

## Intraocular pressure measurements with the Tono-Pen XL<sup>®</sup> and Perkins<sup>®</sup> applanation tonometers in horses and cattle

Pressão intraocular medida com os tonômetros de aplação Tono-Pen XL<sup>®</sup> e Perkins<sup>®</sup> 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<sup>®</sup> and Perkins<sup>®</sup>, 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<sup>®</sup> and Perkins<sup>®</sup>. The correlation coefficient ( $r^2$ ) between manometry and applanation tonometers Tono-Pen XL<sup>®</sup> and Perkins<sup>®</sup>, 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<sup>®</sup> and Perkins<sup>®</sup> were  $20.1 \pm 3.9$  mmHg and  $20.9 \pm 3.2$  mmHg, respectively, and in conscious cattle, these values were  $17.2 \pm 2.4$  mmHg and  $17.9 \pm 1.4$  mmHg, respectively. There was a strong correlation between the IOP values obtained by direct ocular manometry and the Tono-Pen XL<sup>®</sup> and Perkins<sup>®</sup> 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<sup>®</sup> tonometer than with the Perkins<sup>®</sup> tonometer, which justifies a table of normal values differentiated for each tonometer.

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

### RESUMO

O objetivo deste estudo foi comparar a acurácia entre dois tonômetros de aplação, Tono-Pen XL<sup>®</sup> e Perkins<sup>®</sup>, em equinos e bovinos. Os olhos de 20 equinos e 20 bovinos

conscientes e saudáveis foram avaliados para o estudo in vivo e ambos os olhos de 5 equinos e 5 bovinos foram usados como controle para o estudo post-mortem. Nos animais conscientes, a tonometria foi realizada com bloqueio do nervo auriculopalpebral e depois anestesia tópica para ambos os tonômetros e colírio de fluoresceína a 1% somente para o tonômetro de Perkins. Leituras da pressão intraocular (PIO) no estudo post-mortem foram realizadas utilizando manometria e tonometria pelo Tono-Pen XL<sup>®</sup> e Perkins<sup>®</sup>. O coeficiente de correlação ( $r^2$ ) entre a manometria e os tonômetros de aplação Tono-Pen XL<sup>®</sup> e Perkins<sup>®</sup>, em equinos, foi de 0,845 e 0,989, respectivamente, e, em bovinos, foi de 0,772 e 0,988, respectivamente. Os valores médios de PIO nos equinos conscientes com Tono-Pen XL<sup>®</sup> e Perkins<sup>®</sup> foram  $20,1 \pm 3,9$  mmHg e  $20,9 \pm 3,2$  mmHg e, em bovinos conscientes, os valores foram de  $17,2 \pm 2,4$  mmHg e  $17,9 \pm 1,4$  mmHg, respectivamente. Houve uma forte correlação entre os valores obtidos de PIO pela manometria ocular direta e os tonômetros Tono-Pen XL<sup>®</sup> e Perkins<sup>®</sup> em equinos e bovinos. Entretanto, houve uma diferença entre os valores mínimos, em média 2-3 mmHg menor com o tonômetro Tono-Pen XL<sup>®</sup> do que o tonômetro de Perkins<sup>®</sup>, o que justifica uma tabela de valores diferenciada para cada tonômetro.

**Palavras-chave:** tonômetro de aplação, bovinos, equinos, tonômetro de Perkins, tonômetro Tono-Pen XL.

### 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,

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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® applanation 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,

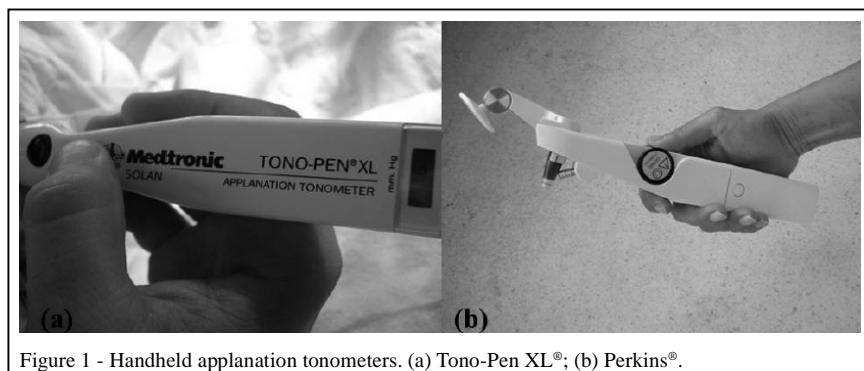


Figure 1 - Handheld applanation tonometers. (a) Tono-Pen XL®; (b) Perkins®.

