CRYOSURGICAL TREATMENT FOR EXPERIMENTALLY INDUCED CATARACT IN DOGS

By

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THESIS

Submitted in partial fulfilment of the requirement for the degree of

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Declaration

DECLARATION

I hereby declare that the thesis entitled "***Cryosurgical Treatment for Experimentally Induced Cataracts in Dogs***" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

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Certificate

CERTIFICATE

Certified that the thesis entitled "***Cryosurgical Treatment for Experimentally Induced Cataract in Dogs***" is a record of research work done independently by **Shri. Neelakanta Praveen Pillai**, under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to him.

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We, the undersigned members of the Advisory Committee of **Shri. Neelakanta Praveen Pillai**, a candidate for the degree of Master of Veterinary Science in Veterinary Surgery, agree that the thesis entitled "***Cryosurgical Treatment for Experimentally Induced Cataracts in Dogs***" may be submitted by Shri. Neelakanta Praveen Pillai, in partial fulfillment of the requirement for the degree.

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Dedicated to my beloved family

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Introduction

1. INTRODUCTION

One major cause of visual handicap in both man and animal, especially in old age is cataract. In the current situation, animals suffering this eminently treatable disease do not always receive what little help it would take to remove this handicap and return to them a useful and productive life.

Cataract may be defined as an opacity of the crystalline lens and is the most common and most important disorder of this major optical component of the eye. Cataracts are usually classified on the basis of their position and extent within the lens, stage of maturity, suspected cause and appearance (Slatter, 1990).

One limiting factor in the treatment of cataract in dogs is that there exist very few pharmacological agents that are capable of exerting any significant influence on its development or regression. Surgery, therefore, is the most promising treatment for those who suffer from this debilitating disease.

Several authors report the incidence of cataract in canines. Animals, both very young and old are seen affected by

cataract and the causes may be indiscriminate administration of drugs, electric shock, trauma, complication of glaucoma, diabetes, or diet.

Although studies into the incidence of cataract among the native canine population in the country are lacking, the condition has been documented as a genetic trait in several of the exotic dog breeds that have now found a new home in our country. The German Shepherd Dog, for example, suffers from a primary hereditary cataract associated with a widespread autosomal recessive gene (Barnett, 1986).

Surgical treatment for cataract has not become very popular in canine patients because of problems like difficulty in post-operative care, using lenses outside the eye, and assessing optical requirement. Various surgical techniques have been conducted in dogs but techniques that require short post-operative care will thus be a choice. Cryosurgical techniques thus are a procedure that can be considered for treatment in dogs.

This study was undertaken with the objective to compare the efficacy of cryo-coagulation with intra-capsular cataract extraction of cataractous lenses in dogs.

Review of Literature

2. REVIEW OF LITERATURE

Vision

Miller and Murphy (1995) stated that in the dog some visual capabilities such as vision in dim light, flicker fusion, field of view, grayscale detection and ability to detect motion have made it a more efficient predator.

Cataract

Philips and Magrane (1959) defined cataract as any opacity of the lens or its capsule.

Barnett (1985) stated that cataract may be described as primary or secondary. Only the lens is affected in the former and no antecedent eye defect is present. In the latter, the opacity is secondary to a disease in another part of the eye.

Incidence

Heywood (1971[a]) reported that 3.6 per cent of purebred Beagle dogs of age upto one year had lens opacities at the posterior aspect of the lens.

Gelatt (1972) reported that cataract was observed in 19.8 per cent of 98 Golden Retriever puppies and 13.6 per cent of 43 adult dogs. In puppies, the disease was limited to the lens nucleus or perinuclear area with numerous vacuoles or frank clefts. Vision was usually impaired. In the adult, the disease was usually limited to the posterior lens cortex and posterior sutures. In two dogs the condition was unilateral at 16-18 months of age, but later it became bilateral within four to six months.

Priester (1972) observed 673 congenital ocular defects among 131,453 horses, cattle, cats and dogs presented at ten Veterinary School Clinics in the United States and Canada during the period from 1964 to 1968. The most frequent defects in the order of frequency were ectasia syndrome, entropion, cataract, microphthalmos, anophthalmos, opacity of cornea, lachrymal anomalies, dermoid cyst, persistent pupillary membrane, and ectropion. The relative frequency in dogs was six times that for any other species, with certain breeds being at high risk for specific defects.

Rubin and Flowers (1972) observed progressive equatorial cataracts that developed prior to two years of age in a family of Standard Poodles. Mode of transmission appeared to be by a simple autosomal recessive gene.

Jussila and Paatsama (1973) recorded eight cases of cataract out of 44 cases where eye defects were present during ophthalmoscopic examination of 144 dogs belonging to 14 different breeds.

Olesen *et al.* (1974) reported cases of congenital subcapsular anterior polar cataract in Red Cocker Spaniels. The disease appeared to be hereditary with genetic studies showing that mode of inheritance was probably complex.

Peiffer and Gelatt (1974) discussed the anatomy, diagnosis, aetiology, classification, prognosis, and treatment of cataract in cats.

Bhargava *et al.* (1975) reported that 40 cattle, 8 months to 10 years old had cataract of one or both eyes and 19 of them were blind. The breeding history showed that the condition was congenital. The lesions varied from a small white round opacity beneath the capsule to complete involvement of the lens.

Ashton *et al.* (1977) described two outbreaks of congenital cataract in dairy herds.

Barnett (1978) discussed the modes of inheritance of cataract, both dominant and recessive in several breeds of dogs including the Boston Terrier, the Staffordshire Bull Terrier, the Miniature Schnauzer, and the Old English Sheepdog.

Yakely (1978) studied the heritability of cataract in the American Cocker Spaniel and cataract as detected in 225 of 1920 dogs examined between 1969 and 1975. Cataract was first noticed in most of the animals when they were 1½ to four years of age, but some were detected in animals as old as seven years.

Barnett (1980) reported a case of hereditary cataract due to a simple autosomal recessive gene in a Welsh Springer Spaniel.

Barnett (1985) described typical primary hereditary cataract as those that occur at about three months of age i.e., that are not congenital, and progress to become total between one and two years of age. Examples of these are found among others in the Boston Terrier, Golden Retriever. Afghan Hound, German Shepherd Dog, and Welsh Springer Spaniel. It was opined that other recently described cataract may be congenital and some develop much later in life and some do not progress.

Barnett (1986) described a primary hereditary cataract found in two test litters of eleven live puppies and ten young German Shepherd Dogs (6-18 months of age) examined over six years in the United Kingdom. These cataracts were bilateral, primary, and progressive to a certain point, but they were not congenital, earliest signs being seen at eight to twelve weeks of age. The condition appeared to be due to a widespread autosomal recessive gene. He also cited the finding of von Hippel that cataract described by the latter in the same breed in Germany in 1930 was congenital, non-progressive and associated with a dominant gene.

Barros (1989) examined 289 dogs (143 male and 146 female) with cataract between 1981 and 1985. The incidence was 79 mongrels, 67 Poodles, 51 English Cocker Spaniels, and 26 in German Shepherd Dogs. Of the 13 cases of congenital cataract, eight were seen in English Cocker Spaniels.

Lorimer (1990) reviewed the incidence and aetiology of cataract in dogs and cats. The disease was found to be rare in cats and usually affected young and middle-aged dogs.

Collins *et al.* (1992) studied a closely inbred line of Chow Chows affected with congenital cataract. The high incidence of cataract in this family of Chow Chows suggested an inherited defect, although the inheritance pattern was undetermined. Clinical appearance of the cataract was variable, ranging from incipient nuclear or capsular lesions to advanced cortical opacity.

Spiess (1994) reported that ophthalmoscopic examination of 276 Bernese Mountain Dogs between 1987 and 1992 revealed a high incidence of cataract, progressive retinal atrophy and glaucoma.

Bjerkas and Haaland (1995) diagnosed pulverulent nuclear cataract in 52 of 102 Norwegian Buhunds examined between 1987 and 1994. Both sexes were equally affected and all animals were otherwise healthy.

Ekesten *et al.* (1997) reported that one dog out of 29 Norwegian Elkhounds with primary glaucoma developed secondary cataract.

Causative Factors/Induction of Cataract

Heywood (1971a) reported the development of cataract as a result of repeated administration of drugs in purebred Beagle Dogs used for drug research at the Huntingdon Research Centre. Drug induced cataract was initiated at the equator, when progression was relatively rapid (over a period of days), or at the posterior pole of the lens when progression took several months. It was opined that these changes represented acute and chronic forms of lenticular toxicity.

Brown *et al.* (1972) described the development of cataract in dogs given three to eleven daily doses of 100 mg/kg rafoxanide by mouth.

Martin *et al.* (1972) recorded that transient cataract was induced with the administration of disophenol in dogs during the treatment of ancylostomiasis. Young weanling puppies were most susceptible to cataract formation, but in the recommended dose and route of administration (10 mg/kg SC) the drug produced either minimal lenticular opacities or none at all.

Gelatt (1974) reported a case of a one and a half-year old Norwegian Elkhound that developed focal pyramidal cataract and

advanced optic nerve atrophy in one eye, caused by a small lead shot lodged in the orbital cavity.

Hirth *et al.* (1974) described small punctate anterior capsular opacities (spurious cataract) in 24 of 1314 Beagle Dogs, which were considered to represent remnants of the embryonic fibrovascular pupillary membrane.

Martin (1975) observed that a commercial preparation of disophenol given at 30 mg/kg SC produced cataract in puppies upto 15 weeks of age. Commercial grade Disophenol dissolved in ethyl alcohol produced identical cataract but ethyl alcohol alone did no produce cataract.

Bours and Hockwin (1976) discovered that the proteins of the lens were species specific within the alpha, beta, and gamma crystalline main fractions. Lens opacity was attributed to a direct influence on protein conformation or synthesis. They also suggested that species specificity might influence individual cataract response to injurious factors.

Glaze and Blanchard (1983) observed that six of a litter of eight Samoyed puppies developed lenticular opacities when reared upto

weaning on a commercial replacement diet for canine milk. Similar opacities did not develop in littermates reared on dam's milk.

Brightman *et al.* (1984) recorded the development of bilateral anterior subcapsular cataract in a three year old mixed breed female dog due to electric shock. Similar cataract in man following severe electric shock was termed "electric cataract."

Bruyette and Feldman (1988) suspected that cataracts diagnosed in six out of 15 dogs at the University of California Veterinary Medical Teaching Hospital with primary hypoparathyroidism were due to secondary hypocalcaemia.

Nasisse *et al.* (1990) reported that cataract formation was a long-term complication of treatment of glaucoma by Neodymium: Yttrium Aluminium Garnet (Nd:YAG) laser energy in canines, as recognized in 37 per cent (12 of 32) dogs so treated.

Dadke *et al.* (1992) induced cataract in buffalo calves (*Bubalus bubalis*) by injection of calcium borogluconate solution or hypertonic (50 per cent) glucose solution into the anterior chamber, or by

direct trauma to the lens. Cataract developed in 18.5, 21.3 and 20.5 days respectively.

Meyer (1992) reported that dogs fed galactose at greater than 5 g/kg showed increased risk of cataract development.

Costa *et al.* (1996) reported that a retrospective study of dogs on long-term ketoconazole therapy revealed 17 non-diabetic cases with similar cataract, which were bilateral and rapidly progressive.

Types of cataract

Philips and Magrane (1959) classified cataract as (a) developmental cataract including congenital and juvenile cataracts caused by degenerative loss of transparency during normal development and (b) degenerative cataract where transparency of the fully developed lens was lost due to various causes. Cataracts included in this group were senile nuclear and cortical cataracts, traumatic cataracts and those associated with systemic or intra-ocular diseases.

Olesen *et al.* (1974) reported hereditary congenital sub-capsular anterior polar cataract in Red Cocker Spaniels.

Bistner *et al.* (1977) described the development of the lens and causes and types of cataract found in animal species.

Clerc (1978) classified cataract into three main forms based on clinical features viz. juvenile, senile, and intermediate. The juvenile forms were those present at birth; senile form was described as the development of radial opacity appearing after eight years of age; and intermediate forms as those occurring at six to seven years of age. According to him, in young adults, cataract could be diabetic, traumatic, hereditary, toxic or inflammatory.

According to Narfstrom (1981) cataract, attributed to the effects of autosomal recessive genes was observed in 49 of 97 related West Highland white Terriers. Of these, 34 had a 'Y' suture cataract (mainly affecting the tips of the posterior 'Y' suture) while 12 had complete cataract.

Glaze and Blanchard (1983) observed the development of mild opacity characterized by equatorial and cortical vacuolization in six of a litter of eight Samoyed puppies reared on a commercial replacement for canine milk upto weaning.

Barnett (1985) described the clinical appearance of hereditary cataract in several breeds of dogs. There was also discussion about cataract secondary to other eye diseases both hereditary and nonhereditary and to systemic conditions.

Barnett and Startup (1985) described bilateral symmetrical and progressive hereditary cataracts in two Standard Poodles, full brothers from different litters, both black males descended from American bloodlines.

Narfstrom and Widebeck (1989), using a defined grading system for lenticular opacity, examined 57 Golden Retrievers two to four times at an interval of one to nine years. Most cataracts were bilateral. Of the 44 cases of posterior polar cataract, 40 (91 per cent) were progressive.

Collins *et al.* (1992) reported that clinical appearance of the cataract was variable, ranging from incipient nuclear or capsular lesions to advanced cortical opacity.

Whitley *et al.* (1993a) suggested that cataract could be classified on the basis of the stage of maturity as incipient, immature,

intumescent and hypermature and this was the best method of classification when considering extraction.

