

The pressure phosphene tonometer—a clinical evaluation

GSM Chew¹, GF Sanderson² and ACB Molteno²

LABORATORY STUDY

Abstract

Aims Pressure phosphene tonometry is said to assess intraocular pressure by inducing a pressure phosphene. This study compared the results of this relatively new technique with Goldmann applanation tonometry.

Methods A total of 100 patients (196 readings) in a general ophthalmology clinic at Dunedin Hospital who consented to take part in this study were randomised to receive by different examiners either pressure phosphene tonometry by a ProviewTM eye pressure monitor (Bausch & Lomb Inc., Tampa, FL, USA) or Goldmann tonometry first. There was no communication between the examiners regarding results.

Results Of the 196 attempted readings, pressure phosphene tonometer readings were only able to be obtained for 136 eyes (69%) compared to all 196 (100%) eyes with the Goldmann tonometer. The mean IOPs were 18.5 mmHg using the pressure phosphene tonometer and 16.0 mmHg using the Goldmann tonometer. The mean difference was +2.43 mmHg (95% confidence interval: 10.37 mmHg below to 15.22 mmHg above Goldmann readings).

Conclusion This study found that 31% of patients could not perceive a pressure phosphene using the ProviewTM eye pressure monitor. Data obtained from those who could perceive the phosphene indicated that large discrepancies between pressure phosphene tonometry and Goldmann tonometry were common.

Eye (2005) 19, 683–685. doi:10.1038/sj.eye.6701600
Published online 11 June 2004

Keywords: pressure phosphene tonometry; glaucoma; evaluation; intraocular pressure

Introduction

Pressure phosphenes were known to Aristotle. Mariotte further elaborated on them in 1681.¹ In

1802, Young² described a bright phantom caused by pressure and in 1823 Purkinje described the subjective impression of a bright central area surrounded by a dark ring with an outer bright halo in some detail.³ A pressure phosphene is usually described as a glow, with arcuate or circular characteristics, and is perceived in the visual field opposite to the area of pressure. If the object applying the pressure is small, the centre of the perceived area appears light with a dark surround and a bright outer portion.

However, this appearance is not universal and published descriptions of the phosphenes vary considerably, being described by Helmholtz as 'If the object that exerts the pressure is not large, the phenomenon usually has a bright centre surrounded by a dark ring and by an outer dark one. To the writer it is the brightest when pressure is exerted at or near the equator of the eye where the sclerotica is the thinnest. The pressure-image appears then on the edge of the dark visual field as a bright arc, nearly semicircular in form.'³ Helmholtz's drawing of his pressure image shows it consisting of a dark spot traversed by a bright vertical band while he points out that 'On the other hand, in a dark visual field there is a bright yellowish circular area within which there is sometimes a dark spot or a dark ring. A dim light is also seen at the entrance of the optic nerve...'³ The authors of this paper are unable to appreciate a localised pressure phosphene as described although slightly longer pressure produces kaleidoscopic displays that are discussed by Helmholtz; thus 'Purkinje has studied these phenomena very carefully, and accurately described and represented them. They seem to have had a high degree of regularity for him. The background generally consisted of fine quadrangles in regular array, on which there were either stars with eight rays, or dark or bright rhombs with vertical and horizontal diagonals; and the patterns were surrounded by alternately bright and dark

¹Eye Department
Dunedin Hospital
Dunedin, New Zealand

²Section of Ophthalmology
Department of Medical and
Surgical Sciences
University of Otago
Dunedin School of Medicine
Dunedin, New Zealand

Correspondence:
ACB Molteno
Ophthalmology Section
Department of Medical and
Surgical Sciences
University of Otago Dunedin
School of Medicine PO Box
913
Dunedin, New Zealand
Tel: +64 3 474 7970
Fax: +64 3 474 7628
E-mail: tui.bevin@
stonebow.otago.ac.nz

Received: 11 November
2003

Accepted: 29 March 2004
Published online: 11 June
2004

None of the authors have
any proprietary interest in
intraocular pressure
measuring devices.