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<sup>®</sup> and Perkins<sup>®</sup> 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 (VAN DER 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<sup>®</sup>; Allergan). The IOP measurements with the Tono-Pen XL<sup>®</sup> 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<sup>®</sup>, 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<sup>®</sup>, 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 ( $r^2$ ) was calculated. Tono-Pen XL<sup>®</sup> and Perkins<sup>®</sup> 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.

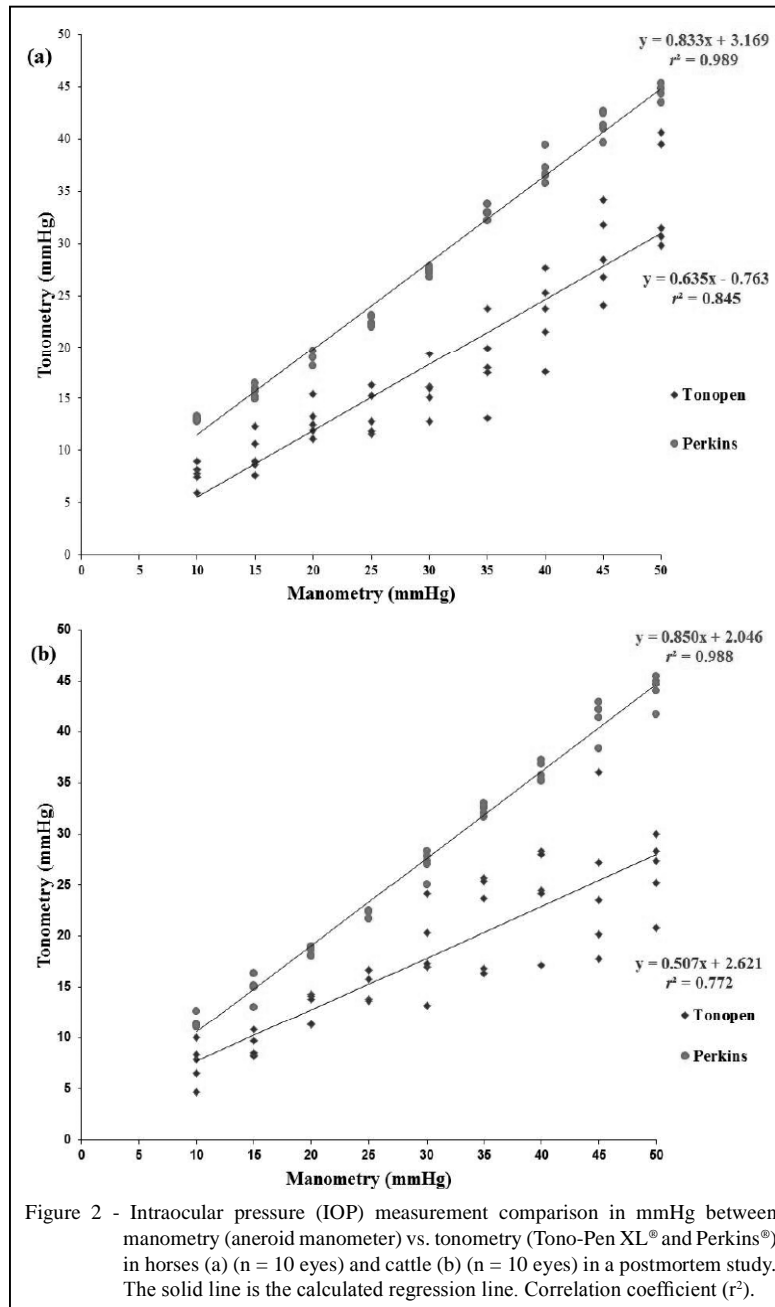
## RESULTS

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

Table 1 - Mean  $\pm$  SD values of intraocular pressure (IOP)\* (mmHg) in horses (n = 10 eyes) and cattle (n = 10 eyes) measured with the Tono-Pen XL<sup>®</sup> and Perkins<sup>®</sup> applanation tonometers in a postmortem study.