Granitz (1994) reviewed, compared, and evaluated clinico-ophthalmological and electro-retinographic results of 73 dogs of 21 different breeds with signs of decreased vision or blindness. Cataract was found in 51 dogs. In English Cocker Spaniels and Miniature and Toy Poodles with cataract, a significant electro-retinographic loss of retinal function was found. This defect was recognized as a result of progressive retinal atrophy, in respect of the breed and age of these dogs.

Ori *et al.* (1996) after ultrasonographic examination of 26 eyes with cataract, found that all the eyes had ultrasonographic abnormalities; the most prevalent were hyper-echoic regions in the anterior and posterior cortices and nuclear poles. Cases of nuclear sclerosis (three eyes) showed no abnormality.

Treatment

Medical

Cobble and Lynd (1977) found that treatment of canine cataract by intra-ocular injection of Orgotein (tissue protein extract)

resulted in varying degrees of clearing of lens opacity and return of functional vision.

Lynd and McDonald (1978) reported that 305 dogs with senile cataract were treated by one or two intra-ocular injections of superoxide dismutase (1.25 mg) followed by citrus bio-flavinoids (40 mg/kg). Ascorbic acid (100 mg/kg) was administered orally for 14 days after the procedure. Out of these dogs 262 showed clearing of the lens and restoration of vision within 72 hours with no evidence of recurrence upto 18 months.

Millan *et al.* (1989) evaluated efficacy of zinc citrate ascorbate in 146 dogs (256 eyes), that had various lens opacities. Of the 138 eyes treated, 86 (62.3 per cent) had no change, 48 (34.8 per cent) had increased lens opacity and four (2.9 per cent) had decreased lens opacity. Zinc citrate ascorbate drops were not significantly more effective in clearing cataract than saline drops.

Peruccio *et al.* (1989) reported that Bendazac Lisin, a proprietary preparation also known as Bindazac (1-benzyl-1 H-indazol-3-yloxy) acetic acid was effective in 90 (35 per cent) of 255 dogs with cataract

Kudo and Minatoya (1991) found that disophenol given subcutaneously once a week at 6.5 to 7.0 mg/kg to 214 dogs (5-13 years of age) with cataract was effective in five animals. Diffuse subcapsular cataract started to decline a week after the start of treatment. Cortical and nuclear opacities were less sensitive to the treatment.

Whitley *et al.* (1993a) discussed the merits of various medical treatments for cataract and stated that although several medical regimens were propounded, none of them was significantly effective in the treatment of cataract and surgery was the only certain cure for the condition.

Basher and Roberts (1995) described the pathogenesis and pathophysiology of diabetic cataract in dogs and methods of treatment of such cataract.

Surgical

Startup (1967) reviewed the modalities of cataract surgery and the history of cryosurgical cataract extraction in dogs. The application of cryo-extraction to intra-capsular extraction of cataractous lenses in dogs was described.

Magrane (1968) attempted an uncomplicated intra-capsular lens extraction in dogs with the use of three types of cryo-probes and two sources intense cold in the normal, cataractous and misplaced lens categories. The two cryogens used were CO_2 snow and Freon. The cataract probes were commercial CO_2 probe, commercial Freon probe, and a homemade Freon probe. It was found that the Freon probes were more suitable and maintained a freezing temperature at the tip for as long as needed. Capsular rupture occurred with normal intact lenses or uncomplicated juvenile or senile cataract., necessitating extra-capsular extraction in all cases. In some cases of hypermature cataract the capsular rupture occurred even when enzymatic zonulysis was used. In others, a successful intra-capsular extraction of the collapsed Morgagnian cataract was accomplished without the use of zonulysin with careful stripping of the vitreous.

Delagarde (1974) reported on the aetiology, pathogenesis, symptoms, and diagnosis of cataract in dogs. Out of the 123 cases where surgical extraction was carried out, only one was unsuccessful as secondary glaucoma developed in both the eyes.

Spreull *et al.* (1980) commented on the wide variety of techniques advocated and used in pre-operative treatment, anaesthesia,

operative technique, and post-operative care of dogs treated for cataract by lens extraction.

Ly (1981) used sodium hyaluronate gel to replace the lost aqueous humour of the anterior chamber in cataract surgery in seven dogs, with satisfactory results.

Rooks *et al.* (1985) reported an overall success rate of 79 per cent over a total of 240 extra-capsular cataract extractions performed on 214 dogs between 1968 and 1980. In dogs where a second eye was operated upon, the overall success rate for the second eye was approximately 20 per cent than for diabetic and senile cataract.

Laage and Marot (1986) described the technique of endo-capsular ultrasonic phaco-emulsification in dogs. In this technique, the lens was phaco-emulsified behind the anterior capsule and removed, protecting the corneal endothelium even during prolonged use of ultrasound.

Laforge (1986) provided a detailed account of the surgery and pre-operative and post-operative care for extra-capsular extraction of cataractous lenses in dogs.

Paulsen *et al.* (1986) in a retrospective study on the effect of lens-induced uveitis (LIU) in the success or failure of cataract removal in dogs, found that LIU could be controlled prior to surgery, but patients with the condition had greater incidence of surgical complications.

Miller *et al.* (1987) reported that out of 56 cases of cataract removal in dogs by phaco-emulsification and aspiration, 53 (94.6 per cent) showed improvement of vision in the immediate post-operative period. Vision was present in 25 (85.2 per cent) of 29 dogs evaluated after two years and in five (71.4 per cent) of seven dogs evaluated after four years. Post-operative development of anterior uveitis was the primary reason for the failure of visual improvement and development of complication. Age at surgery was not a significant factor in restoration of vision.

Bigelbach (1990) described the inter-capsular techniques (envelope or endo-capsular technique), a new method for cataract extraction in dogs. The intra-ocular structures were better protected against surgical trauma by the use of visco-elastic substances. Post-operative inflammatory reactions were reduced to a minimum. The technique could also be used for implantation of intra-ocular lenses in the capsular bag.

Davidson *et al.* (1990) reported that post-operative evaluation of results of 113 unilateral and 77 bilateral extra-capsular cataract extractions (EC-CE's) in dogs revealed that vision was improved or restored in 79.6 per cent of the eyes in dogs with bilateral extraction at weeks four and six. When using the criterion that one or both treated eyes had functional vision, a short-term success rate of 98.7 per cent was achieved for bilateral extractions.

Kielbowicz (1990) reported that after microsurgical cryo-extraction of lenses in 64 dogs. treatment was successful only in patients with senile or symptomatic cataract. In dogs with diabetic cataract no positive results were obtained, because of concurrent retinopathy. In dogs with toxic cataract, retinal atrophy due to intoxication occurred. The return of complete vision was not obtained in any case, because the eyes were aphakic and hypermetropic, but vision was sufficient to enable the dogs to orient themselves in the environment.

Nasisse *et al.* (1990) found that Q-switched ophthalmic Neodymium: Yttrium Aluminium Garnet (Nd: YAG) Laser energy was effective in treating after-cataract, a common complication of canine cataract extraction. The technique was successful in 28 of 36 attempts (77 per cent) and improved pupillary clarity.

Davidson *et al.* (1991) studied surgical outcome and post-operative complications for 182 dogs in which phaco-emulsification with or without intra-ocular lens (IOL) implantations was performed. 160 of 296 eyes had IOL implanted. There was no increase in post-operative complication in eyes receiving IOL implants over eyes not receiving IOL implants.

Gelatt (1991) described the use of cryo-probes frozen by CO_2, nitrous oxide, or liquid nitrogen for the intra-capsular extraction of cataractous lenses in canines.

Young *et al.* (1991) reported that the use of a muscle relaxant (Vecuronium) significantly improved eye position and significantly reduced the halothane vaporizer setting during anaesthesia for cataract surgery in dogs.

Davidson *et al.* (1993) reported that streak retinoscopy documented that a Dioptric power of greater than +38 D was required to achieve emmetropia in dogs, with predicted values for IOL powers in seven breeds ranging from +39.62 D to +43.14 D in order to approximate emmetropia.

Whitley *et al.* (1993b) reviewed the classification of cataract, success rates of various surgical procedures, examination and selection of patients for cataract surgery and factors that complicate or rule out cataract surgery in the canine patient.

Barth (1994) reviewed the technique of cryosurgery for various eye disorders including removal of the lens in cataract.

Kielbowicz and Ratajczak (1995) reported that out of 190 dogs aged 10.6 ± 3.7 years with cataract which underwent extra-capsular cataract extraction, 111 showed restoration of vision at 30 days after surgery, as detected by obstacle tests. Post-operative complications included prolapse of vitreous and development of uveitis and glaucoma. Progressive retinal atrophy was diagnosed in 12 dogs.

Spiess *et al.* (1996) evaluated the use of radio-frequency anterior capsulotomy in cataract extraction by phaco-emulsification followed with IOL implantation in 21 canine eyes during routine cataract extraction (by phaco-emulsification). They found it an easy and reliable method for excision of the anterior lens capsule. They reported that the procedure could be completed in 20 to 30 seconds, thus reducing the overall time of intra-ocular manipulation.

Williams *et al.* (1996) reviewed current practice in the surgery of cataract in dogs in Great Britain, Europe, and the United States of America. They found that success rate had increased particularly as a result of the introduction of phaco-emulsification. They also discussed the developing field of intra-ocular lens implantation and the benefits and potential problems that might arise after the extraction of a cataract and the implantation of a lens.

Materials and Methods

3. MATERIALS AND METHODS

The experimental study was conducted on 12 apparently healthy adult nondescript dogs of either sex aged from eight months to four years. The average body weight was 10 kg. These animals were randomly divided into two groups viz. Groups A and B, each consisting of six animals, numbered serially from AI to A6 and BI to B6.

A clinical study was also carried out in two male dogs suffering from juvenile cataract. These animals were grouped as Group C and numbered CI and C2.

All the animals were maintained under identical regimes of feeding and management throughout the period of observation. The study was carried out as given hereunder:

3.1 Group A

In this group cataract was induced by the injection into the anterior chamber of the right eye of 0.5 ml of sterile calcium borogluconate[1] solution (25 %) after withdrawing the same amount

[1] Calborol - Prima VetCare Pvt. Ltd., Kalol, Gujarat

of aqueous humor observing strict asepsis. Following development of cataract the animals were treated with cryo-coagulation of the lens *in situ*.

3.2 Group B

Cataract was induced observing strict asepsis in the right eye as in Group A. Following development of cataract, the lens was extracted by intra-capsular cryo-extraction.

3.3 Group C

In this group, clinical cases of cataract were treated by intra-capsular cryo-extraction as in Group B.

3.4 Pre-medication

Atropine sulphate[2] was administered at the dose rate of 0.04 mg/kg of body weight SC 24 hours prior to surgery to achieve mydriasis. In addition, starting from two hours prior to surgery,

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[2] Tropine - Neon Laboratories Pvt. Ltd., Mumbai

homatropine hydrobromide[3] eye drops (two per cent) at the rate of two drops every 30 minutes was instilled into the right eye. The animals were also given injections of diclofenac sodium[4] 1 mg/kg body weight and chlorpheniramine maleate[5] two mg/kg of body weight intramuscularly.

3.5 Anaesthesia and control

All animals were premedicated with xylazine hydrochloride[6] at a dose rate of one mg/kg of body weight IM 15 minutes before induction of general anaesthesia.

The dogs were anaesthetized using a 2.5% solution of thiopentone sodium[7] given intravenously at the rate of 25 mg/kg of bodyweight "to effect."

The dogs were secured in left lateral recumbency so that the right eye could be approached.

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3 Homide Eye Drops - Warren Pharmaceuticals.
4 Zobid Injection - Sarabhai Chemicals, Vadodara
5 Zeet Injection - Alembic Chemical Works Co. Ltd., Baroda
6 Xylaxin - Indian Immunologicals, Hyderabad
7 Intraval Sodium - Rhone-Poulenc Chemicals (India) Ltd., Bombay

The area around the right eye was shaved and prepared for aseptic surgery. The eye was irrigated with sterile normal saline solution.

3.6 Surgical Technique

3.6.1 Induction of cataract

Cataract was induced under surgical anaesthesia. The eyeball was fixed and a sterile disposable 24-G hypodermic needle was introduced into the anterior chamber of the eye through the limbus. A sterile syringe was attached to the needle and 0.5 ml of aqueous humour was withdrawn. An equal quantity of calcium borogluconate solution (25%) was then injected into the anterior chamber through the same needle and the needle was then withdrawn.

The average period taken for development of cataract was 22.58 ± 0.66 days (Table 1).

3.7 Treatment of cataract

3.7.1 Surgical procedure

A field drape was applied so that only the margins of the right eyelids were exposed. Lateral canthotomy, extending from the lateral canthus to the anterior margin of the lateral orbital rim was performed in all the animals using heavy Mayo-pattern surgical scissors.

The eyelids were then retracted by application of a Castroviejo self-retaining eyelid retractor. The eyeball was fixed using a single strand of nylon suture passing through the conjunctiva and superficial sclera at a distance of five millimetres from the limbus on the dorsal aspect of the globe.

After exposure and fixation of the eyeball, an incision was taken using a Number 11 Bard-Parker blade in the dorsal half of the limbus, starting from the nine O'clock position and extending to the three O'clock position.

A 3/0 silk suture was placed in the free corneal edge without injury to the corneal endothelium to aid in retracting the cornea.

3.7.1.1 Group A

The surgical cryo-probe was introduced into the anterior chamber of the eye. The lens was then frozen by touching it with the nitrous oxide cryo-surgical probe for a period of 20 seconds. The cryo-probe was then allowed to thaw and removed leaving the lens in place.

Sector iridectomy was performed in all the animals of this group to prevent the formation of synechia between the iris and the lens. The corneal incision was closed using simple interrupted sutures of 8/0 silk on a micropoint spatulate needle, placed two millimetres apart with minimum tension, avoiding distortion of the cornea. The anterior chamber was irrigated and reformed with sterile normal saline solution using an O'Gawa cannula before the last suture was placed.

