonometer.

INTRODUCTION

Glaucoma is a very serious ocular disease, and increased intraocular pressure (IOP), which is one of the major risk factors of glaucoma, decreases blood flow to the optic nerve and retina, causing severe injuries that can lead to vision reduction or even blindness (PICKETT & RYAN, 1993; MILLER,...
2008). The early and accurate diagnosis of the increased IOP is crucial for the control of this disease (CHANG, 1998; MAGGS, 2008; MILLER, 2008).

In clinical settings, IOP measurement is performed with the use of tonometers (fixed or portable) that use various techniques such as indentation, applanation or rebound (CHANG, 1998; KNOLLINGER et al., 2005; LEIVA et al., 2006; MAGGS, 2008). In veterinary medicine, the applanation method, based on the principle that the force required to flatten a certain area of a sphere is equal to the pressure within the sphere (Imbert-Fick Law), is the most frequently used method (MAGGS, 2008). The Tono-Pen XL® (Figure 1A), a handheld applanation tonometer, is the most popular tonometer; however, it is expensive, which restricts the use of this device to a few veterinary ophthalmology clinics.

In human medicine, the applanation method is also the most commonly used, the Goldmann method that use Goldmann slit-lamp fixed or portable in the Perkins® tonometer (Figure 1B), is considered to be the standard procedure for IOP measurement to be accurate and practical (SCHOTTENSTEIN, 1996; CHANG, 1998). Recent studies in dogs and cats (ANDRADE et al., 2009; ANDRADE et al., 2012) and in horses and cattle (GEROMETTA et al., 2004; ANDRADE et al., 2011) demonstrate that the advantages of using the Perkins® tonometer mainly include the accuracy of the IOP measurements when compared with manometry and a more accessible price, which is approximately 3 to 5 times cheaper than the Tono-Pen XL® or Tonovet® tonometers.

There are no comparative studies of the accuracy in IOP measurement between the Tono-Pen XL® and Perkins® application tonometers in horses and cattle. Therefore, the purpose of this study was to evaluate the advantages and disadvantages of these tonometers in healthy horses and cattle.

MATERIALS AND METHODS

Ten eyes from five adult horses and cattle were obtained from a slaughterhouse (King Meat, Apucarana, PR, Brazil) and Bom Mart (Presidente Prudente, SP, Brazil), respectively, for the postmortem study. Both eyes remained in situ within the orbits and were obtained immediately after sacrifice; the heads were transported in refrigerated boxes, and the experiment was performed within 1h after the sacrifice. For the in vivo study, twenty conscious adult horses and cattle were obtained from the Veterinary Teaching Farm of UNOESTE (Presidente Prudente, SP, Brazil). Only normal eyes were used in this study, as determined by ophthalmic examination (direct ophthalmoscopy, pupillary light reflex, Schirmer Tear Test and fluorescein test). All measurements with the tonometers were obtained by the same examiner (RJP) for Tono-Pen XL® IOP reading and by the same examiner (SFA) for Perkins® IOP reading to avoid inter-observer variability. After the procedures, the animals were returned to pasture at the Veterinary Teaching Farm of UNOESTE.

For the postmortem study, the method was based on other previously described studies in dogs and cats (ANDRADE et al., 2009; ANDRADE et al., 2012) and horses and cattle (ANDRADE et al., 2011). The eyelids were separated with an eyelid speculum, and the anterior chamber was cannulated with a 23-gauge scalp vein needle (Embramac, Itapira, SP, Brazil) through the cornea, 2mm from the limbus in the supero-lateral quadrant. Cyanoacrylate glue was applied around the needle to prevent leakage of the aqueous humor. The needle was connected via a polyethylene tube to a three-way stopcock, which was also connected to a reservoir (syringe) containing 10mL of physiologic saline solution (Fresenius Kabi,
Intraocular pressure measurements with the Tono-Pen XL® and Perkins® applanation tonometers in horses and cattle.

Campinas, SP, Brazil) and to an aneroid manometer (Missouri, São Paulo, SP Brazil) that was at the zero position relative to the center of the eye. The calibration curve for manometry versus tonometry was determined by artificially raising the IOP in 5mmHg increments up to 50mmHg (10-50mmHg), in open stopcock mode. Three readings were taken at each level of IOP. First, the Tono-Pen XL tonometer (Medtronic Solan, Jacksonville, FL, USA) was used, and the mean was calculated (MAGGS, 2008); then, the Perkins tonometer (Clement Clarke, Harlow, UK) was used, and the mean was calculated and multiplied by 10 (ANDRADE et al., 2009; ANDRADE et al., 2011). Prior to the Perkins IOP reading, one drop of 1% fluorescein eye drop (Allergan, Guarulhos, SP, Brazil) was instilled for the formation of fluorescein semicircles. The tonometers were calibrated according to the manufacturer’s instructions prior to the study.

For the in vivo study, IOP readings with the Tono-Pen XL® and Perkins® tonometers were obtained in conscious and healthy horses and cattle. The horses were guided into a solid-sided restraint, with a bar in front and a bar or solid gate behind, and the cattle were guided into a funnel corral and then into a neck yoke. The auriculopalpebral nerve block was performed with 10mL of lidocaine 2% without a vasoconstrictor (Hipolabor, Brazil) because the tension of the eyelid may artificially elevate the IOP measurements (VANDER WOERDT et al., 1995; ANDRADE et al., 2011), and then, the cornea was topically anesthetized with two drops of 1% tetracaine and 0.1% phenylephrine (Anestésico®; Allergan). The IOP measurements with the Tono-Pen XL® were made first, then one drop of 1% fluorescein eye drops was instilled and the measurements with the Perkins tonometer were made. Three readings were taken with the Tono-Pen XL®, and the mean was calculated; this procedure was repeated with the Perkins tonometer, and the mean was multiplied by 10. To prevent the transmission of ocular infectious diseases after using the Tono-Pen XL®, the disposable tip-cover was replaced after each patient use (MAGGS, 2008). For the Perkins tonometer, the prism was removed and washed in a 0.9% saline solution and then immersed in a solution of 3% hydrogen peroxide for 5min, washed again in 0.9% saline solution and dried with sterile gauze to prevent infection (LINGEL & COFFEY, 1992).

