Brief Report

Developing Nomogram to Estimate Birth Weight from Head Circumference and Mid-Upper Arm Circumference

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Summary

Background: Despite the huge proportion of the babies in the developing world being born low birth-weight, only about half of the newborns are weighed at birth as weighing scales often tend to be either non-available or defective.

Objective: Designing a nomogram for estimation of birthweight from head circumference (HC) and mid-upper arm circumference (MUAC).

Method: Birthweight, HC and MUAC of 500 newborns who were admitted in the baby nursery of Medical College and Hospital, Kolkata between July 2010 to December 2010 were measured.

Results: Multiple linear regression equation for prediction of birth weight from MUAC and HC was derived and a nomogram was constructed from the same.

Conclusion: The birthweight estimation nomogram is an inexpensive and convenient tool for use in the community setting where weighing machines may not be always available and may thus allow prompt and early referral.

Key words: Nomogram, head circumference, mid-upper arm circumference, birthweight.

Introduction

Low birthweight (LBW) babies account for 17% of all births in the developing world—a rate more than double the level in industrialized countries (7%) [1]. These LBW babies contribute to 60–80% of neonatal deaths [2]. Despite the huge proportion of the babies in the developing world being born LBW, only about half of the newborns are weighed at birth as weighing scales often tend to be either non-available or defective and for a smaller proportion of them gestational age is known [3]. Therefore, there is a need to develop simple, inexpensive and practical methods to identify LBW newborns soon after birth [4]. One such method could be the use of anthropometric surrogates to identify LBW babies. With the help of such measures, the birth attendant should be able to estimate birthweight even if weighing machines are unavailable and identify and refer the high risk babies to appropriate health facilities without the use of more complicated charts to assess gestational age.

Objective

Developing a nomogram for prediction of birthweight from mid-upper arm circumference (MUAC) and head circumference (HC), which will allow health workers to estimate birthweight easily without the help of weighing machines.

Materials and methods

A cross-sectional study was carried out at the baby nursery of the Department of Pediatrics, Medical College and Hospital, Kolkata between July 2010 and December 2010 after obtaining permission from the Institutional Ethics Committee. Five hundred newborns delivered at the Gynecology and

Acknowledgements

S.D. who is overall guarantor conceived and designed the study; M.G. and S.M. were involved in collection, analysis and interpretation of data, they also drafted the manuscript; R.C., A.K.D. and S.C. revised the manuscript and gave final approval to the version to be submitted to the journal.
Obstetrics department of the same hospital and admitted in Nursery were selected by simple random sampling method and chosen as the study population. Newborns who were still born, those with congenital anomalies, dysmorphic features or >7 days old were excluded from the study. Informed consent was taken from guardian of the babies to participate in the study.

**Anthropometric measurements**

**Birthweight.** All the newborns were weighed naked soon after birth while still in the delivery room on an electronic weighing scale by an attending nurse or the neonatologist.

**Circumferences.** To avoid inter observer bias all measurements were taken by one of the investigators (Moumita Ghosh), according to standard methods [5]. The HC was measured on Day 2 or 3 of life to avoid errors due to caput formation and head moulding commonly seen on the first day of life. For our convenience, MUAC was also measured at the same time. A non-extendable and flexible measuring tape with a width of 1 cm and subdivisions of 0.1 cm was used for this purpose.

The HC was measured with the newborn in dorsal decubitus position. The measuring tape was placed along the occipital-frontal circumference, just over the eyebrows and the occiput, in order to obtain the largest measurement. The maximum value of three consecutive measurements was considered, rounded to the nearest 0.1 cm [6].

The MUAC was obtained from the left arm, at the midpoint between the tip of the acromion and olecranon process, with the newborn in dorsal decubitus with the arm lying laterally to the trunk. The midpoint was located by measuring the distance between the acromion and olecranon extremities, with the elbow flexed at an angle of 90°. A small mark was made at the identified point. A total of three consecutive measurements were taken for each newborn, and the mean value (rounded to the nearest 0.1 cm) was considered for analysis.

**Data Analysis.** Multiple linear regression equation was developed for predicting birthweight from combination of HC and MUAC using the procedure of multivariate regression analysis. Finally, nomogram was devised from the multiple regression equation to predict birthweight.

