Risk Factors of Undernutrition in Children with Spastic Cerebral Palsy

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Background: This study was undertaken to investigate the nutritional status of children with spastic cerebral palsy (CP) and to identify the risk factors of undernutrition.

Methods: Seventy-five spastic CP children, 47 boys and 28 girls, (ages, 5 months to 10 years) underwent anthropometric assessment, including body weight, recumbent length, and knee height. Their functional status, medical condition, and feeding status were also recorded. The data were analyzed to estimate the influences of various factors on the nutritional status of the spastic CP children.

Results: The nutritional status of 31 of the 75 children (41.3%) were below the 10th percentile (undernutrition) and three (4%) were above 90th percentile (overnutrition) of healthy children. In the multivariate analysis, we found that undernutrition was significantly associated with: (1) girls ($p=0.006$), (2) more feeding problems ($p=0.018$), (3) shorter duration per meal ($p=0.022$), and (4) poor communication ability ($p=0.001$)

Conclusion: It appears that periodic anthropometric assessments of CP children are indicated for the early identification of nutritional risk. Further nutritional management should be arranged for undernourished children to promote their nutritional status and improve growth and functional capacity.
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Key words: **cerebral palsy, spastic, nutritional status.**

Optimal nutrition is important to infants and children because their growth and development are rapid. In recent years, there has been an increased awareness that children with cerebral palsy (CP) are at high risk of undernutrition.[1-3] If left untreated, severe nutritional problems may be exacerbated, which may even cause impairment of the immune system, cognitive problems, and neuromuscular disabilities.[4-8] When the nutritional condition is improved, researchers have shown several improvements in general health conditions of the children, such as decreases in irritability and spasticity, healing of pressure sores, and improvement in peripheral circulation.[9-12] Therefore, identification of the risk factors associated with undernutrition is important for the early detection and treatment and for the prevention of late complications in the children's behavior, health, or growth.

In addition, researchers have suggested that there is a relationship between the nutritional status and inadequate nutrient intake, malabsorption of nutrients, as well as endocrine problems.[2,10,13]

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Inadequate nutrient intake, however, not the latter two problems, can be corrected through rehabilitation. In our study, only the factors that resulted in inadequate nutrient intake were evaluated.

Nutrient intake depends on getting adequate food, and having the ability to adequately chew and swallow of the food. These factors are associated with the functional status of a child with CP. In this study, we evaluated the functional abilities and the feeding status of the children with CP in order to discover the factors that are significantly associated with undernutrition and that can be corrected in a rehabilitation program. One study by Dahl and Gebre-Medhin showed that children with dystonic CP were at a high risk of developing undernutrition.[14] However, at our hospital, only a few patients with dystonia were referred for rehabilitation. Since spastic CP is the most common type of CP, those children were selected for enrollment in this investigation.

METHODS

Subjects

Seventy-five children with spastic CP (defined as a permanent increased muscle tone and impairment of voluntary movement or posture presumed to be due to non-progressive damage to the immature brain) with various degrees of involvement were selected consecutively from our rehabilitation clinic for this study. Forty-seven of the 75 were boys and 28 were girls. The mean age was 3.79 ± 2.35 years (range, 5 months to 10 years).

Anthropometric measurement

1. Body weight

Body weight was measured to the nearest 0.1 kg on a standard beam balance. If the child could not stand independently, the caregiver held the child, and the two were weighed. The body weight of the child was obtained by subtracting the caregiver's weight from the total weight.

2. Body Length

Body length was measured to the nearest 0.1 centimeter using a supine-length measuring board with a stationary inflexible measuring tape and a plasty headboard. For the children with significant musculoskeletal deformities or severe spasticity, we used an alternative method of measurement to estimate the length based on the knee height (KH), as described by Stevenson.[15] According to this method, the children's stature was calculated using the following equation:

$$\text{Stature} = S - (2.69 \times KH) + 24.2$$

Where S indicated the estimated stature in centimeters, and KH was the knee height, measured from the proximal edge of the patella to the bottom of the heel with both the knee and ankle at 90 degrees of flexion.

Each measurement was taken twice and the mean value was used for data analysis.

3. Normalization

The values of "length for age" and "weight for age" were expressed as n^{th} percentile using the reference growth chart for Taiwanese children produced by the National Health Administration of Taiwan, 1983 and Ministry of Education, 1986.[16,17] "Weight for length" was obtained by plotting the child's weight against his or her own length curve. The values of "weight for length" were converted to percentiles using reference data drawn from the National Center for Health Statistics (NCHS) of the United States,[18] because there is no such reference data in Taiwan for children younger than 3 years old.[19]

Assessment of nutritional status

We defined "undernutrition" as the values of "weight for length" below the 10th percentile, while those values above the 90th percentile were defined as "overnutrition".

Assessment of medical problems

Information from the patients' medical records and parental interviews was used to investigate the occurrences of medical problems, such as seizures and pneumonia, which may have been relevant to the children's feeding and nutritional status.

Assessment of feeding characteristics

Information regarding the following feeding characteristics was collected from interviews with parents and/or caretakers.

1. Feeding problems

The occurrences of some common feeding problems such as tongue thrust, fluid or food loss during eating, choking during eating, biting, drooling, and refusal of food were recorded. For each child, the

sum of the feeding problems were calculated and divided into two groups as having more than one feeding problem or not.

