ORIGINAL ARTICLE

INTRAOCULAR PRESSURE MEASUREMENT: GOLDMANN APPLANATION TONOMETER VS NON CONTACT AIRPUFF TONOMETER

Masood Alam Shah*, Khalid Bin Saleem, Talat Mehmood*****

Department of Ophthalmology, Azad Jammu and Kashmir Medical College, Muzaffarabad, *Women Medical College, Abbottabad, ***Community Health, Combined Military Hospital, Nowshera, Pakistan

Background: An accurate assessment of Intraocular pressure (IOP) is vital in establishing diagnosis of Glaucoma and decision making regarding various treatment modalities available. The purpose of this study is to compare Goldmann Applanation Tonometer (GAT) with Air puff tonometer. **Methods:** Cross-sectional comparative study conducted. 73 eyes from 73 patients were included in this study and intraocular pressure (IOP) was measured by GAT and PT100 at Sheikh Khalifa Bin Zayed Hospital, Muzaffarabad, Benazir Shaheed Teaching Hospital, Abbottabad. **Results:** Mean age of the patients was 53.17±13.80 years. Mean IOP measurements showed significant differences in measurements performed by the two tonometers ($p<0.05$). Correlation revealed significant relation between PT100 and GAT (Pearson's correlation 0.715, $p<0.01$). **Conclusions:** Compared to non-contact air-puff tonometer, the Goldmann applanation tonometer is a reliable and consistent technique for measurement of intraocular pressure.

Keywords: Glaucoma, Intraocular pressure, Goldmann applanation tonometry, Non-contact air puff tonometer

INTRODUCTION

Glaucoma has been established as the second leading cause of blindness. The treatment of glaucoma focuses mainly on lowering intraocular pressure (IOP). The target IOP is often set to a level 20% to 30% of IOP reduction, and consequent large IOP reduction beyond 30% or even 40% in cases of advanced glaucoma.[1] It is difficult to define glaucoma precisely, as it encompasses a diverse group of disorders. All forms of the disease have in common a potentially progressive and characteristic optic neuropathy which is associated with visual field loss as damage progresses, and in which intraocular pressure is usually a key modifying factor.[2] An accurate assessment of IOP is vital in establishing diagnosis of glaucoma and decision regarding various treatment modalities available.[3]

Tonometry, or the measurement of IOP, the pressure of the fluid inside the eye is usually the only modifiable factor in management of all types of glaucoma. It is maintained by the dynamic equilibrium between aqueous humour formation and outflow, and by episcleral venous pressure. Aqueous humour provides a transparent and colourless medium between cornea and the lens and constitutes an important component of the eye's optical system. The aqueous humour is secreted by the non-pigmented ciliary epithelium at a flow rate of 2–3 μL per minute.[3] Anterior chamber volume in human beings is estimated to be 250–300 μL. Aqueous humour turnover is ~1% of anterior chamber volume (~2.5 μL per minute).

The reliability and stability of IOP measurements is very important. Normal IOP is important to maintain the shape of the eye and normal visual function. Long-term high IOP can cause irreversible damage to the retinal ganglion cells and postganglionic nerve fibres. Studies have shown that for every 1 mmHg reduction in IOP, visual field damage can be reduced by 10%.[4]

Pooled data from large epidemiologic studies indicate that the mean IOP is approximately 16 mmHg; however, these pooled data have a non-Gaussian distribution with a skew toward higher pressures, especially in individuals over the age of 40. The value 22 mmHg has been used in the past to both separate normal and abnormal pressures and define which patients required ocular hypotensive therapy. This division was based largely on the erroneous assumptions that glaucomatous damage is caused exclusively by pressures that are higher than normal and that normal pressures do not cause damage.

Screening for glaucoma based solely on IOP 21 mmHg may miss up to half of the people with glaucoma in the screened population. It is now generally agreed that, for the population as a whole, no clear line exists between safe and unsafe IOP. Some eyes undergo damage at an IOP of 18 mmHg or less, whereas other eyes tolerate IOPs in the 30s. However, IOP is still seen as a very important risk factor for the development of glaucomatous damage. Although other risk factors affect an individual's susceptibility to glaucomatous damage, IOP is the only risk factor that can be altered at this time.

