TITLE: Design of an intraocular pressure curve protocol for use in dogs

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Design of an intraocular pressure curve (IOPC) protocol for use in dogs.

Summary:

Objectives:

To establish an intraocular pressure curve protocol that is safe for corneal health and determining if they detect harmful elevations of intraocular pressure outside normal clinic hours. To determine inter-user variability and if repeated measurements affect intraocular pressures.

Methods: Dogs with glaucoma were included in the first part of the study in which intraocular pressures were measured using three protocols. Protocol 1 used applanation tonometry every two hours over 24h. Protocols 2 and 3 used applanation or rebound tonometry, respectively, and measured intraocular pressures every three hours over 30h. Sixty additional intraocular pressure curves from dogs with glaucoma and 20 from healthy dogs were then analysed for inter-user variability.

Results:

128 Intraocular pressure curves were determined in 30 dogs. Protocol 1 resulted in one ulcer in five pressure curve measurements, Protocol 2 in one ulcer in 62 pressure curves, and Protocol 3 in no ulcers in 61. Elevated intraocular pressures were detected on 61 occasions, of which 26 developed outside normal clinic hours. Sixty-one additional intraocular pressure curves revealed that repeated measurements had no effect on intraocular pressure. Assessors had a significant variability in right-eye but not left-eye readings.

Conclusions: Protocol 3, using rebound tonometry every three hours for 30hr is safe and identified elevated intraocular pressures outside normal clinic hours in 12/30 (40%) of patients that single intraocular pressure measurement during consultation hours would not have identified. Intraocular pressure curves may be recommended for clinical practice and glaucoma studies.

5 Key words: tonometry, closed angle glaucoma, open angle glaucoma, secondary glaucoma, intraocular pressure monitoring

Introduction

The objectives of antiglaucoma therapy in veterinary patients are preservation of vision and a pain-free state through the control of intraocular pressure (IOP). Studies in humans suggest that the greater the lowering of the patient's IOP, the greater the effect in preventing or slowing glaucomatous optic nerve damage (Van Veldhuisen *et al.* 2000, Leske *et al.* 2003). The veterinary literature also supports the idea that lowering the IOP in dogs might delay the progression of glaucoma (Miller *et al.* 2000, Van Veldhuisen *et al.* 2000, Leske *et al.* 2003, Plummer *et al.* 2013).

Tonometry is now readily available in many veterinary practices and all referral centres, and IOP is most frequently assessed in veterinary patients through the recording of a single, isolated reading in a consult visit. An important limitation of a single measurement approach is that the previously described circadian rhythm of IOP in dogs and cats (Del Sole *et al.* 2007, Giannetto *et al.* 2009, Sigle *et al.* 2011) is not taken into consideration. Additional limitations are that transient tell-tale ocular signs of episodes of raised intraocular pressure in dogs with a history of glaucoma (e.g. temporary blindness, and/or temporary corneal edema, and/or temporary episcleral vessel congestion) might develop outside consultation hours, that pet owners might not notice them, or that they might not have immediate access to an ophthalmologist if they did. These limitations might give the owner and/or clinician the false impression that antihypertensive treatment is effective when it is not, or that glaucoma is not rapidly progressing when it is.

Studies in humans describe the use of serial measurements of intraocular pressure (IOP) during periods of 24hours for the management of patients with glaucoma (Hughes *et al*. 2003, Barkana *et al*.

2006, Bagga *et al*. 2009). The preliminary results of the development of an IOPC protocol for serial use in dogs with elevated IOPs found that IOPCs might be useful for monitoring IOP in this species, but warned of the development of superficial corneal ulceration, which was theorized to pose a likely challenge (Viera da Silva and Sanchez 2010). To the best of our knowledge, the veterinary literature still contains no established protocols that describe serial measurements of IOP in small animals and its effects on corneal health.

The aims of this study were to establish a standardized intraocular pressure curve (IOPC) protocol for use in dogs that is safe for corneal health, as determined by the study guidelines, and to determine if the use of an IOPC would detect a deleterious increase in IOP during the duration of the curve, that a single IOP measurement taken during regular consulting hours might fail to detect (Part I). Additional objectives included determining if repeated measurements affected IOPs over the period of time the IOPC lasted and if there were differences between assessors (Part II). The study, including the use of control animals, was approved by the Ethical and Welfare Committee of the Royal Veterinary College.

