Original Article

To compare the Day-Time Phasing with One-Time Supine Position IOP in Patients with Primary Open Angle Glaucoma and Normal Tension Glaucoma

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ABSTRACT

Purpose: To compare the intraocular pressure (IOP) during 12 hour day-time phasing with one-time supine position IOP.

Study Design: Prospective, observational.

Place and Duration of Study: Glaucoma clinic of a tertiary eye – care center in Rawalpindi, Pakistan, from September 2020 to February 2021.

Methods: Forty two eyes of 21 participants with primary open angle and normal tension glaucoma were included in the study by convenient sampling technique. Three hourly diurnal Applanation tonometry was performed in sitting position from 9:00 am to 9:00 pm. Mean IOP and standard deviations were calculated. One-time supine position IOP was taken by Perkins tonometer at 9:10 pm. Mean IOP at 9:00 pm in sitting position was compared with the mean IOP in supine position.

Results: There were 15 males (71.42%) and 6 females (28.58%) in the study. Means of sitting position IOP during different times of the day ranged between 16.64 and 18.16 mmHg. The mean of IOP measured at 9:00am, 12:00 pm, 3:00 pm, 6:00 pm and 9:00 pm was 17.62 ± 4.04 mmHg. Mean supine position IOP at 9:10 pm was 22.38 ± 5.92 mmHg. Mean difference between supine and sitting position IOP was 4.75 ± 3.65 mmHg. This was statistically significant p-0.001.Direct comparison between sitting and supine IOP at 9:00 pm and 9:10 pm revealed the values to be 17.88 and 22.38 mmHg respectively ($p < 0.001$).

Conclusion: One-time supine position IOP gives a higher value than any one – time of IOP recorded during 12-hour diurnal phasing performed in sitting position.

Key Words: Intra ocular pressure, diurnal phasing, Primary open angle glaucoma, Normal tension glaucoma.

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INTRODUCTION

Intra ocular pressure (IOP) is a dynamic parameter, which undergoes constant variations during 24 hour time period which are determined by circadian rhythm and body posture.[1,2] It is a well-known fact that a higher IOP constitutes a major risk for glaucomatous damage.[3] Clinical tonometry involves sitting position IOP only. It does not take into account the variations in response to posture, muscular effort, deep respiration, wearing swimming goggles, repeated eye touching, rubbing etc.

There are four different types of IOP fluctuations; instantaneous, diurnal-nocturnal, short-term and long-term. Instantaneous IOP fluctuations occur within seconds e.g. saccades, blinking, eye rubbing etc. There is no evidence that instantaneous IOP fluctuations lead

to glaucoma progression. Diurnal-nocturnal IOP fluctuations occur over 24 hour time period e.g. variations with blood pressure and episcleral venous pressure, changes with body posture, fluctuations in cortisol levels, rate of aqueous production, environment light and dark cycles and seasonal influences.[4] Evidence indicates that 24 hour IOP fluctuations leads to glaucoma progression. De Moraes et al[5] found that the number of larger peaks in IOP and the mean-peak ratio (mean peak height to the time to peak) could very well indicate the chances of accelerated glaucomatous damage. Short-term fluctuations occur over days to weeks and long-term fluctuations occur over months to years.

There are four characteristics of a patient's IOP which are associated with glaucoma progression i.e. a higher base-line IOP, a higher mean IOP, a higher peak IOP and increased IOP fluctuation.[6]Short-term IOP fluctuations can predict long-term fluctuations.[7] Continuous monitoring of IOP fluctuations can be done with contact lens sensor. It can measure the changes in the corneo-scleral limbal circumference with changes in IOP.[8,9] The IOP measurement with contact lens sensor has proven to be correct and can be taken without interrupting the patient's sleep and provides reproducible results.[10,11] Contact lens sensor is not widely available in ophthalmic centers across the world. Literature suggests diurnal/24 hour phasing of IOP in sitting position, which is a very unreliable method because it does not take into account the IOP changes associated with lying down posture.[12] Besides, it is time consuming for both the patient and the doctor. Our study focused on the assumption that a single supine position IOP reading might give a higher value than 12 hour phasing. If it does, then it would provide a better picture about two important factors leading to glaucoma or its progression i.e. the peak and mean IOP.

METHODS

A study of diurnal and one-time supine position IOP was carried out in 42 eyes (21 patients) at Amanat Eye Hospital, Rawalpindi, from September 2020to February 2021. Patients with POAG (primary open angle glaucoma) and NTG (normal tension glaucoma) were included. Ethical committee approved the study. A self-designed proforma was completed by researcher endorsing subject's demography and ocular examination findings. Informed consent was received from the patient and confidentiality of the patient's record was maintained.

