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Citation	長崎大学医療技術短期大学部紀要 = Bulletin of the School of Allied Medical Sciences, Nagasaki University. 1998, 11, p.17-23
Issue Date	1998-03-25
URL	http://hdl.handle.net/10069/18264
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Discrimination of Mentally Retarded Infants among Low Birthweight Infants Assessed by the Brazelton Neonatal Behavioral Assessment Scale

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Abstract The results of a follow-up study were reviewed by discriminant analysis to verify the effectiveness of differential diagnosis for mentally retarded infants by the Brazelton Neonatal Behavioral Assessment Scale (NBAS). The subjects were 86 low birthweight infants for whom the NBAS was performed in the neonatal period and whose developmental progress through age 3 years was confirmed. These infants were divided into 2 groups according to the results of the McCarthy Scales at revised age 3 years, i.e., 17 cases of intelligence quotient (IQ) of less than 90 including borderline area (retarded group) and 69 cases of IS 90 or more (normal group). Fisher's linear discriminant analysis was performed to see if these 2 groups are properly distinguished to the known groups in reference to the results of the NBAS at gestational age 44 weeks. As the result, 61 of the 69 cases in the normal group (88.5%) and 12 of the 17 cases in the retarded group (70.6%) were found to be properly classified in the known groups. The overall rate of proper classification was 84.9%. False discrimination was found in 1 of the 4 cases (25.0%) in the retarded area of IQ 70-79, in 4 of the 9 cases (44.4%) in the borderline area of IQ 80-89, and in 8 of the 69 cases (13.0%) in the normal area of IQ 90-<120. Then, the pooled within-groups correlations between discriminating variables and canonical discriminant functions were calculated. The results showed statistical influences by such NBAS clusters as state range, motor performance, supplemental items, state regulation and orientation, in descending order, indicating the necessity of behavioral assessment in the neonatal period. From the above, it was considered that discrimination of mental retardation in low birthweight infants in reference to the NBAS at gestational age 44 weeks is available at a high accuracy, and that the NBAS is effective on early diagnosis and on determining the application of early intervention and care. It was also indicated that follow-up for a longer period is necessary.

Bull. Sch. Allied Med. Sci., Nagasaki Univ. 11: 17-23, 1997

Key Words : Brazelton Neonatal Behavioral Assessment Scale (NBAS), low birthweight infants, mental retardation, Fisher's linear discriminant analysis

Introduction

The occurrence of major handicap and minor handicap is not scarce despite the fact that the survival rate of low birthweight infants remarkably increased due to the advancement of medical care of neonates in the perinatal period. Nakamura reported that a follow-up study at age 3 of 853 extremely low birthweight infants born in 1990 and discharged alive from 193 major medical institutions for the neonates in Japan disclosed that 75.0% were normal, 10.9% on borderline and 14.1% abnorma[1),2)]. Since the problematic behaviors of infants with developmental disability (retarded infants) in the neonatal or infantile period inhibit the formation of mother-infant relationship and the learning activity interacting with the environment, early intervention to those infants with probable developmental disability (retardation) is important for preventing the actualization and aggravation of problematic behaviors caused by disability to comply with the environment including mother-infant relationship, as well as for cutting off the vicious circulation.

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More effective is intervention and care performed as early as possible. However, more difficult is the early diagnosis of disability as lower is the age. If developmental disability (retardation) can be predicted early by neonatal assessment, it is useful in determining the application of early intervention and care.

