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Effect of Different Body Positions on Intraocular Pressure in Patients with Primary Open Angle Glaucoma

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ABSTRACT
Background: Primary open-angle glaucoma (POAG) is the most common type of glaucoma. Increasing age, elevated intraocular pressure (IOP), and a positive family history are risk factors for POAG incidence. Elevated IOP is a major risk factor for glaucoma development and progression. The mechanism for IOP changes with body position is not completely understood.
Objective: The present study was aimed to investigate the effects of different body positions on IOP in patients with primary open-angle glaucoma.
Patients and methods: This prospective study included a total of 60 glaucoma and glaucoma suspect patients and 30 normal subjects, attending at Aswan University Hospital. Subjects were divided into 3 groups (normal, glaucoma suspect and primary open angle glaucoma). Each subject underwent thorough ophthalmological evaluation including best corrected visual acuity, slit lamp biomicroscopy, tonometry, gonioscopy, and dilated fundus evaluation. The Perkin's tonometer was used to measure IOP in different sleeping positions (at zero ^{o} degree, at 30^{o} degree and 45^{o}) positions. In all these positions, baseline IOP as well as after 30 minutes IOP was measured.
Results: Comparison of both age and gender across different groups showed that there were no statistically significant differences among them. In terms of the IOP, comparing all of the three groups at baseline showed that there was a statistically significant difference across groups ($p<0.0001$). There was a statistically significant reduction of IOP in 30 and 45 degree semi sitting positions compared to supine positions in all study groups.
Conclusion: It could be concluded that certain sleeping positions appear to be associated with changes in intraocular pressure. It is essential not to overlook these short term fluctuations particularly in patients with primary open angle glaucoma as they can affect progression of the disease.
Keywords: Body positions, Intraocular pressure, Primary open angle glaucoma.

INTRODUCTION

Glaucoma is defined as an optic neuropathy in eyes with intraocular pressure (IOP) exceeding the tolerance of ganglion cells axons in optic nerve at lamina cribrosa [(1)]. The prevalence of distinct types of glaucoma differs for each particular region of the world yet the most common form is primary open angle glaucoma (POAG) [(2)].

Risk factors for POAG involve positive family history, increasing age as well as elevated IOP [(3)]. Around half of all primary open-angle glaucoma (OAG) patients have a positive family history, and their first degree relatives (parents, siblings or children) have an approximately 9-fold increased risk of developing glaucoma [(4)].

Elevated intraocular pressure (IOP) is a major risk factor for glaucoma development and progression [(5)]. Therefore, IOP measurements provide important information to clinicians about glaucoma diagnosis, assessing the possibility of progression, and monitoring the clinical response to therapy [(6)]. For many decades studies had investigated short-term IOP changes (generally <30 minutes) in sitting position vs. different recumbent sleeping positions [(7)]. These studies suggested that repeated significant IOP increase over the short-term periods converts to an increase in IOP over the entire sleeping period and hence an increase in the risk of developing or aggravating glaucoma damage [(8)].

The aim of this work was to investigate the effects of different body positions on intraocular pressure in patients with primary open angle glaucoma.

PATIENTS AND METHODS

This prospective study included a total of 60 glaucoma and glaucoma suspect patients and 30 normal subjects, attending at Aswan University Hospital.

All 90 subjects underwent ophthalmological evaluation including best corrected visual acuity, slit lamp biomicroscopy, tonometry using hand held Goldman tonometer (Perkins MK3, Haag-Streit Diagnostics, UK), gonioscopy and dilated fundus evaluation. Visual field analysis (Humphrey FDT, Carl Zeiss Meditec, Inc. Dublin, CA, USA) as well as optic nerve head analysis were done using SD-OCT device (Topcon 3D OCT-2000FA, version 8.30, Japan) for diagnosis of primary open angle glaucoma (POAG).

