

Application of the ICare Rebound Tonometer in Healthy Infants

Anna Lundvall, MD, PhD, Helena Svedberg, MD, and Enping Chen, MD, PhD

Purpose: To study the tolerability of the ICare rebound tonometer (RBT) and to establish reference values of the intraocular pressure (IOP) in healthy infants.

Participants and Methods: Forty-six children were recruited. In 6 infants aged 3 to 18 months, it was not possible to conduct the examination. Five children refused all cooperation. In 1 child, only 1 reading was obtained. In 1, partly uncooperative infant, the difference between the highest and the lowest reading exceeded 3 mm Hg (a difference of 7 mm Hg). These 7 infants were excluded. Totally 39 children, 22 girls and 17 boys, aged 1 month to 36 months were included in the study. The mean age was 14 ± 9 months [mean \pm standard deviation (SD)]. One randomly selected eye of each child was examined with the ICare RBT. Three consecutive readings were made. In 10 children, IOP measurements were conducted twice with an interval of 10 to 30 minutes by 2 different ophthalmologists.

Results: The mean IOP value of the 39 infants was 11.82 ± 2.67 mm Hg. The median value was 10 mm Hg with a range of 7.3 to 17.0 mm Hg. In 10 children, the IOP was determined by 2 examiners. The results were virtually identical with differences of 0 to 1 mm Hg in 9 out of 10 children. The mean difference between Examiner 1 and Examiner 2 (0.77 mm Hg) was not statistically significant ($P > 0.20$). The examinations were very well tolerated, and no child showed any sign of discomfort during or after the examination.

Conclusions: The hand-held RBT in the present study is easy to use, it does not require topical anesthesia and it is very well tolerated by cooperative infants. However, 7 out of 46 infants refused cooperation.

Key Words: IOP, ICare, rebound tonometer

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Childhood glaucoma is a rare but serious condition often leading to visual impairment and even blindness. Diagnosis is important, as treatment can prevent visual handicap.

The diagnosis and management of glaucoma in children pose intricate problems. Clinical examination in infants is known to be difficult, particularly in the context of accurate glaucoma diagnosis. Anterior segment signs, tonometry, and optic nerve examination are often inad-

quate, and perimetry cannot be reliably done. Tonometry is a cornerstone of the diagnosis and in the management of glaucoma. For decades, Goldmann applanation tonometry (GAT) has been the golden standard for measuring intraocular pressure. However, infants are not cooperative and intraocular pressure (IOP) measurement with the Goldmann tonometer is not possible. There are several other instruments, for example the Perkins hand-held applanation tonometer and pneumatonometers, but these often require general anesthesia in small children. General anesthesia is a risk for the patient and is resource demanding and may affect the IOP.¹ Tonopen (Medtronic Ophthalmics, Jacksonville, FL) is used in small children without general anesthesia, but it requires topical anesthesia that often causes discomfort. Thus, there is a need for a hand-held tonometer suitable for infants. The ICare tonometer (Fig. 1) is based on the impact rebound principle (Decking and Coster 1967).² This method was modified and developed by Kontiola.³ The device was tested on experimental animals, which showed good accord with manometrical IOP determinations.⁴ The device consists of a probe with a magnetic shaft introduced into a solenoid. The probe is disposable and has a plastic cover. It is 24-mm long,



FIGURE 1. The rebound tonometer (ICare). The distance between the probe and the central cornea is about 5 to 8 mm.

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From the St. Erik Eye Hospital, Karolinska Institute, Stockholm, Sweden.

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Reprints: Anna Lundvall, MD, PhD, St. Erik Eye Hospital, Polhemsgatan 50, S-112 82 Stockholm, Sweden (e-mail: anna.lundvall@sankterik.se).