Conventionally, the clinical diagnosis of developmental disability in the neonatal period has used neurological examination for early diagnosis of major handicap. Concerning the clinical findings by neurological examination of premature infants at gestational age around 40 weeks in relation to the prognosis, Allen et al reported that a high correlation was observed between the neonatal neurodevelopmental prognosis at age 1; of the 125 infants diagnosed as normal at the neonatal neurodevelopmental examination, 101 (81%) were normal, 16 (13%) with minimal motor disorder and 8 (6%) with cerebral palsy, and of the 85 infants diagnosed as abnormal, 32 infants (38%) were with cerebral palsy, 23 (27%) with minimal motor disorder, and 30 (35%) normal[3]. de Ouden et al followed up 905 infants to age 2 among 1192 extremely premature infants delivered in less than 32 weeks of gestation and very low birthweight infants of less than 1500g with regard to the relationship between the neurodevelopmental examination and the neuro-developmental prognosis at age 2 and reported that, of the 840 infants diagnosed as normal at the neurological examination, 689 infants (84.5%) were normal, 31 (3.8%) with major handicap and 79 (9.7%) with minor handicap; and of the 47 infants suspective of developmental disability, 24 infants (52.2%) were normal, 7 (15.2%) with major handicap and 11 (23.9%) with minor handicap; of the 18 infants diagnosed as having definite developmental disability, 6 infants (33.3%) were normal, 9 (50.0%) with major handicap and 3 (16.7%) with minor development[4]. Thus, the prognostic prediction by neurological examination of premature infants at gestational age around 40 weeks is reliable to some extent but its accuracy is not always high.

On the other hand, Brazelton's Neonatal Behavioral Assessment Scale (NBAS)[5] reportedly is closely correlated with the development in the infantile period. Brazelton et al reported that the NBAS recovery curves of mature infants and low birthweight infants was closely correlated with the correlation analysis of Baley's mental-motor developmental score in both mature infants and low birthweight infants, and that the mental-motor developmental score can be predicted at the statistically significant level of 0.01% to 0.05% even from the results of multiple analysis using 4 clusters of orientation, motor performance, state range and state regulation as descriptive variables[5].

Lester et al analyzed the recovery curves of NBAS clusters and Baley's mental-motor developmental scores at age 9 months, and reported that the recovery curves of the orientation cluster in full term infants and of the motor cluster in premature infants showed a correlation with the mental-motor developmental scores[6),7]. Likewise, we reported as the results of multiple analysis of Baley's mental-motor developmental scores at age 6, 12 and 24 months as objective variables and NBAS parameters of the recovery curve as descriptive variables for mature infants, that the both variables were closely correlated[8]. For low birthweight infants, multiple analysis of mental-motor developmental scores of Baley's scale for infantile mental-motor development at the revised age of 12 months as objective variables and NBAS clusters at gestational age 44 weeks as descriptive variables disclosed a close correlation, indicating that the mental-motor developmental score at revised age 12 months can be explained by the NBAS at gestational age 44 weeks at the accuracy of approximately 60%[9]. Tronick and Brazelton stated that more accurate diagnosis of late effects is available by the NBAS assessment of infants with developmental disability compared to the conventional neurological assessment that does not include behavioral assessment[10]. We also reported that the discrimination of cerebral palsy in low birthweight infants is available by the NBAS at a high accuracy of 88.5%. Akiyama et al studied the neonatal behaviors of mature cerebral palsy infants and described that persistent was the "depression" of neonatal behaviors such as weak crying, decreased feeding and overall decrease of activity and alertness, in addition to the abnormal neurological signs such as weakened muscle tonus and postural tonus, decreased spontaneous movement, and weakened primitive reflex[11),12]. Thus, it is required for assessment in the neonatal period to perform overall assessment incorporating both neurological and behavioral ones.

We have applied the NBAS for assessment and intervention in the neonatal period. In the present study, the results of follow-up were reviewed to see if the NBAS is useful for discrimination of mentally retarded infants.