The lateral canthotomy was repaired at the conclusion of surgery with deeply placed interrupted sutures using nylon.

3.7.1.2 Group B

The nitrous oxide cryo-surgical probe was introduced into the anterior chamber to touch the surface of the lens and frozen until stable cryopexy was achieved. The zonular and vitreal attachments of the lens were then gently detached and the lens was extracted taking care to touch neither the iris nor the corneal endothelium with the cryo-probe. Any vitreous strands that adhered to the lens were gently severed using scissors.

The corneal incision was sutured in simple interrupted pattern using 8/0 silk suture on a micro-point spatulate needle. Sutures were placed two millimetres apart with minimum tension, so as to avoid distortion of the cornea. The anterior chamber was irrigated and reformed with sterile normal saline solution using an O'Gawa cannula before the last suture was placed.

3.7.1.3 Group C

The animals in this group were treated for cataract by intra-capsular cryo-extraction as described in Group B.

3.8 Post-operative care

All the animals were kept under observation for a period of 30 days following surgery.

Soframycin-hydrocortisone acetate[8] eye drops were instilled four times a day throughout the period of observation.

Homatropine hydrobromide eye drops (two per cent) were instilled thrice daily for 10 days following surgery.

Diclofenac sodium and chlorpheniramine maleate were administered intramuscularly at dose rates of 1 mg/kg and 2 mg/kg respectively once a day for seven post-operative days.

Blood samples were collected for haematological studies before surgery, immediately after surgery and at 24 hours, seventh day, 15th day, and 30th day post-operatively.

[8] Sofracort Eye/Ear Drops - Roussel India Limited, Mumbai

3.9 Main items of observation

3.9.1 General condition of animals

The general condition of all the animals was recorded during the period of observation.

3.9.2 Physiological parameters

Respiration, pulse, rectal temperature, and colour of the mucous membrane of the contralateral (left) eye were recorded before surgery, immediately after surgery, and then daily upto the 15^{th} post-operative day.

3.9.3 Haematological parameters

The haematological parameters evaluated were the total leukocyte count and the differential leukocyte count. These were recorded prior to surgery, immediately after surgery, at 24 hours and thereafter on the seventh, 15^{th}, and 30^{th} post-operative days.

3.9.4 Clinical signs

The major clinical signs *viz.* conjunctivitis, keratitis, uveitis, blepharospasm, photophobia, anterior synechia, posterior synechia, haziness/ clarity of the vitreous body, cytology of the lachrymal smear and protein content of the aqueous humor were evaluated following the surgical procedure. Protein content of the aqueous humor was evaluated using the Biuret method. Lachrymal cytology was evaluated by staining and examining smears of lachrymal secretions.

3.9.5 Intra-ocular pressure

Intra-ocular pressure was monitored pre-operatively and at weekly intervals post-operatively till 15th day. Measurements were made using a Schiotz tonometer following the procedure described by Helper (1989).

3.9.6 Functional tests of vision

The animals were monitored for visual capability following surgery. The tests were conducted by evaluating the

animals' ability to negotiate an obstacle course under photopic and scotopic light conditions, after blind folding the left eye with an eye shield. The animals were also tested for their ability to locate a stationary object and to track a moving object under varying conditions of ambient lighting. Tests of ocular functional integrity were conducted by evaluating menace and photomotor pupillary reflexes.

3.9.7 Healing

The operated eye was evaluated for healing by daily observation of the site of surgery.

Results

4. RESULTS

The study was conducted in twelve apparently healthy dogs of either sex, randomly divided into two groups viz., Group A and Group B, each consisting of six animals. The average body weight of the animals was 10 kg. In addition, clinical cases of two dogs each aged one year and suffering from juvenile cataract were subjected to the study and was included as Group C. (Plate 1)

All the animals were maintained under identical conditions of feeding and management throughout the period of observation.

4.1 Anaesthesia

Premedication with xylazine hydrochloride at a dose of one mg/kg IM and anaesthesia induced using a 2.5% solution of thiopentone sodium IV at a dose of 25 mg/kg "to effect" was found satisfactory for cataract surgery. However, supplemental doses of thiopentone sodium were found to be necessary to maintain Plane III of surgical anaesthesia for completion of the procedure. The average

period of surgical anaesthesia achieved following a single dose of thiopentone sodium was 23 minutes.

4.2 Induction of cataract

Cataract was induced in all animals by injection of 0.5 ml of sterile calcium borogluconate solution (25 per cent) into the anterior chamber of the right eye using a sterile 24-G disposable hypodermic needle.

The development of cataract was assessed by visual examination of the lens and determined by its changes in transparency. The average time taken for development of cataract was 22.58 ± 0.66 days (Table 1) (Plate 2).

4.3 Surgical treatment of cataract

In the animals of Group A treatment of cataract was by cryo-coagulation. The lens was frozen by the contact of the cryo-probe for 20 seconds (Plate 3). The lens was left in situ. The limbal incision was sutured using 8/0 virgin silk suture (Plate 4).

In the animals of Group B, cataract was corrected by intra-capsular cryo-extraction of the lens. The limbal incision was sutured as in Group A.

In the animals of Group C, cataract was corrected as in Group B.

4.4 Group A

4.4.1 Observations during surgery

Extensive lateral canthotomy was required to achieve adequate exposure of the globe in all the animals. Haemorrhage was a complication only when damage occurred to either the iris or the scleral vessels.

Copious lavage with sterile normal saline solution was performed in order to prevent drying of the corneal endothelium.

Cryo-coagulation was achieved by applying the cryo-probe to the lens for 20 seconds. The probe was then removed, leaving the frozen lens *in situ*.

Sector iridectomy was performed to obviate glaucoma due to synechia.

4.4.2 Physiological parameters

The observations are presented in Tables 2-11.

1) Rectal temperature (°C)

The rectal temperature before anaesthesia was 38.30 ± 0.05 prior to anaesthesia. There was a decrease to 37.72 ± 0.11 immediately after surgery. The value returned to near normal values 24 hours after surgery and remained within normal limits thereafter (Table 2).

2) Pulse rate (per min.)

The pulse rate in Group A was 113.83 ± 4.20 prior to anaesthesia. A marked decrease to 73.00 ± 4.10 was observed immediately after surgery. The value was 105.33 ± 4.05 at 24 hours post-operatively and was within normal range thereafter (Table 3).

3) Respiration rate (per min.)

The respiration rate was 43.33 ± 2.06 prior to surgery. A sudden decrease to 25.00 ± 1.57 was seen immediately after surgery. This returned to near normal values by the second post-operative day and remained so thereafter (Table 4).

4) Colour of the mucous membrane of the contralateral eye

The mucous membrane of the contralateral eye did not show any change in colour during the period of observation.

4.4.3 Haematology

1) Total leukocyte count ($x10^3$ cells/mm^3)

The total leukocyte count was 10.87 ± 0.31 before anaesthesia. There was a slight increase in the value upto 24 hours post-operatively. Thereafter, it decreased but was within normal range throughout the period of observation (Table 5).

2) Differential leukocyte count

The neutrophil count was 69.33 ± 2.09 per cent before anaesthesia. The value was 75.33 ± 2.30 immediately after surgery. The value became 77.33 ± 1.96 at 24 hours after surgery. Thereafter there was a decrease in the values, but was within normal limits throughout the period of observation (Table 6).

The lymphocyte count was 28.83 ± 2.15 per cent before anaesthesia. A decrease was noticed upto 24 hours post-operatively but the value returned to normal range by the 30th postoperative day (Table 7).

The eosinophil count was 1.33 ± 0.33 per cent before anaesthesia. Following surgery there was a slight increase in the eosinophil count upto the seventh post-operative day. Thereafter it decreased and remained within normal range throughout the period of observation (Table 8).

The pre-anaesthetic monocyte count which was 0.33 ± 0.21 per cent had a marginal increase on the 7th post-operative day.

The value decreased to 0.20 ± 0.20 at the end of the period of observation (Table 9).

4.4.4 Clinical evaluation

4.4.4.1 General Condition

All animals were alert and active following recovery from anaesthesia and throughout the period of observation, except animal A3, which became anorectic on the 26th post-operative day and died on the 29th day of observation.

4.4.4.2 Clinical symptoms observed

1) Conjunctivitis

Conjunctivitis following surgery resolved in all animals by day nine, except in A3, where it persisted until day 11.

2) Corneal clearing/keratitis

Complete Corneal clearing occurred by day seven in animal A4. The cornea was clear from day 23 to 27 in animal A2 but became oedematous thereafter and did not clear even at the end of

the observation period. Keratitis persisted throughout the period of observation in animals A1, A3, A5, and A6. Varying degrees of corneal oedema persisted in all animals except A4. Animal A6 developed a pigmentary keratitis of the dorsal half of the cornea.

3) Uveitis

Uveitis resolved by day five in animal A2, day four in animal A4 and days four and six in animals A5 and A6 respectively. Uveitis persisted until day 10 in animals A1 and A3.

4) Blepharospasm

Blepharospasm resolved in all animals by day six except in animal A3 where it persisted till the eighth day.

5) Photophobia

Post-operative photophobia resolved by day six except in animal A3 where it persisted till day eight.

6) Anterior synechia

The persistent corneal oedema prevented assessment of this condition in any of the animals except in animal A4. In this animal anterior synechia was not a clinical feature following cataract surgery.

7) Posterior synechia

Due to persistent corneal oedema the condition could not be assessed in any of the animals except A4. In this animal posterior synechia was not a clinical feature.

8) Vitreous haziness/clarity

Animal A4, the only animal with a clear cornea, had a clear vitreous body. Corneal oedema prevented assessment in the other animals of this group.

9) Cytology of the lachrymal smear

The major cell type found in the lachrymal smear was epithelial cells with a few leukocytes.

10) Protein content of the aqueous humour (g/dl)

Aqueous humour protein content was 0.46 ± 0.02 prior to anaesthesia. Following surgery, aqueous flare could not be visualized in any of the animals due to the persistent corneal oedema. Protein content of the aqueous humour at the end of the observation period was found to be slightly elevated to 0.51 ± 0.01 in this group (Table 10).

11) Intra-ocular pressure (mm Hg)

The mean intra-ocular pressure in this group prior to surgery was 17.67 ± 0.42. There was a sudden decrease to 13.83 ± 0.31 immediately after surgery. The value increased to 20.17 ± 0.40 on the second day after surgery. The pressure level at the end of the observation period was found to be 17.67 ± 0.42 (Table 11).

4.4.5 Test of visual function

Only animal A4 exhibited the ability to locate and track moving objects and to negotiate an obstacle course. This ability was

limited to good light conditions (daylight). None of the other animals were able to detect stationary or moving objects in any light conditions. Animal A4 had brisk pupillary reflexes. (Plate 4)

4.5 Group B

4.5.1 Observations during surgery

Extensive lateral canthotomy was necessary in all cases in order to ensure adequate exposure of the globe. The haemorrhage was minimal and occurred only when either the scleral vessels or the iris was injured.

Desiccation of the corneal endothelium during surgery was prevented by irrigating the site with sterile normal saline solution.

Minor vitreous prolapse occurred in five of the animals in Group B. This prolapsed vitreous was excised and did not cause complications.

4.5.2 Physiological parameters

The observations are presented in Tables 12-21.

1) Rectal temperature (°C)

The rectal temperature was 38.42 ± 0.06°C prior to anaesthesia. The value increased slightly to 39.12 ± 0.09°C at 24 hours after surgery. The value was seen decreased thereafter and was within normal ranges. The value became 38.25 ± 0.03°C by the 15th postoperative day (Table 12).

2) Pulse rate (per min.)

Pulse rate was 110.00 ± 8.26 immediately before anaesthesia and found decreased to 84.00 ± 2.11 immediately after surgery. The value then returned to the normal range thereafter and continued to be so during the observation period (Table 13).

3) Respiration rate (per min.)

The respiration rate was 37.00 ± 3.71 prior to anaesthesia. A marked decrease to 18.33 ± 0.99 was observed

immediately after surgery. At 24 hours following surgery the value was 32.00 ± 2.62 and continued to be within near normal values thereafter (Table 14).

4) Colour of the mucous membrane of the contralateral eye

The mucous membrane of the contralateral eye did not show any change in colour during the period of observation.

4.5.3 Haematology

1) Total Leukocyte Count ($x10^3$ cells/mm^3)

The total leukocyte count was 11.83 ± 0.45 before anaesthesia and 12.27 ± 0.40 immediately after surgery. The value further increased to 13.90 ± 0.2 24 hours after surgery, but thereafter it remained within normal ranges throughout the period of observation (Table 15).

2) Differential leukocyte count

The Neutrophil count was 71.67 ± 3.49 per cent prior to anaesthesia. It remained slightly increased upto the second

postoperative day, but returned to normal values thereafter (Table 16).

The lymphocyte count before anaesthesia was 26.83 ± 3.73 per cent. There was a marked decrease to 12.17 ± 1.62 24 hours after surgery, but then the value returned to normal range by the 15th postoperative day (Table 17).

The eosinophil count, which was 1.50 ± 0.43 per cent before anaesthesia was seen elevated to 4.67 ± 0.33 24 hours after surgery but started deceasing thereafter and reached near normal values by the seventh post-operative day and remained so thereafter (Table 18).

The monocyte count was zero per cent before anaesthesia. After surgery the value was 0.17 ± 0.17 which became zero at 24 hours after surgery. Thereafter there was slight increase in the values and it was 1.00 ± 0.37 on the 15th postoperative day (Table 19).

4.5.4 Clinical evaluation

4.5.4.1 General condition

All the animals were alert and active following recovery from anaesthesia and during the entire period of observation. All the animals were feeding normally.

The operated eye was compared with the normal contralateral eye to determine any change in the function of the operated eye.