Materials and methods

Part I of the study:

This part of the study aimed to establish a standardized intraocular pressure curve (IOPC) protocol for use in dogs that is safe for corneal health. A protocol would only be considered safe if it was not associated with corneal ulceration the first 60 times the protocol was used (e.g. first 60 IOPCs independent of the patients it was used in). In addition, this part of the study also aimed to determine if the use of an IOPC would detect a deleterious increase in IOP within a 24-hour period that a single IOP measurement taken during regular consulting hours might fail to detect.

Dogs included in the study had primary or secondary glaucoma, and no obvious corneal scarring. All the dogs were on antiglaucoma topical treatment and were routinely undergoing scheduled IOP monitoring over time. Three possible protocols (P1, P2, P3) were designed in case protocol-failure was encountered during the study. P1 would take one IOP reading with an applanation tonometer (Tonopen-Vet®, Reichert, USA) once every two hours for a 24-hour period. P2 would take one IOP reading with the same applanation tonometer as in P1, but once every three hours for a 30-hour period. P3 would take one IOP reading every three hours with a rebound tonometer (Tonovet ® Kruuse, Langeskov, Denmark) for a 30-hour period. A drop of local anesthetic (Proxymetacaine hydrochloride 0.5%, Minims, Bausch & Lomb, UK) was used before taking a measurement with the applanation tonometer (e.g. used in P1 and P2), as required with the use of this instrument. No topical anesthetic was used with the rebound tonometer (e.g. used in P3). A drop of a preservative free viscous tear (Celluvisc®, Carmellose sodium 1%, Allergan, UK) was applied topically after each measurement, independent of the protocol used. Every patient underwent fluorescein corneal testing with slit lamp biomicroscopy for detection of ulcers at the start and end of each curve independent of the protocol used, to prospectively record the incidence of ulcerative keratitis.

IOPCs in all the protocols started between 8.30am and 9.30am. The tonometers were used and maintained throughout the study in accordance with the manufacturer's recommendations. Standard clinical hours were considered to be 9.00am to 6pm and all other times were considered to be out of hours. The handlers (n=5) that took the IOP readings were UK-qualified Veterinary Nurses that were trained by the ophthalmology team and were experienced in tonometry. If an affected patient had two affected eyes, this patient would have had two IOPCs (e.g. one per eye) and each IOPC would have been counted separately. Patients with only one eye had one IOPC at a time. Dogs in the control group had one IOPC per eye. Dogs with only one eye were also accepted into the control population.

All the IOP measurements were taken with the dogs in a sitting position and with minimal restraint. A total of three consecutive readings were taken per eye for every point plotted in an IOPC to account for possible patient positioning and/or handler manipulation effects. The lowest measurement of the three was used to plot the curve. Handlers were instructed to identify readings that differed from the others by more than 4mmHg and to discard the higher readings, which could have been the result of poor patient handling. In such cases, handlers would reassess their handling and re-measure IOP until all three readings were within 4mmHg of each other.

Patients enrolled in the study were on a pre-set antiglaucoma medication regime that they continued while in the hospital. In addition, every patient had individualized treatment protocols to be used if they developed an IOP spike during their IOPC. If the IOP reading of a patient was elevated during an IOPC, the protocol was activated so as to attempt to reduce the IOP, while the IOPC continued to gather valuable information for that patient.

Part II of the study:

This part of the study was designed to determine if repeated measurements affected IOPs during the IOPC, and if there were differences between assessors. However, a record of development of corneal ulcerative disease was also kept. Collection of data was carried out using P2 and P3. Dogs included had primary or secondary glaucoma, or postoperative hypertension following cataract surgery, and were not included in the first part of the study.

A linear mixed-effects model was adopted to analyse log transformed IOP with time, accounting for repeated measures from the same dog and the variation due to different trained personnel. Analyses were carried out separately for right and left eye. As disease process was not relevant to the statistical analysis, this was not accounted for. Data were analysed using the lme4 package in R 2.15.0 (Vienna, Austria) and a significance level of $p<0.005$ was used.

Lastly, the authors planned to obtain an additional 20 IOPCs from a control dog population of 10 dogs using the IOPC protocol that successfully passed the corneal safety criteria (Part I of the study).

