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Optic disc measurements in full-term infants

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Abstract

Background

The objectives of this study were to measure optic disc size in full-term infants and to determine whether this value is influenced by sex or birth weight.

Methods

Retinal images from a cohort of full-term infants admitted to a tertiary perinatal centre were obtained using a retinal camera. Optic disc size was measured by carefully delineating the outline with a cursor using image analysis software. We then systematically searched MEDLINE to compare our data with other published articles.

Results

Thirty-five images of left and right eyes from 35 infants were assessed. Image from one eye per patient was then chosen for analysis. The following results were found: mean birth weight $3050 \pm 706$ g; and gestation $38.9 \pm 1.4$ weeks. Mean optic disc area was $1.26 \pm 0.23$ mm$^2$; mean vertical diameter was $1.37 \pm 0.15$ mm; and mean horizontal diameter was $1.14 \pm 0.12$ mm. The vertical diameter of the optic disc was significantly longer than was the horizontal diameter ($p < 0.0001$).

Conclusion

Birth weight and sex does not influence the size of optic disc in term infants. There were no differences in the optic disc measurements between male and female infants and between low birth weight and normal birth weight infants.
Introduction

Increasing data indicate that birth weight could influence optic nerve head parameters as a person grows (1-3). Low birth weight (LBW) infants (< 2500 g)(4) have been associated with smaller optic disc diameters and larger cup/disc ratios(1). This finding has been proposed to imply a future risk of developing glaucomatous optic disc neuropathy(1). Infants who were born prematurely and who developed adverse events in the prenatal and perinatal periods could develop abnormal optic nerve morphology during childhood(2). Young adults born with a LBW have been shown to display decreased neuroretinal rim size compared with those who were born with a normal birth weight (NBW)(3). It is unknown whether this observed reduction is because of a reduction in axonal area that is restricted to the optic nerve or a more global manifestation of neuronal growth in the brain. It is also unknown whether optic disc abnormality was present at birth in LBW infants or whether growth was impaired. Although a few studies have described optic disc size in children (5-9), the literature available on normal optic disc size at birth in full-term infants is limited. The objectives of this study, therefore, are to measure optic disc size from digital retinal images taken from full-term infants and to determine whether this value is influenced by sex or birth weight. Digital retinal imaging is as an important tool in newborn ophthalmological examination. The ability to store and retrieve images is advantageous from a medico-legal perspective and the ability to transfer images electronically makes it a valuable tool in telemedicine.
We also carry out a literature review to compare the presented results with other published studies.

Materials and Methods
This cross-sectional study was carried out in the Department of Neonatology, Townsville Hospital, Queensland, Australia. The Department of Neonatology is a tertiary perinatal centre that is responsible for more than 10,000 births each year. The study commenced in August 2010, and the data presented in this report are based on patients who were recruited until July 2011. All assessments were performed within the first seven days of life. Babies were classified according to their birth weights:(4) those with birth weights of < 2,500 g were classified as LBW babies, babies weighing 2,500–4,499 g were classified as NBW babies, and babies with birth weights of 4,500 g or more were classified as exceptionally large babies. Only babies who were born full-term (37 weeks of gestation completed; up to 42 weeks of gestation )(4) were included in this study. Infants with syndromes, infants born to diabetic mothers, infants with a history of congenital abnormalities or infection, and infants requiring respiratory support were excluded from this study. This study was approved by the Townsville Health District Human Research Ethics Committee and was conducted in accordance with good clinical practice guidelines, institutional review board regulations, and the tenets of the Declaration of Helsinki. Written consent was obtained from the parents of the infants.

Infants’ pupils were dilated with 2.5% phenylephrine and 0.5% cyclopentolate eye drops. After pupillary dilation, digital images of both retinas were obtained using a digital retinal camera (RetCam, Clarity Medical Systems Inc, Pleasanton CA, USA). Similar to the methodology from a previously published study that measured optic
disc size in neonates, one (best) image was selected from each infant for analysis(10). Eyes with unfocused or poorly centred disc images were considered unsuitable and were excluded (11, 12). Optic disc size was measured according to previously published techniques(12) by carefully delineating the outline with a cursor using image analysis software (Photoshop Extended CS5; Adobe Systems Incorporated, San Jose, CA, USA). The areas and vertical and horizontal diameters were then calculated by the software. The optic disc was defined by the inner border of the scleral rim surrounding the nerve tissue. Conversion from pixels to millimeters was based on a calibration provided by the manufacturer of the retinal camera (0.0176 mm/pixel with an 80° lens). An intraclass correlation coefficient (ICC) was used to determine the reliability of this technique(13).

