Investigation of Intraocular Pressure Changes Due to Different Serum Level Heights by Using Tonopen in Acquired Globes from the Iran Eye Bank

Mahmood Joshaghani, MD[1] • Ali Asghari, MD[2] • Alireza Foroutan, MD[3]
Mohammad-Jafar Ghaempanah, MD[1] • Ali Ahadian, MD[4]
Masoud Janahmad, MD[5] • Maryam Almasi, MD[4]

Abstract

***Purpose*:** To investigate intraocular pressure (IOP) changes due to different serum level heights by using Tonopen in acquired globes from the Iran Eye Bank (IEB).

***Methods*:** In this interventional prospective case series, serum were infused into 18 normal globes acquired from IEB by using 21G needle inserted in vitreal space through optic nerve head to change the IOP by different fluid level heights from the globe surface. IOP of globes were measured and recorded by Tonopen over the sclera and over the cornea at different serum level heights.

***Results*:** Twelve globes were acquired from male donors and 6 globes were from female donors. Mean age of donors were 57 year old. Mean measured pressures by Tonopen of the 18 globes at the serum level heights of 13.6, 27.2, 40.8, 54.4 and 68 cm from the globe surface were 14, 23.6, 34.8, 44 and 52.8 mmHg over the sclera and 13.1, 22.8, 34.8, 44.1 and 52.8 mmHg over the cornea respectively.

***Conclusion*:** Using a Tonopen is a proper method to measure the acquired globes IOP, except in serum level height of 13.6 cm (10 mmHg) from the globe surface. In addition, if tonometry over the cornea is not available, it can be done by using Tonopen over the sclera.

***Keywords*:** Tonometry, Tonopen, Globe, Intraocular Pressure, Serum Level Height

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1. **Assistant Professor of Ophthalmology, Eye Research Center, Rassoul Akram Hospital, Iran University of Medical Sciences**
2. **Fellowship in Anterior Segment, Eye Research Center, Rassoul Akram Hospital, Iran University of Medical Sciences**
3. **Associate Professor of Ophthalmology, Eye Research Center, Rassoul Akram Hospital, Iran University of Medical Sciences**
4. **General Practitioner, Eye Research Center, Rassoul Akram Hospital, Iran University of Medical Sciences**
5. **Resident in Ophthalmology, Eye Research Center, Rassoul Akram Hospital, Iran University of Medical Sciences**

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Correspondence to:
Mahmood Joshaghani, MD
Eye Research Center,
Rassoul Akram Hospital, Tehran
Tel:+98 21 66559595
Email: joshaghani206@yahoo.com

Introduction

Corneal grafts are usually used either to improve the corneal clarity (optical grafts) or to save the globe structure in corneal perforation or thin cornea (tectonic graft). The first successful corneal graft was done by Zim in 1905. Ersmas Darwin suggested substituting the corneal scar by a clear cornea in 1970 for the first time.

By technology improvements, using microscopes and fine suture threads in addition of steroidal anti inflammatory agents and their role in preventing the corneal graft rejection, success rate of corneal grafts has raised during the past 50 years. Around 33,000 corneal grafts are done each year in United States nowadays and many studies are being done on effective factors on corneal grafts.

Exact measuring of the intraocular pressure (IOP) of the donor globe is necessary in many studies based on the acquired globes from the eye banks such as topographic changes of donor globes in different pressures, relation of SimK of acquired globes from the eye banks with globe SimK after grafting, etc.

On the other hand, different results were reported in previous studies on globes IOP. For example in 1988, Bothe reported that using Tonopen is a good method to measure IOP of the globes,[1] whereas Davis' study in 1991 showed that beside other serum level heights, at the level of 13.6 cm (10 mmHg) from the globe surface, Tonopen was not a proper tool to measure the IOP of the globe.

Our study is designed upon the connected tubes law ($h_A\rho_A=h_B\rho_B$) to investigate the correlation of IOP of the globes with different serum level heights. The serum was infused to vitreal space by using a 21 G cannula in 2 minutes and while the serum level height was raising the IOP was measured by using a Tonopen.

In fact, the aim of this study is to determine the IOP of the globe (mmHg) in different serum level heights (cmH_2O) to use the results in other future studies.