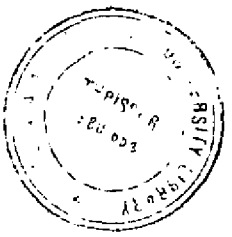
4.5.4.2 Clinical symptoms observed

1) Conjunctivitis

Conjunctivitis following surgery was observed throughout the period of observation in animals B1, B2, and B4. It had resolved by day 25,16, and nine in animals B3, B5, and B6 respectively.

2) Corneal clearing/keratitis

Corneal clearing was complete by day 25 in animals B3, B5 and B6. Animals B1, B2 and B4 failed to show corneal clearing even at the end of the period of observation.



3) Uveitis

Clinical signs of uveitis had resolved in all animals by the 12th post-operative day.

4) Blepharospasm

Blepharospasm following surgery resolved by day 13 in all animals except B2 in which it persisted upto 27th day

5) Photophobia

Signs of photophobia was not observed in any of the animals beyond 13 days following surgery.

6) Anterior synechia

Mild anterior synechia at the suture line was seen in animals B3, B5 and B6.

7) Posterior synechia

Posterior synechia was not observed in any of the animals.

8) Vitreous haziness/clarity

Vitreous haze was not present in any of the animals.

9) Cytology of the lachrymal smear

The major cell types seen in the lachrymal smear were epithelial cells, with a few leukocytes.

10) Protein content of the aqueous humour (g/dl)

None of the animals showed increased protein in the aqueous humour as evidenced by aqueous flare throughout the period of observation. Pre-operative aqueous humour protein content was found to be 0.45 ± 0.01. Aqueous humour protein content at the end of the period of observation was 0.46 ± 0.01 (Table 20).

11) Intra-ocular pressure (mm Hg)

The mean pre-operative intra-ocular pressure in this group was 18.50 ± 0.56. This value rose to 22.17 ± 0.54 on day two

following surgery but had returned to normal values by the 15th day following surgery (Table 21).

4.5.5 Tests of visual function

All animals in this group, except B1, B2, and B4 were able to negotiate an obstacle course in bright and dim ambient light. All animals except B1, B2 and B4 were able to track and locate stationary and moving objects in both photopic and scotopic ambient light conditions. Animals B1, B2 and B4 could not locate stationary or moving objects even in conditions of bright ambient light.

4.6 Group C

The animals in this Group were clinical cases of cataract that were included in the study.

The animals in this Group were treated for cataract by intra-capsular cryo-extraction, as in Group B.

Animal C2 died on day six of the observation period. This animal was in prolonged anaesthesia and recovered completely only 52 hours after induction of anaesthesia.

4.6.1 Observations during surgery

Extensive lateral canthotomy was required in both the animals of Group C in order to ensure adequate exposure of the globe for surgery. Haemorrhage was minimal and occurred only when either the scleral vessels or the iris was injured.

Desiccation of the corneal endothelium during the course of surgery was prevented by lavage with normal saline solution.

As in Group B, minor vitreous prolapse occurred during surgery. This was excised and did not cause complications.

Animal C2 did not recover from the surgical anaesthesia until 52 hours after surgery and died on the sixth post-operative day of unrelated causes.

4.6.2 Physiological parameters

The observations are presented in Tables 22-31.

1) Rectal temperature (°C)

The rectal temperature was 38.35 ± 0.05 prior to anaesthesia and 37.60 ± 0.00 immediately after surgery. The value increased slightly to 38.75 ± 0.05 at 24 hours after surgery, but returned to normal ranges thereafter and remained so for the remainder of the observation period (Table 22).

2) Pulse rate (per min.)

The pulse rate in this Group prior to surgery was 117±3.00. This decreased to 81.50 ± 1.50 immediately after surgery. The pulse rate was 109 ± 2.50 by 24 hours and returned to normal values by the eighth post-operative day and remained so thereafter (Table 23).

3) Respiration rate (per min.)

The respiration rate was 46.50 ± 1.50 prior to surgery. This decreased markedly to 30.00 ± 2.00 immediately after surgery,

but had returned to normal ranges by 24 hours after surgery and remained so thereafter (Table 24).

4) Colour of the mucous membrane of the contralateral eye

The mucous membrane of the contralateral eye did not show any change in colour at any time during the period of observation.

4.6.3 Haematology

1) Total leukocyte count ($x10^3$ cells/mm^3)

This parameter had a value of 12.05 ± 0.05 prior to surgery. It rose slightly to 12.35 ± 0.55 after surgery and was increased slightly to 13.15 ± 0.05 at 24 hours after surgery. Thereafter it returned to normal ranges and remained so till the end of the observation period (Table 25).

2) Differential leukocyte count

The neutrophil count was 69.50 ± 0.50 per cent prior to surgery. At 24 hours it increased to 82.00 ± 1.00 but returned to normal ranges thereafter (Table 26).

The lymphocyte count prior to anaesthesia was 29.00 ± 1.00 per cent. There was a marked decrease to 13.50 ± 1.50 at 24 hours after surgery, but the value then returned to normal ranges by the seventh post-operative day and continued so thereafter (Table 27).

The eosinophil count was 1.00 ± 0.00. This value increased to 3.50 ± 0.50 immediately after surgery and was 4.00 ± 0.00 at 24 hours post-operatively. The value then returned to normal ranges and continued so thereafter (Table 28).

The pre-operative value for this parameter was 0.00 ± 0.00. The value increased slightly to 0.50 ± 0.50 24 hours after surgery, but then returned to pre-operative levels and remained so thereafter (Table 29).

4.6.4 Clinical evaluation

4.6.4.1 General condition

Animal C1 was alert and active following recovery from anaesthesia, and during the entire period of observation. The animal was feeding normally.

Animal C2, however, failed to recover from surgical anaesthesia until 52 hours post-operatively. This animal was feeding normally, but died on the sixth post-operative day. Therefore observations could not be continued.

4.6.4.2 Clinical symptoms observed

1) Conjunctivitis

Conjunctivitis persisted in animal C1 until the eighth post-operative day, but disappeared thereafter. In animal C2 conjunctivitis was visible until the sixth post-operative day, when the animal died.

2) Corneal clearing/keratitis

Animal C1 had a cornea that was still hazy at the end of the observation period, but responded to light stimuli and had a visible iris.

3) Uveitis

Post-operative uveitis had cleared in animal A1 by the sixth day after surgery.

4) Blepharospasm

Blepharospasm had cleared in animal C1 by the fourth post-operative day. In animal C2 the sign persisted until day five following surgery.

5) Photophobia

Photophobia following surgery had resolved in both animals C1 and C2 by the third post-operative day.

6) Anterior synechia

Anterior Synechia could not be visualized in either of the animals in this group at any time during the period of observation.

7) Posterior synechia

Posterior synechia was not observed in either of the animals.

8) Vitreous haziness/clarity

Vitreous clarity could not be assessed in either of the animals in this Group

9) Cytology of the lachrymal smear

The major cell types visualized in the lachrymal smear were of epithelial origin, with a few leukocytes being seen.

10) Protein content of the aqueous humour (g/dl)

Neither of the animals showed signs of increased protein content of the aqueous humour as clinically expressed by aqueous flare during the period of observation. Pre-operative protein content of the aqueous humour was found to be 0.44 ± 0.01. Protein content of the aqueous humour at the end of the period of observation was found to be 0.52 ± 0.04. The value for animal C2 was obtained on the sixth post-operative day, following the death of the animal and was found to be 0.55 (Table 30).

11) Intra-ocular pressure (mm Hg)

The mean pre-operative intra-ocular pressure in this Group was 18.50 ± 0.50 prior to surgery. This value decreased to 17.00 ± 0.00 24 hours after surgery but returned to normal ranges thereafter (Table 31).

4.6.5 Tests of visual function

Animal C1 was unable to locate stationary objects in dim light but could do so in bright light, and could track moving objects in all light conditions. Animal C2 died on the sixth day following surgery. At that point the animal was unable to locate or track either stationary or moving objects under any conditions of ambient light.

Table 1 Time taken for experimental induction of cataract in dogs (in days)

Animal	Time Taken (Days)
A1	20
A2	23
A3	25
A4	22
A5	21
A6	21
B1	20
B2	22
B3	24
B4	23
B5	28
B6	22
Mean	22.58
SE	0.66

Table 2 Rectal temperature (^{0}C) before and after cryo-coagulation of cataract in dogs (Group A)

Day/ Animal	Pre-Op	Post-Operative															
		Post-Op	24 Hr	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day 10	Day 11	Day 12	Day 13	Day 14	Day 15
A1	38.20	38.00	38.30	38.80	38.80	38.80	38.90	38.70	38.70	38.60	38.70	38.50	38.50	38.30	38.10	38.10	38.30
A2	38.30	37.90	38.60	38.70	38.70	38.70	38.90	38.90	38.50	38.60	38.40	38.40	38.30	38.30	38.30	38.20	38.30
A3	38.50	37.90	38.90	39.00	39.00	39.00	39.10	39.00	39.00	38.90	38.90	38.70	38.70	38.70	38.60	38.60	38.30
A4	38.20	37.40	38.90	38.70	38.70	38.70	38.60	38.50	38.40	38.40	38.40	38.50	38.40	38.40	38.20	38.20	38.20
A5	38.40	37.70	38.60	38.70	38.70	38.70	38.60	38.40	38.50	38.40	38.30	38.30	38.30	38.40	38.30	38.40	38.40
A6	38.20	37.40	38.60	38.70	38.70	38.70	38.60	38.70	38.50	38.50	38.70	38.50	38.30	38.20	38.40	38.30	38.30
Mean	38.30	37.72	38.65	38.77	38.77	38.77	38.78	38.70	38.60	38.57	38.57	38.48	38.42	38.38	38.32	38.30	38.30
SE	0.05	0.11	0.09	0.05	0.05	0.05	0.09	0.09	0.09	0.08	0.10	0.05	0.07	0.07	0.07	0.07	0.03

Table 3 Pulse rate (per min.) before and after cryo-coagulation of cataract in dogs (Group A)

Day/ Animal	Pre-Op	Post-Operative															
		Imme-diate	24 Hr	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day 10	Day 11	Day 12	Day 13	Day 14	Day 15
A1	128.00	72.00	115.00	117.00	110.00	119.00	111.00	100.00	95.00	105.00	105.00	110.00	92.00	97.00	110.00	108.00	109.00
A2	108.00	83.00	96.00	99.00	89.00	110.00	115.00	100.00	95.00	96.00	98.00	97.00	90.00	93.00	100.00	102.00	99.00
A3	125.00	60.00	120.00	123.00	124.00	118.00	120.00	117.00	105.00	109.00	115.00	119.00	120.00	101.00	112.00	117.00	103.00
A4	102.00	62.00	104.00	97.00	109.00	105.00	112.00	98.00	112.00	100.00	96.00	97.00	97.00	105.00	110.00	114.00	110.00
A5	110.00	81.00	98.00	105.00	103.00	99.00	100.00	103.00	110.00	115.00	108.00	104.00	100.00	98.00	105.00	104.00	97.00
A6	110.00	80.00	99.00	108.00	100.00	105.00	115.00	102.00	100.00	104.00	98.00	109.00	92.00	102.00	97.00	100.00	100.00
Mean	113.83	73.00	105.33	108.17	105.83	109.33	112.17	103.33	102.83	104.83	103.33	106.00	98.50	99.33	105.67	107.50	103.00
SE	4.20	4.10	4.05	4.15	4.77	3.23	2.75	2.82	3.00	2.73	3.01	3.46	4.56	1.73	2.49	2.78	2.21

Table 4 Respiration rate (per min.) before and after cryo-coagulation of cataract in dogs (Group A)

Day/ Animal	Pre-Op	Post-Operative															
		Imm-ediate	24 Hr	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day 10	Day 11	Day 12	Day 13	Day 14	Day 15
A1	43.00	25.00	39.00	38.00	44.00	43.00	39.00	40.00	41.00	36.00	37.00	42.00	40.00	45.00	41.00	40.00	36.00
A2	42.00	23.00	37.00	42.00	37.00	36.00	38.00	43.00	41.00	32.00	39.00	40.00	36.00	42.00	41.00	43.00	44.00
A3	53.00	31.00	48.00	44.00	40.00	45.00	42.00	37.00	41.00	43.00	48.00	43.00	39.00	40.00	45.00	41.00	39.00
A4	42.00	28.00	38.00	35.00	42.00	40.00	42.00	39.00	45.00	40.00	39.00	39.00	37.00	42.00	45.00	43.00	40.00
A5	38.00	22.00	39.00	41.00	40.00	36.00	39.00	35.00	38.00	42.00	39.00	37.00	38.00	36.00	42.00	40.00	41.00
A6	42.00	21.00	38.00	41.00	39.00	40.00	43.00	41.00	40.00	38.00	39.00	43.00	41.00	36.00	42.00	38.00	41.00
Mean	43.33	25.00	39.83	40.17	40.33	40.00	40.50	39.17	41.00	38.50	40.17	40.67	38.50	40.17	42.67	40.83	40.17
SE	2.06	1.57	1.66	1.30	0.99	1.48	0.85	1.17	0.93	1.67	1.60	0.99	0.76	1.47	0.76	0.79	1.08

Table 5 Total leukocyte count (x 10^3/dl) before and after cryo-coagulation of cataract in dogs (Group A)

Day/Animal	Pre-Op.	Immediate Post-Op.	24 Hr. Post-Op.	Post-Operative Days			
				2	7	15	30
A1	9.70	10.30	12.10	11.80	10.40	10.30	10.50
A2	10.30	11.50	12.10	12.00	11.70	11.10	10.80
A3	11.40	12.50	12.80	11.90	11.10	12.10	
A4	10.80	11.60	11.80	11.50	11.10	11.10	11.00
A5	11.80	12.50	12.90	12.40	12.10	12.00	11.50
A6	11.20	11.60	12.80	12.30	12.30	12.10	12.20
Mean	10.87	11.67	12.42	11.98	11.45	11.45	11.20
SE	0.31	0.33	0.19	0.14	0.29	0.30	0.30