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weighs 11 mg, and is magnetic. An electrical pulse generator creates a magnetic field that repels the probe that moves toward the cornea, impacts, and rebounds. The probe causes a voltage in the solenoid and the deceleration signal is analyzed. Deceleration increases with increased intraocular pressure. The instrument is portable and hand-held. Its main advantages are that the instrument is quick, easy to use, and topical anesthesia is not required, as the measuring probe touches the eye so swiftly and gently that it is barely noticeable. In school children, measurement of IOP with the ICare rebound tonometer (RBT) is a highly reproducible method showing high intraobserver and interobserver correlation.⁵

The purpose of our study was to evaluate the tolerability of ICare RBT and to provide reference values of IOP in healthy children aged 1 month to 36 months.

PARTICIPANTS AND METHODS

The study was conducted in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki. Informed consent for participation was obtained from each participant's parent before the study.

We used the ICare RBT to measure the IOP of randomly chosen 1 eye each of the 39 white, healthy, cooperative, awake children (22 girls and 17 boys) aged 1 month to 3 years (mean 14.0 ± 9 mo, median 10 mo). Forty-six children were recruited. Twenty-nine were recruited from a child welfare centre, and 17 were recruited from children seen at the clinic because of suspected strabismus. None of the children had signs of glaucoma, corneal disorders, or high refractive errors. None was on medication. All cooperative participants were sitting quietly on their parent's lap, and the measurement was done, when the child was calm and not crying with eyes open without assistance. The IOP measurements were conducted by 2 experienced ophthalmologists (Examiner 1, AL and Examiner 2, HS). Older children were asked to look straight ahead to a far point. Infants usually spontaneously fixated the instrument. The distance from the tip of the probe to the central cornea was aimed to be 5 to 8 mm. The readings were taken within a few seconds. Three consecutive IOP readings were obtained in one randomly chosen eye in each of the 39 children. Initial experiences with the ICare tonometer showed that it is often difficult to obtain the 6 readings recommended in the ICare software in infants. Hence, we chose to limit the examination to 3 IOP readings. The IOP values reported are the means of 3 readings. The examination was excluded, if the difference between the lowest and the highest reading exceeded 3 mm Hg. For statistical analysis, data from one eye of each child was randomly selected.

RESULTS

For 6 infants aged 3 to 18 months, it was not possible to conduct the examination; 5 children refused any cooperation. For 1 child, only 1 reading was obtained. For 1, partly uncooperative infant, the difference between the highest and the lowest reading exceeded 3 mm Hg (a difference of 7 mm Hg). These 7 infants were excluded. Otherwise, the examinations were very well tolerated by the cooperative infants and none of these children showed any signs of discomfort.

The mean IOP value in the 39 children was 11.82 ± 2.67 (SD) corresponding to a 95% confidence

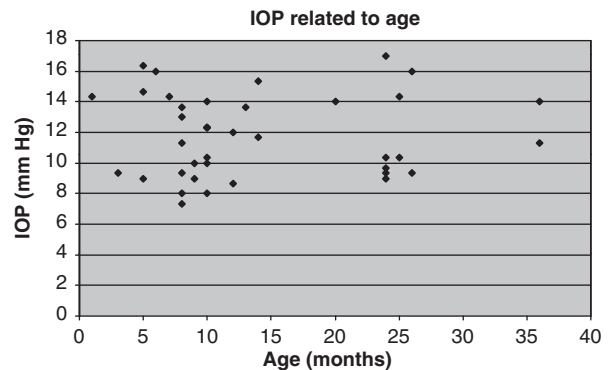


FIGURE 2. IOP in healthy infants.

interval of 6.5 to 17.2 mm Hg. The median value was 10 mm Hg with a range of 7.3 to 17.0 mm Hg. There was no correlation ($r = 0.04$) between IOP and age in this group (Fig. 2).

For 10 children (3 boys and 7 girls with a median age of 8 mo), the IOP measurements were obtained by 2 experienced ophthalmologists (Examiner 1, AL and Examiner 2, HS) with an interval of 10 to 30 minutes. Examiner 2 had no information of the results of Examiner 1. The results are based on 3 readings. The results were virtually identical with differences of 0 to 1 mm Hg in 9 out of 10 children. In 1 girl aged 8 months, the difference was considerable (13.7 mm and 8.0 mm Hg). The mean value of Examiner 1 (12.5 ± 3.4 mm Hg) was not statistically different from that of the mean value of Examiner 2 (11.8 ± 0.8). The mean difference of 0.77 mm Hg was not statistically different ($P > 0.20$), and the results of Examiners 1 and 2 were highly correlated ($r = 0.89$).