bands. In the author's own experience there is not such regularity in the figures.³

The source of pressure phosphenes in the retina is thought to be the bipolar cells, or parts of the rods and cones (photoreceptor nuclei, axons, and terminals), situated anterior to the external limiting membrane.⁴

Pressure phosphene tonometry, based on the entoptic phenomenon of pressure phosphenes, was introduced by Fresco⁴ who has published the only study to date validating the technique by comparing the results of pressure phosphene tonometry with Goldmann applanation tonometry.^{5,6}

Pressure phosphene tonometry is inherently safe, portable, and relatively easy to perform. If reliable, it would be a valuable method for measuring intraocular pressure (IOP). This report compares IOP measurements obtained by pressure phosphene tonometry and Goldmann applanation tonometry in 100 patients attending a general ophthalmology clinic at Dunedin Hospital in 2002.

Materials and methods

The pressure phosphene tonometer (PPT), Proview™ eye pressure monitor (Bausch & Lomb Inc., Tampa, FL, USA), is a spring compression device calibrated in millimetres of mercury and consists of a probe with a flat applicator the same diameter (3.06 mm) as the area applanated by the Goldmann tonometer (GT). Although the PPT was designed for self-use, the IOPs in this study were measured by the medical staff of the ophthalmology clinic to match the situation in Fresco's original study.

Consecutive patients being assessed in general ophthalmology clinics at Dunedin Hospital in July 2002, who required routine IOP measurement as part of their examination, were approached to participate in this study. Those who consented to participate were informed about the technique and the appearance of the expected phosphene using the artist's impressions in the Bausch & Lomb Inc. information pamphlet.

Two Proview™ eye pressure monitors were used by one clinician (GSMC) to perform pressure phosphene tonometry in order to eliminate interobserver variability and instrument error. The PPT was applied to a closed eyelid without topical anaesthetic. The patient was instructed to abduct and depress his/her eye. The PPT was placed on the superior nasal portion of the eyelid. Increasing force was gently applied. Initially, a phosphene was induced with greater force than required in order to familiarise the patient with a phosphene. Subsequently, the patient was instructed to indicate as soon as the pressure phosphene was perceived with the PPT in place. The IOP was read off the graticule. The

graticule has a fiducial indicator that does not move from the highest reading until reset. The use of the superior nasal aspect was chosen as described by Fresco. This area was easy to access and produced a phosphene most readily. This corresponds to the inferotemporal visual field.⁴ In cases where the patient could not perceive a phosphene at the first attempt, the patient was rested for 5 min and after checking that the explanation had been clearly understood the PPT was applied again. This process was repeated for a total of five attempts before deciding that the patient could not perceive a phosphene. Any error in the PPT readings as a result of the massage effect of repetition would be in the direction of lowering the PPT reading.

Goldmann tonometry was performed by four experienced nurses who were responsible for routine tonometry in ophthalmology clinics using seven different, regularly calibrated Goldmann tonometers mounted on Haag Streit slit lamps. To obtain readings by the GT, one drop of proxymethacaine hydrochloride 5 mg/ml was instilled and then a fluorescein strip applied to the palpebral conjunctiva of the lower lid. Fixation was in the primary position of gaze.⁷

Patients were randomised to receive either PPT or GT first and the readings were attempted within 5 min of each other. There was no communication between the examiners. Results were analysed with reference to Bland and Altman's guidelines.⁸ Ethical approval was obtained from the Otago Ethics Committee.

Results

In total, 196 eyes of 100 patients were tested. The age range was 21–90 years (median 73 years). GT readings were obtained for all 196 (100%) eyes. Of the 196 attempted readings, PPT readings were able to be obtained for 136 (69%), 68 (50%) of whom required more than one attempt to perceive a pressure phosphene. The mean IOPs were 18.5 mmHg (range 8–32 mmHg, SD 5.1 mmHg) using PPT and 16.0 mmHg (range 9–37 mmHg, SD 4.3 mmHg) using GT (Figure 1). Overall, the mean difference (PPT-GT) was +2.43 mmHg; however, there was wide scatter with 95% confidence intervals ranging from 10.4 mmHg below to 15.2 mmHg above Goldmann readings (Figures 1 and 2). Analysis excluding an outlier (who had recurrence of herptic keratouveitis with corneal oedema but no bullae) with –32 difference between the PPT and GT readings revealed limits of agreement (95% CI) of 9.9 below and 15.3 above Goldmann readings.