Diurnal IOP readings were taken with Applanation tonometer in sitting position at 9.00 am, 12.00 noon, 3.00 pm, 6.00 pm and 9.00 pm. Their mean and SD (standard deviation) were calculated. After the last reading at 9.00 pm, the patients were laid in supine position. 10 minutes later, IOP was checked by Perkins tonometer, in supine position. The mean IOP and standard deviations were calculated. For each case, the calibration of Perkins tonometer was checked (in sitting position) and confirmed by comparing with Applanation tonometer.

Statistical Package for Social Sciences (SPSS 20.0) for windows was used for statistical analysis. Descriptive statistics i.e. mean ± standard deviation for quantitative values (age, IOP) and frequencies along with percentages for qualitative variables (gender, laterality of eyes, over/under estimation) were used to describe the data. Shapiro wilk test was used to test normality of data. Post normality testing, Paired 't' test was used to compare mean IOP measurement during sitting positions with mean IOP measured during supine position. P value of < 0.05 was considered statistically significant.

RESULTS

There were 15 males (71.42%) and 6 females (28.58%) in the study. The age ranged from 20 to 90 years. Out of 21 patients, 18 fell into the 40-70 years age group. A total of 42 eyes of 21 patients were evaluated. Laterality of eyes was thus equal (50% right and 50% left).There were 13 POAG, 5 NTG and 3 ocular hypertension patients. On diurnal phasing, mean IOP showed a slight elevation at 9.00 am, a fall at 12.00 noon, a rise again at 3.00 pm, followed by a fall at 6.00 pm and then a rise at 9.00 pm (Table 1). Mean IOP ranged between 16.64 to 18.16 mmHg during the day-time phasing (Table 1).

Table 1: *Mean Intraocular Pressure in Upright Position with Standard Deviation.*

Obs. No.	Time of the Day	Mean Intraocular Pressure (mmHg)	Standard Deviation
1.	9.00 am	18.00	4.2138
2.	12.00 pm	17.4524	4.27815
3.	3.00 pm	18.1667	3.88189
4.	6.00 pm	16.6429	4.81776
5.	9.000 pm	17.881	4.58099

Overall mean of IOP measured at 9am, 12pm, 3pm, 6pm, and 9pm (calculated for ease of comparison) was 17.62 ± 4.04 mmHg. Mean IOP measured in supine position was 22.38 ± 5.92 mmHg (Figure 1). Mean difference of supine position IOP and day – time sitting position IOP was 4.75 ± 3.65 mmHg which was statistically significant $p < 0.001$.

On direct comparison in the evening time, mean IOP in upright position at 9:00 pm was 17.88 mmHg (SD 4.58099) while mean IOP in supine position at 9.10 pm was 22.38 mmHg (SD 5.92206). This difference was statistically significant $p < 0.001$. The highest IOP was recorded in 35.7% eyes at 9.00 am, 31% eyes at 3.00 pm, 19% eyes at 9.00 pm and 7.1% eyes at 12.00 noon and 6.00 pm. The lowest IOP was recorded in 31% eyes at 6.00 pm, 26.2% eyes at 12.00 noon, 21.4% eyes at 9.00 am, 16.7% at 9.00 pm and 4.8% at 3.00 pm.

Mean change in IOP from maximum observed IOP in sitting position to supine position was 3.07 ± 3.92 mmHg while the mean change from minimum observed IOP in sitting position to supine position was 6.57 ± 4.06 mmHg. This signifies the fluctuations in IOP. Majority of the cases (18 eyes) had the difference between means of upright position phasing IOP and supine position IOP in the range of 2 – 4 mmHg. (Table 2).

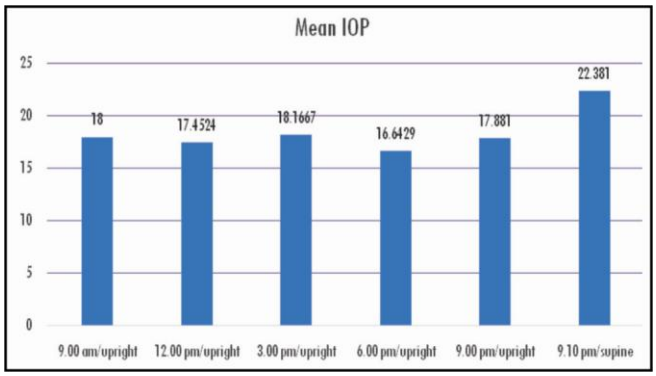

Figure 1: Comparison of Means of Diurnal Upright Phasing With One-Time Supine Position IOP.

