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Effects of autonomic ophthalmic drugs on the visual field and colour vision of healthy Igbos

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Abstract

The study on the effects of autonomic ophthalmic drugs (miotics and mydriatics) on visual field and colour vision was conducted on visually active Igbo volunteers of either sex, whose ages ranged between 19 and 30 years and mean (19.5±0.6 years). Visual field was measured by perimetry while the colour vision testing was done using Ichihara charts and analysed on Humphrey Field Analyser (HFA).Results showed a constriction of the visual field following the administration of atropine (mydriatic) and pilocarpine (miotic) but no effect on the colour vision. Topical autonomic ophthalmic drugs have paradoxical effects on the visual field and colour vision. Phenylephrine (miotic) and timolol (mydriatic) had no effect on the visual field and colour vision, while atropine (mydriatic) and pilocarpine (miotic) constricted the visual field 32.5% and 35.4% respectively ($t > 0.05$) without affecting the colour vision. We conclude that when autonomic ophthalmic drugs are applied according to the recommended dose and duration can cause ocular toxicity in the form of visual field changes.

Keywords: Autonomic; Ophthalmic; Colour Vision; Visual field

1. Introduction

Autonomic ophthalmic drugs, i.e. miotics and mydriatics, are those medications that have effect on the ocular system and adnexa, whether administered orally or applied topically or through any other route. These ophthalmic drugs could be therapeutic e.g. pilocarpine or diagnostic e.g. atropine or could have combined effects. These drugs affect many systems in the body including the ocular system and adnexa. The present study will examine the effects of these autonomic drugs on visual field and colour vision when used therapeutically or otherwise on visually active Igbos of Nigeria in whom no record is available.

The visual field is the area within which objects may be seen when the eye is fixed. It is the spatial array of visual sensations available to absorption in introspectionist, psychological experiments [1]. It is equivalent concept of optical instruments and image sensors in the field of view.

In optometry, ophthalmology and neurology, visual field test is used to determine whether the visual field is affected by diseases that cause local scotoma or a more extensive loss of vision or a reduction in sensitivity or increase in the threshold [2]. The classical image of the shape and size of the visual field show that the visual field is considerably larger on the temporal side than the often quoted 90^0 extent [3].

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The normal (monocular) human visual field extends to approximately 60^0 nasally toward the nose or inward from the vertical meridian in each eye to 107^0 temporally (away from the nose or outward) from the vertical meridian, and approximately 70^0 above and 80^0 below the horizontal meridian [2],

The binocular visual field in the superimposition of the two monocular fields, the area left of the vertical meridian is the left visual field, which is temporally to the left and nasally for the right eye. Visual field loss may occur due to disease or disorders of the eye, optic nerve or brain or drug. Four types of visual field defects include; altitudinal field defects, loss of vision above or below the horizontal, associated with ocular abnormalities; bitemporal hemianopia, loss of vision at the sides, central scotoma, i.e. loss of vision at one side of the visual field for both eyes or defects located behind optic chiasm [4].

The visual field is affected by pupil size which affects the retinal luminance [5], refractive error which affects the sensitivities at fixation [6], fatigue which affects the screening results [3], media opacities which degrade the retinal image [7] age which decreases the sensitivity [8]. Visual field defects occur in the following areas; territory 1, or outer retina and choroids, territory II consisting of the ganglion cell layer and the ganglion cell axon; territory III or the chiasm and this visual field loss is heteronymous hemianopsia, a bilateral field loss, and territory IV which includes the optic tracts, lateral geniculate bodies, visual radiations and the visual cortex [4].

Colour vision is the ability of an organism to distinguish objects based on the value length or frequencies of light they reflect, emit or transmit. Colours can be measured and quantified in various ways, and a person's perception of colours is a subjective process whereby the brain responds to the stimuli that are produced when an incoming light reacts with the several types of cone cells in the eye. In essence, different people see the same illuminated object or light source in different ways [9].

In very low light levels, vision is scotopic, light is detected by rod cells of the retina. Rods are maximally sensitive to wavelength near 500 nm and play little, if any role in colour vision. In brighter condition, such as day light, vision is photopic, light is detected by cone cells which are responsible for colour vision. Cones are sensitive to a range of wavelengths but are most sensitive to wave lengths near 555 nm. Between these regions mesopic vision comes into play and both rods and cones provide signals to the retinal ganglion cells. The shift in colour perception from dim light to daylight gives rise to differences known as Purkinje effect [10, 11].

In our earlier studies, it had been shown that topically administered autonomic ophthalmic drugs affected the eye, its functions, structures and selectivity of action, etc. Oral laevodopa improved the Visual Acuity (VA) of functional amblyopes [12].