In normal individuals, IOP varies by 2–6 mmHg over the course of a 24-hour as aqueous humour production changes. Higher IOP is associated with greater fluctuation and a diurnal fluctuation. A diurnal

variation of greater than 10 mm Hg is suggestive of glaucoma. Many people reach their peak IOP in the morning hours, but others do so in the afternoon, in the evening, or during sleep; still others follow no reproducible pattern. A precise assessment of the IOP is crucial for diagnosis and decision making regarding treatment modalities in patients with glaucoma. Recent epidemiologic studies show that a difference of only 1 mm Hg in the mean IOP may be critical enough to determine the visual field prognosis in patients with glaucoma.[5] Elevated IOP is a cause of visual field defects in many normal tension glaucoma patients. Among IOP-visual field-concordant patients, particular attention is required to visual field changes in the eyes of patients with higher IOP.[6]

Raised IOP is an important risk factor for the development and progression of glaucoma.[7] Reduction of IOP is the best, and only evidence-based, treatment modality. Pharmacologic as well as surgical interventions aimed at reducing IOP may successfully slow the progression of structural damage and visual field loss in patients with glaucoma. Therefore, IOP measurement by tonometry is essential in ophthalmological assessment.

Applanation tonometry is based on the Imbert-Fick principle, which states that a perfect sphere has its internal pressure equally distributed and that the external force needed to flatten a known area of that sphere is directly proportional to the internal pressure of the sphere. The Goldmann applanation tonometer (GAT), which is current gold-standard, is not precise enough to measure the true IOP within an error of 1 mm Hg. There are many clinically proposed correction algorithms to correctly measure IOP.[8] Numerous corneal features may affect IOP measurement with GAT. Before any interpretation of an IOP, measurement conditions should be checked and the central corneal thickness evaluated, since GAT overestimates IOP in thick corneas and underestimates IOP in thin ones. When GAT is not applicable, other IOP measurement devices, which have their own limits, are available. For example, the ocular response analyser (ORA) and dynamic contour tonometry (DCT) provide IOP readings that are less influenced by corneal properties and may be useful after refractive surgery. Regardless of the choice of tonometer, the IOP value must not be considered alone but from a clinical point of view including multiple IOP measurements over a day since the IOP fluctuates over 24-hour time period. A complete clinical examination is necessary in each case to search for glaucomatous neuropathy.[9]

In 1970's individuals without a medical degree were not permitted to instil topical anaesthesia which was a prerequisite to perform tonometry with any device. Non-contact tonometry was a timely invention which allowed optometrists to measure IOP without anaesthesia. Non-contact (also called air-puff) tonometers do not touch the eye because they use a puff of air to flatten (applanate) the cornea. Once initiated, the puff force increases until the cornea is applanated over a predetermined area. The tonometer then translates the applanation force into a measure of IOP. Because the air puff tonometer relies on corneal applanation, it is subject to the same potential measurement errors induced by variations in corneal properties, as is the Goldmann tonometer and these errors are exaggerated in the measurement outcome. The rebound and non-contact tonometer behave similarly when used to measure IOP taking GAT measurements as the reference standard.[7]

The objective of this study was to compare Goldmann Applanation Tonometer (GAT) with Air puff tonometer.

MATERIAL AND METHODS

This was a cross-sectional comparative study. The study samples were selected by convenience sampling who presented for check-up in the Eye Department of Muzaffarabad, Azad Jammu & Kashmir, and Benazir Shaheed Teaching Hospital, Abbottabad. Patients with corneal diseases and previous corneal surgery were excluded from the study. Patients did not have glaucoma based on medical history or previous exams. The study was approved by ethical committee of the hospital.

Patients signed a written consent to have their IOP checked using the PT100 and GAT, and right eye was selected for analysis. Patients were recruited from both morning and afternoon clinics and IOP measurements were obtained at different time intervals. All IOP readings were taken in the sitting position over fifteen minutes in a masked manner.

The Non Contact Air Puff Tonometer (NCAT) was performed before the GAT to avoid the known mild reduction of IOP by anterior chamber compression with GAT. An average of three readings was recorded. After instillation of topical propacaine drops, GAT was performed according to standard protocol, using a Haag-Streit slit lamp, calibrated according to the instructions and schedule provided by the manufacturer. Only the first GAT measurement on each eye was used for the GAT data because serial readings using the GAT result in a statistically significant decrease in final IOP measurements.

Student's *t*-test was performed to compare the mean IOP obtained with two methods. The statistical analysis was performed using SPSS and $p<0.05$ was considered statistically significant.

