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A Review of Intraocular Pressure and A Novel Interpretation Tool for the Emergency Eye Examination Setting: A Technical Report

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Abstract

Tonometers are used to measure intraocular pressure (IOP) and are not a common diagnostic investigation used in the emergency department. They are becoming increasingly utilised by the emergency physician to aid in the differentiation of serious ocular pathologies. However, the interpretation of IOP measurements remains difficult and no current guideline or tool exists to assist the emergency physician in the interpretation of these values. Defining and categorising IOP readings is complex, challenging and controversial. Therefore, a comprehensive literature review of intraocular pressure values was undertaken and a novel tool designed to assist the emergency physician identify sight threatening ocular emergencies including hypotony, scleral perforation, retinal detachment, uveitis, retrobulbar haemorrhage, acute angle closure glaucoma and endophthalmitis. This simple, visual interpretation tool aims to provide the emergency physician with diagnostic assistance that is not currently available in current literature to support faster diagnosis of emergency ocular pathologies. Intraocular pressure values will be influenced by type of tonometer, physician technique and patient variation therefore, as with any diagnostic tool, results should be interpreted within the clinical context.

Key words: emergency medicine and trauma, teaching in emergency medicine, pneumatic tonometer, blunt ocular trauma, intraocular pressure measurement.

Introduction

Intraocular pressure (IOP) is the fluid pressure of the eye and is measured in millimetres of mercury (mmHg). Calculated using a piece of equipment called a tonometer, IOP assessment forms a vital aspect of the emergency ocular examination. In the absence of other specialist pieces of ophthalmological diagnostic equipment, an IOP measurement can be very useful in differentiating sight threatening emergency ocular pathology quickly. In addition, IOP assessments allow more thorough general eye assessments; support decisions to allow safe discharge; and develop more comprehensive referrals.

Despite the value of IOP measurements in an emergency setting, the ability to interpret IOP values can be challenging when physicians are not accustomed to the normal ranges and the various factors that can influence the measurements. One study analysing Emergency Department (ED) referrals to ophthalmology centres found that 75% of referrals did not measure IOP at all, and those that did varied from ophthalmologists' readings by an average of 4.30 +/- 4.39 mmHg [1].

To be able to accurately differentiate sight threatening ocular pathologies associated with intraocular pressure values, an appreciation of the factors that influence IOP is important. There are a spectrum of factors which affect IOP which make the definition of IOP values complex.

Several tonometer dependent factors can influence the measurement. Applanation tonometry, such as Goldman's, is considered the gold standard for IOP measurement however typically in the (ED) setting handheld devices that utilise non-contact principles to estimate IOP are more common. These non-contact tonometry methods may underestimate high IOP values and overestimate low IOP values when compared to Goldman [2]. Applying eyelid pressure whilst measuring IOP may falsely increase the IOP reading and excessive or insufficient tear film on the examining eye may influence accuracy.

Several patient specific factors can also alter the measurements of IOP. The thickness of the cornea, known as central corneal thickness (CCT), affects the accuracy of intraocular pressure measurements however typically CCT measurement is not undertaken in the ED. Thicker corneas produce a falsely high IOP measurement and thinner corneas a falsely low [3]. Other corneal factors such as a high astigmatism and previous corneal scarring will affect the accuracy of measurements [4]. High blood pressure and high heart rates are associated with higher IOP [5, 6]. Obesity has been associated with higher IOP [7, 8]. IOP has a diurnal variation and tends to be higher when measured in the morning. Some studies have found that IOP decreases with age, although other studies have found no difference [5, 8, 9].

Although these complex factors make IOP analysis difficult, a simple guide of IOP interpretation is felt to be useful for clinicians diagnosing patients in the emergency ocular examination environment. No systematic review of IOP values or interpretation analysis with their associated pathologies currently exists in published literature.

Technical report

To ensure the accuracy of the data gathered for this review, this literature review of intraocular pressure values was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) statement. A comprehensive search of the literature was conducted for papers using the online biomedical search engines the Medline and PubMed. One author identified the articles, and all relevant articles were included. Search terms used were: 'intraocular pressure' AND 'emergency'. Figure 1 shows the PRISMA diagram of the systematic review.