In another study conducted in 2015, it was also shown that oral diazepam caused increase in Near Point of Convergence (NPC) and Amplitude of Accommodation (AA) without affecting the pupil size (diameter), near and distant VA. The phoria status of the individual tended towards orthophoria thereby enhancing heterophoria [13]. It was further found that miotics, due to their induced spasm of accommodation, caused a decrease in accommodation- convergence accommodation (AC/A) ratio [14].

The purpose of this study was to assess the changes that occur in visual field and colour vision following the use of these autonomic ophthalmic drugs on the Igbos of Nigeria on whom no records are available.

2. Material and methods

20 healthy emmetropic adult volunteers of either sex whose ages ranged between 19 and 30 years (mean 19.5$\pm$0.6)yrs., and body weight 55-60kg were screened and selected from those attending the University Optometry Clinic (Abia State University, Uturu, Nigeria). The protocol for the study was explained to each participant and those not willing to comply were excluded. Subjects on any form of medication, oral or topical or smokers/ alcoholics were also not enlisted in the study.

Each volunteer was interviewed separately and information on sociodemographic data, medical history obtained by the physician. Each volunteer was further subjected to screening: ocular and visual examinations by the optometrist to ensure ocular health i.e., refractive errors or ocular pathologies which might introduce errors in the study. Additionally, each volunteer had a normal near point of convergence (NPC) of 8-10 cm before the study.

Subjects had initial measurements of pupil diameter (size, PD), visual acuity (VA), at far and near, near point convergence (NPC), visual field and the colour vision so as to establish their initial value. Furthermore, each volunteer

served as his or her own control. This study lasted for 10 weeks. Thereafter, the subjects were divided into 4 groups A, B, C, D of 5 each, and 2 drops of the autonomic ophthalmic drugs (atropine, timolol, pilocarpine and phenylephrine) were administered to the subjects in the groups at intervals of 30 min respectively, and the above ocular parameters were reassessed every 5 min for the next 60 min in order to establish the effects of these drugs on the subjects. During the 2nd week, drug administration was swapped in a Latin Square Technique so that each group receives another autonomic ophthalmic drug different from the one received during the first week and the procedure repeated. By the 3rd and 4th weeks, each group had received the four study drugs.

Differences between the initial values of the visual parameters or function and those observed after the autonomic ophthalmic drug administration were regarded as the effects of the drug on the particular visual parameter or function. Emphasis was placed on the pupil diameter, VA, visual field and colour vision.

2.1. Measurement

The pupil size (PD) and the visual acuity (VA) were measured using the standard methods [4].

2.2. Visual field

The visual field was measured by perimetry, a kinetic process, where spots of light are shone on the white interior of a half sphere and slowly moved inwards until the observer sees them or static, where the light spots are flashed at varying intensities at fixed locations in the sphere until detected by the subject. The perimeter used was the Humphrey Field Analyzer (HFA).

Another method used was the light spot pattern in which the central 24^0 or 30^0 of the visual field are tested and used. This is capable of testing up to 80^0 or 90^0

2.3. Colour vision

The colour vision testing was done using Ishihara charts. Subjects were analyzed on Humphrey Field Analyser (HFA) for visual field changes. HFA uses the normal testing distance of 30 cm, dim ambient light source subjects' chin was placed on position chin holder. Full refractory correction was carried out in subjects with existing refractory errors. One eye was tested at a time whereby the other was occluded. The eye was centered in cross hairs of eye position monitor and the subject was made comfortable with the button in the dominant hand while the other hand was supported on the table.

The test was started by prosecuting four primary points, one in each quadrant. It assumes the blind spot location and maps it only if the subject misses the periodic fixation test. The fixation is monitored by both the corneal reflex method and television view of the subject's eye. The HFA uses two systems for monitoring subject fixation- the standard Heijl-Krakau periodic blind spot monitoring and the IR Gaze Tracking system. The subject was asked to look in the centre of the green fixation marks. Lights will flash up in different places and the subject was asked to push the button in his/her hand, whenever he/she saw the light. The test was repeated in a similar manner in the other eye. Results were recorded for Oculus Dexter (OD) and Oculus Sinister (OS) respectively.

2.4. Statistical analysis

Statistical software SPSS (version 20.0) and Microsoft Excel were used to carry out the statistical analysis of the data. Paired 't' test was employed to compare changes in the visual functions in the studied eyes. T-value less than 0.05 was considered statistically significant.

3. Results

The effect of autonomic drugs on visual field and colour vision are variable. Table 1 shows that timolol, an adrenergic antagonist, mydriatic autonomic drug did not produce any change in the visual field while Table 2 shows that timolol ophthalmic drug has no effect on colour vision. On the other hand, pilocarpine, a cholinergic miotic and autonomic drug affected the visual field without affecting the colour vision (Table 3 and 4).

However, atropine, an anticholinergic mydriatic and an autonomic drug produced highly significant changes in the visual field ($t>0.05$) or 32.5% without affecting colour vision (Tables 5 and 6).Phenylephrine, a mydriatic adrenergic and autonomic drug did not produce any significant effect on the visual field and colour vision.

