ORIGINAL ARTICLE

Air Puff Tonometer Versus Goldmann Applanation Tonometer In Glaucomatous Eyes: Comparative Evaluation Conducted At Rawal Institute Of Health Sciences

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Objective: This study aims to determine the suitability of the Air-puff tonometer as a reliable alternative to the Goldmann applanation tonometer for measuring Intraocular Pressure (IOP).
Methodology: A cross-sectional study was conducted at the Outpatient Department (OPD) of Ophthalmology, Rawal Institute of Health Sciences, Islamabad, from April 2022 to September 2022. It involved 100 patients (200 eyes) aged above 20 years with suspected raised IOP. Both genders were included in the study. IOP measurements were obtained using the Air-puff tonometer and Goldmann Applanation Tonometer (GAT) mounted on the Slit-lamp. Three measurements were obtained with each instrument on both eyes within 15 minutes, and the average was used for analysis. Data analysis was performed using SPSS version 22.
Results: Among the total 100 patients, the mean age was 44.19 years. The mean IOP was 17.108 mmHg with the Air-puff tonometer and 15.873 mmHg with the Goldmann applanation tonometer. The difference between the instruments was < 2mmHg in 131 eyes and >2-3mmHg in 69 eyes. The Mean Difference (Air-puff – Goldmann) for these 200 eyes was 1.234mmHg (<2mmHg), with a standard deviation of 1.713.
Conclusion: The study concludes that while the Air-puff tonometer lacks correspondence to the Goldmann tonometer at high or low pressures, it measures IOP that closely corresponds to the Goldmann tonometer, particularly within 10-20mmHg intervals and moderately within 20-30mmHg. The Air-puff tends to overestimate low IOP and underestimate high IOP. *Al-Shifa Journal of Ophthalmology 2022; 18(4): 136-142.*

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Introduction:

Glaucoma, a neurodegenerative disease, stands as a leading cause of irreversible blindness globally.[1] Predictions estimate its prevalence to rise to 111.8 million people by 2040.[2] In Pakistan, surveys identify glaucoma as the fourth leading cause of blindness, with a prevalence of 0.03% across all age groups.[3,4] This optic neuropathy involves the progressive loss of retinal ganglion cells and thinning of the retinal nerve fiber layer, contributing to its multifaceted pathology. Raised intraocular pressure (above 22mm Hg) remains a significant treatable risk factor for glaucoma, emphasizing the importance of

early detection and accurate monitoring to slow its progression.[5] It is a multifactorial disease with complex underlying pathophysiology which is still not clearly understood[2,5]. Most significant and treatable risk factor for developing glaucoma is raised intraocular pressure (above 22mmHg).

Early and accurate detection and monitoring of high IOP is very important as lowering of IOP can slow down progression of glaucoma[5,6]. Almost all therapeutic modalities aim toward lowering of IOP[7]. Unfortunately, glaucoma is silent killer of vision, which remained silent until the significant and noticeable damage to the vision is done. This is because ganglion cells responsible for peripheral visual field die first[8].

Gauging of IOP is very important to slow the progression of glaucoma and ultimately prevent further visual field loss[9]. The patients whose IOP is lowered, visual field loss slowed down significantly. In case of glaucoma, the eye that has higher IOP tends to have higher risk of visual field loss[10].

Goldmann applanation tonometer (GAT) is currently considered as internationally recognized gold standard to measure IOP. It uses principal of force required to flatten the cornea. GAT is widely in use from last seven decades and is largely accepted in clinical practices and also considered as reference standard in various clinical trials[11]. However, there are significant limitation of GAT. Its readings are significantly affected by examiner and patient. It needs topical anesthesia, fluoresceine staining and technical expertise. Also, if it is not properly disinfected, there is risk of transmission of various diseases such as HIV, Hep C[12].

In recent years there has been considerable interest in devising alternative instruments for measuring IOP with aim of less time-consuming measurement not being influenced by examiner and also non-contact assessment[12, 13].

Air-Puff is one such instrument. It uses high intensity column of air to flatten the cornea. It is non-contact, easier to use, not examiner biased and in addition it does not require any anaesthesia However, sensitivity and accuracy of the Air-puff tonometer compared to Goldmann applanation tonometer remain controversial[14]. In literature, studies have differed quite markedly in their conclusions about the agreement between two instruments. Some authors have suggested a close correlation other have indicated that the correlation may not be clinically acceptable[15].