Subjects and Methods

The subjects were 86 infants of premature birth for whom the NBAS was performed and whose developmental progress to age 3 was confirmed. (Cerebral palsy infants were excluded from the present study.) These 86 infants were divided by the general intelligence score of McCarthy Scales[13] at revised age 3 into a normal group (score 90 or more) and a retarded group (score less than 90) including borderline infants. (The reason for including borderline infants in the retarded group is that the occurrence of infants with problematic behaviors such as learning disability, attention deficit disorders with or without hyperactivity, and autism or autistic tendency is frequent among borderline infants.) As the results, 69 infants were assigned to the normal group and 17 to the retarded group. The normal group showed the mean gestational period 32.8 weeks (SD 2.5w, 25w2d-38w2d), mean birthweight 1564g (SD 369.3g, 670-2490g), mean Apgar 1-minute score 6.9 (SD 1.7) and 5-minute score 8.5 (SD 1.0), and mean general intelligence score 104.8 (SD 9.5), and included 6 extremely low birthweight infants. The retarded group showed the respective values of 29.1 weeks (SD 3.7w, 24w6d-38w1d), 1173.0g (SD 472.7g, 579-2120g), 1-minute 5.6 (SD 2.1), 5-minute 7.5 (SD 0.8), and 77.4 (SD 7.5), and included 8 extremely low birthweight infants.

Fisher's linear discriminant analysis was performed to see if the infants could be distinguished as normal or retarded using the NBAS results at gestational age 44 weeks. The NBAS assesses 4 behavioral abilities, i.e., 1. autonomic stability, 2. state regulation, 3. interaction, and 4. motor performance of the neonate through the process of accommodation between the neonate and the environment (examiner). The NBAS results were processed to calculate the scores of 6 clusters according to Lester et al's cluster method, i.e., orientation, motor performance, state range, state regulation, autonomic stability, and elicited response, and the mean of 9 supplemental items. These 7 scores were used as variables in the discriminant analysis. Statistics package "SPSS" was used for statistical analysis.

Results

1. Analysis of variables in two groups

As the result of t-test, a significant difference (p<0.01) between the two groups was observed in the clusters of orientation, motor performance, state range and state regulation and in the score of supplemental items, not including the clusters of autonomic stability and elicited response (Table 1).

Table 1 Results of t-test between normal group and retarded group

	Normal Group	Retarded Group
Orientation	6.14 ± 0.97	5.22 ± 1.04**
Motor Performance	5.75 ± 0.62	4.71 ± 0.92**
State Range	4.21 ± 0.49	3.29 ± 0.63**
State Regulation	5.14 ± 1.03	3.98 ± 1.17**
Autonomic Stability	6.93 ± 0.99	6.89 ± 0.70
Elicited Response	1.12 ± 1.35	1.77 ± 1.48
Supplemental Items	7.24 ± 1.04	5.69 ± 1.35**

** : p<0.01

2. Fisher's linear discriminant analysis

Sixty-one (61) of the 69 cases (88.5%) in the normal group and 12 of the 17 cases (70.6%) in the retarded group were properly classified into respective known groups, the overall rate of proper classification being 84.9% (Table 2). In relation to the general intelligence quotient (GIQ), erroneous determination was found in 1 of the 4 cases (25.0%) in the retarded area of GIQ 70-79, 5 of the 9 cases (44.4%) in the borderline area of GIQ 80-89, 5 of the 22 cases (22.7%) of GIQ 90-99, 2 of the 24 cases (8.3%) of GIQ 100-109, and 1 of the 21 cases (4.8%) of GIQ 110-120 or more (Table 3).

Table 2 Results of Fisher's linear discreminant analysis

	Correct	Error
Normal Group 69cases	61 (88.4%)	8 (11.6%)
Retarded Group 17cases	12 (70.6%)	5 (29.4%)

3. Pooled within-groups correlations between discriminating variables and canonical discriminant functions

Review was made on the degree of contribution to the discriminant functions by the variables, that

Table 3 Relationship between IQ and error discrimination cases

IQ	Cases	Error cases (%)
120≦	2	0
110~119	21	1 (4.8%)
100~109	24	2 (8.3%)
90~ 99	22	5 (22.7%)
80~ 89	9	4 (44.4%)
70~ 79	4	1 (25.0%)
≧ 69	4	0
Total	86	13

is, how the 7 NBAS clusters influenced the discrimination of developmental retardation. Effect was strong statistically in the order of state range, motor performance, supplemental items score, state regulation and orientation (Table 4). This result was in conformity with the result as seen by each variable.