Results

Part I of the study:

A total of 30 dogs (47 eyes) with either primary (n=12) or secondary glaucoma (n=18) (Table 1) were included. A total of 128 IOPCs were performed in these dogs.

P1 was used in only 3 dogs (5 IOPCs) because it was associated with a superficial corneal ulcer in 1/5 IOPCs (1/3 dogs, case 19, with primary glaucoma). As a result, the protocol was not used in any other patient and P2 was used from that point onward. P2 was used in 18 dogs (62 IOPCs) and was associated with the development of a superficial corneal ulcer in 1/62 IOPCs (1/18 dogs). This was a non-diabetic, secondary glaucoma patient (patient 7). As a result P2 was discarded in favour of P3, which was used in 12 dogs (61 IOPCs) and was associated with no corneal ulcers in any of the 61 IOPCs collected (12 dogs).

All the ulcers detected during the study were superficial, non visible to the naked eye without the use of fluorescein, central to paracentral, and averaged 2 to 3 mm in diameter. All the ulcers healed within 4 to 7 days with supportive medical therapy consisting of a topical antibiotic (chloramphenicol 0.5%, Martindale Pharmaceuticals, Ireland) and a preservative free viscous tear (Celluvisc®, Carmellose sodium 1%, Allergan, UK).

Overall, there were 61 elevations in IOP (>24mmHg) in 16/30 dogs (53.33%) (case nos. 2, 3, 5-8, 11, 17, 19, 20, 21, 23-26 and 28). A total of 26/61 (42.62%) elevations of IOP developed outside consultations hours in 12/30 dogs (40%) (case nos. 2, 6, 7, 17, 19, 20, 21, 23-26 and 28). There were 8 dogs that had IOPs in the normal reference range during the consultation period but that presented

with a history potentially compatible with progression of glaucoma (e.g. the owners reported sudden episodes of what was interpreted as being vision deterioration, and/or sudden development of corneal oedema, and/or sudden development of a red eye), and the authors confirmed that 5/8 dogs had elevations of IOP each during the course of their IOPCs (case nos. 5, 6, 7, 20 and 21 out of case nos. 3, 5, 6, 7, 10, 11, 20, 21). The elevations of IOP in four cases (nos. 6, 7, 20, 21) were outside consultation hours.

Part II of the study:

A total of 60 IOPCs were obtained from dogs with glaucoma or postoperative hypertension. Applanation tonometry (P2) was used in 26 curves (16 patients) and a superficial ulcer was recorded. As with the other ulcers in the study, it healed with supportive medical therapy and without complications. Rebound contact tonometry (P3) was used in the other 35 curves (22 patients) of this part of the study. There were no ulcers associated with the use of P3. The findings also indicated that there were no significant trends in IOP over time as a result of repeated IOP measuring, and that there was a significant variation in the inter-user variability for the right eye (4.2% total variation; $p=0.02$) but not in the left eye (0.4% total variation; $p=0.8$) ($P<0.05$ was considered as significant).

P3 was chosen for the 20 IOPCs performed in the control patient population (10 dogs) without ocular disease (Table 2). The owners of the control patient population gave informed consent for the patient's enrolment after approval by the College's Ethics and Welfare committee. None of the control animals developed elevations in pressure or corneal ulcers.

Discussion

The results of this study showed that the use of a 30-hour IOPC in which IOP is measured every 3 hours with rebound tonometry is safe for ocular surface health, as defined in the aims of the study. Moreover, the use of IOPCs identified patients with elevated IOPs outside standard consultation hours that a single IOP measurement during standard consultation hours would not have identified.

A previous publication described using IOPCs with topical anaesthesia and applanation tonometry in Rhesus monkeys, but the authors did not mention the corneal health status of the eyes after each IOPC (Ollivier *et al.* 2004). A preliminary study on the development of an IOPC protocol for use in dogs suggested that while IOPCs might be useful for use in dogs, superficial corneal ulceration could pose a likely challenge (Viera da Silva and Sanchez 2010). Since, one veterinary paper has described the use of IOPCs in rabbits using rebound tonometry and no topical anesthesia, but the authors did not comment on the effect of the protocol used on the ocular surface health of the rabbits tested (Wang *et al.* 2013).