This study aims to evaluate whether the Air-Puff tonometer's IOP measurements align sufficiently with those of the Goldmann tonometer, utilizing Goldmann applanation tonometry as the reference standard.

Materials and Methods:

This cross-sectional study was conducted at Ophthalmology department of Rawal institute of health sciences Islamabad, after taking ethical approval from institutional research department. Patients presented to OPD with suspicion of raised IOP, of age above 20 years and both genders were included in the study. Patients with corneal pathology, known systemic infection HIV, HCV and those within one week of ocular surgery were excluded from the study. All patients were selected by non-probability purposive sampling from the outpatient department. Complete history was taken and thorough clinical examination including visual acuity testing by Snellen's chart, pin hole testing, slit lamp examination, intraocular pressure measurements using both the Goldmann tonometer (GAT) and the air-puff tonometer (APT) and fundus examination was done on patients fulfilling the exclusion and inclusion criteria.

Patients having raised IOP were referred for further investigations. The Full auto tonometer (air-puff tonometer) and the Goldmann Applanation Tonometer Haag-Streit International AT-900 mounted on the Slit-lamp TOPCON-SL 2D was used for the IOP measurements in the study. The

same Air-puff and Goldmann tonometer were used throughout the study. Three measurements were obtained with each instrument on both eyes within 15 minutes subsequently, and the average was used in the analysis.

The data was entered and analyzed in SPSSv2022. Descriptive statistics like Mean +/- Standard Deviation (S.D) was calculated for the age of the patients. Frequencies and Percentages were calculated for the gender. Three measurements were taken on each eye with the Air-puff and Goldmann tonometer. The average of the three measurements with each instrument was calculated and used in the analysis. Mean was calculated for the IOP values with each instrument. The Difference (Air-puff---Goldmann) was calculated for each case. The Mean, Standard Deviation and 95% of Confidence Interval was calculated for the Difference between the two. Sensitivity and specificity along with the positive predictive value, negative predictive value and accuracy was calculated to prove the validity of study.

Results:

In a study involving 100 patients (aged 20-63, mean age 44.19 ± 10.94), with a gender distribution of 48% male and 52% female, intraocular pressure (IOP) data was classified into five groups based on varying pressure ranges. Using the Goldmann tonometer (GAT), IOP measurements indicated 36 eyes within 1-10 mmHg, 127 eyes between 11-20 mmHg, and so forth, with only 2 eyes above 40 mmHg. In contrast, with the Air-puff tonometer, 2 eyes fell within 1-10 mmHg, 147 eyes between 11-20 mmHg, and 2 eyes above 40 mmHg, among others. The mean IOP was 17.108 mmHg (Air-puff) and 15.873 mmHg (Goldmann). Differences between instruments were mostly <2mmHg in 65.5% of cases, and within 3mmHg in 94% of cases. The mean difference (Air-puff – Goldmann) was 1.234mmHg, with a standard deviation of 1.713. Sensitivity of the Air-puff was 94.51%, specificity was 94.44%, positive predictive value was 82.93%, and negative predictive value was 98.74%.

Table 1: Demographics of Study Population

Number of Patients	**100**
Age	Age in Years
Minimum	20
Maximum	63
Mean	44.19
Standard Deviation	10.94

Table 2: Mean IOP groups (GAT versus APT)

Valid	1-10mmHg		11-20mmHg		21-30mmHg		31-40mmHg		Above 40mmHg		Total
	GAT	APT	GAT	APT	GAT	APT	GAT	APT	GAT	APT	
Frequency	36	2	127	147	29	42	6	7	2	2	200
Percent	18.0	1.0	63.5	73.5	14.5	21.0	3.0	3.5	1.0	1.0	100
Valid percent	18.0	1.0	63.5	73.5	14.5	21.0	3.0	3.5	1.0	1.0	100
Cumulative percent	18.0	1.0	81.5	74.5	96.0	95.5	99.0	99.0	100.0	100.0	

