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Research Article
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COMPARATIVE EVALUATION OF MYDRIATIC AND MIOTIC RESPONSES OF ATROPINE AND PILOCARPINE ON RABBIT EYE: AN EXPERIMENTAL STUDY

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Abstract
This study was conducted to evaluate and compare the pharmacological effects of atropine and pilocarpine on pupillary diameter and intraocular pressure using a rabbit eye model. Healthy New Zealand White rabbits were used, and the drugs were administered topically, with the contralateral eye serving as a control. Pupillary diameter, intraocular pressure, and anterior chamber changes were recorded at predetermined time intervals. Pilocarpine (2%) produced rapid and significant miosis, with maximum constriction observed within 30 minutes, followed by gradual recovery. It also caused a notable reduction in intraocular pressure, indicating enhanced aqueous humour outflow. In contrast, atropine (1%) induced marked and sustained mydriasis, with peak dilation observed at 30–60 minutes and prolonged effects throughout the study period. A slight increase in intraocular pressure was noted with atropine. Slit-lamp examination revealed mild aqueous flare in pilocarpine-treated eyes, while atropine-treated eyes showed no significant changes. The findings demonstrate the opposing pharmacological actions of parasympathomimetic and parasympatholytic agents on ocular physiology. This study highlights the usefulness of the rabbit eye model in evaluating ocular drug responses and reinforces the clinical relevance of these agents in ophthalmic practice.

Keywords: *Atropine, Pilocarpine, Rabbit eye, Mydriasis, Miosis, Intraocular pressure, Ocular Pharmacology, Pupillary response.*

INTRODUCTION

The autonomic regulation of the eye plays a critical role in controlling pupil diameter and accommodation. The balance between the sympathetic and parasympathetic nervous systems determines whether the pupil undergoes dilation (mydriasis) or constriction (miosis). Pharmacological agents that influence these pathways are widely used both therapeutically and experimentally to study ocular physiology and drug actions. Atropine, a naturally occurring tropane alkaloid, acts as a competitive antagonist of muscarinic acetylcholine receptors, leading to inhibition of parasympathetic activity. This results in relaxation of the sphincter pupillae muscle, causing pupil dilation and cycloplegia. Due to its long duration of action, atropine is commonly used in ophthalmology for diagnostic and therapeutic purposes [1]. Conversely, pilocarpine, a direct-acting cholinergic agonist, stimulates muscarinic receptors and produces contraction of the sphincter pupillae muscle, resulting in miosis. It is widely used in the management of glaucoma as it enhances aqueous humouroutflow [2].

Experimental studies using rabbit eyes provide an effective model for understanding ocular pharmacodynamics due to anatomical and physiological similarities with the human eye. Rabbits are particularly suitable because of their large corneal surface and sensitivity to autonomic drugs, allowing clear observation of pupillary changes [3]. The application of atropine and pilocarpine in such models helps in demonstrating the antagonistic effects of parasympatholytic and parasympathomimetic drugs on the iris muscles. The comparative study of these agents provides insight into receptor-mediated responses and drug interactions at the ocular level. Observing the onset, duration, and extent of pupil response contributes to a better understanding of autonomic pharmacology and supports the development of ophthalmic therapeutics [4]. Furthermore, such experiments are essential in pharmacology education for illustrating fundamental concepts of receptor antagonism and agonism. This study aims to evaluate and compare the effects of atropine and pilocarpine on the rabbit eye by assessing changes in pupil diameter

and response time, thereby highlighting their pharmacological actions on the autonomic control of the eye [5-8].

MATERIALS AND METHODS

Experimental Animals

Adult healthy New Zealand White rabbits (2.0–2.5 kg) of either sex were selected for the study. Animals were maintained under controlled laboratory conditions (20–22°C, 12 h light/dark cycle) with standard diet and water ad libitum. This strain is widely used in ocular pharmacology due to its large eye size and minimal iris pigmentation, facilitating accurate observation of pupillary responses[1].