The three different protocols described in the present study (P1, P2 and P3) were developed in a progressive manner with the aim to identify a protocol that would offer useful information about a patient's fluctuations in IOP, while being safe for corneal health. If P1were not to meet the safety criteria set by the study it would be discarded in favour of P2. The authors theorized that if P1 failed, P2 would be better because it would require less frequent IOP measurements per hour. If P2 were not to meet the safety criteria set by the study, it would be discarded in favour of P3. The authors theorized that P3 would be better because it would use a rebound tonometer, which does not require a topical anesthetic and touches a smaller area of the cornea than the applanation tonometer used in P1 and P2.

The results indicated that only P3, which used rebound tonometry once every three hours for 30 hours, and did not require topical anesthesia, was associated with no ulcerative disease in any of the

IOPCs included. Superficial corneal ulceration associated with applanation tonometry in P1 and P2 was theorized to be secondary to the epitheliotoxic effects of the topical anesthetic used (Gundersen and Liebman 1944) and the frequent contact of the tonometer with the cornea. The ulcers healed quickly with supportive therapy and none developed further complications. It is clear that ocular surface health is an important aspect associated with the use of IOPCs, and the authors of the present study recommend that all future veterinary studies using IOPCs take corneal health into consideration independent of the animal species studied. The findings of the present study suggest that, from a corneal health perspective, rebound tonometry used without a topical anesthetic is preferable to applanation tonometry used with topical anesthetic for use in plotting an IOPC, when IOP is measured serially. It is still possible that ulcers could develop using a protocol like P3 described here. This is because even in the absence of the epitheliotoxic effects of a topical anaesthetic, iatrogenic ulcers resulting from accidental injury with very uncooperative patients could theoretically develop. None of the ulcers in this study were in this category. However, the authors also recommend that all patients undergoing an IOPC undergo corneal examination including fluorescein testing before and at the end of every IOPC even when rebound tonometry is used.

It is possible that IOP spikes shorter than 3 hours might be missed in IOPC protocols that measure IOP every 3 hours. The same could be said of episodes that last less than 2 hours or even 1 hour if readings were taken at 2 or 1-hour intervals, respectively. However, the median duration of the elevations of IOP in the present study were 3 hours, with a range that spanned from 3 to 12 hours (Table 1). This means that most of the increases in IOP in this study would have been detected if IOPs had been measured every 3 hours in every case. It is possible that in certain curves (e.g. see Figure 1) measuring IOP every three instead of every two hours would have resulted in lower peaks of maximal IOP, had certain measurements coincided with the downward trend of the spike in pressure and not with its peak. However, this assumes that the peaks plotted in a curve that measures IOP every 2 hours coincide with the maximal IOP peaks, which might not be the case. A close match of the IOP fluctuations in an

eye would require very frequent readings, and the present study has shown that corneal health is an important limiting factor to how frequently readings can be taken over a 30-hour period. In addition, a high frequency of IOP measurement might pose a significant logistical challenge for a hospital. However, it would be interesting for future studies to look into the usefulness and effects of an IOPC protocol that uses rebound tonometry and takes IOPs every 1 or 2 hours during a period of 30 hours, or more, in dogs.

Overall, nearly one half of the IOPCs [61/128 (47.65%)] in the present study identified elevations in IOP >24mmHg. Interestingly, a large proportion of these IOPCs [26/61 (42.62%)] identified IOP elevations that happened outside standard consultation hours. It is also worth noting there were 5 dogs that presented with signs consistent with progression of glaucoma despite topical antihypertensive treatment. These dogs had IOPs in the normal reference range in a single IOP measurement taken during standard working hours, but had confirmed elevations of IOP outside consultation hours during their IOPC.