The included subjects were divided into three groups; **Group A (*control*)** included 30 subjects having IOP 10-20 mmHg with no visual field or optic disc abnormalities. **Group B (*Suspicious*)** comprised 30

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subjects who are relatives to patients with primary open angle glaucoma and had one of the following: IOP > 21 mmHg, suspicious disc or C/D asymmetry of > 0.2 or suspicious 24-2 visual field defect and **Group C (*Glaucoma*)** comprised 30 patients with POAG; IOP > 21mmHg with characteristic glaucomatous visual field changes or optic nerve damage.

The Perkin's tonometer was used to obtain intraocular pressure (IOP) in different sleeping positions; flat supine position (zero degree), at 30^o degree as well as at 45^o semi setting positions. For each position, baseline measures of IOP as well as after 30 minutes were obtained.

Exclusion criteria included patients with other types of glaucoma, those with other ocular diseases and subjects less than 18 years old or elder than 60 years old.

Ethical Considerations:

The study protocol was approved by the Institutional Review Committee of Aswan University . All clinical procedures were conducted according to the principles of the Declaration of Helsinki. Informed written consent was obtained from all subjects involved in the study. The steps of the study, the aims and the potential benefits all were discussed with the patients involved in the study. Confidentiality of all data was ensured throughout the study.

Statistical analysis: Data were collected and analyzed using SPSS 26.0 program (IBM Inc., Chicago, IL, USA). Data was presented in the form of mean ±SD, inferential analysis was done using Chi^2 test for categorical variables, where analysis of variance was used to investigate differences across groups which was followed by Post-hoc analysis using (Tukey Test). Student’s t Test was then used to investigate statistically significant difference between pre- and post-measurements. Confidence intervals were set as 95% where a p value less than 0.05 was used as indicator for statistical significance.

RESULTS

The current study involved a total number of 90 subjects with 180 eyes where IOP assessment were taken for both right and left eyes independently. Of those 90 subjects, 40 (44.4%) where men while 50 (55.6%) were women and their age ranged 20 – 59 years with mean age (40.9±10.8). Comparing both age and gender showed that there was no statistically significant difference among study groups where p values were 0.199 and 0.096 for age and gender, respectively [Table 1].

Table (1): Demographic characteristics of different groups

Characteristic		Group: Normal (n=30)	Suspicious (n=30)	POAG (n=30)	Total	P-value
Age (years) Mean (SD), Range		39.4 (8.2) [27 – 58]	43.8 (11.5) [25 – 59]	39.5 (11.9) [20 – 59]	40.9 (10.8) [20 – 59]	0.199
Gender No. (%)	Male	18 (60%)	10 (33.3%)	12 (40%)	40 (44.4%)	0.096
	Female	12 (40%)	20 (66.7%)	18 (60%)	50 (55.6%)	

POAG, primary open angle glaucoma; P value < 0.05= significant

In terms of the IOP, comparing all of the three groups at baseline showed that there was a statistically significant difference across study groups at different assessment positions (flat zero^o , at angle 30^o as well as at 45^o semi setting position (p<0.0001) [Table 2].

Table (2): Baseline intraocular pressure values among different study groups

Position		Group: Normal (n=30)	Suspicious (n=30)	POAG (n=30)	P-value
Angle 0^o	Mean (SD) Range	12.2 (3.1) [10 – 20]	20.4 (2.3) [14 – 24]	26.3 (2.5) [22 – 30]	<0.0001
Angle 30^o	Mean (SD) Range	11.5 (2.4) [6 – 18]	20.1 (1.9) [15 – 24]	25.7 (2.5) [22 – 30]	<0.0001
Angle 45^o	Mean (SD) Range	10.9 (1.8) [7 – 18]	20.5 (2.9) [12 – 24]	26.1 (2.9) [20 – 30]	<0.0001

POAG, primary open angle glaucoma; P value < 0.05= significant

Conduct of post-hoc analysis showed that there is a statistically significant difference between each pair of the compared groups at different study positions [Table 3].