RESULTS

A total of 73 eyes in 73 patients were studied. The mean age of the patients was 53.17±13.80 year. The

study population consisted of 36 (49.3%) men and 37 (50.7%) women. The mean intraocular pressure was 16±3.2 mmHg for GAT, and 16.58±2.7 mmHg for PT 100 respectively. The median IOP was 16.0 mmHg for the GAT and 17 for the PT100 measurements. The range of measurements by GAT was from 7 to 21 mmHg and by PT100 was 9–22 mmHg. The difference between IOP measured by two instruments were statistically significant (p=0.03).

Table-1: Number of patients in different categories of IOP

IOP Categories (mmHg)	GAT (n=73)		APT (n=73)	
7–10	6	8.22	1	1.37
11–14	20	27.4	15	20.55
15–18	26	35.62	39	53.42
19–22	21	28.76	18	24.66
Mean±SD	16.0±3.205		16.589±2.702	

DISCUSSION

Goldmann Applanation Tonometer and Non Contact Air Puff Tonometer are usually commonly used in day-to-day ophthalmic clinic practice. Usually it is thought that GAT is superior and more reliable. The GAT is currently the most widely used instrument for measuring IOP[3], and is considered the 'gold standard'.[10]

However, the GAT has two disadvantages. First, the instrument probe must come into direct contact with the cornea, which can increase the risk of infection. Second, use of the GAT requires a local anaesthetic, and some patients, especially children, are unwilling or unable to tolerate drug instillation. With these factors in mind, several non-contact tonometers have been developed to facilitate measurement of IOP during vision screening. Several comparative studies have demonstrated the reliability and accuracy of IOP measurements obtained with non-contact tonometers (both desktop and portable) and their correlation with measurements obtained with the GAT in subjects with and without glaucoma.[11]

Several studies have compared intraocular pressure measurements made with non contact tonometers and Goldmann tonometers. In one study, the accuracy of two non-contact tonometers, including the Reichert AT550, Goldmann applanation tonometer, and a Perkins tonometer was tested in a young normal population. The results showed a high level of agreement between the AT550 and Goldmann applanation tonometer.[12] Therefore, we concluded that intraocular pressure readings obtained by AT550 are comparable clinically with those obtained by the Goldmann applanation tonometer in a population having intraocular pressure within the normal range.

Clinical agreement between the non-contact tonometer and the GAT has been demonstrated in previous studies of normotensive subjects with a propensity for the non-contact tonometer to return about 3 mmHg higher IOP measurements than the GAT in subjects with IOPs up to 21 mmHg. In one of the two previous published studies comparing the PT100 and the GAT, a strong agreement was observed between the two instruments. In the study by Salim *et al* a close level of agreement in the normal range of IOPs was observed, with an increased variation as the magnitude of measurements increased.[12]

Like this study, another study concluded that the average IOP measured by both tonometers is the same, and no significant difference was found between the repeatability and reproducibility coefficients for the GAT and the PT100 non-contact tonometer.[13]

Repeatability was assessed using all IOP measurements for each technique per subject. Reproducibility was assessed by a re-evaluation of each subject's IOP during a second measurement session taken approximately one week later. The average IOPs for both sessions using one method were compared to assess the reproducibility of that method. The agreement between both techniques was statistically quantified using the repeatability (for each technique) as the basis for comparison.

The portability and ease of use of the PT100 non-contact tonometer makes it an ideal IOP measuring device for use in children. The effect of the corneal properties on both GAT and non-contact tonometer is considerable since the latter is more affected by central corneal thickness than the GAT.[14]

One study has concluded that both techniques are consistent in their measurement of IOP in the same session and between sessions. The difference in intraocular pressure measurements between techniques did not differ significantly (p>0.05) in both sessions, and therefore the techniques can be used interchangeably for measurement of intraocular pressure in normal young adults.[15] In our study also the difference between IOP measured by two instruments were statistically significant (p=0.03).

Another study showed no statistically significant differences when comparing the Canon TX-10 NCT with GAT, displaying close level of agreement with GAT as seen by the 95% LoA (-4.78 mmHg to +4.00 mmHg). CCT ranged from 419 micron to 585 micron and no relationship was found between CCT and IOP measurements. The coefficients of repeatability were 3.70 mmHg and 3.41 mmHg for GAT and TX-10 tonometers, respectively.[16]

CONCLUSIONS

Compared to non-contact air-puff tonometer, the Goldmann applanation tonometer is a reliable and consistent technique for measurement of intraocular pressure.

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Address for Correspondence:

Dr. Masood Alam Shah, Department of Ophthalmology, Azad Jammu and Kashmir Medical College, Muzaffarabad.
Cell: +92-322-6660075
Email: mas1469@gmail.com