The Classification of the Low Birth-weight Infants from the Viewpoint of Mental Development

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(Received for publication on July 2, 1990)

Abstract. Periodical checkups on 206 infants were carried out in order to elucidate which of various factors would pose decisive influence upon the retardation of mental development after birth with the AIKEN method. Correlations between average DQ (development quotient) and figures of physical measurements at birth were sought after. Consequently, weeks of gestation, body weight, cephalic circumference and body length at birth revealed certain correlation with the retardation of mental development. Multiple regression analysis disclosed highly significant correlations of body length and cephalic circumference toward the birth weight. Therefore, both weeks of gestation and birth weight are the direct contributory factors to average development quotient. Based on this result, a prediction equation for the mental development after birth has been proposed. Low average DQ was found in high percentages among infants born with toxemia of pregnancy or premature rupture of membranes. However, it is suggested that they are not the direct causes of such retardation, but are rather provoking short weeks of gestation and low birth weight. In summary, the newborn with less than 37 weeks of gestation and below 2,000 grams of birth weight would be named and classified as a SFD (small for dates) with the problem for mental development (MD-SFD). (Keio J Med 39 (4): 242–246, December, 1990)

Key words: small-for-date infants, follow-up, development quotient, weeks of gestation

Introduction

The classification of low birth weight infants somewhat differs according to each investigator. Lubchenko defines it as below 10 percentile of the standard curve for the birth weight classified by weeks of gestation.1 Funakawa defines SFD (small for dates) infants as below −3/2 S.D. from the mean value of the standard curve proposed by him.2 Harvey et al. defines SFD infants as below 10 percentile of the standard birth-weight beyond 37 weeks of gestation.3 On the other hand, Lipper et al. define low birth-weight infants as below 10 percentile of the above values prior to 37 weeks of gestation.4 Premature infants are defined by some investigators solely depending upon the figure of birth-weight and nothing else. These classifications are mainly based upon the still-birth rate, incidence of congenital malformation, disturbances of physical growth after birth and so on. However, it has not been well known whether or not these classifications are adequate enough from the viewpoint of mental development after birth. The primary purpose of this study is to elucidate which of such factors as weeks of gestation, birth-weight, cephalic circumference and so on would pose the decisive influence upon retardation of mental development after birth by carrying out the follow-up investigation on various infants with different birth-weight and/or weeks of gestation as to their mental development from immediately after birth up to 3 years of age. Simultaneously, the relationship between maternal complications during pregnancy as well as delivery and mental development of the infant has been also investigated.

Methods

Two hundreds and six cases of sucklings and infants born at the Fujita Health University Hospital have been longitudinally checked with the AIKEN method5 on the
mental development at 8 different stages; i.e. 4, 16, 28, 40 weeks post partus; 1 year, 18 months, 2 years and fully 3 years after birth. This method consists of such subtests involving perception, motor activity, sociability, material-manipulation on the scene, learning, memory and language. Sucklings and infants with the birth-weight of ranging from 1050 grams to 3200 grams and gestational age ranging from 29 to 42 weeks have been collected for this study. In order to evaluate mental development after birth, we have picked up the average figures of various development quotients obtained from 16, 28, 40 weeks, 1 year and 18 months after birth as the ADQ (average development quotient) for each individual infant. This is based on two reasons: 1) rather small divergence of DQ (developmental quotients) calculated a 8 stages. 2) fairly large number of cases were available at these five stages. This newly defined ADQ has been investigated in relation to the gestational age, birth-weight, body length at birth, cephalic circumference, circumference of the chest, occipito-frontal diameter and the weight of placenta. Maternal complications during pregnancy and at delivery include such conditions as toxemia of pregnancy, placenta praevia, premature rupture of membranes and cord entanglement.