Table 1 Effect of topical timolol (mydriatic) on visual field

S/N	Sex	Age	Visual field (degree) before drug administration	Value after drug administration (degree)
1	F	25	30	30
2	M	22	27	27
3	M	26	25	25
4	M	24	25	25
5	M	19	30	30
6	M	19	24	24
7	F	21	27	27
8	F	22	25	25
9	M	23	25	25
10	M	24	27	27
11	F	19	28	28
12	F	25	25	25
13	M	20	27	27
14	F	19	30	30
15	M	27	24	24
16	F	25	27	27
17	M	26	25	25
18	M	23	25	25
19	F	20	24	24
20	M	28	27	27

Table 2 Effects of topical timolol (a mydriatic) on colour vision

S/N	Sex	Age	Value before drug administration(degree)	Value after drug administration (degree)
1	F	25	24	24
2	M	22	24	24
3	M	20	24	24
4	M	24	24	24
5	M	19	24	24
6	M	19	24	24
7	F	21	24	24
8	F	22	24	24
9	M	23	24	24
10	M	24	24	24
11	F	19	24	24
12	F	25	24	24
13	M	20	24	24
14	F	19	24	24
15	M	27	24	24
16	F	25	24	24
17	M	26	24	24
18	M	23	24	24
19	F	20	24	24
20	M	28	24	24

Table 3 Effect of topical pilocarpine (a miotic) on visual field

S/N	Sex	Age	Value before drug administration (degree)	Value after drug administration(degree)
1	F	22	28	22
2	M	25	25	19
3	M	20	27	19
4	M	20	30	25
5	M	26	30	20
6	M	27	25	15
7	F	30	25	18
8	F	30	27	21
9	M	19	24	17
10	M	23	27	23
11	F	20	28	22
12	F	22	24	18
13	M	19	27	21
14	F	20	30	23
15	M	26	28	21
16	F	20	25	18
17	M	25	24	18
18	M	19	25	20
19	F	27	30	21
20	M	30	28	22

Table 4 Effect of topical atropine (cholinergic mydriatic) on colour vision

S/N	Sex	Age	Colour vision before drug administration(degree)	Colour vision after drug administration (degree)
1	F	20	24	24
2	F	19	24	24
3	F	23	24	24
4	M	20	24	24
5	F	30	24	24
6	F	25	24	24
7	M	28	24	24
8	M	19	24	24
9	F	26	24	24
10	M	28	24	24
11	F	27	24	24
12	F	26	24	24
13	M	26	24	24
14	F	25	24	24
15	M	28	24	24
16	M	25	24	24
17	M	30	24	24
18	F	28	24	24
19	F	19	24	24
20	M	25	24	24

Table 5 Effect of topical atropine, (cholinergic mydriatic) on visual field

S/N	Sex	Age	Value before drug administration(degree)	Value after drug administration (degree)
1	F	20	24	18
2	F	19	25	20
3	F	25	25	19
4	M	20	28	21
5	F	30	30	20
6	F	25	28	19
7	M	19	25	20
8	M	28	25	21
9	F	26	27	22
10	M	28	27	17
11	F	27	25	20
12	M	28	30	20
13	F	26	28	22
14	F	26	30	24
15	M	28	30	22
16	M	25	28	23
17	M	30	25	19
18	F	25	27	22
19	F	19	24	20
20	M	25	24	18

4. Discussion

Two classes of drugs were used for this study which are autonomic acting drugs, and are further classified into miotics and mydriatics, and generally sympathetic (timolol, phenylepherine) and parasympathetic (atropine, pilocarpine) drugs.

The effects of these drugs on the visual field and colour vision are variable. Colour vision and visual field are necessary for normal and good vision; hence alteration in either or both of them will interrupt vision. Due to subjective nature of visual field testing, there is no normal visual field [15]. Visual fields vary to some extent, in a peripheral visual field, size of the pupil, ambient room illumination, attention span in response time. Controlling these possible variations is of importance when evaluating the visual field.

The pupil diameter is one of the controllable variables that regulate the amount of light entering the eye and this affects the illumination of the retina. Pilocarpine produces pharmacological miosis and has a detrimental effect on visual field. A study with HFA on the effect of 2% pilocarpine showed that pupillary constriction (miosis) decreased the threshold sensitivity [16], and decreased the visual field as obtained in the present study, The decrease in sensitivity is due to decrease in retinal illumination that accompanies miosis. Furthermore, some workers have advocated that patients undergoing treatment with the miotic autonomic drug pilocarpine, should have visual field testing [17]. The visual field test is a subjective measure of central and peripheral vision or side vision and is used to diagnose, determine the severity of, and monitor glaucoma. The most employed visual field test uses a light spot that is repeatedly presented in different areas of peripheral vision. It evaluates vision loss due to glaucoma, damage to the visual pathways of the brain and other optic nerve diseases.