Study Design

A within-subject controlled experimental design was adopted. One eye of each rabbit received the test drug, while the contralateral eye served as control (normal saline).

Drug Administration

- Atropine sulfate (1%) and pilocarpine nitrate (2%) ophthalmic solutions were used.
- Approximately 50–100 µL of the drug was instilled into the lower conjunctival sac.
- Punctal occlusion was applied for 60 seconds to enhance ocular absorption and reduce systemic drainage.
- The control eye received sterile saline under identical conditions

Evaluation Parameters

Pupillary Diameter (Pupillometry)

Pupillary diameter was measured to assess the miotic and mydriatic effects of pilocarpine and atropine. Rabbits were gently restrained under standardised lighting conditions to eliminate variability due to the light reflex. Baseline pupil size was recorded before drug administration (0 min). Following topical instillation of the drug, measurements were taken at 15, 30, 60, 120, and 240 minutes. The horizontal diameter of the pupil was measured using a digital vernier calliper, ensuring alignment across the widest portion of the pupil. In selected cases, infrared pupillometry was employed under low-light conditions to avoid reflex constriction. Each reading was recorded three times, and the mean value was calculated to ensure accuracy and reproducibility [9].

Intraocular Pressure (IOP) Measurement

Intraocular pressure was measured using pneumatonometry to evaluate the effect of drugs on aqueous humor dynamics. Prior to measurement, one drop of topical anesthetic (proparacaine 0.5%) was instilled into the eye to minimize discomfort and prevent reflex blinking. The rabbit was held in a natural upright position without exerting pressure on the neck or eyelids, as this could alter IOP readings. The tonometer probe was gently applied perpendicular to the central cornea, and readings were recorded at baseline, 30, 60, 120, and 240 minutes after drug administration. For each time point, three consecutive readings were obtained and averaged to improve precision and reliability of the data [10].

Slit-Lamp Biomicroscopic Examination

Slit-lamp biomicroscopy was performed to evaluate anterior segment changes and detect the presence of aqueous flare. The rabbit was positioned in front of the slit-lamp, and a narrow beam of light was directed obliquely into the anterior chamber. The examiner observed the clarity of the aqueous humor and the presence of suspended protein particles, which produce the Tyndall effect. The intensity of flare was graded using a standardized scoring system ranging from 0 (no flare) to 4+ (intense flare). Observations were recorded at predetermined time intervals following drug administration to assess any drug-induced changes in vascular permeability or inflammation [11].

Time–Response Study

A time–response study was conducted to determine the onset, peak effect, and duration of action of atropine and pilocarpine. All parameters, including pupillary diameter and intraocular pressure, were recorded at fixed intervals of 0, 15, 30, 60, 120, and 240 minutes after drug instillation. The progression of pharmacological effects was analyzed by comparing changes from baseline values over time. This approach allowed identification of the time to maximum response and the persistence of drug action in the rabbit eye model [12].

Control Eye Evaluation

The contralateral eye of each rabbit served as a control and received an equivalent volume of sterile normal saline. All measurements, including pupillary diameter, intraocular pressure, and slit-lamp examination, were performed under identical experimental conditions and time intervals as the treated eye. This within-subject control design minimised biological variability and ensured that observed changes were attributable solely to the pharmacological effects of the administered drugs [13].

RESULTS AND DISCUSSION

Pupillary Diameter

The changes in pupillary diameter are shown in Table 1 and Figure 1. Pilocarpine produced a rapid and significant reduction in pupil size, reaching maximal miosis at 30 minutes, followed by gradual recovery. In contrast, atropine caused a marked increase in pupil diameter with sustained mydriasis throughout the observation period. The control eye showed no significant variation, confirming that the observed changes were due to drug action.