Table (3): Post-hoc analysis of mean differences in IOP between different study groups for all positions

Compared groups		Mean difference	P-value	95% Confidence Interval [Min – Max]
Angle 0º/baseline				
Normal	Suspicious	8.1 (0.5)	<0.0001	[6.99 – 9.27]
Normal	POAG	14.1 (0.5)	<0.0001	[12.93 – 15.21]
Suspicious	POAG	5.9 (0.5)	<0.0001	[4.79 – 7.07]
Angle 30º/ baseline				
Normal	Suspicious	8.7 (0.4)	<0.0001	[7.66 – 9.64]
Normal	POAG	14.2 (0.4)	<0.0001	[13.21 – 15.9]
Suspicious	POAG	5.6 (0.4)	<0.0001	[4.56 – 6.54]
Angle 45º / baseline				
Normal	Suspicious	9.6 (0.5)	<0.0001	[8.47 – 10.73]
Normal	POAG	15.2 (0.4)	<0.0001	[14.07 – 16.33]
Suspicious	POAG	5.6 (0.5)	<0.0001	[4.47 – 6.73]

POAG, primary open angle glaucoma; P value < 0.05= significant

Moreover, to monitor the specific change within each group, the mean difference in IOP was evaluated after 30 minutes.

In the normal group, findings from such comparison revealed that there was a reduction in the mean IOP from 12.2 (3.1) mmHg to 11.5 (2.6) mmHg where this reduction was statistically significant (p=0.032). At 30º angle, the IOP reduced from 11.5 (2.4) to 10.9 (2.3) mmHg which was also statistically significant (p=0.024). Moreover, at 45º position the IOP slightly reduced from 10.9 (1.8) to 10.7 (1.9) mmHg after 30 minutes although this change was not significant (p=0.477) (Fig. 1).

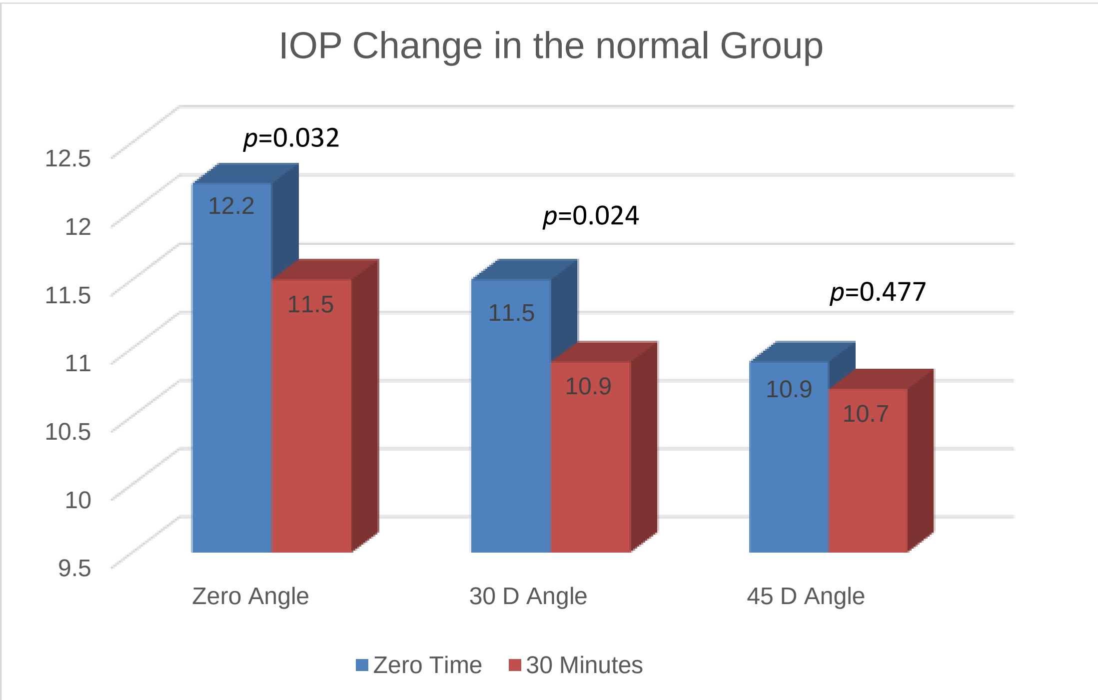

Figure (1): IOP change in normal group after 30 minutes.