The use of serial IOP measurement in people is controversial. Some authors suggest that the use of 24-hour monitoring in humans with open angle glaucoma could be of benefit (Wilensky 2004, Barkana *et al.* 2006, Chiseliță *et al.* 2008, Detry-Morel 2008, Bagga *et al.* 2009). A separate study reported that a single office IOP measurement in people was similar to the mean 24-hour IOP, though it was not possible to elucidate the maximum IOP within the 24-hour period or the IOP fluctuation based on single office IOP measurements (Nakakura *et al.* 2007). The authors of another study concluded that there was not enough evidence to support the use of a diurnal tension curve or single IOP measurements in humans with the purpose of assessing IOP fluctuation as a risk factor for glaucoma progression (Health Quality Ontario 2011). Recognition of potentially damaging elevations of IOP, some of which occurred outside consultation hours, through the use of IOPCs in the present study allowed clinicians to opt for immediate change of antihypertensive treatment, and/or to recommend surgical treatment, in an attempt to help prevent pain and the immediate deterioration of vision at those

times. Although it would seem sensible to assume the early identification of deleterious increases in IOP might be of help in the short term management of glaucoma, the effect of the use of IOPCs in the ocular health of the animals in the present study is beyond the scope of the study. The short and long term effects of monitoring canine patients through the use of IOPCs remain unknown, and should be studied. The use of an IOPC protocol that is safe for corneal health, such as P3 described in the present study, would be instrumental to achieve this.

The use of tonometry by inexperienced examiners can falsely elevate IOP readings (Whitacre *et al.* 1991) and the positioning of the patient during IOP measurement might also increase IOP readings (Broadwater *et al.* 2008). It is also possible inter-user variability might affect the results of a particular IOPC if different people with different degrees of experience take the readings. Users in the present study were UK-licensed veterinary nursing professionals trained by a full-time ophthalmologist (e.g. the main author) to take IOP readings. Intraocular pressure readings in the present study were taken with the patient in a sitting position and all handlers were trained to avoid exerting pressure on the patients' necks or globes while manually parting the eyelids. More over, three consecutive IOP measurements were taken each time a reading was recorded, which has been shown to reduce the effect of inter-user variability (Dielemans *et al.* 1994). The lowest reading of the three was used to plot each point of the IOPC. An average of the three readings could have been used instead but the authors did not use this approach because it was theorized the lowest reading was less likely to have been falsely elevated.

A study demonstrated that successive measurements obtained by applanation tonometry one minute apart showed an almost linear decrease of IOP (Motolko *et al.* 1982), whereas another study found no statistical significance between two measurements performed 10 minutes apart (Recep *et al.* 1998). The second part of the present study indicated the overall IOP trend was not affected by serial measurements of IOP and that episodes of hypertension did not seem to be affected by the repeated measuring of IOP.

Statistical analysis showed that there was a significant operator difference between measurements taken from the right eye when compared to the left. Interestingly, other studies have previously shown a difference between the right and left eyes of the subjects under study, although the cause of this was never clearly elucidated (Mercado *et al.* 2010, Wang *et al.* 2013). The authors of the present study hypothesised that because the majority of the operators were right handed, they might have found it more difficult to steady their right hand on the right side of the animal's head, where the animal's nose would have been in contact with the abaxial side (e.g. the side of the little finger) of the operator's hand. This is speculative, although it would seem prudent to focus part of the training of operators on ways to steady their working hand during IOP measurement.

The authors decided to ask operators to discard readings in the same eye if they were off by more than 4mmHg because it was theorised reading differences of more than 4mmHg could have been due to patient and/or handler effects. The reason 4mmHg was chosen was that IOP is known to vary in an eye by approximately 4mmHg (more in eyes with glaucoma), and that IOPs between the right and left eye of the same patient also tend to vary no more than by 4mmHg (more in eyes with glaucoma) (Plummer *et al.* 2013). The authors felt it was important to choose a point at which differences between a series of IOPs taken a few seconds apart in the same eye would have been too high to be due to natural variation of the IOP or the mechanics of the instrument. To the author's knowledge there are no studies that show what variation between consecutive IOP readings taken from the same eye with applanation or rebound tonometry is considered to be acceptable or unacceptable.

Biomechanical properties of the cornea, like central corneal thickness, can alter the result of tonometry. One study demonstrated that for every 100µm increase in central corneal thickness in normal dogs there was an elevation of 1mmHg in IOP using applanation tonometry (Park *et al.* 2011). However, another study demonstrated that central corneal thickness did not affect applanation tonometry (Kato 2014). Other viscoelastic properties of the cornea such as corneal hysteresis and corneal resistance factor can also alter IOP readings in humans (Liu and Roberts 2005). A recent

study has demonstrated that corneal pathology can also alter IOP readings using rebound and applanation tonometry (Spiessen *et al.* 2015). However, although the mean difference between the rebound and applanation tonometers tested was statistically significant it was considered to be clinically negligible and neither of the tonometers was more susceptible than the other to result in a false reading due to corneal pathology (Spiessen *et al.* 2015). No animals with obvious corneal scarring were included in this study, but more subtle factors altering corneal hysteresis were not taken into consideration and therefore their potential effect would not have been taken into account.