Table 6 Differential leukocyte count (%) Neutrophil count (%)before and after cryo-coagulation of cataract in dogs (Group A)

Day/Animal	Pre-Op.	Immediate Post-Op.	24 Hr. Post-Op.	Post-Operative Days			
				2	7	15	30
A1	64.00	72.00	77.00	75.00	73.00	73.00	72.00
A2	68.00	74.00	75.00	74.00	72.00	72.00	74.00
A3	78.00	86.00	87.00	84.00	81.00	73.00	
A4	65.00	71.00	75.00	73.00	72.00	70.00	72.00
A5	69.00	72.00	75.00	73.00	70.00	70.00	74.00
A6	72.00	77.00	75.00	70.00	73.00	70.00	71.00
Mean	69.33	75.33	77.33	74.83	73.50	71.33	72.60
SE	2.09	2.30	1.96	1.96	1.57	0.61	0.60

Table 7 Differential leukocyte count (%) Lymphocyte count (%) before and after cryo-coagulation of cataract in dogs (Group A)

Day/Animal	Pre-Op.	Immediate Post-Op.	24 Hr. Post-Op.	Post-Operative Days			
				2	7	15	30
A1	35.00	25.00	20.00	23.00	24.00	25.00	25.00
A2	31.00	20.00	21.00	23.00	25.00	26.00	23.00
A3	20.00	10.00	10.00	13.00	15.00	25.00	—
A4	32.00	25.00	22.00	24.00	28.00	27.00	26.00
A5	29.00	25.00	20.00	24.00	26.00	27.00	24.00
A6	26.00	21.00	21.00	24.00	24.00	27.00	28.00
Mean	28.83	21.00	19.00	21.83	23.67	26.17	25.20
SE	2.15	2.38	1.83	1.78	1.84	0.40	0.86

Table 8 Differential leukocyte count (%) Eosinophil count (%) before and after cryo-coagulation of cataract in dogs (Group A)

Day/Animal	Pre-Op.	Immediate Post-Op.	24 Hr. Post-Op.	Post-Operative Days			
				2	7	15	30
A1	1.00	2.00	3.00	2.00	3.00	2.00	2.00
A2	0.00	4.00	3.00	3.00	3.00	2.00	3.00
A3	2.00	4.00	3.00	2.00	2.00	1.00	
A4	2.00	4.00	3.00	3.00	2.00	2.00	2.00
A5	1.00	3.00	4.00	3.00	3.00	3.00	1.00
A6	2.00	2.00	4.00	6.00	3.00	3.00	1.00
Mean	1.33	3.17	3.33	3.17	2.67	2.17	1.80
SE	0.33	0.40	0.21	0.60	0.21	0.31	0.37

Table 9 Differential leukocyte count (%) Monocyte count (%) before and after cryo-coagulation of cataract in dogs (Group A)

Day/Animal	Pre-Op.	Immediate Post-Op.	24 Hr. Post-Op.	Post-Operative Days			
				2	7	15	30
A1	0.00	0.00	0.00	1.00	0.00	0.00	1.00
A2	1.00	2.00	1.00	0.00	0.00	0.00	0.00
A3	0.00	0.00	0.00	1.00	2.00	1.00	
A4	0.00	0.00	0.00	0.00	0.00	1.00	0.00
A5	1.00	0.00	1.00	0.00	1.00	0.00	1.00
A6	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mean	0.33	0.33	0.33	0.33	0.50	0.33	0.40
SE	0.21	0.33	0.21	0.21	0.34	0.21	0.20

Table 10 Protein content of aqueous humour (g/dl) before and after cryo-coagulation of cataract in dogs (Group A)

Day/Animal	Pre-Operative	30th Post-Operative Day
A1	0.45	0.48
A2	0.41	0.51
A3	0.48	0.50
A4	0.48	0.53
A5	0.51	0.50
A6	0.42	0.52
Mean	0.46	0.51
SE	0.02	0.01

Table 11 Intra-ocular pressure (mm Hg.) before and after cryo-coagulation of cataract in dogs (Group A)

Day/Animal	Pre-Op.	Immediate Post-Op.	24 Hr. Post-Op.	Day 2	Day 7	Day 15
A1	18.00	14.00	19.00	20.00	18.00	18.00
A2	19.00	15.00	18.00	20.00	18.00	17.00
A3	18.00	13.00	17.00	19.00	16.00	18.00
A4	17.00	14.00	20.00	22.00	20.00	19.00
A5	18.00	14.00	18.00	20.00	18.00	18.00
A6	16.00	13.00	16.00	20.00	17.00	16.00
Mean	17.67	13.83	18.00	20.17	17.83	17.67
SE	0.42	0.31	0.58	0.40	0.54	0.42

Table 12 Rectal temperature (^{0}C) before and after intra- capsular cryo-extraction of cataract in dogs (Group B)

Day/ Animal	Pre-Op	Post-Operative															
		Immediate	24 Hr	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day 10	Day 11	Day 12	Day 13	Day 14	Day 15
B1	38.50	38.00	39.20	39.00	38.80	38.70	38.50	38.50	38.40	38.30	38.20	38.30	38.20	38.20	38.10	38.20	38.20
B2	38.60	38.40	39.30	39.10	39.10	39.00	38.90	39.00	38.80	38.60	38.40	38.40	38.40	38.20	38.30	38.30	38.30
B3	38.20	38.00	39.10	39.10	39.10	38.80	38.90	38.80	38.70	38.40	38.30	38.20	38.10	38.20	38.20	38.20	38.10
B4	38.40	38.20	39.10	39.20	39.20	39.20	39.20	39.10	39.10	38.90	38.90	38.70	38.80	38.40	38.30	38.30	38.30
B5	38.50	38.20	39.30	39.40	39.30	39.30	39.20	39.20	39.00	39.00	39.00	38.80	38.70	38.70	38.30	38.30	38.30
B6	38.30	38.10	38.70	38.80	38.80	38.90	38.80	38.70	38.50	38.70	38.70	38.40	38.40	38.40	38.40	38.20	38.30
Mean	38.42	38.15	39.12	39.10	39.05	38.98	38.92	38.88	38.75	38.65	38.58	38.47	38.43	38.35	38.27	38.25	38.25
SE	0.06	0.06	0.09	0.08	0.08	0.09	0.11	0.11	0.11	0.11	0.14	0.10	0.11	0.08	0.04	0.02	0.03

Table 13 Pulse rate (per min.) before and after intra- capsular cryo-extraction of cataract in dogs (Group B)

Day/ Animal	Pre-Op	Post-Operative														
		Immediate	24 Hr	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day 10	Day 11	Day 12	Day 13	Day 14	Day 15
B1	88.00	90.00	85.00	86.00	90.00	90.00	96.00	90.00	92.00	88.00	89.00	120.00	90.00	86.00	88.00	99.00	85.00
B2	128.00	88.00	89.00	94.00	99.00	102.00	80.00	96.00	85.00	91.00	95.00	105.00	90.00	92.00	95.00	98.00	101.00
B3	98.00	76.00	85.00	110.00	82.00	90.00	89.00	92.00	95.00	92.00	95.00	96.00	90.00	95.00	92.00	93.00	95.00
B4	96.00	85.00	95.00	90.00	95.00	98.00	99.00	92.00	90.00	95.00	90.00	105.00	100.00	92.00	98.00	82.00	90.00
B5	110.00	80.00	96.00	95.00	92.00	102.00	100.00	96.00	91.00	92.00	100.00	114.00	110.00	92.00	99.00	118.00	110.00
B6	140.00	85.00	123.00	110.00	115.00	100.00	104.00	105.00	115.00	99.00	99.00	100.00	100.00	100.00	95.00	105.00	107.00
Mean	110.00	84.00	95.50	97.50	95.50	97.00	94.67	95.17	94.67	92.83	94.67	106.67	96.67	92.83	94.50	99.17	98.00
SE	8.26	2.11	5.83	4.16	4.54	2.29	3.57	2.20	4.28	1.54	1.84	3.63	3.33	1.87	1.65	4.91	3.98

Table 14 Respiration rate (per min.) before and after intra- capsular cryo-extraction of cataract in dogs (Group B)

Day/ Animal	Pre-Op	Post-Operative															
		Immediate	24 Hr	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day 10	Day 11	Day 12	Day 13	Day 14	Day 15
B1	28.00	16.00	29.00	29.00	28.00	28.00	28.00	29.00	28.00	29.00	30.00	36.00	30.00	34.00	24.00	26.00	30.00
B2	36.00	15.00	29.00	20.00	28.00	26.00	29.00	30.00	32.00	36.00	31.00	32.00	35.00	25.00	22.00	25.00	30.00
B3	31.00	20.00	29.00	32.00	30.00	31.00	30.00	26.00	24.00	27.00	29.00	31.00	30.00	26.00	27.00	27.00	28.00
B4	31.00	18.00	25.00	28.00	31.00	30.00	31.00	29.00	25.00	28.00	29.00	31.00	35.00	30.00	29.00	25.00	29.00
B5	45.00	21.00	39.00	32.00	30.00	36.00	32.00	30.00	28.00	31.00	28.00	35.00	27.00	31.00	25.00	28.00	31.00
B6	51.00	20.00	41.00	43.00	40.00	38.00	46.00	52.00	49.00	39.00	41.00	39.00	38.00	36.00	37.00	38.00	42.00
Mean	37.00	18.33	32.00	30.67	31.17	31.50	32.67	32.67	31.00	31.67	31.33	34.00	32.50	30.33	27.33	28.17	31.67
SE	3.71	0.99	2.62	3.05	1.83	1.89	2.73	3.91	3.78	1.96	1.98	1.32	1.69	1.76	2.17	2.02	2.11

Table 15 Total leukocyte count (x 10^3/dl) before and after intra- capsular cryo-extraction of cataract in dogs (Group B)

Day/Animal	Pre-Op.	Immediate Post-Op.	24 Hr. Post-Op.	Post-Operative Days			
				2	7	15	30
B1	11.40	11.80	14.30	12.10	10.80	11.00	10.00
B2	10.90	11.30	13.50	12.40	11.10	10.70	10.80
B3	11.40	12.10	14.20	13.10	12.30	11.50	11.10
B4	12.40	12.90	14.10	13.20	12.90	12.30	12.20
B5	11.10	11.60	13.10	12.40	10.40	11.20	11.00
B6	13.80	13.90	14.20	14.10	13.90	13.60	12.80
Mean	11.83	12.27	13.90	12.88	11.90	11.72	11.32
SE	0.45	0.40	0.20	0.30	0.56	0.44	0.41

Table 16 Differential leukocyte count (%) Neutrophil count (%)before and after intra- capsular cryo-extraction of cataract in dogs (Group B)

Day/Animal	Pre-Op.	Immediate Post-Op.	24 Hr. Post-Op.	Post-Operative Days			
				2	7	15	30
B1	68.00	72.00	81.00	75.00	65.00	68.00	67.00
B2	61.00	65.00	83.00	74.00	68.00	67.00	69.00
B3	71.00	76.00	82.00	74.00	70.00	73.00	75.00
B4	86.00	82.00	90.00	85.00	81.00	76.00	74.00
B5	68.00	71.00	81.00	72.00	61.00	65.00	66.00
B6	76.00	77.00	81.00	81.00	80.00	74.00	73.00
Mean	71.67	73.83	83.00	76.83	70.83	70.50	70.67
SE	3.49	2.39	1.44	2.06	3.30	1.80	1.56

Table 17 Differential leukocyte count (%) Lymphocyte count (%)before and after intra- capsular cryo-extraction of cataract in dogs (Group B)

Day/Animal	Pre-Op.	Immediate Post-Op.	24 Hr. Post-Op.	Post-Operative Days			
				2	7	15	30
B1	30.00	23.00	14.00	23.00	34.00	31.00	31.00
B2	38.00	32.00	11.00	22.00	30.00	29.00	28.00
B3	28.00	23.00	12.00	24.00	29.00	21.00	22.00
B4	12.00	14.00	5.00	10.00	18.00	22.00	23.00
B5	32.00	28.00	16.00	26.00	38.00	31.00	31.00
B6	21.00	20.00	15.00	16.00	17.00	24.00	23.00
Mean	26.83	23.33	12.17	20.17	27.67	26.33	26.33
SE	3.73	2.55	1.62	2.46	3.47	1.86	1.71

Table 18 Differential leukocyte count (%) eosinophil count (%)before and after intra- capsular cryo-extraction of cataract in dogs (Group B)

Day/Animal	Pre-Op.	Immediate Post-Op.	24 Hr. Post-Op.	Post-Operative Days			
				2	7	15	30
B1	2.00	4.00	5.00	2.00	1.00	1.00	2.00
B2	1.00	3.00	6.00	4.00	2.00	2.00	2.00
B3	1.00	1.00	5.00	2.00	1.00	1.00	1.00
B4	2.00	4.00	4.00	4.00	1.00	1.00	2.00
B5	0.00	1.00	4.00	2.00	1.00	1.00	1.00
B6	3.00	3.00	4.00	3.00	2.00	2.00	2.00
Mean	1.50	2.67	4.67	2.83	1.33	1.33	1.67
SE	0.43	0.56	0.33	0.40	0.21	0.21	0.21

Table 19 Differential leukocyte count (%) Monocyte count (%)before and after intra- capsular cryo-extraction of cataract in dogs (Group B)