Methods

This study was done at the eye research center of Iran University of Medical Sciences (IUMS) on 18 complete normal globes and in all cases tonometry was done by the same ophthalmologist**.**

At first, a tool was designed and made to keep the globe steady while a 21 G needle attached to infusion set was inserted into vitreal space through head of optic nerve. Normal saline was used to moist the corneal surface. Different pressures were made upon the connected tubes law in which "*A"* is the first container, "*B"* is the second container, "*P"* is the pressure of the container, "*ρ"* is density, "*h"* is level height of fluid and "*g"* is gravity (Figure 1)**.**

$$P_A=P_B \Rightarrow \rho_A h_A g = \rho_B h_B g \Rightarrow \rho_A h_A=\rho_B h_B$$

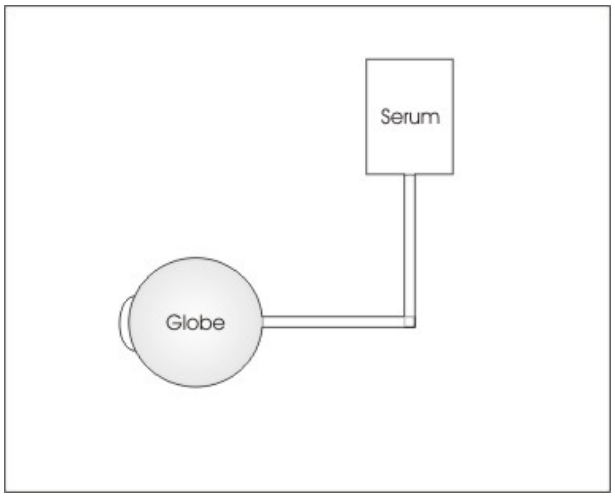

Figure 1. Designed set to infuse the serum fluid to the globe using a 21 G needle at the cut edge of the optic nerve.

Based on physics laws, the expected IOP depend on serum level height from the surface of the globe are charted in Table 1.

Table 1. Expected IOP (manometric) based on serum level height from the globe surface

Expected IOP (mmHg)	Serum level Height (cmH_2O)
10	13.6
20	27.2
30	40.8
40	54.4
50	68

In this study, all the muscles around the acquired globes were completely detached and all globes had normal corneal epithelium. None of globes had history of any ocular diseases or surgery.

To put pressures at 10, 20, 30, 40 and 50 mmHg, the serum level heights were being changed in order of 13.6, 27.2, 40.8, 54.4 and 68 cm from the globe surface and the serum was being infused into vitreal space in 2 minutes.

The corneal epithelium was removed to prevent the false decreasing of IOP. At the end of tonometry, each globe was checked for any serum leakage from the globe. In case of any leakage that globe was omitted from the study.

Tonometry was done by using a Tonopen in different serum level heights over both the cornea and the sclera (bare sclera & equator) on 18 globes. In each level height, tonometry was done 3 times while the globe surface was kept moist and the mean of the each 3 pressures was recorded in specific data sheets and was processed and analyzed by computer using SPSS version 15.

Results

Eighteen normal globes (12 globes from male donors and 6 globes from female donors) acquired from the IEB were investigated in this study.

Mean age of donors was 57 year old (range of 25 to 65 years) and mean time of tonometry and eye emptying was 24 hours.

Mean IOP at 13.6 cm of all 18 globes measured by Tonopen over the center of cornea and sclera were 13.1±5.3 and 14.0±4.9 mmHg.

Mean measured pressure in each level height of 27.2, 40.8, 54.4 and 68 cm were in order 22.8±6.1, 34.7±12.1, 45.1±8.8 and 51.8±10.8 mmHg over the center of cornea and 24.6±8.0, 36.8±11.9, 44.1±12.3 and 52.8±12.1 mmHg over the sclera.

Measured IOP by Tonopen from cornea and sclera at different serum level heights are compared with expected pressures of 10, 20, 30, 40 and 50 mmHg (Paired T-test) in tables 2 and 3; which show that except in height of 13.6 cm from the globe surface, there is no significant correlation with expected pressures.

Table 2. Comparing the measured IOP on the cornea by Tonopen with the expected pressures in different serum level heights

Serum Level Height (cmH_2O)	IOP on Cornea by Tonopen (mmHg)	Expected Manometric IOP (mmHg)	Compared IOP on the Cornea by Tonopen with Expected Manometric IOP (mmHg)*
13.6	13.1 (±5.3)	10	0.023
27.2	22.8 (±6.1)	20	0.066
40.8	34.7 (±12.1)	30	0.101
54.4	45.1 (±8.8)	40	0.166
68	51.8 (±10.8)	50	0.328

* Paired T-test, P-value

Table 3. Comparing the measured IOP on the sclera by Tonopen with the expected pressures in different serum level heights