Dogs with diagnosis of primary and secondary glaucoma were included in this study. In line with a previous study, eyes had a diagnosis of glaucoma if they had an IOP ≥25mmHg and had clinical signs consistent with glaucoma (Slack *et al.* 2012). All of the IOPCs in dogs were started in the morning because the diurnal cycle of IOP in this species shows their highest pressure to naturally occur this time of day (Giannetto *et al.* 2009). As mentioned earlier, the aims of the present study did not include the application of the results of IOPCs to a particular medical approach for glaucoma. However, the authors feel it is very important that clinicians take into account the type of tonometry they choose for serial measurement of IOP through an IOPC, not solely due to the effects of the protocol on corneal health, but also due to the potential effects of the tonometer choice on the reading. Reference values for IOP in healthy dogs range from 16.7 ± 4.0 mm Hg (Miller *et al.* 1991) to 19.2 ± 5.9 mm (Gelatt and MacKay 1998), as recorded through applanation tonometry. Rebound tonometry has shown a strong linear relationship when compared to results obtained with manometry in enucleated dog eyes (Knollinger *et al.* 2005). A separate study using manometry reported that rebound tonometry was reliable in hypertensive eyes (Nagata *et al.* 2011). When compared to each other, rebound tonometry gives higher readings than applanation tonometry in dogs with acute glaucoma and an IOP that is >25mmHg (Slack *et al.* 2012). However, other studies have found that the values obtained with rebound tonometry in dogs with elevated IOPs had a near ideal relationship with the reference applanation tonometer used (e.g. Goldman tonometer), and that applanation

tonometry underestimated the IOP (Görig *et al.* 2006, Spiessen *et al.* 2015). As a result, and mainly due to its relationship with manometric readings, rebound tonometry has been previously suggested as potentially being a better tonometer choice in dogs with glaucoma (Spiessen *et al.* 2015). Solely from a corneal health perspective, and based on the findings of the present study, rebound tonometry seems more appropriate than applanation tonometry for the purpose of serial measurement of IOP for the purpose of plotting an IOPC. In addition, the authors of the present study also recommend the same tonometer is used throughout an IOPC and in subsequent IOPCs in the same patient, because rebound and applanation tonometers might result in different readings of the same eye (Görig *et al.* 2006, Slack *et al.* 2012).

Lastly, it should be noted that there were one or two more IOPCs included when trialling P2 and P3 than the 60 that were originally planned. The reason for this was that by the end of the study, more than the required number of patients were hospitalized for an IOPC on the same day. To avoid a selection bias, all of these patients were included.

The results of this study show that the use of a 30-hour IOPC with IOP measured every 3 hours with rebound tonometry and in the absence of topical anesthesia is safe for corneal health as defined in this study, and is useful to clinical practice. The use of IOPCs might also be useful in the study of medical and surgical treatments of glaucoma in dogs, and could assist in the standardization of future treatment studies.