Results

First, the gestational age and various figures of physical measurements were classified into 5 groups in order to evaluate their correlation with each ADQ. Figure 1. reveals relatively high correlation between ADQ and the gestational age, birth-weight, body length at birth and the cephalic circumference. No directional correlation was observed between ADQ and the circumference of the chest, occipito-frontal diameter as well as the weight of placenta. Figure 1 hence indicates the most linear correlation between ADQ and the gestational age, i.e., the longer the weeks of gestation, the higher the figure of ADQ. The group 32-34 weeks of gestation is apparently poor in ADQ compared with the group 35-37 weeks of gestation (t=2.74, df=55, p<0.05). The birth-weight also discloses somewhat linear correlation with ADQ, however, no significant difference was statistically found among 3 groups above 2000 grams. Cephalic circumference revealed the similar tendency and no significant difference was observed among groups above 2000 cm. Even the group below 29 cm showed quite low incidence of ADQ below 80. As to the body length at birth, the group below 40 cm showed statistically significant difference from the group 40.1 to 43 cm (t=3.6, df=39, p<0.01), and no difference was found among 4 groups above 40 cm. The apparent retardation of mental development would be defined with the ADQ below 80. For this point, infants with such conditions as the gestational age less than 31 weeks, birth-weight less than 1500 grams and body length at birth less than 40 cm would be retarded.

Figure 2 shows the incidence of ADQ classified into 6 groups according to 4 different categories which were already described in Figure 1. There were 21 infants with ADQ below 79.9, 36 with ADQ 80 to 89.9, 48 with ADQ 90 to 99.9, 51 with ADQ 100 to 109.9, 19 with ADQ 110 to 114.9 and 31 with ADQ above 115, respectively. As to DQ above 80, the mode was present at the group with 38 to 40 weeks of gestation. On the other hand, the incidence of ADQ above 100 was extremely low and that of DQ below 80 was rather high among infants with the gestational age of 37 weeks and less. These facts strongly suggest that the critical point would exist between 37 and 38 weeks of gestation. As to birth-weight, the mode of DQ above 80 was present either at the group 2501 to 3000 grams or 2001 to 2500 grams. On the other hand, the incidence of DQ above 100 was quite low among infants with the birth-weight below 2000 grams. Like with the gestational age, the critical point as to birth-weight would exist around 2000 grams. Both the cephalic circumference and the body length at birth disclosed rather similar patterns with the birth-weight concerning with the incidence of ADQ classified into 6 groups. Consequently, high correlation would be anticipated
among various physical measurements mentioned above. Multiple regression analysis was carried out in order to sort the direct contributory factors to DQ.

Table 1 revealed the result of above analysis by means of the stepwise method. As shown here, rather high correlation was presented between the birth-weight and the body length at birth, between the birth-weight and the circumference of the chest, between the birth-weight and the cephalic circumference as well as between the body length at birth and the circumference of the chest. Based on above facts, the partial regression coefficient and the constant which are the explanatory variables toward ADQ have been sought for. Generally, ADQ is considered as the criterion variable and the explanatory variable should be solely correlated with it. The lowest line of Table 1 discloses the fact that any factor except for the birth-weight and the gestational age would not directly contribute to ADQ. In other words, the birth-weight and the gestational age would be the only predictable factors for the mental development after birth. Also, the value of loading coefficient for the gestational age is greater than that for the birth-weight. The following prediction equation for ADQ has been introduced from such loading coefficients.

\[
ADQ = 20.88 + 0.007 \times \text{(birth-weight)} + 1.64 \times \text{(weeks of gestation)}
\]

Figure 3 indicates the relationship between the inci-
Table 1 Correlation Matrix and the Partial Regression Coefficients. Multiple Regression Analysis