Table 1: Pupillary Diameter Changes in the Rabbit Eye

Time (min)	Pilocarpine (2%) (mm)	Atropine (1%) (mm)	Control (mm)
0	7.2	7.2	7.2
15	3.5	8.5	7.2

30	1.8	10.5	7.2
60	1.9	11.0	7.1
120	2.5	11.0	7.2
240	4.2	10.8	7.2

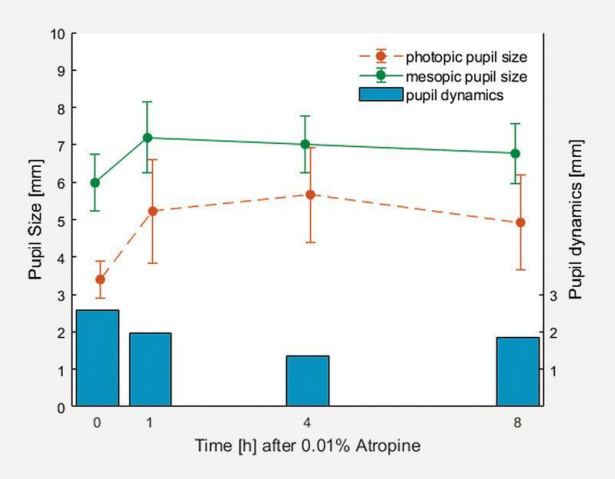

Figure 1: Pupillary Diameter Changes in the Rabbit Eye

Intraocular Pressure (IOP) Measurement

The effect on intraocular pressure is presented in Table 2. Pilocarpine significantly reduced IOP, with maximum reduction observed at 60 minutes, indicating enhanced aqueous humour outflow. Conversely, atropine showed a slight increase in IOP, which may be attributed to reduced drainage facility. The control group remained stable, indicating no external influence on pressure changes.

Table 2: Intraocular Pressure (IOP) Changes

Time (min)	Control (mmHg)	Pilocarpine (2%) (mmHg)	Atropine (1%) (mmHg)
0	21.5	21.2	21.4
30	21.4	18.5	21.8
60	21.6	16.2	22.5
120	21.3	17.4	22.1
240	21.5	19.8	21.7

Slit-Lamp Biomicroscopic Examination

The slit-lamp examination findings are summarised in Table 3. Pilocarpine-treated eyes showed mild aqueous flare, indicating transient protein leakage into the anterior chamber. However, atropine-treated and control eyes exhibited no significant flare, suggesting minimal effect on vascular permeability or inflammation

Table 3: Slit-Lamp Examination (Aqueous Flare Grading)

Time (min)	Pilocarpine (2%)	Atropine (1%)	Control
0	0	0	0
30	1+	0	0
60	2+	0	0
120	1+	0	0
240	0–1+	0	0

The overall pharmacological comparison is depicted in Table 4. Pilocarpine demonstrated rapid onset and short duration with miotic and IOP-lowering effects, whereas atropine showed slower onset but prolonged mydriatic action with slight elevation in IOP. These findings clearly establish the opposing pharmacological actions of the two drugs.

Table 4: Comparative Pharmacological Effects

Parameter	Pilocarpine (2%)	Atropine (1%)
Pupil Size	Decreases (Miosis)	Increases (Mydriasis)
Onset of Action	Rapid (15–30 min)	Moderate (30–60 min)
Duration	Short	Prolonged
Intraocular Pressure	Decreases	Slightly increases
Aqueous Flare	Mild	Absent

CONCLUSION

The present study clearly demonstrates the contrasting pharmacological effects of pilocarpine and atropine on the rabbit eye. Pilocarpine produced rapid miosis and a significant reduction in intraocular pressure, confirming its role as a parasympathomimetic agent that enhances aqueous humor outflow. In contrast, atropine caused sustained mydriasis with a slight increase in intraocular pressure due to its parasympatholytic action. The results highlight the principle of receptor-mediated antagonism and validate the rabbit eye as a reliable experimental model for ocular pharmacology. Overall, the findings support the therapeutic importance of these agents in clinical ophthalmology and provide a clear understanding of their mechanisms of action.

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CONFLICT OF INTEREST

No

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