The mean variance of triplicate readings was 0.56 mm Hg corresponding to a SD of 0.75. The coefficient of variance based on single readings was 6.3% and based on triplicates, 3.6%.

DISCUSSION

IOP measurement is often indicated in pediatric ophthalmology. IOP measurements with conventional methods, however, are difficult to do in infants. There is great need for a reliable tonometer which can be accepted by small children in order to minimize the need for general anesthesia. The ICare RBT has been extensively evaluated in adults and was reported to give reproducible results.⁶⁻¹⁵ According to several studies, there is a good accordance between IOP values obtained with the Goldmann applanation tonometer (usually considered to be the golden standard) and IOP values obtained with the ICare RBT. The values obtained with the ICare RBT, however, were reported to be consistently higher than values obtained with the GAT. The mean difference between the 2 methods has been reported to be 0.43 to 3.4 mm Hg in adults.^{7-9,11,12,14,16,17} However Munkwitz et al¹⁸ found that in the higher IOP range (23 to 60 mm Hg), the deviation was considerably larger making the ICare method less reliable in the higher range. The ICare tonometer has been compared with other portable tonometers, that is, Tonopen XL (Medtronic Ophthalmics, Jacksonville, FL) and the Perkins applanation tonometer in young adults. ICare and tonopen give similar results, but systematically overesti-

mate the IOP compared with the Perkins tonometer.¹⁹ To our knowledge, there are no studies of the tonopen in awake infants in this age group.

Even with experienced personnel, it is often complicated and sometimes impossible to conduct IOP examination in infants without general anesthesia. In a similar agegroup, Pensiero et al²⁰ could not conduct examination with a pneumotonometer in about one third of the children. Hence, we found it necessary to simplify the procedure and therefore reduced the readings from the recommended 6 to 3 readings. The measure error is small in cooperative infants.

One source of variation is the central corneal thickness; the IOP is positively related with the corneal thickness in most tonometers.^{11,21,22} Central corneal thickness was not measured in this study. The corneal thickness in healthy children in this age group shows small variation; so, this source of error should be of less importance.²³ However, in pediatric glaucoma patients, the central corneal thickness might be higher when compared with controls that should be taken into consideration when using ICare for monitoring these patients.

The interobserver repeatability was high in 9 out of 10 children with virtually identical IOP values for the 2 examiners. In 1 girl aged 8 months, there was a great difference between the IOP values obtained by the 2 examiners. In non cooperative children, reiterated examinations may be necessary. The IOP is lower in children than in adults.²⁰ There was no correlation with age in this series, probably owing to the limited age span.

There are few studies of IOP conducted in infants without general anesthesia. Pensiero et al, using a pulsair tonometer, reported mean values of 71 awake children, subdivided in groups of 0 to 1 years, 1 to 2 years and 2 to 3 years and obtained mean values of 10.6, 12.0 and 12.7 mm Hg, respectively. Thus, the IOP values in that study were of the same order as in our study. The variance was also of the same order.²⁰ The ICare was used in 152 school children.⁵ This method was found to be highly reproducible and very comfortable. Only a few children experienced slight discomfort. The ICare was compared with Tonopen XL in 69 premature infants. The IOP values were significantly lower measured with ICare (mean 9 mm Hg) than Tonopen (mean 16 mm Hg). It was suggested that the Tonopen values were probably falsely elevated owing to discomfort reactions to the anesthetic drop installation.²⁴

However, there is no information available on the normal IOP range of healthy infants measured with the ICare tonometer.

The main limitation of the present and similar methods is the lack of cooperation from many infants; sometimes it is not possible to conduct IOP examinations in infants without general anesthesia.

In conclusion, the hand-held rebound tonometer in the present study is easy to use; it does not require topical anesthesia and it is very well tolerated by cooperative infants.

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