We systematically searched MEDLINE (US National Library of Medicine) for published articles using the following keywords: optic disc, size, measurements, newborn, infants, neonates, and childhood. Searches were restricted to English language articles published between January 1, 1970 and May 31, 2011. Statistical analyses were performed using MedCalc Version 11.6 (MedCalc Software bvba, Mariakerke, Belgium). The student’s t-test was used with p values < 0.05 considered significant. Mean values with standard deviations are provided where appropriate. The normality of the variables was determined using the D’Agostino–Pearson test(14).

Results

A total of 267 full-term infants were admitted to the department during the study period. Of these babies, 112 were suitable for recruitment, and their parents
were approached for participation. Consent was ultimately obtained for 35 infants.

Thirty-five images of left and right eyes from 35 full term infants were assessed. The mean gestation was 38.9 ± 1.4 weeks. Only one eye was included for each infant, and the best quality image was selected from the right and left eyes. Mean optic disc size was 1.26 ± 0.23 mm²; mean vertical diameter was 1.37 ± 0.15 mm; and mean horizontal diameter was 1.14 ± 0.12 mm. The vertical diameter of the optic disc was significantly longer than was the horizontal diameter (p < 0.0001). Optic disc size and horizontal and vertical diameter had normal distributions. Table 1 compares male and female infants regarding birth parameters and optic disc sizes. Furthermore, optic disc size was not influenced by birth weight (Table 2). The results of this study were compared with previously published reports that investigated optic disc size in newborn infants (Table 3). The ICC was 0.87 (95% CI (0.66–0.95)).
Table 1. Birth parameters and optic disc sizes in male and female infants.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Overall</th>
<th>Female</th>
<th>Male</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number</td>
<td>35</td>
<td>20</td>
<td>15</td>
<td>–</td>
</tr>
<tr>
<td>Birth weight (g)</td>
<td>3050 ± 706</td>
<td>2917 ± 716</td>
<td>3229 ± 675</td>
<td>0.2</td>
</tr>
<tr>
<td>Length (cm)</td>
<td>48.4 ± 3.1</td>
<td>47.9 ± 3.0</td>
<td>49.1 ± 3.1</td>
<td>0.2</td>
</tr>
<tr>
<td>Mean disc area</td>
<td>1.26 ± 0.23</td>
<td>1.24 ± 0.24</td>
<td>1.28 ± 0.22</td>
<td>0.6</td>
</tr>
<tr>
<td>(mm²)</td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>
Table 2. Comparison of optic disc sizes in LBW and NBW Full term infants.

<table>
<thead>
<tr>
<th>Variables</th>
<th>LBW</th>
<th>NBW</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of infants</td>
<td>11</td>
<td>24</td>
<td>–</td>
</tr>
<tr>
<td>Birth weight (g)</td>
<td>2266 ± 202</td>
<td>3410 ± 539</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>Length (cm)</td>
<td>45.3 ± 1.4</td>
<td>49.8 ± 2.4</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>Mean disc area (mm²)</td>
<td>1.31 ± 0.21</td>
<td>1.24 ± 0.24</td>
<td>0.3</td>
</tr>
</tbody>
</table>
Table 3. Published studies on disc measurements in full-term neonates.