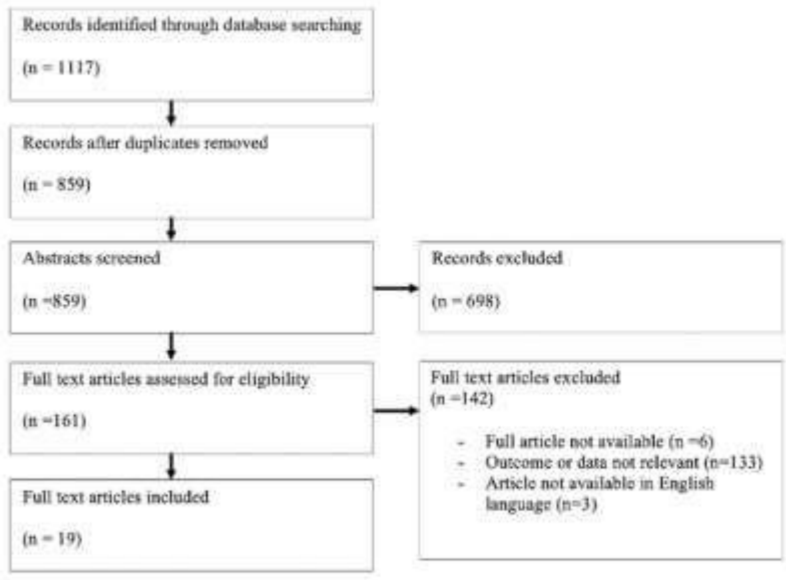

Figure 1 - PRISMA Diagram

The data analysed in this review was collated to formulate and define ranges of IOP values into 'normal', 'low', 'very low', 'high' and 'very high' categories.

Defining a normal IOP is challenging given the multiple factors that can influence the measurements - the corneal curvature, CCT and scleral elasticity vary between each of an individual's eyes [10]. When adjusted for all of these factors, our review found the range of IOP within the mean ± 2 standard deviations was between 9.0 and 18.1 mmHg [5-7, 9-11]. Therefore, for the purposes of this review, these are the normal values that have been used in the interpretation tool.

This review has defined 'low IOP' to be considered as less than 9.0mmHg at two standard deviations below the mean [5-7, 9-11]. Other studies define hypotony statistically as an IOP three standard deviations below the mean at less than 6.5mmHg and depicts a low enough IOP to cause visual loss and is in itself an ocular emergency [12-13]. Therefore, this is the value used for 'very low' IOP values.

A 'high IOP' in the emergency setting can be considered as a measurement more than two standard deviations above the mean at over 18.2mmHg [5-7, 9-11]. In other eye examination settings such as glaucoma assessments, an IOP of greater than 21mmHg is considered to reflect a high measurement [14]. An IOP higher than 40mmHg can precipitate rapid visual loss through retinal vascular occlusion and is usually associated with significant acute pathologies [15]. Therefore, this is the value that has been used for 'very high' IOP values.

These measurements have been collated to form a novel IOP interpretation tool shown in Figure 2. The aim of this tool is to give the emergency physician quick access to easily interpretable IOP values and associated prompts relating to sight threatening pathology.