Day/Animal	Pre-Op.	Immediate Post-Op.	24 Hr. Post-Op.	Post-Operative Days			
				2	7	15	30
B1	0.00	1.00	0.00	0.00	0.00	0.00	0.00
B2	0.00	0.00	0.00	0.00	0.00	2.00	1.00
B3	0.00	0.00	0.00	0.00	0.00	1.00	2.00
B4	0.00	0.00	0.00	0.00	0.00	1.00	1.00
B5	0.00	0.00	0.00	0.00	0.00	2.00	2.00
B6	0.00	0.00	0.00	0.00	1.00	0.00	2.00
Mean	0.00	0.17	0.00	0.00	0.17	1.00	1.33
SE	0.00	0.17	0.00	0.00	0.17	0.37	0.33

Table 20 Aqueous humour protein content (g/dl) before and after intra- capsular cryo-extraction of cataract in dogs (Group B)

Day/Animal	Pre-Operative	30th Post-Operative Day
B1	0.45	0.48
B2	0.44	0.45
B3	0.48	0.42
B4	0.50	0.49
B5	0.41	0.44
B6	0.42	0.46
Mean	0.45	0.46
SE	0.01	0.01

Table 21 Intra – ocular pressure (mm Hg.) before and after intra- capsular cryo-extraction of cataract in dogs (Group B)

Day/Animal	Pre-Op.	Immediate Post-Op.	24 Hr. Post-Op.	Day 2	Day 7	Day 15
B1	18.00	16.00	18.00	23.00	20.00	21.00
B2	18.00	14.00	18.00	24.00	18.00	20.00
B3	21.00	16.00	20.00	22.00	20.00	22.00
B4	19.00	15.00	19.00	22.00	20.00	19.00
B5	17.00	14.00	17.00	20.00	19.00	21.00
B6	18.00	14.00	21.00	22.00	18.00	20.00
Mean	18.50	14.83	18.83	22.17	19.17	20.50
SE	0.56	0.40	0.60	0.54	0.40	0.43

Table 22 Rectal Temperature (^{0}C) before and after intra- capsular cryo-extraction of cataract in dogs (Group C)

Day/ Animal	Pre-Op	Post-Operative															
		Imm-ediate	24 Hr	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day 10	Day 11	Day 12	Day 13	Day 14	Day 15
C1	38.30	37.60	38.70	38.80	38.80	38.80	38.80	38.80	38.90	38.80	38.60	38.60	38.30	38.40	38.40	38.40	38.30
C2	38.40	37.60	38.80	38.50	38.60	38.80	-	-	-	-	-	-	-	-	-	-	-
Mean	38.35	37.60	38.75	38.65	38.70	38.80	38.80	38.80	38.90	38.80	38.60	38.60	38.30	38.40	38.40	38.40	38.30
SE	0.05	0.00	0.05	0.15	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 23 Pulse rate (per min.) before and after intra- capsular cryo-extraction of cataract in dogs (Group C)

Day/ Animal	Pre-Op	Post-Operative															
		Imm-ediate	24 Hr	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day 10	Day 11	Day 12	Day 13	Day 14	Day 15
C1	114.00	83.00	112.00	110.00	108.00	111.00	113.00	115.00	120.00	108.00	105.00	98.00	100.00	104.00	99.00	100.00	100.00
C2	120.00	80.00	107.00	98.00	100.00	111.00	-	-	-	-	-	-	-	-	-	-	-
Mean	117.00	81.50	109.50	104.00	104.00	111.00	113.00	115.00	120.00	108.00	105.00	98.00	100.00	104.00	99.00	100.00	100.00
SE	3.00	1.50	2.50	6.00	4.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 24 Respiration rate (per min.) before and after intra- capsular cryo-extraction of cataract in dogs (Group C)

Day/ Animal	Pre-Op	Post-Operative															
		Immediate	24 Hr	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day 10	Day 11	Day 12	Day 13	Day 14	Day 15
C1	45.00	28.00	40.00	38.00	42.00	39.00	43.00	44.00	46.00	40.00	41.00	39.00	37.00	42.00	45.00	44.00	38.00
C2	48.00	32.00	41.00	40.00	39.00	47.00	43.00	-	-	-	-	-	-	-	-	-	-
Mean	46.50	30.00	40.50	39.00	40.50	43.00	43.00	44.00	46.00	40.00	41.00	39.00	37.00	42.00	45.00	44.00	38.00
SE	1.50	2.00	0.50	1.00	1.50	4.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 25 Total leukocyte count ($x10^3$/dl) before and after intra- capsular cryo-extraction of cataract in dogs (Group C)

Day/Animal	Pre-Op.	Immediate Post-Op.	24 Hr. Post-Op.	Post-Operative Days			
				2	7	15	30
C1	12.10	12.90	13.10	12.70	12.40	12.40	12.30
C2	12.00	11.80	13.20	12.50	-	-	-
Mean	12.05	12.35	13.15	12.60	12.40	12.40	12.30
SE	0.05	0.55	0.05	0.10	0.00	0.00	0.00

Table 26 Differential leukocyte count (%)before and after intra- capsular cryo-extraction of cataract in dogs (Group C)

Day/Animal	Pre-Op.	Immediate Post-Op.	24 Hr. Post-Op.	Post-Operative Days			
				2	7	15	30
C1	69.00	73.00	81.00	76.00	71.00	72.00	73.00
C2	70.00	74.00	83.00	79.00	-	-	-
Mean	69.50	73.50	82.00	77.50	71.00	72.00	73.00
SE	0.50	0.50	1.00	1.50	0.00	0.00	0.00

Table 27 Differential leukocyte count (%) Lymphocyte count (%)before and after intra- capsular cryo-extraction of cataract in dogs (Group C)

Day/Animal	Pre-Op.	Immediate Post-Op.	24 Hr. Post-Op.	Post-Operative Days			
				2	7	15	30
C1	30.00	24.00	15.00	21.00	27.00	25.00	26.00
C2	28.00	27.00	12.00	20.00	-	-	-
Mean	29.00	25.50	13.50	20.50	27.00	25.00	26.00
SE	1.00	1.50	1.50	0.50	0.00	0.00	0.00

Table 28 Differential leukocyte count (%) Eosinophil count (%)before and after intra- capsular cryo-extraction of cataract in dogs (Group C)

Day/Animal	Pre-Op.	Immediate Post-Op.	24 Hr. Post-Op.	Post-Operative Days			
				2	7	15	30
C1	1.00	3.00	4.00	2.00	2.00	3.00	1.00
C2	1.00	4.00	4.00	1.00	-	-	-
Mean	1.00	3.50	4.00	1.50	2.00	3.00	1.00
SE	0.00	0.50	0.00	0.50	0.00	0.00	0.00

Table 29 Differential leukocyte count (%) Monocyte count (%)before and after intra- capsular cryo-extraction of cataract in dogs (Group C)

Day/Animal	Pre-Op.	Immediate Post-Op.	24 Hr. Post-Op.	Post-Operative Days			
				2	7	15	30
C1	0.00	0.00	0.00	1.00	0.00	0.00	0.00
C2	0.00	0.00	1.00	0.00			
Mean	0.00	0.00	0.50	0.50	0.00	0.00	0.00
SE	0.00	0.00	0.50	0.50	0.00	0.00	0.00

Table 30 Aqueous humour protein count (g/dl) before and after intra- capsular cryo-extraction of cataract in dogs (Group C)

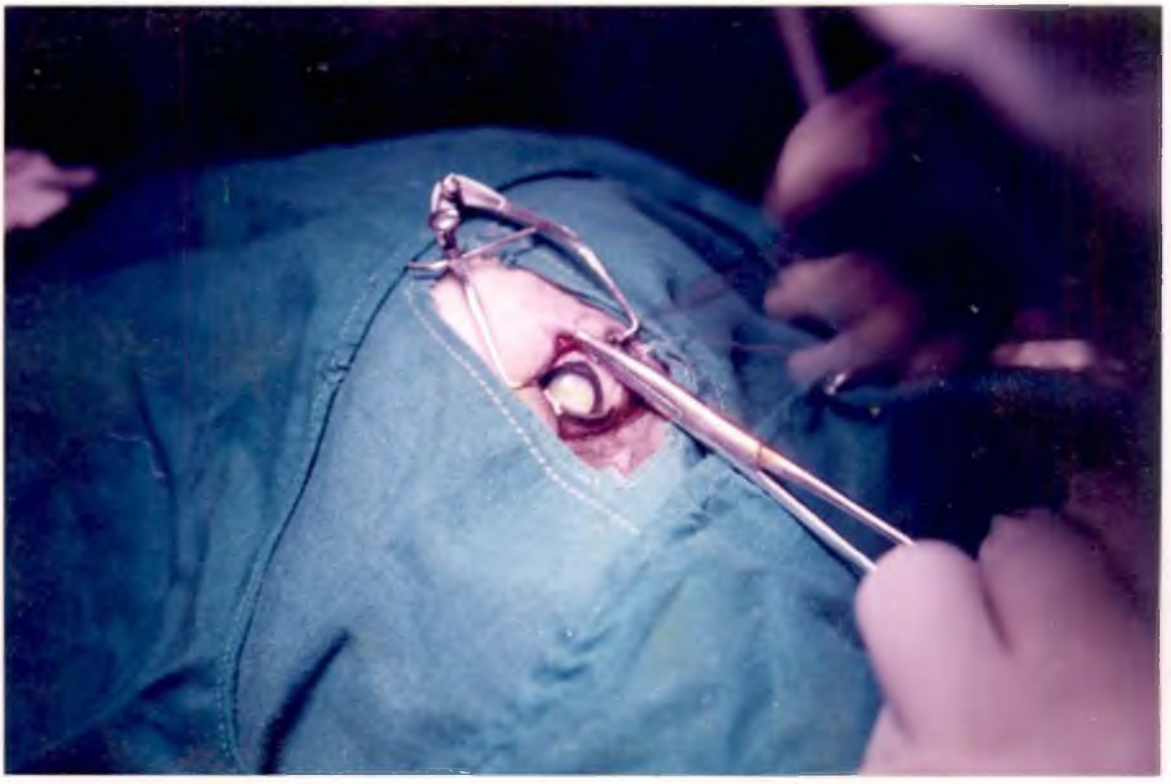
Day/Animal	Pre-Operative	30th Post-Operative Day
C1	0.45	0.48
C2	0.43	0.55
Mean	0.44	0.52
SE	0.01	0.04

Table 31 Intra-ocular pressure (mm Hg.) before and after intra- capsular cryo-extraction of cataract in dogs (Group C)

Day/Animal	Pre-Op.	Immediate Post-Op.	24 Hr. Post-Op.	Day 2	Day 7	Day 15
C1	18.00	15.00	17.00	26.00	24.00	23.00
C2	19.00	17.00	17.00	31.00		
Mean	18.50	16.00	17.00	28.50	24.00	23.00
SE	0.50	1.00	0.00	2.50	0.00	0.00