Case No.	**Signalment**	**Type of glaucoma**	**No. of eyes/ No. of eyes affected** (* one eye was removed at some point)	**No. of times a patient was in hospital for an IOPC / No. of IOPCs per patient – Protocol used (P1, P2 or P3)**	**No. of times IOP was >24mmHg**	**Duration of elevation of IOP in hours**	**No. of elevation of IOP outside consultation hours**
1	JR Terrier, M,/N 13y	SG post-phaco	*1 / 1	1 / 1 – 1P2	0	0	0
2	Labrador M/N, 10y	SG post-phaco	2 / 1	2 / 4 – 4P2	2	3,6	1
3	JR Terrier, M/N, 11y	SG post-phaco	*1 / 1	3 / 3 – 3P2	1	3	0
4	Cross breed, M/N, 8y	SG post-ICLE	*1 / 1	4 / 4 – 2P1 & 2P2	0	0	0
5	JR Terrier, M/N, 11y,	SG post-ICLE	1 / 1	3 /3 – 2P1 & 1P2	3	3,3,3	0
6	E Setter, F, 8y	SG post-ICLE	2 / 2	1 / 2 – 2P2	2	3,3	1
7	JR Terrier, M/N, 4y	SG post-ICLE	2 / 2	5 / 10 – 10P2	5	3,9,3,3,3	1
8	A Terrier, M/N, 11y,	SG post-ICLE	2 / 1	1 / 1 – 1P2	2	0	0
9	Lhasa Apso, M, 8y	SG post-ICLE	*1 / 1	1 /1 – 1P2	0	0	0
10	Poodle, F/N, 13y	SG due to lens subluxation	2 / 2	2 / 4 – 4P2	0	0	0
11	MEB Terrier, M/N, 4y,	SG due to lens subluxation	*1 / 1	3 / 3 – 3P2	1	3	0
12	JR Terrier, M/N, 5y	SG due to lens subluxation	*1 / 1	4 / 4 – 4P3	0	0	0
13	JR Terrier, F/N, 5y	SG due to lens subluxation	*1 / 1	4 /4 – 4P3	0	0	0
14	E Cocker Sp, M 10y	SG due to uveitis	2 / 2	1 / 2 – 2P2	0	0	0
15	AmB Terrier, F, 8y	SG due to uveitis	*1 / 1	2 / 2 – 2P2	0	0	0
16	Labrador, M, 6m	SG due to uveal mass	*2 / 1	1 / 2 – 2P3	0	0	0
17	Labradoodle, F/N, 5y	SG due to Optic neuritis	*2 / 2	4 / 5 – 5P3	2	3,3	1
18	JR Terrier, F/N, 7y	SG due to lens luxation	*1 / 1	7 / 7 – 7P3	0	0	0
19	B Hound, M/N 8y	PACG	*2 / 1	5 / 9 – 1P1 & 8P2	7	6,9,3,3,3,3,9	4
20	Papillon, 10y, M/N	PACG	*1 / 1	2 / 2 – 2P2	1	6	1
21	B Hound, M/N, 4y	PACG	2 / 2	2 / 3 – 3P2	5	12,9,6,3,3	2
22	JR Terrier, F/N, 1y	PACG	*1 / 1	6 / 6 – 6P2	0	0	0

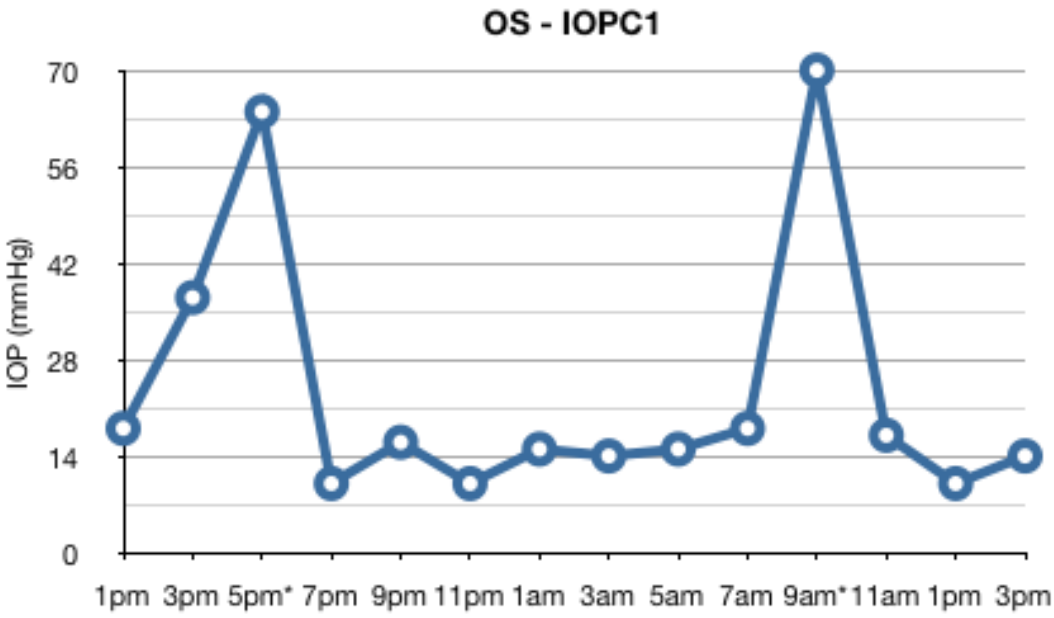
23	JR Terrier, F/N, 5y	PACG	*2 / 1	6 / 7 – 7P2	4	6,3,9,6	2
24	Chihuahua, F/N, 12y	PACG	2 / 2	4 / 8 – 8P3	11	6,6,6,3,6,3,3,3,3,3,3	7
25	Chihuahua, M/N, 9y	PACG	2 / 2	5 / 10 – 10P3	1	3	1
26	B Hound, M, 6y,	PACG	2 / 2	3 / 4 – 4P3	6	3,3,6,3,3,6	2
27	Sharpei, M/N, 8y	PACG	2 / 2	1 / 2 – 2P3	0	0	0
28	W Terrier, F/N, 11y	PACG	2 / 2	5 / 10 – 10P3	10	3, 3, 3, 6, 3, 3, 3	3
29	W Springer Sp, F/N, 9y	PACG	2 / 2	3 / 4 – 4P3	0	0	0
30	Husky, F/N, 9y	PACG	*1 / 1	1 / 1 – 1P3	0	0	0
TOTAL	-	**18 SG 12 PACG**	-	**92 admissions and 128 IOPCs with 5P1, 62P2 and 61P3 protocols carried out**	**61 times in 16 patients (45 times in 8 dogs with PACG and 18 in 8 dogs with SG)**	**Median duration (range): 3 (3-12)h**	**26 spikes outside consultation hours (12 with P2 and 14 with P3) in 12 dogs**