Table 4 Poled within-groups correlations between discriminating variables and canonical discriminant functions

1.State Range	.8190
2.Motor Performance	.7711
3.Supplemental Items	.6585
4.Orientation	.6117
5.State Regulation	.5321
6.Elicited Response	−.4376
7.Autonomic Stability	.2027

4. Behavioral characteristics of the infants in the retarded group may be described as follows.

1) Behavioral characteristics

State regulation is generally low in activity and conscious level and poor in alertness. The activity and conscious level either persist at a low level, or gradually restore the normal level, or change to be hypersensitive, showing irritability, lability of state and poor self-regulation from a crying state. Orientation, in association with the cost of state regulation and attention, shows little or no response such as no interest in object and poor change of facial expression, or contrarily shows restless behavior with unsteady visual points and reflective excessive eyeball movement, indicating difficulties in keeping attention. Motor performance is often dominated by Uncoordinated spontaneous movement of the limbs with overshooting and jerky movement, or by minimal activity. Postural tonus is generally hypotonic, occasionally showing opisthotonic posture in association with stress. Physiological consistency is usually stable, although infants with respiratory disorder show cyanosis and unstable respiration in association with stress.

Consideration should be given to the adjustment and handling of stimulation since stress signs of the behavioral system are likely to arise in usual handling. For example, such considerations are required as to give vestibulo-tactile stimulation to regulate the awake level, to give single moderate stimulation to suppress excessive responses, to provide the site of examination without multiple environmental stimulations in order to maintain attention, to cover the limbs with towel to suppress excessive movement of the limbs, and to hold the infant in such a manner as to suppress opisthotonic posture and backward bending.

2) neurological characteristics

Abnormal neurological signs are not so definite as that in cerebral palsy infants with diseases of the central nervous system, and the items of abnormal elicited response are less. Postural tonus is mostly hypotonus within normal range and likely to show increased partial extensive tonus in association with increased stress while maintaining hypotonus as the basis.

Discussion

Problematic behaviors in and after the neonatal period would cause difficulties in formation of mother-infant relationship and in adaptation to the environment, thus becoming risk factors of developmental disability. If early prediction of developmental disability or retardation is possible by the assessment in the neonatal period, it will be beneficial in determining the application of early intervention and care, leading the developmental progress in a better direction through the adjustment of mother-infant relationship and environment. In the present study, Fisher's linear discriminant analysis using the results of follow-up by

McCarthy Scales at revised age 3 was performed to see if normal infants and mentally retarded infants among low birthweight infants can be properly distinguished by the NBAS assessment at gestational age 44 weeks, and the effectiveness of discriminating mentally retarded infants by the NBAS was reviewed.

As the result, 61 of the 69 cases in the normal group (88.5%) and 12 of the 17 cases in the retarded group (70.6%) were found to be properly classified in the known groups at a high overall accuracy of 85.9%, indicating that the NBAS assessment at gestational age 44 weeks is useful for the prognostic determination of developmental retardation. A review on the degree of contribution to discriminant functions by variables, that is, how the 7 NBAS clusters influence the discrimination of mental retardation, disclosed statistically strong influence of the clusters of state range, motor performance, supplemental items, state regulation and orientation in descending order. This is due to the fact that the signs of mental retardation are likely to appear as behavioral signs, while abnormal sings of major handicap are likely to appear as neurological signs. It was indicated that behavioral assessment in the neonatal period is essential.

The above results were in conformity with the following behavioral characteristics. The behavioral characteristics in the retarded group included a decrease of awake level and activity or problems of state regulation such as irritability, lability of state and poor self-quieting ability, fluctuation of postural tonus from hypotonus to hypertonus (often hypotonus), problems of motor performance such as dominance of non-coordinated movement of the limbs with overshooting and jerky movement, decreased attention and poor social response with hyperactivity or unsteady excessive eye movement and liability of stress in state regulation, motor performance and interaction during the course of interaction between environmental stimulation and the infant.