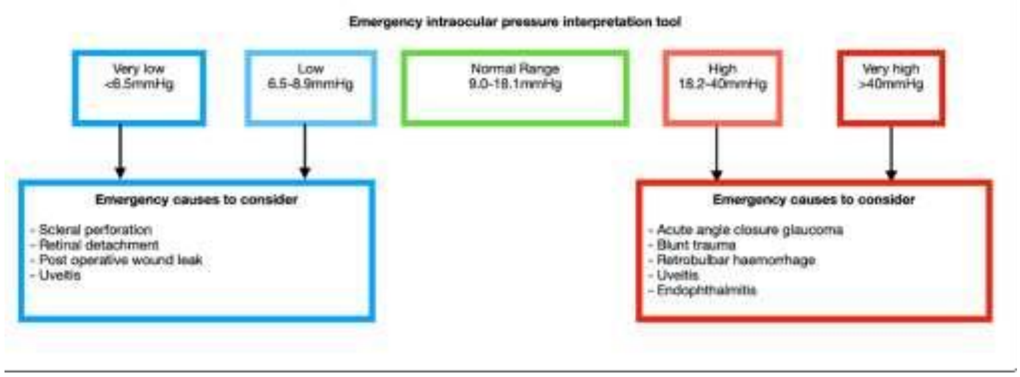

Figure 2 - Emergency intraocular pressure interpretation tool

Discussion

The pathophysiology of low IOP occurs from either increased outflow of aqueous humour or from reduced production. Increased outflow is seen following a surgical wound leak such as following glaucoma surgery or trauma causing a scleral perforation. Some inflammatory conditions such as uveitis, iridocyclitis and posterior scleritis can affect the ciliary body production of aqueous humour and result in low IOP [12-13]. Retinal detachment is often associated with lower IOP due to increased outflow of fluid through the exposed retinal pigment epithelium [16]. Bilaterally low IOP is rare and suggests a systemic problem such as uraemia, diabetic coma or osmotic dehydration [17].

Conversely, high IOP occurs from reduced outflow of aqueous humour or from increased production. Any process which acutely occludes the drainage trabecular meshwork of the anterior chamber can quickly increase the IOP. In acute angle closure glaucoma, often pupil dilatation results in iris and lens contact causing a pupillary block and closing the drainage angle, resulting in a symptomatically high IOP. Blunt trauma to the orbit can increase IOP through a variety of mechanisms. Damage to the trabecular meshwork, or lens can disrupt the anatomy of the drainage angle. Inflammatory or blood products following trauma through the formation of a hyphaema or vitreous haemorrhage can also interrupt the effective drainage of the trabecular meshwork and increase IOP [15]. Similarly, the presence of infection within the eye such as hypopyon or endophthalmitis can result in the accumulation of inflammatory and infective debris in the drainage angle and typically presents with elevated IOP [18]. Trauma resulting in the accumulation of blood in the retrobulbar space behind the eye, known as a retrobulbar haemorrhage, is often associated with raised IOP and requires urgent surgical intervention to preserve visual function [19]. As well as presenting with low IOP, chronic uveitis can also present with high IOP where inflammatory products within the anterior chamber reduce the outflow from the drainage angle.

It should be noted that ocular emergencies such as vitreous haemorrhages, central retinal artery occlusion and chemical injuries can and often present with normal IOP measurements.

Conclusion

Through technological advances, an IOP measurement is now a quickly and easily performed investigation in the ED which can provide vital information to assist the emergency physician differentiate emergency ocular presentations. There are many factors which can influence an individual's IOP and the technique in which it is measured, therefore as with any diagnostic aid, the IOP measurement should be interpreted within the clinical context of the patient. This tool aims to provide the emergency physician with quickly accessible information on factors that influence IOP, IOP ranges and emergency pathology which can present with high and low measurements.

Addition information

Disclosures

Human subjects: All authors have confirmed that this study did not involve human participants or tissue. Animal subjects: All authors have confirmed that this study did not involve animal subjects or tissue. Conflicts of interest: In compliance with the ICMJE uniform disclosure form, all authors declare the following:

Payment/services info: All authors have declared that no financial support was received from any organization for the submitted work. Financial relationships: All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work. Other relationships: All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.