<table>
<thead>
<tr>
<th>Authors</th>
<th>Type of study</th>
<th>Gestational age (weeks)</th>
<th>No. of eyes</th>
<th>Horizontal disc diameter (mm)</th>
<th>Vertical disc diameter (mm)</th>
<th>Mean disc area (mm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rimmer et al.</td>
<td>Post-mortem</td>
<td>&lt; 40 weeks</td>
<td>20</td>
<td>0.93 ± 0.15</td>
<td>1.10 ± 0.21</td>
<td>0.82 ± 0.26</td>
</tr>
<tr>
<td>De Silva et al.</td>
<td>Digital retinal imaging</td>
<td>30.1 ± 4.7</td>
<td>51</td>
<td>1.05 ± 0.13</td>
<td>1.41 ± 0.19</td>
<td>1.17 ± 0.26</td>
</tr>
<tr>
<td>Present study</td>
<td>Digital retinal imaging</td>
<td>38.9 ± 1.4</td>
<td>35</td>
<td>1.14 ± 0.12</td>
<td>1.37 ± 0.15</td>
<td>1.26 ± 0.23</td>
</tr>
</tbody>
</table>
Discussion

This study provides baseline normal values for future studies. It is also the first study to compare optic size measurements between male and female neonates and between LBW and NBW neonates during infancy. We showed that there is no significant differences in optic disc size in male and female infants, similar to findings in adults(15).

Only two other published studies (5, 10) on optic disc size in full-term infants have been conducted during infancy (Table 3). The study by De Silva et al. used a combination of premature and full-term infants, with a mean gestational age of 30.1 ± 4.7 weeks (range 23–40)(10). The study by Rimmer et al. was based on autopsy findings. However, there were concerns that paraffin embedding and formalin used in the preparation of the tissue samples might have altered the findings(5). Meanwhile, Hellstrom et al. investigated children aged 3 to 9 years(6).

Optic disc size is likely to be determined by a combination of the number and calibre of existing nerve axons, number and volume of neuroglial cells, number of formed ganglion cells, and percentage of ganglion cells lost during embryogenesis(15, 16). Using human foetuses, Provis et al. showed that at least 70% of the optic axons generated during the development of the primary visual pathway are lost during fetal life(16). Part of this loss might occur as a result of the refinement of the terminal distribution of ganglion cell projections within their target nuclei. Axonal loss from the human fetal optic nerve occurs most rapidly between approximately 16 and 20 weeks of gestation. After this period, the number of optic nerve axons remains static
at approximately 1.3 million nerve fibres(16). The number of axons in adults has been shown to be between 1.1 and 1.3 million(17). In a study carried out on adults, the mean optic disc area measured 2.69 ± 0.70 mm², mean diameter horizontally 1.76 ± 0.31 mm, and vertically 1.92 ± 0.29 mm (15). The cause for an increase in optic disc size from infancy is not well established. Rimmer et al. proposed that the growth in size is caused by a differential increase in neural glia and septal elements(5). Similar conclusion was made by Dolman et al. after performing histological studies of optic nerve in 300 autopsy specimens from subjects ranging in age from birth to 96 years(18).

The presented data also suggest that there is no difference in optic disc size between LBW and NBW infants. The most common cause of LBW is uteroplacental insufficiency, which results in fetal hypoxia (19, 20). In response to hypoxia, the fetus uses a compensatory mechanism to redistribute cardiac output and blood supply to the brain to maintain constant blood delivery to this organ (the head-sparing effect)(21). We postulate that this head-sparing mechanism would have prevented any reduction in optic nerve growth in utero. Optic discs stop increasing in size by the age of three years with most of the growth occurring in the first 12 months of life (5, 11). LBW individuals have been shown to have smaller and abnormal optic disc measurements in comparison with NBW children(1) and young adults(3).

One of the main limitations of this study is the inability to account for any refractive errors that could have influenced the measurements (22). In adult and children’s eyes, corrections can be applied to compensate for inaccuracies in the measurements of retinal structure that occur because of refractive error; these corrections require ocular biometric measurements, including axial length, anterior chamber depth, lens thickness, vitreous chamber depth parameters, and keratometry.
These measurements can easily be acquired in adults and young children. However, these calculations are more challenging in infants because of the continued growth of the eye and the inability of infants to remain still while measurements are taken. The presented study is also limited by its relatively small sample size. Approximately one-third of the parents approached in this study agreed to let their children participate. In the future, the use of a non-contact retina camera could increase this consent rate.

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Competing Interest: None

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Reference


