Neonatal Nutritional Assessment by a Method Independent of Precise Maturity Determination

by C. O. Eregie MBBS, FWACP, FMCPaed

Institute of Child Health, University of Benin, P.M.B. 1154, Benin City, Nigeria

Summary

Data from a previous study were analysed to develop a new model for neonatal nutritional evaluation which is independent of precise maturity determination. Birth weights and arm/head ratios were recorded for each infant recruited for the study. Both indices were correlated by simple regression analysis with gestational age as the independent variable. Birth weight showed highly significant correlation with gestational age ($r = 0.77; P < 0.001$). Arm/head ratio was also correlated with birth weight with highly significant correlation coefficient ($r = 0.81; P < 0.001$). The regression line of arm/head ratio on birth weight, with the demarcated 95 per cent confidence spread, formed the new model for neonatal nutritional assessment. The model had a sensitivity of 80.54 per cent and specificity of 90.22 per cent using nutritional status determined by clinical features as reference. Since the model is independent of precise maturity determination, which limits the potential usefulness of several methods of neonatal nutritional assessment, it is recommended as a rapid, simple, and reliable appropriate health technology for developing communities.

Introduction

Reliable determination of nutritional status of newborn infants is an essential step in the identification of abnormal intra-uterine growth with increased risks for neonatal morbidity. Standards of arm/head ratio have been reported previously for simple, rapid and reliable nutritional assessment of newborn infants.$^{1-3}$ The use of these standards, however, requires reliable determination of gestational maturity of the newborn. Most of the clinical methods currently available for maturity determination do not have precision or 95 per cent confidence limits on prediction better than ±2 weeks.$^{4-9}$ The basis of the biological limits on accuracy of maturity determination has been suggested previously.$^{10}$ The imprecise determination of maturity, therefore, limits the potential usefulness of these simple methods of neonatal nutritional assessment. This limitation may be resolved by investigating the effectiveness of methods independent of precise maturity determination. This report presents such an approach.

Materials and Methods

A study was conducted from July, 1987 to June, 1988 in three centres (St Philomena, Central and University Teaching Hospitals in Benin City, Nigeria) to develop the arm/head ratio standard which was reported previously for neonatal nutritional assessment.$^3$ For this report, the data from that study were re-analysed to develop a standard of arm/head ratio on birth weight. The infants had their birth weight, head circumference, and mid-arm circumference measured and recorded as previously reported.$^3$ Their gestational ages were determined from reliable maternal last normal menstrual period (LMP) and recorded in completed weeks. The maternal LMP was regarded as reliable if there was agreement between the LMP recorded antenatally and that obtained after delivery. For the 848 appropriate-for-gestational age (AGA) infants included in the analysis, the birth weight and arm/head ratio were independently correlated with gestational age using simple regression analysis to investigate their relationship with gestational age.

The 848 AGA infants were singletons born to mothers who were married, multiparous, aged 20–29 years, of middle and upper socio-economic status, did not smoke or drink, and were not on oral contraceptives 6 months preceding pregnancy. To develop the new standard, arm/head ratios of the infants were then correlated with birth weight by simple regression analysis. The regression line of arm/head ratio on birth weight, with the 95 per cent confidence limits on the prediction of arm/head ratio from birth-weight demarcating the 95 per cent confidence spread, formed the new model for nutritional assessment. Infants that fell within the 95 per cent confidence belt of the new model were regarded as well-nourished for further analysis. Age-weight classification of the infants was done by using the Olowe Chart.$^{11}$

A prospective sample of 246 infants was evaluated to investigate the usefulness of the new model of MAC/HC on birth weight. Without prior knowledge of the gestational age and birth weight, a pediatrician assessed the nutritional status of the infants using clinical features described previously$^{12,13}$ as reference. Malnourished
infants had the following features: absent vernix caseosa, dry desquamating skin, subcutaneous tissue wasting, thin arms and legs, and relatively large head for body size. The author also, without prior knowledge of the birth weight, gestational age, and assigned nutritional status, independently assessed the nutritional status of the infants using the new model. Infants within the 95 per cent confidence belt of the model were regarded as well-nourished, while those above and below were regarded as malnourished. The nutritional assessments by the two methods (clinical features and model) were then compared. Infants with congenital and chromosomal anomalies were not included in this analysis. The characteristics of this prospective sample of 246 infants were reported previously.3

Statistical Analysis
Correlation studies were done by simple regression analysis. The 95 per cent confidence limits on predictive values were determined by treating them as binomial proportions.14 An IBM System 3 Computer was used for analysis of data.

Results
The re-analysed sample of 848 AGA infants included 395 males and 453 females with birth weight range 0.90–4.40 kg (3.38 ± 0.72 kg). The sample included 254 preterm infants. Also, there were 232 low-birth weight (LBW) infants. The distribution of the infants by weight categories is shown in Table 1. The mean arm/head (MAC/HC) ratio for the weight categories is also shown in Table 1 (0.26 for <1.00 kg to 0.31 for ≥3.50 kg).