References

1. Akhilesh S Pathipati, Edward Wood, Carson K Lam, Christopher Sanchez Sales, Darius M Moshfeghi: Intraocular Pressure Measurement In The Emergency Department Is Inconsistently Documented And Significantly Varies From Ophthalmologist IOP. Invest. Ophthalmol. Vis. Sci. 2016, 57(12):6430.
2. Stamper R: A History of Intraocular Pressure and its Measurement . Optom Vis Sci. 2011, 88:16-28. 10.1097/OPX.0b013e318205a4e7.
3. Tonnu P-A, Ho T, Newson T, et al.: The Influence Of Central Corneal Thickness And Age On Intraocular Pressure Measured By Pneumotonometry, Non-Contact Tonometry, The Tono-Pen XL, And Goldmann Applanation Tonometry. Br J Ophthalmol. 2005, 854:89-7. 10.1136/bjo.2004.056622
4. Chui W, Lam A, Chen D, Chiu R: The Influence Of Corneal Properties On Rebound Tonometry . Ophthalmology. 2008, 115:80-4. 10.1016/j.ophtha.2007.03.061
5. Wong TT, Wong TY, Foster PJ, Crowston JG, Fong C-W, Aung T: The Relationship Of Intraocular Pressure With Age, Systolic Blood Pressure, And Central Corneal Thickness In An Asian Population. Invest Ophthalmol Vis Sci. 2009, 50:4097-102. 10.1167/iovs.08-2822
6. Wang YX, Xu L, Wei W Bin, Jonas JB: Intraocular Pressure And Its Normal Range Adjusted For Ocular And Systemic Parameters. The Beijing Eye Study 2011. PLoS One. 2018, 17:0196926-0196926. 10.1371/journal.pone.0196926

7. Mitchell P, Lee AJ, Wang JJ, Rochtchina E: Intraocular Pressure Over The Clinical Range Of Blood Pressure: Blue Mountains Eye Study Findings. Am J Ophthalmol. 2005, 140:131-2. 10.1016/j.ajo.2004.12.088

8. Carel RS, Korczyn AD, Rock M, Goya I: Association Between Ocular Pressure And Certain Health Parameters. Ophthalmology. 1984, 91:311-4. 10.1016/s0161-6420(84)34282-8

9. Baek SU, Kee C, Suh W: Longitudinal Analysis Of Age-related Changes In Intraocular Pressure In South Korea. Eye (Lond). 2015, 625:9. 10.1038/eye.2015.11.

10. Rochtchina E, Mitchell P, Wang JJ: Relationship between age and intraocular pressure: the Blue Mountains Eye Study. Clin Experiment Ophthalmol. 2002, 30:173-5. 10.1046/j.1442-9071.2002.00519.x

11. Badakere SV, Chary R, Choudhari NS, Rao HL, Garudadri C, Senthil S.: Agreement of Intraocular Pressure Measurement of Icare ic200 with Goldmann Applanation Tonometer in Adult Eyes with Normal Cornea. . Ophthalmol Glaucoma. 2021, May-Jun;4(3):238-243. 10.1016/j.ogla.2021.04.002

12. Costa VP, Arcieri ES: Hypotony Maculopathy. Acta Ophthalmologica Scandinavica. 2007, 85(6):586-97. 10.1111/j.1600-0420.2007.00910.x

13. Fannin LA, Schiffman JC, Budenz DL: Risk Factors For Hypotony Maculopathy. Ophthalmology. 2003, 110:1185-91. 10.1016/S0161-6420(03)00227-6.

14. Jonas JB, Wang N, Wang YX, You QS, Yang D, Xu L: Ocular Hypertension: General Characteristics And Estimated Cerebrospinal Fluid Pressure. The Beijing Eye Study 2011. PLoS One. 2014, 9:100533. 10.1371/journal.pone.0100533

15. P T Khaw, P Shah, and A R Elkington: Glaucoma—1: Diagnosis. BMJ. 2004, 10; 328(7431):97-99. 10.1136/bmj.328.7431.97

16. Burton TC, Arafat NI, Phelps CD: Intraocular Pressure In Retinal Detachment. Int Ophthalmol. 1979, 1:147- 52. 10.1007/BF00137492.

17. Schleis MN, Atanasoff TL: Bilateral Ocular Hypotony Secondary To Dehydration Clin Exp Optom. 2022, 3:340-1. 10.1080/08164622.2021.1947744

18. Schwartz SG, Flynn HWJ, Das T, Mieler WF: Ocular Infection: Endophthalmitis. Dev Ophthalmol. 2016, 55:176-88. 10.1159/000431195

19. Bojikian KD, Stein AL, Slabaugh MA, Chen PP: Incidence And Risk Factors For Traumatic Intraocular Pressure Elevation And Traumatic Glaucoma After Open-Globe Injury. Eye (Lond). 2015, 29:1579-84. 10.1038/eye.2015.173.