Plate 1: Mature clinical cataract in a dog

Plate 2: Induced cataract in a dog



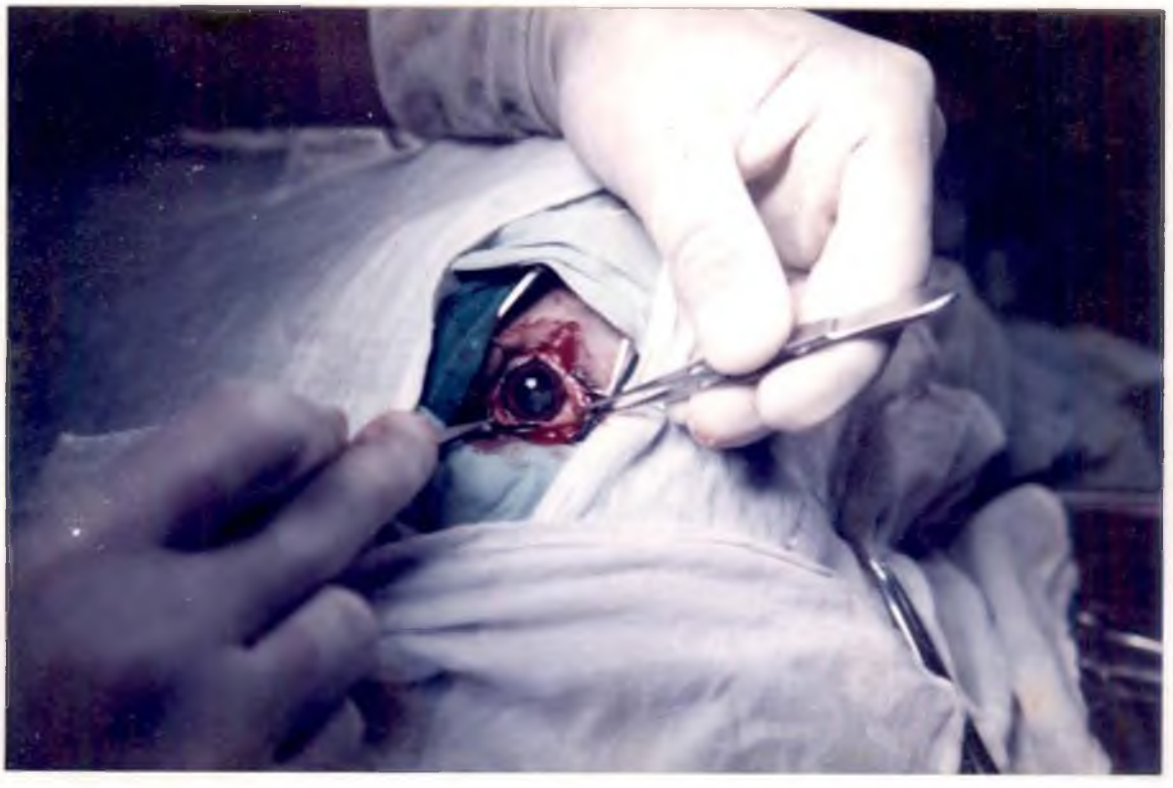
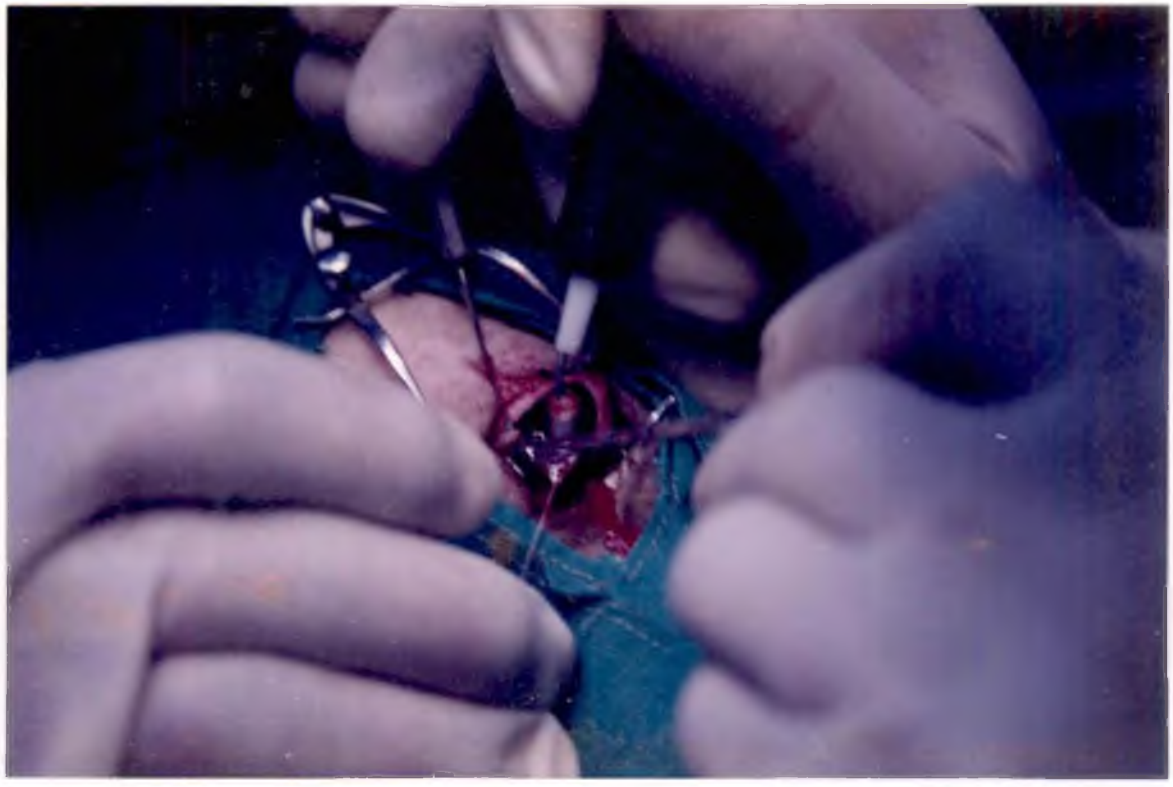
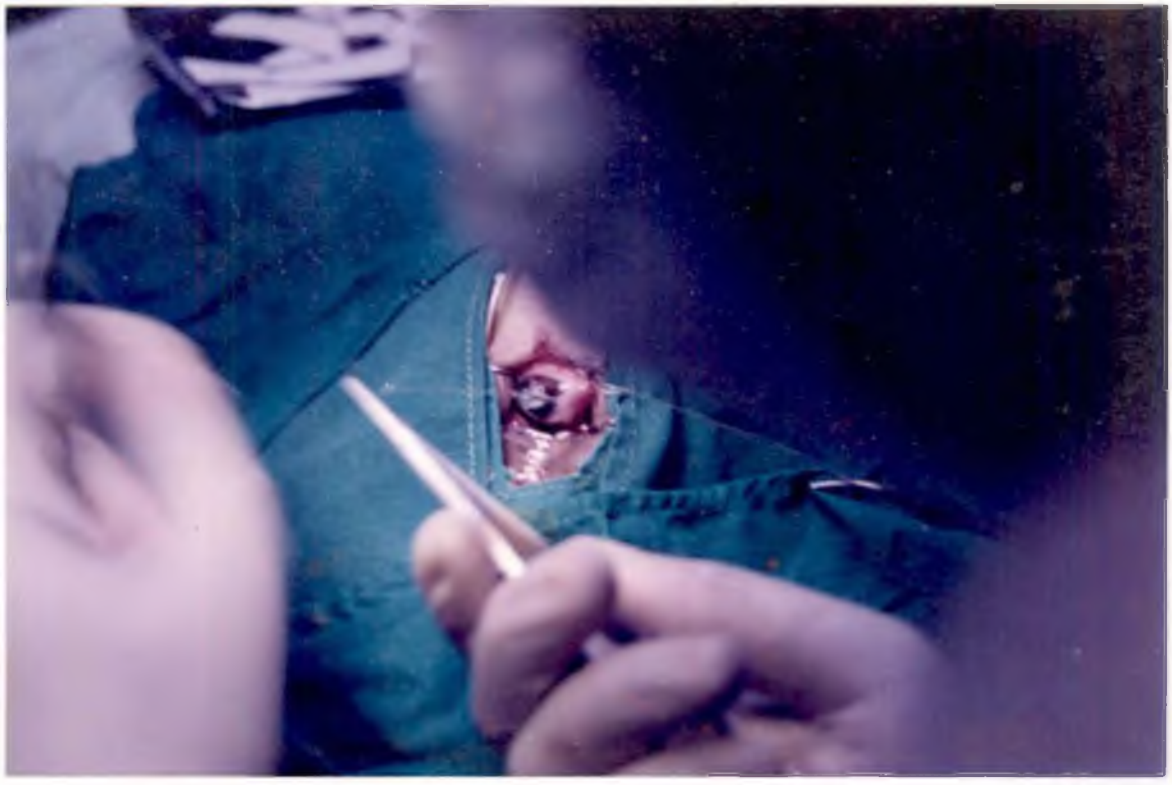


Plate 3: **Surgical view showing achievement of stable cryopexy (ice ball) between cryo–probe and crystalline lens**

Plate 4: **Surgical view showing placement of sutures for closure of the corneal incision**





Discussion

5. DISCUSSION

5.1 Induction of cataract

Cataract was experimentally induced and the treatment modalities were studied in fourteen adult dogs. In the present study, cataract was successfully induced by the injection of 0.5 ml of 25% calcium borogluconate solution into the anterior chamber of the right eye, as reported by Dadke *et al.* (1992), who induced artificial cataract in buffalo calves by the injection of calcium borogluconate solution into the anterior chamber of the eye.

One of the experimental animals (C2) in the study, a male dog of one year of age, had a history of progressive blindness with development of opacity in both eyes. It had total mature cataract when presented for treatment at the clinics. Progressive equatorial cataract that developed prior to two years of age was reported by Rubin and Flowers (1972).

For the purposes of this study, cataract was induced in dogs by injection of 25% calcium borogluconate solution into the anterior chamber of the eye.

The cataract that developed in these animals primarily involved the anterior capsular region of the lens and gradually extended to other regions of the lens.

One of the experimental animals involved in the study had bilateral cataract involving the entire lens and was clinically blind. The animal had a history of progressive blindness and opacification of the lenses that started from infancy and progressed to the present state. The cataract affecting this animal were probably of a juvenile type, as reported by Clerc in 1978, and developmental in nature (Philips and Magrane, 1959), since they involved gradual degenerative loss of transparency of the lens during normal development. The cataract were mature and occupied the entire lens, preventing visualization of the fundus (Whitley *et al.*, 1993a).

5.1.1 Physiological parameters

Group A

Rectal temperature and respiration rate dropped slightly post-operatively, but returned to normal values by the second day after surgery.

Pulse rate dropped markedly following surgery, but returned to normal by the sixth day after surgery.

Total leukocyte count increased slightly 24 hours after surgery, but then decreased and remained within normal ranges thereafter.

There was increase in neutrophil, eosinophil and monocyte count had increased upto 24 hours after surgery, but was normal thereafter. Lymphocyte count decreased upto 24 hours post-operatively.

Group B

Rectal temperature increased slightly 24 hours after surgery, but had returned to normal values by the 15^{th} post-operative day.

Pulse rate decreased slightly 24 hours after surgery, but attained normal values by the second post-operative day and stayed so thereafter.

Respiration rate decreased markedly for 24 hours following surgery, but reached normal values two days post-operatively.

There was no change in the colour of the mucous membrane of the contralateral eye (used as control) at any time during the period of observation.

The total leukocyte count increased slightly following surgery and continued to be so till 24 hours after surgery and thereafter it decreased and was within normal limits thereafter. The neutrophil count increased till 24 hours post-operatively and returned to normal range thereafter. Lymphocyte count decreased slightly 24 hours after surgery, but returned to normal range by the 15^{th} post-operative day. Eosinophil count increased 24 hours after surgery, but had reached normal values by the 15^{th} post-operative day. Monocyte count became zero after surgery, but then increased slightly and continued so thereafter.

Group C

Rectal temperature decreased slightly following surgery, and then increased slightly but returned to normal values at the end of the observation period.

Pulse rate decreased immediately after surgery and then returned to normal ranges by the eighth day after surgery.

Respiration rate decreased markedly immediately after surgery, but returned to the normal range within 24s after surgery.

Colour of mucous membrane of the contralateral eye did not show any change at any time during the period of observation.

Total leukocyte count increased slightly upto 24 hours after surgery but returned to normal ranges thereafter.

The neutrophil and eosinophil and monocyte counts increased after surgery but returned to normal ranges thereafter. The lymphocyte count was markedly decreased at 24 hours after surgery, but then returned to normal ranges thereafter.

These changes following surgery for cryo-extraction (Group A and C) and cryo-coagulation of cataract (Group B) in the physiological parameters of the experimental animals were probably due to the effects of anaesthesia (Lumb and Jones, 1984).

5.2 Treatment of cataract

5.2.1 Medical

Several studies have been undertaken by various authors in order to prove the efficacy of medical methods for the treatment of cataract in canines. Many drugs have been tried with varying degrees of success. Whitley *et al.* (1993b), in discussing the merits of various medical treatments for cataract, stated that although several medical regimens were propounded, none of them were significantly effective. It was opined that surgery was the only certain cure for the condition.

5.2.2 Surgical

Cataract of dogs in Group A were treated by cryo-coagulation, following which the lenses were left in situ. Cryo-coagulation was performed by freezing the lens for a period of 20 seconds using a cataract probe frozen by Nitrous Oxide.

Cataractous lenses of the dogs in Groups B and C were surgically removed by intra-capsular cryo-extraction using a similar cataract probe as used in Group A, frozen by Nitrous Oxide.

In the present study, in the cryo-coagulation group (Group A) only one animal out of six animals had functional vision at the end of the observation period. In the intra-capsular cryo-extraction Groups (Groups B and C) out of the eight animals treated, four had functional vision by the end of the observation period.

Magrane (1968) attempted intra-capsular cryo-extraction of cataract in dogs, but found that capsular rupture occurred in all cases of normal intact lenses or uncomplicated juvenile or senile cataract, necessitating extra-capsular extraction in all cases. The present study was also in confirmation with the reports of Delagarde (1974) who stated only one failure out of 12 surgical cataract extractions in dogs.

Stripping of the vitreous advocated by Magrane (1968) was found to be effective in the present study.

The cryo-probes used in the study were frozen using Nitrous Oxide in both cryo-coagulation and intra-capsular extraction methods.

Gelatt (1991) also reported on the use of cryo-probes frozen by CO_2, nitrous oxide or liquid Nitrogen for the intra-capsular extraction of cataractous lenses in dogs.

In this study, a total of 12 experimentally induced cataract (six animals each in Groups A and B) and two clinical cases of cataract (Group C) were treated surgically by cryo-coagulation or intra-capsular cryo-extraction as practiced by Magrane (1968), Delagarde (1974), Rooks *et al.* (1985), Miller *et al.* (1987) and Kielbowicz and Ratacjzak (1995).

In the 14 animals used in the study, functional vision was restored in five animals (one in Group A, three in Group B and one in Group C) following treatment of cataract by cryo-coagulation and intra-capsular cryo-extraction. All the other animals showed persistent corneal oedema and other signs of chronic intra-ocular inflammatory processes. This is in agreement with the findings of Miller *et al* (1987), who reported that development of anterior uveitis was the primary reason for the failure of visual improvement and development of complications. The result confirmed the findings of Kielbowicz and Ratacjzak (1995), who described prolapse of

vitreous and development of uveitis and glaucoma as common post-operative complications following cataract surgery.

The major complications in the treatment of cataract by cryo-coagulation (Group A), were increased intra-ocular pressure, persistent corneal opacity due corneal oedema, and injury to the corneal endothelium due to inadvertent contact with the cryo-probe. Even though extreme care was taken to prevent the occurrence of these complications persistent corneal oedema was noticed in all animals of this group, except in animal A4, in which it was mild enough to permit observation of the fundus.

Mildly elevated intra-ocular pressure was noticed in all animals in this group. Sector iridectomy was performed in this group in order to prevent the development of glaucoma due to posterior synechia.

The persistent corneal edema and elevated intra-ocular pressure were probably the result of the presence of the coagulated lens, which would be undergoing active resorption. Iridocyclitis and anterior uveitis were also considered to be the possible causes of these post-surgical complications in this group. Miller *et al* (1987)

had also reported that anterior uveitis was the primary reason for the failure of visual improvement and development of complications.

The surgical complications encountered in Group B (intra-capsular cryo-extraction) were rupture of the lens capsule, damage and injury to the iris and corneal endothelium as a result of inadvertent contact with the cryo-probe and failure of adequate adhesion between the cryo-probe and the lens. Another common complication was the prolapse of vitreous humor as a result of adherence to the lens capsule. These findings are in agreement with those of Magrane (1968), who found that capsular rupture occurred in all cases of cryosurgical extraction of normal intact lenses or uncomplicated juvenile or senile cataract, necessitating extra-capsular extraction in all cases.