On the other hand, neurologically abnormal signs like abnormal elicited responses seen in major handicap as cerebral palsy infants are scarce (The prematurity seen in extremely low birthweight infants and neurologically abnormal signs are distinguished).

Neonatal behaviors are organized on the basis of autonomic stability including physiological consistency of organs in the respiratory and circulatory systems, and this is followed by the organization of state regulation, motor performance and social interaction including audio-visual responses. The above- mentioned behavioral characteristics seen in the retarded group would cause difficulties in adaptation to the external environment, affecting the progress of forming mother-infant relationship and organizing neonatal behaviors as well as the mental-motor development. The present study disclosed that the NBAS at gestational age 44 weeks is useful as a means to determine the application of early intervention and it helps in guidance to apply mother-infant intervention according to the behavioral characteristics of individual neonates and to facilitate environmental adjustment and sensorimotor activity. It is necessary for the intervention to regulate the awake level, improve the sensory processing ability and to facilitate stimulation-response, using the vestibular, proprioceptive and sensory stimulations. This will provide the basis for the development of communication and learning that are the functions of the superior central nervous system.

In the discriminant analysis, 3 of the 8 cases in the normal group and 2 of the 4 cases in the retarded group who had falsely been determined as such were extremely low birthweight infants. This indicates that the determination of extremely low birthweight infants in the neonatal period is difficult, and it is considered essential to perform assessment at intervals and long-term observation of the progress. The difficulty in establishing a definite diagnosis in the neonatal period may be attributed to the fact that, in low birthweight infants, particularly in extremely or very low birthweight infants, it is difficult to distinguish abnormalities since they have neurological and behavioral prematurity, that the neonates whether mature or premature are liable to change in awake state and behavioral state, and that they have potential capability to develop after functional repair by plasticity since the central nervous system of the neonates is in maturing process. We speculate from the results of our review of the recovering process of neonatal behaviors in high risk infants, that the recovering process was quick in the normalized infants and delayed in the infants with developmental disability or mental retardation, and consider it important to perform the NBAS assessment about three times at intervals and to observe the recovering progress of behaviors.

Kitchen et al compared DQ at age 2 years and IQ at age 5 of extremely premature infants and indicated that a trend of improvement was observed at age 5. Hence, they pointed out that a definite diagnosis of developmental retardation on the basis of DQ around age 2 is difficult to establish, and follow-up at least to age 5 is necessary[14]. Saigal et al[15], Teplin et al[16] and Nickel et al[17] reported that minimal cerebral dysfunction such as learning disability or attention deficit disorder has been observed in many extremely low birthweight infants in the infantile period and schoolchild period[14]. It is possible that developmental disability may occur in the infants classified in the normal group in the present study and that normalization may arise in some of those classified in the retarded group. Although it is feasible to determine the prognosis of developmental retardation at a relatively high accuracy by the NBAS assessment at gestational age 44 weeks, it is advisable to avoid easy diagnosis but to perform follow-up from the longitudinal point of view.