In the suspicious group, at zero angle position, the mean IOP increased from baseline value of 20.4 (2.3) to 21.1 (2.2) after 30 minutes, where this rise was not found to be statistically significant (p=0.053). In the same group, at 30º angle position, the mean IOP increased from baseline of 20.1 (1.9) mmHg to 21.2 (2.0) mmHg after 30 minutes but this increase was statistically significant (p=0.003). On the other hand, at 45º semi setting position, the mean IOP reduced from 20.5 (2.9) to 12.3 (1.7) which was statistically significant (p<0.0001) (Fig. 2).

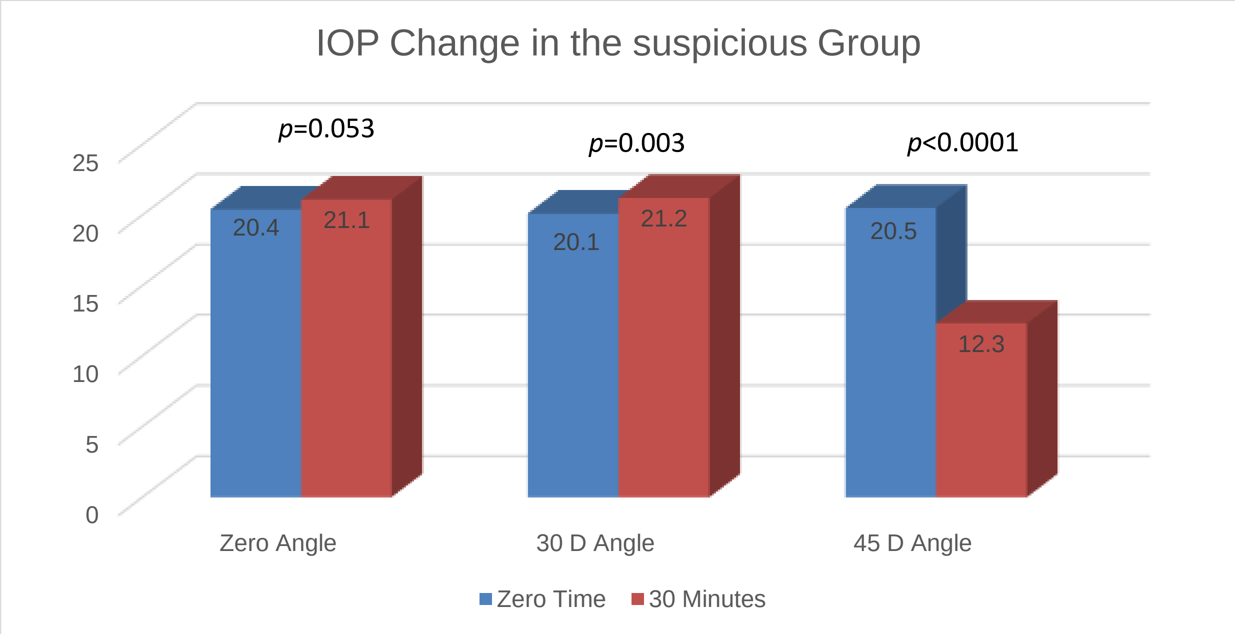

Figure (2): IOP change in suspicious group after 30 minutes.

Looking at the POAG group at zero angle position, the mean IOP had slightly reduced from 26.3 (2.5) to 25.4 (2.8) mmHg after 30 minutes where this reduction was not statistically significant (p=0.062). Moreover, at angle 30º position, there was a reduction in the mean IOP from 25.7 (2.5) to 25.1 (3.4) where this change was not also statistically significant (p=0.271). Finally, at 45º angle position, there was a reduction from baseline IOP of 26.1 (2.9) mmHg to 24.9 (3.7) mmHg after 30 minutes where this change was found to be statistically significant (p=0.034) (Fig. 3).