Table 2: *Mean Upright Phasing IOP and Supine Position IOP Difference versus number of Eyes.*

IOP Difference (mmHg)	No. of Eyes (42)
□ 2	8
2 – 4	18
5 – 9	11
□ 10	5

DISCUSSION

Phasing is a dynamic observation of IOP. Our study showed that one-time supine position IOP at 9.10 pm gave a higher value than 3 hourly phasing in sitting position. This difference was statistically significant. Mean IOP at 9.00 pm in sitting position was 17.88 mmHg and at 9.10 pm in supine position was 22.38 mmHg. The literature says that on assuming supine position, the IOP rises within 2 minutes.[13]

If the day-time supine position IOP is significantly higher than the day-time sitting position IOP, we may presume that the same phenomenon works at night time and during sleep. One of the studies of 177 patients with normal tension glaucoma has shown that night-time habitual position IOP is significantly higher than night-time sitting position IOP.[14] However, no correlation was found between IOP and visual field damage. In contrast, our study included both POAG and NTG. However, the number of cases was much less and visual field correlation was not determined. Both studies showed elevation of IOP on assuming supine position.

The ideal method of studying 24-hour IOP behavior in patient's physiological conditions is by using the Triggerfish contact lens. This can help in diagnosing the true NTG patients. Researchers in Toyama University, Japan studied the 24 hour IOP fluctuations between 14 NTG and 12 non-glaucoma patients by Sensimed Triggerfish contact lens.[15] They discovered that IOP fluctuations were significantly higher in NTG patients (p-0.007). This higher range of IOP fluctuations among NTG patients could be the reason behind progressive visual field deterioration in these patients. Our study highlights the significance of combined diurnal phasing and supine IOP in the absence of availability of Triggerfish contact lens to observe the IOP behavior in NTG cases.

Generally, the at-risk glaucoma patients require 24-hour IOP monitoring, especially those who show progression despite treatment. Due to its practical difficulties, a surrogate method can be adopted. This includes diurnal IOP readings and a single morning supine position IOP measurement. The supine position IOP elevation may represent the nocturnal IOP.[16] In our study, a single supine IOP was recorded at 9.10 pm. If it was recorded in the morning, the IOP might have been even higher as the normal diurnal fluctuation shows a higher IOP in early morning. The hindrance was availability of patients and the staff

during early morning hours. Supine position IOP elevation reverses 10 minutes after resuming the erect position. Supine measurement of IOP in office hours can improve the estimate of maximum IOP during 24 hours period in patients with glaucoma.[13]

Fogagnolo P et al[13] concluded that the collection of supine and sitting office-hour measurements help in estimation of 24 hour IOP characteristics in both control subjects and glaucoma patients. Only a minority of patients require 24 hour phasing. The implications of our study are similar to their findings.

In a study of healthy volunteers and untreated POAG patients regarding 24-hour IOP fluctuation, it was revealed that nocturnal supine IOP was higher than the day-time sitting and supine IOP.[17] Their study contradicts our assumption that day – time supine IOP represents nocturnal supine IOP. We did not determine the nocturnal supine IOP. However, both studies strengthen the significance of supine IOP. Supine daily IOP measurements may estimate the peak nocturnal IOP better than the sitting position IOP.[18]

One of the studies on patients of pigment dispersion syndrome and glaucoma has shown a significant increase in IOP on posture change from recumbent to lateral decubitus and more so in prone position. It implies that dependency enhances IOP elevation.[19] Just like our study, this fact is also proven in similar studies for other conditions.[20,21] Change in neck position may affect the internal carotid artery and internal jugular vein thus resulting in raised episcleral venous pressure.[22] On recumbent position, episcleral venous pressure rises suddenly due to absence of valves in orbital veins.[23]

Even if we know that supine position IOP is higher than the sitting position IOP, the question is; does it really lead to glaucomatous damage? In one of the studies performed on NTG patients, it was seen that the eyes with higher recumbent position IOP showed a greater visual field loss on Humphrey field analyzer as increasing mean deviation and decreasing visual field index.[24] The focus of our study was on supine IOP rather than visual field changes.