Aneroid Manometer (mmHg)	-----Horses-----		-----Cattle-----	
	Tonopen XL <sup>®</sup>	Perkins <sup>®</sup>	Tonopen XL <sup>®</sup>	Perkins <sup>®</sup>
10	7.7 $\pm$ 1.1	13.0 $\pm$ 0.2	7.5 $\pm$ 2.0	11.5 $\pm$ 0.7
15	9.6 $\pm$ 1.8	15.6 $\pm$ 0.6	9.1 $\pm$ 1.1	14.9 $\pm$ 1.2
20	12.8 $\pm$ 1.7	19.1 $\pm$ 0.6	13.0 $\pm$ 3.8	18.6 $\pm$ 0.5
25	13.6 $\pm$ 2.1	22.6 $\pm$ 0.5	15.3 $\pm$ 1.5	22.1 $\pm$ 0.4
30	15.9 $\pm$ 2.3	27.4 $\pm$ 0.4	18.4 $\pm$ 4.1	27.1 $\pm$ 1.3
35	18.5 $\pm$ 3.9	33.0 $\pm$ 0.6	21.6 $\pm$ 4.6	32.4 $\pm$ 0.5
40	23.2 $\pm$ 3.8	37.1 $\pm$ 1.4	24.4 $\pm$ 4.5	36.0 $\pm$ 0.9
45	29.1 $\pm$ 4.0	41.4 $\pm$ 1.2	24.9 $\pm$ 7.1	41.4 $\pm$ 1.8
50	34.4 $\pm$ 5.2	44.5 $\pm$ 0.7	26.3 $\pm$ 3.5	44.2 $\pm$ 1.5

\*Three IOP readings were measured with the Tonopen 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.



(Tono-Pen XL®) and  $y=0.833x+3.169$  (Perkins®). In cattle (Figure 2B), the correlation coefficient ( $r^2$ ) between the manometer and the Tono-Pen XL tonometer was 0.772 and between the manometer and the Perkins® tonometer was 0.988; the linear regression equations were  $y=0.507x+2.621$  (Tono-Pen XL®) and  $y=0.850x+2.046$  (Perkins®).

In the *in vivo* study, the IOP value for horses with the Tono-Pen XL® tonometer was  $20.1\pm 3.9$  (12.2-27.7mmHg), and the IOP value

with the Perkins tonometer was  $20.9\pm 3.2$ (14.6-27.0mmHg). In cattle, the IOP value with the Tono-Pen XL® tonometer was  $17.2\pm 2.4$  (12.8-21.2mmHg), and the IOP value with the Perkins® tonometer was  $17.9\pm 1.4$ (15.7-20.7mmHg).

## DISCUSSION

The Tono-Pen XL® 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., 20011), 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<sup>®</sup> and Perkins<sup>®</sup> tonometers (Figure 2); however, the Perkins<sup>®</sup> tonometer was more accurate than the Tono-Pen XL<sup>®</sup> tonometer, producing measurements that were much closer to the real IOP values measured with manometry (Table 1). The Tono-Pen<sup>®</sup> XL tonometer underestimated IOPs between 15 and 50mmHg 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<sup>®</sup> tonometer with other tonometers, such as the Perkins<sup>®</sup> and TonoVet<sup>®</sup> 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<sup>®</sup> 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<sup>®</sup> and Perkins<sup>®</sup> tonometers. There was only a difference between the minimum values (approximately 2 to 3mmHg lower with the Tono-Pen XL<sup>®</sup> tonometer).