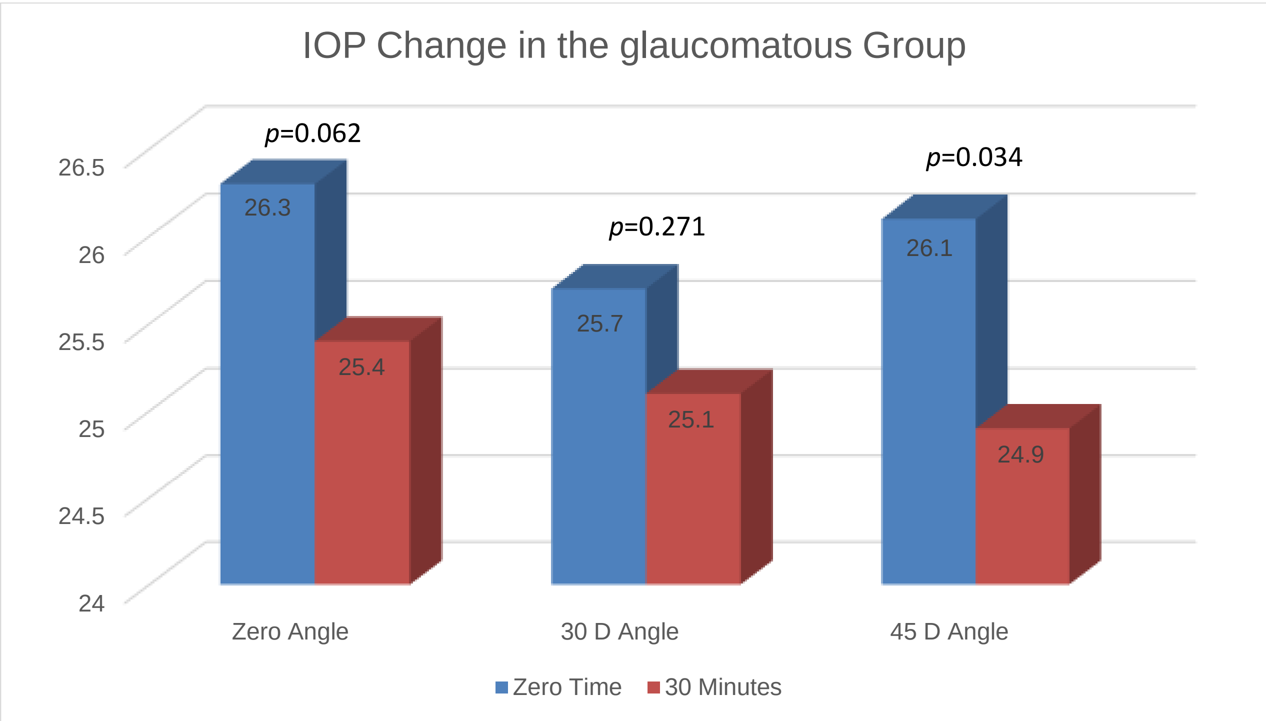

Figure (3): IOP change in POAG group after 30 minutes.

DISCUSSION

Intraocular ocular pressure (IOP) level and its fluctuation seem to play a role in the primary open angle glaucoma (POAG) development and progression, even in cases with statistically normal pressures. Various local and systemic factors are thought to affect person's IOP. IOP values are amenable to cyclic fluctuations all over the day [(9)]. Intraocular pressure can be altered by changing both body and head positions. The angle and duration of tilt as well as presence of glaucoma itself can affect the degree of IOP change [(10)].

In the present study IOP measuring was done using Perkins applanation tonometry that can be efficiently used in supine, sitting as well as semi settings positions. **Arora *et al.*** [(12)] reported the mean difference between readings from Perkins versus Goldmann tonometry to be 0.22 ±0.44 mmHg which yields its use for IOP measurements closely comparable with Goldmann tonometry [(11)]. Other investigators reported comparable but slightly higher IOP readings on using Perkins compared to I-Care tonometer.

The mechanism for intraocular pressure (IOP) changes with body position is not fully understood. According to previous reports, IOP increased following changes from sitting to supine or lateral decubitus position due to hydrostatic effects and increased episcleral venous pressure or alterations in uveoscleral outflow rate [(13)].