References

1. Nakamura H: National survey on the prognosis at age 3 of extremely low birthweight infants. Jpn J Ped 99: 1266-1274, 1995.
2. Nakamura H: Assessment of perinatal medical system as seen from the prognosis of extremelypremature infants. Shinseijishi 29: 494-501, 1993.
3. Allen MC, Capute AJ: Neonatal neuro-developmental examination as a predictor of a neuromotor outcome in premature infants. Pediatrics 83: 498-506, 1989.
4. de Ouden L, Varloove-Vanhorick SP, van Zebenvan der Aa DM: Neonatal neurological dysfunction in a cohort of very preterm and/or very low birthweight infants - relation to other perinatal factors and outcome at 2 years. Neuropediatrics 21: 66-71, 1990.
5. Brazelton TB: Neonatal Behavioral Assessment Scale.2nd Edn. Clinics in Development Medicine No.88.London: Spastics International Medical Publication. 1982.
6. Lester BM: A Method of Study of Change in Neonatal Behavior. Infants at Risk; Assessment and Intervention. Elsevier, New York, 1983.
7. Lester BM: Data analysis and prediction. In: Brazelton TB; Neonatal Behavioral Assessment Scale, 2nd Edn. London: Spastics International Medical Publications. 85-96, 1984.
8. Akiyama T, Tsurusaki T, Ogi S: Neonatal behavior and mental-motor development - age 0 to age 5 -. Bull Sch of Allied Med Sci, Nagasaki Univ 4: 19-26, 1990.
9. Ogi S, Akiyama T: Neonatal behavioral assessment of low birthweight infants in relation to mental-motor development at age 12 months. J Physiotherapy 23: 355-358, 1996.
10. Tronick EZ, Brazelton TB: Clinical use of the Brazelton Scale. In: Friedlander BZ, Sterritt GM, Kirk G (Eds) Exceptional Infant: Assessment and Intervention. Vol. 3. New York: Bruner-Mazel. 137-151, 1975.
11. Akiyama T, Kawaguti Y: Study on early diagnosis and care of cerebral palsy infants - statistical review of early diagnosis by the NBAS of premature infants having resulted in cerebral palsy -. Overall Study on Medical Care of Mentally or Physically Handicapped Children (Adults). 1995.
12. Akiyama T, Kawaguti Y: Neonatal findings and motor development. Kyodo Isho Shuppan, Tokyo, 108-128, 1979.
13. McCarthy D: McCarthy Scales of Children's Abilities. New York: Psychological Corp. 1972.
14. Kitchen W, Ford G, Orgill A: Children of birth weight <1000g: Changing outcome between ages 2 and 5 years. Pediatrics 110: 283-288, 1987.
15. Saigal S, Szatmari P, Rosenbaum P: Intellectual and functional status at school entry of children who weighed 1000 grams or less at birth. Pediatrics 116:409-416, 1990.
16. Teplin SW, Burchinal M, Johnson-Martin N: Neurodevelopmental, health, and growth status at age 6 years of children with birth weights less than 1000 grams. Pediatrics 118: 768-777, 1991.
17. Nickel RE, Gallenstein JS: School performance of children with birth weight of 1000g or less. Am J Disability Child 136: 105-113, 1992.

低出生体重児を対象としたブラゼルトン新生児行動評価による精神発達遅滞児の判別

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要　旨　ブラゼルトン新生児行動評価法（Neonatal Behavioral Assessment Scale；ＮＢＡＳ）による精神発達遅滞児の鑑別診断の有効性を確認するため，追跡調査の結果を用いた判別分析による検討を行った．対象は新生児期にＮＢＡＳを行い，３才までの発達経過を確認した低出生体重児86例である．これらの対象児を修正３才時のマッカーシー知能発達検査の結果から，境界値を含む一般知能指数90未満の17例（遅滞群）と，一般知能指数90以上の69例（正常群）の２群に分類し，この２群が胎齢44週時のＮＢＡＳの結果から既知のグループに正しく区別されるかどうかについて，フィッシャーの線型判別式を用いた判別分析を行った．その結果，胎齢44週時のＮＢＡＳの結果から正常群では69例中61例（88.5%）が，遅滞群では17例中12例（70.6%）が既知のグループに正しく分類され，その全体に対する割合は84.9%であった．また，一般知能指数と判別結果では指数70～79の遅滞域の４例中１例（25.0%），指数80～89の境界域の９例中４例（44.4%），指数90～120未満の正常域の69例中８例（13.0%）が誤判別であった．次に，関数値と各変数値とのグループ内相関を算出した結果，ＮＢＡＳのクラスターのうち「意識状態の幅」，「運動の調整」，「補足項目値」，「意識状態の調整」，「方位反応」のクラスターが順に統計的に影響力が強く，新生児期の行動評価の必要性を示した．以上より，胎齢44週時のＮＢＡＳから低体重出生の精神発達遅滞児の判別は高い精度で可能で，早期診断と介入，療育の適応決定に有効であると考えられた．また，より長期的なフォローの必要性も示唆した．

長崎大医療技短大紀　11: 17-23, 1997