A nomogram is a graphical calculating device. Typically it has three scales: two scales represent known values and one scale is the scale where the result is read off. The known scales are placed on the outside; i.e. the result scale is in the center. Each known value of the calculation is marked on the outer scales and a line is drawn between each mark. Where the line and the inside scale intersects is the result.

A $p < 0.05$ was considered statistically significant. Statistical analyses were carried out by the program STATA Version-9. Stata Corp LP, College Station, TX, USA.

**Results**

Of the 500 newborns, 255 were males and 245 were females and there was no statistically significant difference between them for birthweight, MUAC and HC (Table 1).

<table>
<thead>
<tr>
<th>Patient characteristics</th>
<th>Sex</th>
<th>Calculated ‘r’</th>
<th>Significance (p)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Female</td>
<td>Male</td>
<td></td>
</tr>
<tr>
<td>Birthweight (g)</td>
<td>2405.96 ± 834.70</td>
<td>2443.65 ± 822.08</td>
<td>0.51</td>
</tr>
<tr>
<td>MUAC</td>
<td>8.34 ± 1.68</td>
<td>8.46 ± 1.71</td>
<td>0.79</td>
</tr>
<tr>
<td>HC</td>
<td>31.33 ± 4.04</td>
<td>31.58 ± 4.18</td>
<td>0.68</td>
</tr>
</tbody>
</table>

NS = Not significant.

<table>
<thead>
<tr>
<th>Patient characteristics</th>
<th>Birthweight</th>
<th>Normal birthweight</th>
<th>Calculated ‘r’</th>
<th>Significance (p)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>LBW (244)</td>
<td>Normal birthweight (256)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MUAC</td>
<td>6.94 ± 1.09</td>
<td>9.79 ± 0.74</td>
<td>33.95</td>
<td>&lt;0.0001 (S)</td>
</tr>
<tr>
<td>HC</td>
<td>28.44 ± 3.46</td>
<td>34.33 ± 2.16</td>
<td>22.70</td>
<td>&lt;0.0001 (S)</td>
</tr>
</tbody>
</table>

S = Significant.

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**TABLE 1**

*Patient characteristics: mean values ± standard deviation by gender*

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**TABLE 2**

*Patient characteristics: mean value ± standard deviation for LBW and normal birthweight*
Among them 244 newborns were of LBW and statistically significant difference was found between the HC and MUAC of the LBW babies with babies with normal weight (Table 2).

Multiple regression analysis was carried out in a step-wise fashion, considering birthweight as the dependent variable and HC and MUAC as the independent variables.

The regression equation was 

\[
\text{birthweight} = -968.288 + (-38.170 \times \text{HC}) + (546.909 \times \text{MUAC})
\]

(Table 3).

The coefficient of determination \( R^2 = 0.91 \).

**Table 3**

*Multiple linear regression equation for birthweight estimation*

<table>
<thead>
<tr>
<th>Model</th>
<th>Coefficientsa</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Unstandardized coefficients</td>
</tr>
<tr>
<td></td>
<td>B</td>
</tr>
<tr>
<td>(Constant)</td>
<td>-968.288</td>
</tr>
<tr>
<td>Mid-arm circumference (cm)</td>
<td>546.909</td>
</tr>
<tr>
<td>Head circumference (cm)</td>
<td>-38.170</td>
</tr>
</tbody>
</table>

aDependent variable: birthweight (g).
S = Significant.

**Fig. 1.** Nomogram for estimation of birth weight from MUAC and HC.

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From the Analysis of Variance for birthweight, $F = 2511.086$, $p < 0.001$, thus indicating the usefulness of MUAC and HC in predicting birthweight.

Nomogram was finally constructed on the basis of the above multiple regression equation for predicting birthweight from these two anthropometric measurements (Figure 1).

**Discussion**

Significant correlations have been described between birthweight and different anthropometric measurements including MAC, Body mass index (BMI), chest circumference and HC, which can be used as surrogate markers of LBW [5, 7–11]. Prior attempts have been made to develop nomograms to predict birthweight based on MUAC and chest circumference [12] or based on HC and chest circumference [13]. But measurement of chest circumference by health workers may be less accurate than MUAC at the community level [14].

Nomogram developed on the basis of the regression equation is of great practical significance for predicting birthweight due to its simplicity and non-invasiveness. It will allow health workers to identify the high risk LBW babies even if direct weighing is not feasible. The device is inexpensive and convenient and is an example of appropriate technology for primary health care.

**References**