Table 3: Comparison of IOP Measurements Air-Puff vs GAT

	IOP mm Hg (Air-Puff)	IOP mmHg (Goldman)
No. of eyes	200	200
Minimum	9.3	6.0
Maximum	45.7	51.3
Mean	17.108	15.873
Difference in Mean IOP (Air puff Vs Goldman)	1.234	
Standard Deviation	1.713	

Discussion:

Estimated 3.5% of total world population of age range 40 -80years is affected with some kind of glaucoma[16].Our study consisted mostly of the middle-aged persons, mean age (44.19 years) Table 1, so most of the patients fall in this age range. We compared IOP obtained using the Air-puff and the Goldmann tonometer, considering the readings made with the Goldmann tonometer as gold standard.

Our study showed that the Mean difference in IOP readings with the two tonometers (Air-puff -Goldmann) was < 2mmHg especially between 10-30mmHg (Table 2) Thus, the reliability of the IOP

measurements with the Air-puff was comparable to that of the Goldmann tonometer especially between 10-30mmHg. In this study when the IOP was <10 mmHg the Air-puff overestimated the actual IOP and when the IOP was >30mmHg the Air-puff underestimated the actual IOP.

This study results are congruent with findings of Stock and Ströher who reported that in 180 eyes total mean IOP obtained by APT is significantly higher (p=0.0018) than GAT in extreme IOP range. However, it is similar in range of 10-15mmHg[17].

In another study conducted by Yeh SJ et al both instruments were compared r in eyes with corneal edema after penetrating keratoplasty PKP. Mean IOP measurements obtained by an Air-puff tonometer were significantly higher than with the GAT in the PKP and control groups. Poor agreement was noted between the air- puff tonometer and GAT in both groups. In PKP group Air-puff tonometer overestimate IOP. In normal corneas, the GAT and air-puff tonometers were affected by central corneal thickness (CCT) and corneal curvature (CC)[18].

Ghani MU et al reported statistically significant difference in mean IOP between both instruments in 50 vitrectomized eyes. Mean intraocular pressure measured by GAT and air puff tonometer was 14.59±2.13 mmHg and 14.93±1.88 mmHg respectively. They concluded if air puff is used for IOP measurement in post-vitrectomized cases then overestimation of IOP should be kept in mind[19].

Another study in Pakistan conducted by Shaheen S and coworkers on 500 individuals concluded that the sensitivity and specificity of APT for measuring IOP in glaucomatous eyes was 84.04% and 73.53% respectively and these results correlate with our study. It also showed that the Mean IOP in glaucomatous eyes measured by GAT and APT was 16.01+5.57 mmHg and 17.31+7.22 mmHg respectively[20].

In clinical studies, an error of less than +3mmHg has been suggested as tolerable in clinical and screening situations. But an average error of more than +3mmHg can not be tolerated in the diagnosis and treatment of vision threatening diseases when more accurate techniques are available. Discrepancies in IOP measurements by the Air-puff even in small percentage of cases could lead to incorrect clinical decisions in the detection and treatment of glaucoma[21].

However, in all these studies the authors concluded that the Air-puff was good enough for the purpose of adequate screening, presumably because in most studies the difference was small when compared with the limits of agreements.

In contrary to this study Basuony RE concluded that non-contact Air-puff tonometer yields higher IOP as compared to Goldmann tonometer and therefore requires further investigation to be used as clinical screening tool22.

Limitations of our study include readings taken by multiple observers; the investigators were not masked to the results. So intra and inter-observer bias may be present. One limitation of the present study is regarding the importance of central corneal thickness (CCT) in the accuracy of IOP measurements with instruments used. This relationship has implications on the results of the present study, and may partly help explain the variability between the two tonometers.

Conclusion:

In conclusion, the Air-puff tonometer demonstrates reliability in measuring IOP, particularly within specific intervals, but lacks consistency at extreme pressures. It serves as a viable alternative in situations where Goldmann tonometry is unfeasible, such as in pediatric or uncooperative patients. However, considering discrepancies at high and low pressures, the Goldmann tonometer remains the standard choice.

Recommendations:

While the Air-puff tonometer shows promise, its universal application in Glaucoma clinics requires further investigation. Future studies should consider corneal thickness and curvature, aiming for larger sample sizes, especially in high-pressure ranges.

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