This study demonstrated that both the Tono-Pen XL<sup>®</sup> and the Perkins<sup>®</sup> 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 2-3mmHg lower with the Tono-Pen XL<sup>®</sup> tonometer than those measured with the Perkins tonometer, which justifies a table of normal values differentiated for each tonometer.

## BIOTHICS AND BIOSSECURITY COMMITTEE APPROVAL

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

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## REFERENCES

- ANDRADA MÁRQUEZ, M.T. et al. Comparative study of two portable tonometers: Tono-Pen XL and Perkins. **Archivos de la Sociedad Española de Oftalmología**, v.78, n.4, p.189-196, 2003. Available from: <<http://dx.doi.org/10.4321/S0365-66912003000400004>>. Accessed: Feb. 21, 2012. doi: 10.4321/S0365-66912003000400004.
- ANDRADE, S.F. et al. Evaluation of the Perkins<sup>®</sup> handheld applanation tonometer in the measurement of intraocular pressure in dogs and cats. **Veterinary Ophthalmology**, v.12, n.5, p. 277-284, 2009. Available from: <<http://onlinelibrary.wiley.com/doi/10.1111/j.1463-5224.2009.00702.x/abstract;jsessionid=2DF166390CD4687AA74F8E3C3233C409.d04t02>>. Accessed: Jul. 12, 2012. doi: 10.1111/j.1463-5224.2009.00702.x.
- ANDRADE, S.F. et al. Evaluation of the Perkins handheld applanation tonometer in horses and cattle. **Journal of Veterinary Science**, v.12, n.2, p.171-176, 2011. Available from: <<http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3104172/?tool=pubmed>>. Accessed: Jul. 12, 2012. doi: 10.4142/jvs.2011.12.2.171.
- ANDRADE, S.F. et al. Comparison of intraocular pressure measurements between the Tono-Pen XL<sup>®</sup> and Perkins<sup>®</sup> applanation tonometers in dogs and cats. **Veterinary Ophthalmology**, v.15, suppl.1, p.14-20, 2012. Available from: <<http://onlinelibrary.wiley.com/doi/10.1111/j.1463-5224.2011.00926.x/abstract>>. Accessed: Jul. 12, 2012. doi: 10.1111/j.1463-5224.2011.00926.x.
- CHANG, D.F. Ophthalmologic examination. In: VAUGHAN, D. et al. **General ophthalmology**. Stamford:Appleton & Lange, 1998. p.27-56.
- FRENKEL, R.E. et al. Comparison of the Tono-Pen to the Goldmann applanation tonometer. **Archives of Ophthalmology**, v.106, n.6, p.750-753, 1988. Available from: <<http://archophth.jamanetwork.com/article.aspx?articleid=637295>>. Accessed: Jul. 12, 2012. doi:10.1001/archophth.1988.01060130820030.
- GEROMETTA, R. et al. Steroid-induced ocular hypertension in normal cattle. **Archives of Ophthalmology**, v.122, n.10, p.1492-1497, 2004. Available from: <<http://archophth.jamanetwork.com/article.aspx?articleid=416614>>. Accessed: Jul. 12, 2012. doi: 10.1001/archophth.122.10.1492.
- IESTER, M. et al. New Tono-Pen XL: comparison with the Goldmann tonometer. **Eye**, v.15, n.1, p.52-58, 2001. Available from: <<http://www.nature.com/eye/journal/v15/n1/abs/eye2001113a.html>>. Accessed: Jul. 11, 2012. doi: 10.1038/eye.2001.13.
- KALESNYKAS, G.; UUSITALO, H. Comparison of simultaneous readings of intraocular pressure in rabbits using Perkins handheld,