Table 1 also shows the regression statistics. Birth weight showed a highly significant correlation with gestational age (r = 0.77; P < 0.001) while MAC/HC had a correlation coefficient with gestational age of 0.89 (P < 0.001). There was also a significant correlation of MAC/HC with birth weight (r = 0.81; P < 0.001); 95 per cent confidence limits ± 0.03).

Figure 1 illustrates the new model showing the regression line of MAC/HC on birth weight with the demarcated 95 per cent confidence belt. Infants within the confidence belt were regarded as well-nourished. Of the 246 infants, 184 were clinically well-nourished while 62 were clinically malnourished (Table 2). The model correctly identified 50 of the 62 clinically malnourished infants with a sensitivity of 80.64 per cent. Of the 184 clinically well-nourished infants, 166 were also correctly identified with specificity of 90.22 per cent (Table 2).

Discussion
The new model was developed by re-analysing only the 848 AGA infants whose mothers had reliable LMP and met the strict study criteria for analysis. This was done in order to evaluate an ‘idealized’ sample of infants that possibly experienced normal intra-uterine growth so that the weight, arm, and head measurements documented closely reflected the expected indices for the documented gestational ages. This probably explains the highly significant correlations of birth weight and arm/head ratio with gestational age and MAC/HC with birth weight. The model consisted of the regression line of

<table>
<thead>
<tr>
<th>Birth weight group (kg)</th>
<th>No.</th>
<th>Mean MAC/HC (95% CL)</th>
</tr>
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<tbody>
<tr>
<td>&lt;1.00</td>
<td>33</td>
<td>0.26 (0.02)</td>
</tr>
<tr>
<td>1.00 to &lt;1.50</td>
<td>61</td>
<td>0.27 (0.02)</td>
</tr>
<tr>
<td>1.50 to &lt;2.50</td>
<td>138</td>
<td>0.28 (0.02)</td>
</tr>
<tr>
<td>2.50 to &lt;3.50</td>
<td>389</td>
<td>0.29 (0.02)</td>
</tr>
<tr>
<td>≥3.50</td>
<td>227</td>
<td>0.31 (0.04)</td>
</tr>
<tr>
<td>Total</td>
<td>848</td>
<td></td>
</tr>
</tbody>
</table>

95% CL, 95 per cent confidence limits; MAC/HC, arm/head ratio.
Regression statistics of MAC/HC on gestational age:
Y = 0.0040x + 0.1250; r = 0.89; P < 0.001; 95% CL = ± 0.025.
Regression statistics of birth weight on gestational age:
Y = 0.1973x - 4.6660, r = 0.77; P < 0.001; 95% CL = ±0.92 kg.
Regression statistics of MAC/HC on birth weight:
Y = 0.0144x + 0.2490, r = 0.81; P < 0.001; 95% CL = ±0.03.
MAC/HC on birth weight and the demarcated 95 per cent confidence belt. There is, therefore, a probability of accommodating 95 per cent of possible MAC/HC ratios for each birth weight within the limits which are a fixed magnitude from the regression line. The model is suggested as a useful tool for neonatal nutritional evaluation considering its good sensitivity, specificity, and predictive values, with their errors of prediction, using nutritional status by clinical features as reference. Specifically, in the analysis of the prospective sample of 246 infants, the model had sensitivity and specificity of 80.64 and 90.22 per cent, respectively.

The useful value of the model probably relates to the fact that MAC/HC is a ratio that assesses body proportionality. Protein-energy malnutrition is characterized by marked body disproportionalitv and the MAC/HC ratio readily identifies this disproportionalitv because arm and head measurements are differentially affected by malnutrition with relative sparing of the brain. It is noteworthy that the use of the new model is independent of precise determination of maturity which limits the potential usefulness of methods dependent on accurate assessment of gestational age. While development of the new model relied on gestational age as an independent variable, the suggested use of the model does not require determination of gestational maturity. This should greatly improve the usefulness of the model considering the biological limits on precision of maturity determination in newborn infants.

Similar methods of nutritional evaluation in early childhood, independent of precise age, have been reported previously particularly for developing communities and include QUAC Stick, MAC/HC ratio, weight-for-height, and Shakir Strip. The usefulness of a standard of MAC/HC on birth weight for neonatal nutritional assessment is presented in this report. Its use, independent of precise maturity determination, recommends it as a simple, rapid, and reliable appropriate health technology for developing communities particularly those emphasizing primary health care as the cornerstone of their National Health Policy. Since it was developed in an African population, its usefulness should be investigated in other populations.

<table>
<thead>
<tr>
<th>Model</th>
<th>Malnourished</th>
<th>Well-nourished</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Malnourished</td>
<td>50</td>
<td>12</td>
<td>62</td>
</tr>
<tr>
<td>Well-nourished</td>
<td>18</td>
<td>166</td>
<td>184</td>
</tr>
<tr>
<td>Total</td>
<td>68</td>
<td>178</td>
<td>246</td>
</tr>
</tbody>
</table>

(1) Sensitivity = 80.64 per cent.
(2) Specificity = 90.22 per cent.
(3) Positive predictive value = 73.53 per cent, 95 per cent confidence limits = ±5.51 per cent.
(4) Negative predictive value = 93.26 per cent; 95 per cent confidence limits = ±3.13 per cent.

References