Although autonomic drugs do not affect colour vision at the applied dosage, literature is replete with information on the effects of drugs on colour vision, e.g., toluene, an organic solvent, and during exposure to the chemical induces colour vision loss [18]. Alcohol beverage use has been associated with loss of red vision, ethambutol when used in the treatment of tuberculosis caused changes or derangement in colour vision, visual acuity and visual field [19],

It is advocated that visual field testing should be carried out as a routine exercise at the first visit so as to assess its status because subjects with visual field loss may not be aware of the condition. On the other hand, since colour vision is an important part of ocular assessment of a patient's real vision it will provide useful information on patients with reduced vision due to ocular disease.

5. Conclusion

Finally, we concluded that autonomic ophthalmic therapy in routine ocular use, when applied in the recommended dose and duration can cause ocular toxicity. This ocular toxicity manifests in changes in pupil diameter, visual acuity at far and near, as well as in visual field.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors declare that they have no conflict of interests.

Statement of ethical approval

The approval of the Abia State University Ethical Committee on human studies was gotten before undertaking the study and informed written consent of the subjects were obtained.

Statement of informed consent

Written Informed consent was obtained from all individual participants included in the study.

References

[1] Smythies J. A note on the concept of visual field in neurology, psychology as visual sciences, Perception. 1996; 25(3): 369-371.

[2] Spector RH. Clinical Methods. The history, physical and laboratory examination 3rd edition. 1990; 24-30.

[3] Strasburger H, Rentsdiler I, Juttuer. Peripheral vision and pattern recognition: review. Journal of vision. 2011; III (5): 1-82.

[4] Borish IM. Clinical Refraction 14th edn.WB Saunders comp. 1998; 242-294.

[5] De-Gergerio F, Pecori-Gilade J, De-Stefano, Viro M. Correlation between ocular hypertension –induced by ibopamine and perimetric defect in primary Ope Angle Glaucoma (POAG), Eur J Ophthalmol Physiol Opt8.n3-r7. 1997.

[6] Henson DB, Morris EG. (1993) Effect of uncorrected refractive error upon central visual filed testing. Ophthalmol physiol Opt. 1993; 8:123-127.

[7] Grere EL. Visual fields, glaucoma and cartaract, In: Grere EL, ed. Glaucoma Symposium, Diagnosis and Therapy, The Hague. 1980; 79-88.

[8] Heiji A, Lingrean G, Lawrenson J. Ocular side effects to therapeutic administration of digoxin, Ophthalmol Physiol Opt. 1991; 11:391.

[9] Nathans J, Thomas D, Hogness DS. Molecular Genetics of human colour vision. The genes encoding blue, green and red pigments. Science. 1986; 232 (4747): 193-2002.

[10] Jacobs GH. The distribution and nature of colour vision among the mammals. Biological Reviews. 1993; 68(3):413-471.

[11] Jacobs GH, Deegan JF. Photopigments and colour vision in new world nonkeys from the family Ateliade, Proceed of the Royol Society B: Biological Sciences. 2001; 268(1468):695-702.

[12] Igwe SA, Akuyili DN, Okorie ME. The effect of oral hevodopa on the visual acuities of Nigerian amblyopes. Journal of Health and Visual Science. 2008; 9 (1-2): 17-22.

[13] Igwe SA, Nwobodo NN, Ibezim OI, Igwe JI. Effects of diazepam on visual functions of healthy Nigerian volunteers Int. J Biochem Research. 2015; 6(06): 421-424.

[14] Igwe SA, Nwobodo N, Ibeawuchi I. The effects of miotics on accommodative convergence/ accommodation (AC/A) ratio of Nigerian youths. World J of pharmaceutical sciences. 2015; 3(4): 702-705.

[15] Kurdua GR, Johnson MA, Remiston LA. Pupillary dilatation and its effects on automated perimetary results. J AM Opt Association. 1995; 66:675-680.

[16] Lindermith KA, Stut RR, Musch DC. Effects of pupillary constriction on automated perimetry in normal patiens. Ophthalmology. 1989; 96: 1298-1301.

[17] Harrington DO. Pupillary dilatation and its effect on automated perimetary result. J Am Optiom Association. 1995; 66:675-680.

[18] Zaralic M, Mendi CZ, Turk R, Bogadi-Save, Plavee D. Quantitative assessment of colour vision impairment in workers exposed to toulene. Am J Ind med. 1998; 33:207-304.

[19] Garg P, Garg R, Mishra AK, Prasad R. A prospective study of ocular toxicity in patients receiving ethambutol as a part of directly observed treatment schedule (DOTs) strategy therapy. Lung India. 2015; 32: 16-19.