In a questionnaire about the preferred lateral decubitus position during sleep, it was observed that it correlated with asymmetric and more visual field loss, in eyes with NTG and POAG.[21] Short-term recumbent position IOP studies (5 – 30 min) have not shown significant ocular perfusion pressure changes, which makes this position vulnerable to glaucomatous damage.[25] Inclusion of supine position IOP provides a closer picture of the mean IOP, which is one of the major factors determining glaucomatous damage. Conventional day-time phasing in sitting position gives a very limited information and can misdiagnose a lot of POAG as NTG cases.

Our study highlights the significance of supine IOP. We recommend that supine IOP be included in the routine ophthalmic examination for the diagnosis of NTG and unexplained visual loss in POAG patients who are apparently controlled on anti-glaucoma therapy. For cases with advanced glaucoma, diurnal phasing and supine position IOP should be combined in order to get a better picture of mean IOP and fluctuations.

The weakness of our study is that comparative 3 hourly supine position IOP was not taken. If that is included in further studies, we can get information about the maximum fluctuation that is possible between the lowest and the highest IOP. Further studies should be carried out on larger population samples to compare the supine IOP with phasing, determine the effects of supine position on nocturnal IOP and consequent visual field changes.

CONCLUSION

One time supine position IOP gives a higher value than any one time of IOP reading in sitting position in day-time phasing. Supine IOP measurement gives a better information for diagnosis of normal tension glaucoma. Moreover, for patients with unexplained visual loss but normal sitting IOP during diurnal phasing, supine IOP should be obtained. Combined sitting IOP in phasing and supine IOP measurement should be conducted in high risk cases to obtain better information about mean IOP and fluctuations in 24 hours.

Ethical Approval

The study was approved by the Institutional review board/ Ethical review board **(RIPAH/IRC/20/218).**

Conflict of Interest

Authors declared no conflict of interest.