The mean IOP values measured using ocular manometry and tonometry in the postmortem study were used to create a calibration curve. Linear regression analysis was performed to analyze the relationship between the postmortem manometry vs. tonometry IOP measurements, and a correlation coefficient (r²) was calculated. Tono-Pen XL® and Perkins® tonometer readings taken from the in vivo study were compared and analyzed by Student’s t-tests. A significance level of P<0.05 was adopted.

**RESULTS**

In the post-mortem study (Table 1) in horses (Figure 2A), the correlation coefficient (r²) between the manometer and the Tono-Pen XL® tonometer was 0.845, and between the manometer and the Perkins® tonometer, the coefficient was 0.989; the linear regression equations were y=0.635x-0.763

<table>
<thead>
<tr>
<th>Aneroid Manometer (mmHg)</th>
<th>Horses</th>
<th>Cattle</th>
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<tbody>
<tr>
<td>10</td>
<td>7.7±1.1</td>
<td>7.5±2.0</td>
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<tr>
<td>15</td>
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<td>20</td>
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<td>15.9±2.3</td>
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<td>18.5±3.9</td>
<td>21.6±4.6</td>
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<td>40</td>
<td>23.2±3.8</td>
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<tr>
<td>50</td>
<td>34.4±5.2</td>
<td>26.3±3.5</td>
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*Three IOP readings were measured with the Tono-Pen XL® tonometer and the mean was calculated. Three IOP readings were measured with the Perkins® tonometer, and the mean was calculated and multiplied by 10.
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The correlation coefficient \( r^2 \) between the manometer and the Tono-Pen XL tonometer was 0.772 and between the manometer and the Perkins \({}^\circledast\) tonometer was 0.988; the linear regression equations were \( y=0.507x-2.621 \) (Tono-Pen XL\({}^\circledast\)) and \( y=0.850x+2.046 \) (Perkins\({}^\circledast\)).

In the in vivo study, the IOP value for horses with the Tono-Pen XL\({}^\circledast\) tonometer was 20.1±3.9 (12.2-27.7mmHg), and the IOP value with the Perkins tonometer was 20.9±3.2 (14.6-27.0mmHg). In cattle, the IOP value with the Tono-Pen XL\({}^\circledast\) tonometer was 17.2±2.4 (12.8-21.2mmHg), and the IOP value with the Perkins\({}^\circledast\) tonometer was 17.9±1.4 (15.7-20.7mmHg).

**DISCUSSION**

The Tono-Pen XL\({}^\circledast\) tonometer has been used for more than 3 decades, and although it is
the most popular tonometer in veterinary medicine, its accuracy has always been questioned in human medicine (FRENKEL et al., 1988; IESTER et al., 2001; ANDRADA MÁRQUES et al., 2003; KALESNYKAS & UUSITALO, 2007). In addition, its high cost has restricted its use to specialized veterinary ophthalmology centers. With the recent publications of the use of the Perkins tonometer in dogs and cats (ANDRADE et al., 2009; ANDRADE et al., 2012) and in horses and cattle (GEROMETTA et al., 2004; ANDRADE et al., 2001), comparing the accuracy of the tonometers with that of ocular manometry was the objective of this study.

With regard to the accuracy, there was a strong correlation between the IOP values obtained with ocular manometry and the IOP values obtained with the Tono-Pen XL® and Perkins® tonometers (Figure 2); however, the Perkins® tonometer was more accurate than the Tono-Pen XL® tonometer, producing measurements that were much closer to the real IOP values measured with manometry (Table 1). The Tono-Pen® XL tonometer underestimated IOPs between 15 and 50 mmHg in horses and cattle, which was in agreement with other studies (Pries et al., 1990; ANDRADA MÁRQUES et al., 2003; PASSAGLIA et al., 2004; LIM et al., 2005; KALESNYKAS & UUSITALO, 2007). Some studies comparing the Tono-Pen XL® tonometer with other tonometers, such as the Perkins® and TonoVet® tonometers in rabbits (KALESNYKAS & UUSITALO, 2007) and the Goldmann tonometer in humans (FRENKEL et al., 1988; IESTER et al., 2001) suggested a lower accuracy of the Tono-Pen XL® tonometer for high IOP values.

In the in vivo study, there was no significant difference between the average IOP values obtained with the Tono-Pen XL® and Perkins® tonometers. There was only a difference between the minimum values (approximately 2 to 3 mmHg lower with the Tono-Pen XL® tonometer).

This study demonstrated that both the Tono-Pen XL® and the Perkins® tonometers are excellent devices for measuring IOP in horses and cattle. There was no statistically significant difference between the mean IOPs obtained with both tonometers in conscious animals; however, there was a difference between the minimum values, which were on average 2-3 mmHg lower with the Tono-Pen XL® tonometer than those measured with the Perkins tonometer, which justifies a table of normal values differentiated for each tonometer.

**BIOTHECS AND BIOSSECURITY COMMITTEE APPROVAL**

This experiment was approved by the Animal Ethics Committee of the University of Oeste Paulista (UNOESTE) (Protocol n.18).

**ACKNOWLEDGMENT**

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