Table 1. Patient list showing case number, case signalment and type of glaucoma. The fourth column shows the number of eyes in each patient, the number of eyes affected by glaucoma, and if an eye was removed at any point in time due to glaucoma. The number of times a patient visited the hospital for an IOPC is also shown, as well as the number of IOPCs each patient had, the total number of times each protocol was used in a particular patient and the type of protocol used. Lastly, the table shows the number of times a patient's IOP was 25mmHg or higher during any of the IOPCs, and the number of times an elevation of IOP at or above 25mmHg developed outside standard consultation hours of 9am to 6pm. (Breed: A= Airdale, AmB= American Bull, E= English, JR= Jack Russell, MEB = Miniature English Bull, Sp= Spaniel, W= Welsh) (Sex: M= Male, F=Female, N= Neutered) (SG= Secondary glaucoma, PACG= Primary angle closure glaucoma).

Case Number	Signalment	Admitting service / procedure	No. of eyes	No. of IOPCs and type of protocol used (P1, P2 or P3)	No. of times IOP was >24mmHg
C1	Cocker Spaniel, M/N, 3y	Soft tissue surgery	2	2P3	0
C2	Yorkshire Terrier, M, 6y	Soft tissue surgery	2	2P3	0
C3	Min. Schnauzer, F/N, 7y	Soft tissue surgery	2	2P3	0
C4	Cross breed, F/N, 1y	Soft tissue surgery	2	2P3	0
C5	Boxer, M, 8y4m	Soft tissue surgery	2	2P3	0
C6	Golden Retriever, F, 6y	Soft tissue surgery	2	2P3	0
C7	Min. Schnauzer, F/N, 8y	Soft tissue surgery	2	2P3	0
C8	Chihuahua, F/N, 3y	Soft tissue surgery	2	2P3	0
C9	Mastiff, M/N, 4y	Soft tissue surgery	2	2P3	0
C10	Cross breed, M/N, 8y	Soft tissue surgery	2	2P3	0
TOTAL			**20 eyes**	**20 IOPCs with P3 protocol**	**0 elevations in IOP >24mmHg**

Table 2. List of dogs used as controls showing signalment and admitting service, as well as the procedure they were admitted for. All patients had a single IOPC per eye and none had a history of ocular problems and all had healthy eyes during ophthalmic examination prior to the start of the IOPC. (Sex: M= Male, F=Female, N= Neutered).

Figure 1. Figure 1. Example of an IOPC in case no 5. The owner reported the eye was turning cloudy two to three times per week at the time of the IOPC was plotted using intraocular-pressure-curve protocol P1. The spikes in IOP demonstrate this patient was refractory to the treatment given. The drop in pressure coincides with additional treatment given at the time the IOPC was being ran.



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