Friberg *et al.* [(14)] reported causes of the rise in IOP in recumbent/ inversion positions as mechanical compression of the orbit and increased orbital venous pressure resulting from lack of venous valves in the orbits and increased orbital arterial pressure. They also found a strong correlation between increases in IOP and episcleral pressures as independent parameters in supine vs. 90° inversion.

Other studies suggested that the more the congestion of venous drainage system of the head, the more elevated the IOP can become. Significantly higher IOP could be ensued with neck flexion and extension than in a neck neutral position which was attributed also to venous compression and increased episcleral venous pressure [(15)]. **Krieglstein *et al.*** [(16)] had shown that the changes of IOP with different body positions, has a nonlinear relationship with changes from 60° semi-upright tilt to 30° head-down tilt. **Kaplowitz *et al.*** [(17)] added that the side of the worse eye is related to the preferred sleeping position.

Results of the current study showed that in the normal group significant reduction in IOP was found from semi setting 45º and 30º compared to the more dependent supine position.

This result agreed with other studies that determined the effects of different body positions on IOP in healthy individuals. **Lee *et al.*** [(18)] investigated the effects of different sleeping positions of head and body on ocular perfusion pressure (OPP) and IOP in healthy young subjects. All sleeping positions of head and body resulted in an elevation of IOP and an increase in the calculated OPP compared with the sitting position. They found also that postural change from supine to lateral decubitus or prone with head turn position increased the IOP of the dependent eyes without significant alteration in OPP.

In another study, IOP was measured in 19 healthy young Korean subjects in the sitting and supine positions, revealing an increase of approximately 3 mmHg from the first to the second position [(19)].

Previous studies have also demonstrated wide variation in the difference between IOP values obtained in supine and sitting positions. This difference ranged between 0.3 mmHg and 5.6 mmHg in studies evaluating healthy individuals and patients with glaucoma [(9, 20)].

Alternatively, other investigators **found that** the mean IOP was not significantly different when measured in the supine position with the head elevated at 30° using multiple pillows [(21)]. Likewise, **Mayalı *et al.*** [(22)] stated that there were no statistically significant differences between IOP values measurements taken in the sitting, standing, and lying positions.

In the suspicious group, the recent study revealed significant reduction in IOP with change from semi setting 45º and 30º compared to the supine position while in POAG group significant reduction of IOP encountered mainly after 30 minutes of 45º semi setting position.

Earlier study by **Weinreb *et al.*** [(23)] evaluated IOP changes in intraocular pressure in eyes with POAG after inversion from sitting position into a totally dependent position with the head down and compared them with the IOP changes in healthy non-glaucomatous eyes. They reported increase in mean IOP in both groups after five minutes following inversion. Later on; **Carlson *et al.***[(24)] have measured changes in IOP in response to changes in body position (from 15° and 50° tilt from horizontal) while also looking at aqueous turnover as measured by fluorophotometry. They concluded insensitivity of aqueous formation to IOP changes with significant reduction in IOP in 50° semi setting compared to horizontal position.

IOP increases as a result of changes in position among POAG patients. It was found to be significantly higher than in normal subject [(25)]. Moreover, **Buys *et al.*** [(26)] found that the 30-degree head-up sleeping position lowers IOP by about 20% in one third of glaucomatous patients as compared with the supine position. Also, **Sawada and Yamamoto**[(27)] study results showed that the IOP in the lateral decubitus position was significantly higher in eyes with open-angle glaucoma.

Effect of position on treated and untreated glaucoma patients were studied by **Katsanos *et al.*** [(28)]; they observed that eyes in the treated POAG and untreated POAG groups had significantly larger posture-induced IOP elevation upon changing from the sitting to the supine position. Furthermore, with change from sitting to lateral decubitus positions, **Sawada and**

Yamamoto[29] compared alteration of IOP in medically treated vs. those surgically treated POAG patients. They found significant IOP increase in the medically treated group compared with the surgically treated group.

CONCLUSION

It could be concluded that certain sleeping positions appear to be associated with changes in intraocular pressure. It is essential not to overlook these short term fluctuations particularly in patients with primary open angle glaucoma as they can affect progression of the disease.

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