<table>
<thead>
<tr>
<th>Correlation Matrix</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
<th>(7)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Birth-weight</td>
<td></td>
<td>.799</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(2) Body Length</td>
<td></td>
<td>.856</td>
<td>.700</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(3) Circumference</td>
<td></td>
<td>.709</td>
<td>.644</td>
<td>.607</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(4) Cephalic</td>
<td></td>
<td>.442</td>
<td>.390</td>
<td>.413</td>
<td>.531</td>
<td></td>
<td></td>
</tr>
<tr>
<td>circumference</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(5) Occipito-frontal</td>
<td></td>
<td>.232</td>
<td>.136</td>
<td>.162</td>
<td>.095</td>
<td>.141</td>
<td></td>
</tr>
<tr>
<td>Diameter</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(6) Weight of the</td>
<td></td>
<td>.554</td>
<td>.513</td>
<td>.481</td>
<td>.539</td>
<td>.362</td>
<td>-.025</td>
</tr>
<tr>
<td>placenta</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(7) Gestational age</td>
<td></td>
<td>.407</td>
<td>.365</td>
<td>.341</td>
<td>.385</td>
<td>.135</td>
<td>-.289</td>
</tr>
<tr>
<td>(8) ADQ</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.431</td>
</tr>
</tbody>
</table>

\[
ADQ = 20.88 + 0.007 \times (\text{Birth-weight}) + 1.64 \times (\text{Weeks of gestation})
\]

Fig. 3 Incidences of toxemia of pregnancy and premature rupture of membranes according with the ADQ classified into 6 grades.

Table 1: The correlation matrix and partial regression coefficients for multiple regression analysis. The equation for ADQ is shown.

Discussion

We have carried out the analysis of various physical conditions and gestational age at birth in order to clarify the contributory factors for the retardation of mental development thereafter. We have pointed out the gestational age as the most important factor and the birth-weight as the second. The retardation of mental development will take place with high probability among infants born either with the gestational age less than 37 weeks or the birth-weight less than 2000 grams. It seems in good accordance with the fact that a number of researchers have classified SFD by setting the borderline at the 37 weeks of gestation. So far, those with the birth-weight below 2500 grams have been classified as premature infants; however, from the viewpoint of mental development, infants weighing less than 2000 grams should be on close observation.

The prediction equation for ADQ after birth has been proposed by multiple regression analysis. This equation consists of one constant and two coefficients for both the birth-weight and the gestational age. Actual figures were put into this equation and we have obtained somewhat higher ADQ with infants having DQ below 90. On the contrary, such trial with those having actual DQ above 110 disclosed rather lower ADQ. Therefore, the accuracy of this equation should be checked and revised in future by collecting much more cases.

Toxemia of pregnancy or premature rupture of membranes will bring about the retardation of mental development after birth with high probability. However, these complications during pregnancy and at delivery would not be considered as the direct contributory factors for the retardation of mental development after birth. Abnormal infants with ADQ below 100 revealed the average figures of gestational age as 35 weeks and the birth-weight as 1970 grams. On the other hand, abnormal infants with ADQ above 100 revealed though small in number, the average figures of gestational age as 39.5 weeks and the birth-weight as 2341 grams. Looking at both gestational age and birth-weight, the average figure of the former were definitely less than the critical points mentioned previously, and yet these of the latter surpassed them. These findings lead us to the assumption that the complications during pregnancy and at delivery would not be considered as the direct contributory factors for the retardation of mental development after birth and that they would rather pose certain influence upon the gestational age or the birth-weight by compelling the incidence of ADQ for this complicated group classified into 6 grades. We must emphasize the fact that such complications will evoke high incidence of DQ below 100, especially as much as 47.6% of 41 infants, practically half in all, sustained the ADQ below 80.
termination of pregnancy. Contributory factors to the shorter gestational age and the lower birth-weight should be further sought after, and at the present time the cardinal predictable factors for the retardation of mental development of the newborns are clearly pointed out; that is to say, the gestational age and the birth-weight.

In conclusion, we may well define the MD-SFD (small-for-dates infants for mental development) as the newborns weighing less than 2000 grams and with the gestational ages less than 37 weeks.

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