- Tono-Pen XL, and TonoVet tonometers. **Graefe's Archives of Clinical Experimental Ophthalmology**, v.245, n.5, p.761-762, 2007. Available from: <<http://www.springerlink.com/content/p4478u241081357m/?MUD=MP>>. Accessed: Jul. 10, 2012. doi: 10.1007/s00417-006-0470-8.
- KNOLLINGER, A.M. et al. Evaluation of the rebound tonometer for measuring intraocular pressure in dogs and horses. **Journal of American Veterinary Medical Association**, v.227, n.2, p.244-248, 2005. Available from: <<http://avmajournals.avma.org/doi/abs/10.2460/javma.2005.227.244?journalCode=javma>>. Accessed: Jul. 12, 2012. doi: 10.2460/javma.2005.227.244.
- LEIVA, M. et al. Comparison of the rebound tonometer (iCare®) to the applanation tonometer (Tono-Pen XL XL®) in normotensive dogs. **Veterinary Ophthalmology**, v.9, n.1, p.17-21, 2006. Available from: <<http://onlinelibrary.wiley.com/doi/10.1111/j.1463-5224.2005.00429.x/abstract>>. Accessed: Jul. 12, 2012. doi: 10.1111/j.1463-5224.2005.00429.x.
- LIM, K.S. et al. Accuracy of intraocular pressure measurements in New Zealand white rabbits. **Investigative Ophthalmology & Visual Science**, v.46, n.7, p.2419-2423, 2005. Available from: <<http://www.iovs.org/content/46/7/2419.long>>. Accessed: Jul. 12, 2012. doi: 10.1167/iovs.04-0610.
- LINGEL, N.J.; COFFEY, B. Effects of disinfecting solutions recommended by the Centers for Disease Control on Goldmann tonometer biprisms. **Journal of American Optometrists Association**, v.63, n.1, p.43, 1992. Available from: <<http://www.ncbi.nlm.nih.gov/pubmed?term=A.%20Effects%20of%20disinfecting%20solutions%20recommended%20by%20the%20Centers%20for%20Disease%20Control%20on%20Goldmann%20tonometer%20biprisms.%20#>>. Accessed: Jul. 12, 2012.
- MAGGS, D.J. Basic diagnostic techniques. In: MAGGS, D.J. et al. **Slatter's fundamentals of veterinary ophthalmology**. St. Louis: Elsevier, 2008. p.81-106.
- MILLER, P.E. The glaucomas. In: MAGGS, D.J. et al. **Slatter's fundamentals of veterinary ophthalmology**. St. Louis: Elsevier, 2008. p.230-257.
- PASSAGLIA, C.L. et al. Tono-Pen XL calibration curves for cats, cows and sheep. **Veterinary Ophthalmology**, v.7, n.4, p.261-264, 2004. Available from: <<http://onlinelibrary.wiley.com/doi/10.1111/j.1463-5224.2004.04038.x/abstract>>. Accessed: Jul. 12, 2012. doi: 10.1111/j.1463-5224.2004.04038.x.
- PICKETT, J.P.; RYAN, J. Equine glaucoma: a retrospective study of 11 cases from 1998 to 1992. **Veterinary Medicine**, v.42, n.6, p.756-763, 1993. Available from: <<http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1476223/>>. Accessed: Jul. 12, 2012.
- PRIEHS, D.R. et al. Evaluation of three applanation tonometers in dogs. **American Journal of Veterinary Research**, v.51, n.10, p.1547-1550, 1990. Available from: <<http://www.ncbi.nlm.nih.gov/pubmed/2240775>>. Accessed: Jul. 12, 2012.
- SCHOTTENSTEIN, M.S. Intraocular pressure and tonometry. In: RITCH, R. et al. **The glaucomas – basic sciences**. St. Louis: Mosby, 1996. p.407-428.
- VAN DER WOERDT, A. et al. Auriculopalpebral effect of nerve block and intravenous administration of xylazine on intraocular pressure and corneal thickness in horses. **American Journal of Veterinary Research**, v.56, n.2, p.155-158, 1995. Available from: <<http://www.ncbi.nlm.nih.gov/pubmed?term=Auriculopalpebral%20Effect%20of%20nerve%20block%20and%20intravenous%20administration%20of%20xylazine%20on%20intraocular%20pressure%20and%20corneal%20thickness%20in%20horses>>. Accessed: Jul. 12, 2012.