Serum Level Height (cmH_2O)	IOP on Sclera by Tonopen (mmHg)	Expected Manometric IOP (mmHg)	Compared IOP on the Sclera by Tonopen with Expected Manometric IOP (mmHg)*
13.6	14.0±4.9	10	0.003
27.2	24.6±8.0	20	0.055
40.8	34.8±11.9	30	0.101
54.4	44.1±12.0	40	0.166
68	51.8±10.8	50	0.328

* Paired T-test, P-value

Discussion

In some cases such as children, head tremors, nystagmus, severe palpebral edema or corneal ulcers, the IOP can not be measured by using Goldman applanation. In these cases other methods of measuring IOP such as tonometry by Tonopen can be used but there are different opinions about the accuracy of this method in different studies.

Biologic or physiologic factors and variables such as hypertension, anxiety, respiration, conversion or extraocular muscles contractions which effect on the IOP are usually omitted from studies on the globe.

In a study done on the globes received from the eye bank by Bothe in 1985, Tonopen accuracy was measured by putting a sensor in the globe wall.[1] The results revealed that Tonopen is a trustable tool in measuring the globe's pressure.

Mendelson's study in 1987 on received globes from the eye bank showed that tonometry by Tonopen has more accurate results than using Pneumatonometer and Perkins tonometry.[4]

In Khan's study on 15 globes in 1991, tonometry by using Tonopen on the center of cornea showed that except at the level height of 13.6 cm there are no statistical correlation with the expected manometric pressure and at the other serum heights.[2] In addition regarded to the results of Khan's study, using Tonopen on the sclera is not valuable method. The same results about using Tonopen on the sclera were achieved by the Talia Kholin's study in 2003.[5]

Other study done by Hessmer in 1988 on acquired globes from donors who have died between 3 to 6 hours before,[4] showed that tonometry results by using Tonopen at the serum level heights over 27.2 cm, have obvious statistical correlation and were more than expected manometric pressures. At the lower heights than 27.7 cm, results of tonometry had statistically correlation lower than expected manometric pressures.

In our study which was done on 18 acquired globes from the Iran Eye Bank (IEB), results of tonometry on sclera or cornea only at the level height of 13.6 cm had statistical correlation with expected manometric pressure (10 mmHg) and at the other serum heights (27.7, 40.8, 54.6 and 60 cm) there were no statistical correlation found with expected manometric pressures (20, 30, 40 and 50 mmHg) which reveals similar results to Mayli Davis study (Figure 2). Even in literature reviews we could not find a clear cause for this finding. In addition there was no significant correlation between the results of tonometry by Tonopen at different serum level heights on the sclera and center of cornea. In fact in our study, the results of tonometry by Tonopen on the sclera of the acquired globes from the eye bank are valuable.

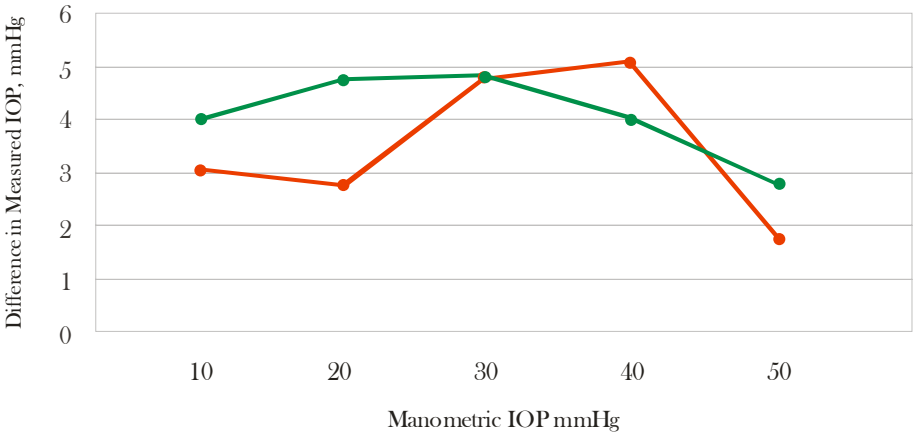

Figure 2. Compared mean IOP of tonometry on the cornea with tonometry on the sclera by Tonopen of the 18 acquired globes from the eye bank

Conclusion

Except at serum level height of 13.6 cm (10 mmHg) from the globe surface, tonometry by Tonopen on acquired globes from the eye bank is a proper method in evaluation of the IOP of globes. In addition in case that tonometry by Tonopen is not available, tonometry by Tonopen can be done on the sclera of the globes.

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