PPT readings for two eyes were obtained for 59 patients. These observations were not independent in the statistical sense and limits of agreement adjusted for multiple observations for two eyes on the same patient

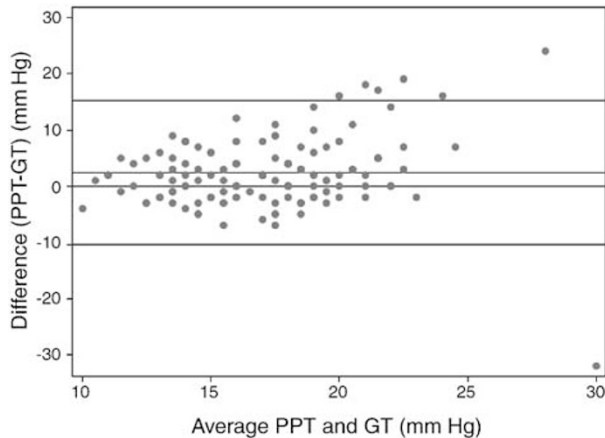


Figure 1 Plot of the difference between PPT and GT readings vs the average PPT and GT readings.

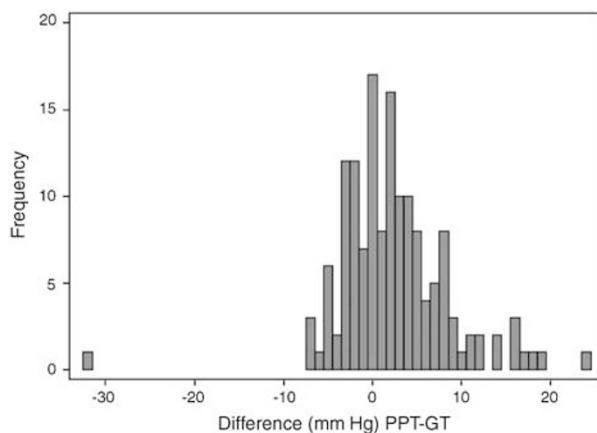


Figure 2 Frequency histogram of the difference between the PPT and GT readings.

were slightly wider at 11.1 mmHg below to 15.7 mmHg above Goldmann readings.

Discussion

In Fresco's initial report, the mean difference between GT and PPT was 0.3 mmHg below GT in a series of 192 eyes from 100 patients.⁴ However, Fresco's analysis did not take into account inherent statistical dependence when two eyes of a single patient were measured. We have calculated the 95% confidence interval for mean IOP

difference from Fresco's data at 4.3 mmHg below to 4.9 mmHg above Goldmann readings.

In our study, 31% of patients could not detect a phosphene compared to 3% of Fresco's patients,⁴ while half of the patients who eventually did perceive a phosphene required more than one attempt to do so. The expected effect of these repeated applications of the PPT before eliciting the phosphene would be to lower the PPT reading and reduce the difference between mean PPT and GT readings. Our data showed a difference between mean IOP readings of 2.43 mmHg above GT with a 95% confidence interval that the GT reading was between 11.1 mmHg below and 15.7 mmHg above GT. This widespread range indicates that PPT readings cannot be relied on as reliable measures of IOP.

Acknowledgements

We thank Sheila Williams, biostatistician, Department of Preventative and Social Medicine, Dunedin School of Medicine, for statistical advice; Tui Bevin for help with manuscript revision; and Dr Harry Bradshaw, Margaret O'Connell, Barbara Bucke, Vise Elisara and Vivian Harwood for help with data collection.

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