The findings of the present study also agree with Kielbowicz and Ratacjzak (1995) who described prolapse of vitreous and development of uveitis and glaucoma as common post-operative complications following cataract surgery.

The intra-capsular extraction of the lens was difficult as stated by Gelatt, (1991); Helper, (1989); and Slatter, (1990). These

authors reported that intra-capsular extraction of the cataractous lens in the dog was more difficult than in the human, due to the firmer attachments of the lens both to the *fossa lentis* of the vitreous humor and to the zonular ligaments.

Out of the two animals in Group C, one (C1) had no complications. But the other animal (C2) failed to recover from general anaesthesia till 52 hours following surgery, although no complications had been noted before, during or after surgery. The animal died of unrelated causes on the sixth day following surgery. The cause of death could not be attributed to any complications of the cataract surgery.

5.3 Visual function

The results of cataract surgery were gauged during the observation by assessing the visual capabilities of the operated eyes. The animals were tested for their ability to negotiate obstacle courses, locate stationary objects and locate and track moving objects. The tests (Kielbowicz and Ratacjzak, 1995) were conducted both in photopic (daylight) and scotopic (low light) conditions.

Functional vision following cataract surgery was present at the end of the observation period in one of six animals (A4) in Group A, three of six animals (B3, B5 and B6) in Group B and one of two animals (C1) in Group C. Although these animals exhibited varying degrees of visual capability in the operated eye, vision was not as acute as in the normal eye. This is in agreement with the findings of Kielbowicz (1990) who reported that following micro-surgical cryo-extraction of cataractous lenses, return of complete vision was not obtained in any of the cases, as the eyes were aphakic and hypermetropic, but the vision was sufficient to enable the dog to orient themselves in the environment.

Summary

6. SUMMARY

This study was conducted in 12 apparently healthy adult dogs of either sex, which were maintained under identical regimes of feeding and management. In addition to the twelve experimental animals included in the study, two animals presented at the clinics with cataract were also treated and included as a separate group. This study was conducted in order to compare the efficacy of cryocoagulation and intracapsular cryoextraction of experimentally induced cataracts in dogs.

Cataracts were induced in the experimental animals by intra-ocular injection of calcium borogluconate solution (25%) into the anterior chamber of the eye under aseptic conditions under general anaesthesia.

Surgery for cryo-coagulation (Group A) or intra-capsular cryo-extraction (Groups B and C) was performed under general anaesthesia with thiopentone sodium after premedication with xylazine hydrochloride. The anaesthesia was found to be satisfactory at the time of induction and during cataract surgery.

Extensive lateral canthotomy was found to be necessary in all the animals at surgery in order to ensure adequate exposure of the globe.

Rectal temperature and respiration rate dropped slightly post-operatively, but returned to normal values by the second day after surgery.

Pulse rate dropped markedly following surgery, but returned to normal by the sixth day after surgery.

Total leukocyte count increased slightly 24 hours after surgery, but then decreased and remained within normal ranges thereafter.

There was increase in neutrophil, eosinophil and monocyte count had increased upto 24 hours after surgery, but was normal thereafter. Lymphocyte count decreased upto 24 hours post-operatively.

All the animals remained in good condition throughout the observation period, except for one animal.

Conjunctivitis persisted only in one upto the 11th day. Corneal edema persisted throughout the period of observation in four animals. One animal had complete corneal clarity by day seven. In the other animal the cornea cleared on day 23.

Uveitis persisted for varying periods in the animals. Photophobia and blepharospasm resolved by day six in all animals. One animal had no posterior or anterior synechia following surgery and its vitreous body was clear, allowing easy examination of the retina.

Aqueous flare, indicative of increased protein in the aqueous humour, could not be determined in any animal.

Functional vision was not returned in any animal except A4.

In Group B, vitreous prolapse occurred during surgical removal of the lens by intracapsular cryoextraction. This prolapsed vitreous was excised and did not cause complications.

Rectal temperature increased slightly 24 hours after surgery, but had returned to normal values by the 15th post-operative day.

Pulse rate decreased slightly 24 hours after surgery, but attained normal values by the second post-operative day and stayed so thereafter.

Respiration rate decreased markedly for 24 hours following surgery, but reached normal values two days post-operatively.

There was no change in the colour of the mucous membrane of the contralateral eye (used as control) at any time during the period of observation.

The total leukocyte count increased slightly following surgery and continued to be so till 24 hours after surgery and thereafter it decreased and was within normal limits thereafter. The neutrophil count increased till 24 hours post-operatively and returned to normal range thereafter. Lymphocyte count decreased slightly 24 hours after surgery, but returned to normal range by the

15th post-operative day. Eosinophil count increased 24 hours after surgery, but had reached normal values by the 15th post-operative day. Monocyte count became zero after surgery, but then increased slightly and continued so thereafter.

All the animals remained in good general condition until the end of the observation period, with no evidence of infection in the operated eye.

Intraocular pressure decreased slightly following surgery, but had returned to normal ranges by the end of the observation period.

Animals B1, B2 and B4 had persistent conjunctivitis and corneal oedema throughout the period of observation and were unable to negotiate an obstacle course or locate and track mobile or stationary objects even in conditions of bright ambient light. All other animals in this group were able to perform satisfactorily in the tests of visual function by the end of the observation period.

In Group C, treatment of cataract was by intra-capsular cryo-extraction, as in Group B. The results obtained were similar to

those for Group B. Animal C2, however, took 52 hours to recover from anaesthesia and died on the sixth day following surgery. The death could not be attributed to complications of cataract surgery.

Rectal temperature decreased slightly following surgery, and then increased slightly but returned to normal values at the end of the observation period.

Pulse rate decreased immediately after surgery and then returned to normal ranges by the eighth day after surgery.

Respiration rate decreased markedly immediately after surgery, but returned to the normal range within 24s after surgery.

Colour of mucous membrane of the contralateral eye did not show any change at any time during the period of observation.

Total leukocyte count increased slightly upto 24 hours after surgery but returned to normal ranges thereafter.

The neutrophil and eosinophil and monocyte counts increased after surgery but returned to normal ranges thereafter. The

lymphocyte count was markedly decreased at 24 hours after surgery, but then returned to normal ranges thereafter.

The surviving animal in Group C showed low grade corneal oedema until day 31 following surgery, but it had blink reflexes and the iris was visible.

Conjunctivitis had cleared by day six following surgery.

The animals were monitored for visual capability following surgery. The tests were conducted by evaluating the animals' ability to negotiate an obstacle course under photopic and scotopic light conditions, after blind folding the left eye with an eye shield. The animals were also tested for their ability to locate a stationary object and to track a moving object under varying conditions of ambient lighting. Tests of ocular functional integrity were conducted by evaluating menace and photomotor pupillary reflexes. Animal C1 was able to locate or track stationary objects in dim light. It could track moving objects in all light conditions.

From the results obtained in the present study, it was found that only one out of the six animals showed restoration of functional vision following treatment of cataract by cryo-coagulation of the lens. In the case of the treatment by intra-capsular cryo-extraction, four out of eight animals showed restoration of functional vision thus showing a success rate of 50% for intra-capsular cryo-extraction of cataract.

From the results it can be concluded that:

1. Cataract could be effectively induced using 0.5 ml of calcium borogluconate solution (25%) injected into the anterior chamber of the eye.

2. Pre-medication using xylazine hydrochloride followed by general anaesthesia using thiopentone sodium IV was satisfactory for the induction of cataract and the treatment of the cataractous lens.

3. Intra-capsular cryo-extraction is a better method in treating cataractous lenses in dogs.

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CRYOSURGICAL TREATMENT FOR EXPERIMENTALLY INDUCED CATARACT IN DOGS

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ABSTRACT OF A THESIS

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ABSTRACT

This study was conducted with the objective of comparing the efficacy of cryo-coagulation and intra-capsular cryo-extraction of experimentally induced cataract in dogs. Twelve nondescript dogs aged approximately one year were used for the study in two groups, A and B, each consisting of six animals. Two clinical cases of cataract were included under the study as Group C. In all the animals of Group A and B, cataract was experimentally induced by injection of 0.5 ml of a 25% solution of calcium borogluconate into the anterior chamber of the eye, in strict aseptic conditions and under general anaesthesia.

In group A, cataract was treated by cryo-coagulation and in Groups B and C intra-capsular cryo-extraction of the cataractous lens was performed after pre-medicating and anaesthetising the animals.

Surgery for cryo-coagulation (Group A) or intra-capsular cryo-extraction (Groups B and C) was performed under general anaesthesia with thiopentone sodium after premedication with xylazine hydrochloride. The anaesthesia was found to be satisfactory at the time of induction and during cataract surgery.

Extensive lateral canthotomy was found to be necessary in all the animals at surgery in order to ensure adequate exposure of the globe.

Rectal temperature and respiration rate dropped slightly post-operatively, but returned to normal values by the second day after surgery.

Pulse rate dropped markedly following surgery, but returned to normal by the sixth day after surgery.

Total leukocyte count increased slightly 24 hours after surgery, but then decreased and remained within normal ranges thereafter.

There was increase in neutrophil, eosinophil and monocyte count had increased upto 24 hours after surgery, but was normal thereafter. Lymphocyte count decreased upto 24 hours post-operatively.

All the animals remained in good condition throughout the observation period, except for one animal.

Conjunctivitis persisted only in one upto the 11^{th} day. Corneal oedema persisted throughout the period of observation in four

animals. One animal had complete corneal clarity by day seven. In the other animal the cornea cleared on day 23.

Uveitis persisted for varying periods in the animals Photophobia and blepharospasm resolved by day six in all animals. One animal had no posterior or anterior synechiae following surgery and its vitreous body was clear, allowing easy examination of the retina.

Aqueous flare, indicative of increased protein in the aqueous humour, could not be determined in any animal.

Functional vision was not returned in any animal except A4.

In Group B, vitreous prolapse occurred during surgical removal of the lens by intra-capsular cryo-extraction. This prolapsed vitreous was excised and did not cause complications.

Rectal temperature increased slightly 24 hours after surgery, but had returned to normal values by the 15^{th} post-operative day.

Pulse rate decreased slightly 24 hours after surgery, but attained normal values by the second post-operative day and stayed so thereafter.

Respiration rate decreased markedly for 24 hours following surgery, but reached normal values two days post-operatively.

There was no change in the colour of the mucous membrane of the contralateral eye (used as control) at any time during the period of observation.

The total leukocyte count increased slightly following surgery and continued to be so till 24 hours after surgery and thereafter it decreased and was within normal limits thereafter. The neutrophil count increased till 24 hours post-operatively and returned to normal range thereafter. Lymphocyte count decreased slightly 24 hours after surgery, but returned to normal range by the 15^{th} post-operative day. Eosinophil count increased 24 hours after surgery, but had reached normal values by the 15^{th} post-operative day. Monocyte count became zero after surgery, but then increased slightly and continued so thereafter.

All the animals remained in good general condition until the end of the observation period, with no evidence of infection in the operated eye.

Intra-ocular pressure decreased slightly following surgery, but had returned to normal ranges by the end of the observation period.

Animals B1, B2 and B4 had persistent conjunctivitis and corneal oedema throughout the period of observation and were unable to negotiate an obstacle course or locate and track mobile or stationary objects even in conditions of bright ambient light. All other animals in this group were able to perform satisfactorily in the tests of visual function by the end of the observation period.

In Group C, treatment of cataract was by intra-capsular cryo-extraction, as in Group B. The results obtained were similar to those for Group B. Animal C2, however, took 52 hours to recover from anaesthesia and died on the sixth day following surgery. The death could not be attributed to complications of cataract surgery.

Rectal temperature decreased slightly following surgery, and then increased slightly but returned to normal values at the end of the observation period.

Pulse rate decreased immediately after surgery and then returned to normal ranges by the eighth day after surgery.

Respiration rate decreased markedly immediately after surgery, but returned to the normal range within 24 hours after surgery.

Colour of mucous membrane of the contralateral eye did not show any change at any time during the period of observation.

Total leukocyte count increased slightly upto 24 hours after surgery but returned to normal ranges thereafter.

The neutrophil and eosinophil and monocyte counts increased after surgery but returned to normal ranges thereafter. The lymphocyte count was markedly decreased at 24 hours after surgery, but then returned to normal ranges thereafter.

The surviving animal in Group C showed low grade corneal oedema until day 31 following surgery, but it had blink reflexes and the iris was visible.

Conjunctivitis had cleared by day six following surgery.

The animals were monitored for visual capability following surgery. The tests were conducted by evaluating the animals' ability to negotiate an obstacle course under photopic and scotopic light conditions, after blind folding the left eye with an eye shield. The animals were also tested for their ability to locate a stationary object and to track a moving object under varying conditions of ambient lighting. Tests of ocular functional integrity were conducted by evaluating menace and photomotor pupillary reflexes.

Animal C1 was able to locate or track stationary objects in dim light. It could track moving objects in all light conditions.

From the results obtained in the present study, it was found that only one out of the six animals showed restoration of functional vision following treatment of cataract by cryo-coagulation of the lens. In the case of the treatment by intra-capsular cryo-extraction, four out of eight animals showed restoration of functional vision thus showing a success rate of 50% for intra-capsular cryo-extraction of cataract.

From the results it can be concluded that:

1. Cataract could be effectively induced using 0.5 ml of calcium borogluconate solution (25%) injected into the anterior chamber of the eye.
2. Pre-medication using xylazine hydrochloride followed by general anaesthesia using thiopentone sodium IV was satisfactory for the induction of cataract and the treatment of the cataractous lens.
3. Intra-capsular cryo-extraction is a better method in treating cataractous lenses in dogs.