REFERENCES

1. **Quaranta L, Katsanos A, Russo A, Riva I.** 24-hour Intraocular Pressure and Ocular Perfusion Pressure in Glaucoma. Surv Ophthalmol. 2013; **58 (1):** 26-41.
2. **Liu JHK, Zhang X, Kripke DF, Weinreb RN.** Twenty Four Hour Intraocular Pressure Pattern Associated With Early Glaucomatous Changes. Invest Ophthalmol Vis Sci. 2003; **44 (4):** 1586-1590.
3. **Leske MC, Heijl A, Hussein M, Bengtsson B, Hyman L, Komaroff E.** Factors for Glaucoma Progression and the Effect of Treatment: the Early Manifest Glaucoma Trial. Arch Ophthalmol. 2003; **121:** 48-56.
4. **Kim JH, Caprioli J.** Intraocular Pressure Fluctuation: Is It Important? J Ophthalmic Vis Res. 2018; **13 (2):** 170-174.
5. **De Moraes CG, Jasien JV, Simon-Zoula S, Liebmann JM, Ritch R.** Visual Field Change and 24-hour IOP-related Profile With a Contact Lens Sensor in Treated Glaucoma Patients. Ophthalmology, 2016; **123:** 744-753.
6. **Komori S, Ishida K, Yamamoto T.** Results of Long-term Monitoring of Normal-tension Glaucoma Patients Receiving Medical Therapy: Results of an 18-year Follow-up. Graefes Arch Clin Exp Ophthalmol. 2014; **252 (12):** 1963-1970.
7. **Tojo N, Abe S, Miyakoshi M, Hayashi A.** Correlation between short-term and long-term intraocular pressure fluctuation in glaucoma patients. Clin Ophthalmol. 2016 Sep 2; **10:** 1713-7. Doi: 10.2147/OPTH.S116859. PMID: 27621590; PMCID: PMC5015882.
8. **Mansouri K, Shaarawy T.** Continuous Intraocular Pressure Monitoring With a Wire-less Ocular Telemetry Sensor: Initial Clinical Experience in Patients with Open Angle Glaucoma. Br. J Ophthalmol. 2011; **95 (5):** 627-629.
9. **Leonardi M, Pitchon EM, Bertsch A, Renaud P, Mermoud A.** Wire-less Contact Lens Sensor for Intraocular Pressure Monitoring: Assessment on Enucleated Pig Eyes. Acta Ophthalmol. 2009; **87 (4):** 433-437.
10. **Mottet B, Aptel F, Romanet JP, Hubanova R, Pépin JL, Chiquet C.** 24-Hour Intraocular Pressure Rhythm in Young Healthy Subjects Evaluated With Continuous Monitoring Using a Contact Lens Sensor. JAMA Ophthalmol. 2013; **131 (12):** 1507-1516.
11. **Dunbar GE, Shen BY, Aref AA.** The Sensimed Triggerfish Contact Lens Sensor: Efficacy, Safety and Patient Perspectives. Clin Ophthalmol. 2017; **11:** 875-882.
12. **Tajunisah I, Reddy SC, Fathilah J.** Diurnal Variation of Intraocular Pressure in Suspected Glaucoma Patients and Their Outcome. Graefes Arch Clin Exp Ophthalmol. 2007; **245 (12):** 1851-1857.
13. **Fogagnolo P, Orzalesi N, Ferrerras A, Rossetti L.** The Circadian Curve of Intraocular Pressure: Can We Estimate its Characteristics During Office Hours? Invest Ophthalmol Vis Sci. 2009; **50 (5):** 2209-2215.
14. **Lee YR, Kook MS, Joe SG, Na JH, Han S, Kim S, et al.** Circadian (24-hour) Pattern of Intraocular Pressure and Visual Field Damage in Eyes with Normal-Tension Glaucoma. Invest Ophthalmol Vis Sci. 2012; **53:** 881-887.
15. **Tojo N, Abe S, Ishida M, Yagau T, Hayashi A.** The Fluctuation of Intraocular Pressure Measured by a Contact Lens Sensor in Normal Tension Glaucoma Patients and Nonglaucoma Subjects. J Glaucoma, 2017; **26 (3):** 195-200.
16. **Konstas AG, Kahook MY, Araie M, Katsanos A, Quaranta L, Rossetti L, et al.** Diurnal and 24-h Intraocular Pressures in Glaucoma: Monitoring Strategies and Impact on Prognosis and Treatment. Adv Ther. 2018; **35 (11):** 1775-1804.
17. **Liu JHK, Bouligny RP, Kripke DF, Weinreb RN.** Nocturnal Elevation of Intraocular Pressure is Detectable in the Sitting Position. Invest Ophthalmol Vis Sci. 2003; **44:** 4439-4442.
18. **Mosaed S, Liu JHK, Weinreb RN.** Correlation between Office and Peak Nocturnal Intraocular Pressures in Healthy Subjects and Glaucoma Patients. Am J Ophthalmol. 2005; **139:** 320-324.
19. **Sedgewick JH, Sedgewick JA, Sedgewick BA, Ekmekci B.** Effects of Different Sleeping Positions on Intraocular Pressure in Secondary Open Angle Glaucoma and Glaucoma Suspect Patients. Clin Ophthalmol. 2018; **12:** 1347-1357.
20. **Lee TE, Yoo C, Kim YY.** Effects of Different Sleeping Positions on Intraocular Pressure and Ocular Perfusion Pressure in Healthy Young Subjects. Ophthalmology, 2013; **120 (8):** 1565-1570.
21. **Kim KN, Jeoung JW, Park KH, Kim DM, Ritch R.** Relationship Between Preferred Sleeping Position and Asymmetric Visual Field Loss in Open Angle Glaucoma Patients. Am J Ophthalmol. 2014; **157 (6):** 739-745.
22. **Sulek CA, Gravenstein D, Blackshear RH, Weiss L.** Head Rotation During Internal Jugular Vein Cannulation and The Risk of Carotid Artery Puncture. Anaesth Analg. 1996; **82 (1):** 125-128.
23. **Friberg TR, Sanborn G, Weinreb RN.** Intraocular and Episcleral Pressure Increase during Inverted Posture. Am J Ophthalmol. 1987; **103 (4):** 523-526.
24. **Kiuchi T, Motoyama Y, Oshika T.** Relationship of Progression of Visual Field Damage to Postural Changes in Intraocular Pressure in Patients with Normal Tension Glaucoma. Ophthalmology, 2006; **113 (12):** 2150-2155.

25. **Buys YM, Alasbali T, Jin YP, Smith M, Gouws P, Geffen N, et al.** Effect of Sleeping in a Head-up Position on Intraocular Pressure in Patients with Glaucoma. Ophthalmology, 2010; **117 (7):** 1348-1351.

Authors' Designation and Contribution

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Asim Mehboob; Consultant Ophthalmologist: *Design, Data analysis, Statistical analysis.*

Muhammad Usman Arshad; Assistant Professor: *Design, Literature search, Data analysis.*

Sohail Zia; Associate Professor: *Design, Literature search, Data acquisition, Manuscript review.*

Aamir Asrar; Consultant Ophthalmologist: *Design, Literature search, Data acquisition, Manuscript review.*