2. Feeding habits

The feeding habits such as the major texture of food taken, the duration of time per meal, and frequency of meals per day were recorded. "Duration of time per meal" was divided into two groups by using the cut off point at 20 minutes. "Food texture" was defined into two categories: milk / liquid / soft food, and table food.

Assessment of Functional Status

The current functional status of the children with CP was assessed by interviewing the parents and examining the children.

1. Limb Involvement

Based on the involvement of the limbs, all children with spastic CP were divided into two groups: 1) four-limb involvement -including all quadriplegic children, and 2) two-limb involvement--including the hemiplegic children and the diplegic children.

2. Locomotion

Locomotion status was classified as wheelchair-bound, household walker, or community walker. A household walker was defined as one who walked inside the home, but required a wheelchair in other settings. A community walker was a child who required a wheelchair only for mobility over long distances.[8]

3. Communication ability

Communication ability was based on the child's functional speaking ability and classified into two groups: 1) voicing only or clear words but no sentences and 2) understandable sentences.

4. Dependence on feeding

We classified dependence on feeding into three groups: 1) totally dependent on a caretaker, 2) partially dependent (some help required), and 3) totally independent in feeding.

Data analysis

The data was analyzed to determine the influences of the various factors, including medical conditions, feeding characteristics, and functional abilities, on the nutritional status.

The univariate analyses were performed to identify which variables were predictors of undernutrition. Statistical significance was determined for categorical data using either the chi-square test or the Fisher Exact test for expected number less than five. The *t* test was used for determining the statistical significance of continuous or ordinal data. Multivariate analyses were performed using the logistic regression model to identify variables notably associated with undernutrition. All *p* values in this report were 2-tailed, and a $p \leq 0.05$ was considered statistically significant.

RESULTS

Table 1 illustrates the results of the anthropometric measures of nutritional status for the children with spastic CP. As shown, 31 of the 75 children fulfilled the criteria for undernutrition, and three of the 75 were overnourished. Thirty-five of the 75 children fell below the 10th percentile of the reference data for "weight for age". With regard to length for age, 27 of the 75 children fell below the 10th percentile of the reference data.

When comparing the groups of children with and without undernutrition based on the result of univariate analysis, there were no significant differences between the two groups with regard to age and gender (Table 2). Furthermore, there was no significant association between undernutrition and seizure or pneumonia history (Table 2).

Undernutrition was significantly associated with

Table 1. Classification of Anthropometric Measures of the Study Population

	Weight/Height	Weight/Age	Height/Age
<10th percentile	31 (41.30%)	35 (46.70%)	27 (36%)
10-90th percentile	41 (54.7%)	34 (45.30%)	45 (60%)
>90th percentile	3 (4%)	6 (8%)	3 (4%)

Table 2. Demographic Characteristics and Medical Problems of CP Children With Respect to the Presence of Undernutrition or Not

	Undernutrition		
	No (N=44)	Yes (N=31)	*p*
Age (years)	4.09±2.19	3.36±2.52	0.184
Gender (F/M)	13 (46.4%)/31(66%)	15(53.6%)/16(34%)	0.097
Seizure	12 (27.3%)	15 (48.4%)	0.061
Pneumonia	14 (31.5%)	10 (32.3%)	0.968

Table 3. Comparisons of Feeding Problems and Feeding Habits of CP Children With and Without Undernutrition

	Undernutrition		χ value	p
	No (N= 44)	Yes (N= 31)		
Choking	12 (44.4%)	15 (55.6%)	3.519	0.061
Drooling	21 (58.3%)	15 (41.7%)	0.003	0.955
Tongue thrust	6 (50%)	6 (50%)	0.443	0.506
Refusing food	7 (53.8%)	6 (46.2%)	0.151	0.698
Biting	7 (41.2%)	10 (58.8%)	2.773	0.096
Food loosing during eating	5 (33.3%)	10 (66.7%)	4.962	0.026*
Feeding problem ≥2	18 (47.4%)	20 (52.6%)	4.055	0.044*
Food Texture milk/liquid/soft food	13 (37.1%)	22 (62.9%)	12.538	0.000*
table food	31 (77.5%)	9 (22.5%)		
Duration per meal (min.)				
<20	8 (40%)	12 (60%)	3.466	0.063
≥20	34 (64.2%)	19 (35.8%)		
Number or meal per day	4.65±1.02	4.85±1.08		0.401

Significant difference between CP children with and without undernutrition. ($p<0.05$)

Table 4. Comparisons of Functional Status of CP Children With and Without Undernutrition

	Undernutrition		χ value	p
	No (N= 44)	Yes (N=31)		
Limb involvement				
Quadriplegia	11 (39.3%)	17 (60.7%)	6.921	0.009*
Hemiplegia or diplegia	33 (70.2%)	14 (29.8%)		
Locomotion				
Wheelchair-bound	25 (49%)	26 (51%)	6.117	0.013*
Household or community walker	19 (79.2%)	5 (20.8%)		
Community ability				
Voicing or word	16 (40%)	24 (60%)	12.317	0.000*
Sentences	28 (80%)	7 (20%)		
Dependence on feeding				
Total	15 (38.5%)	24 (61.5%)	13.679	0.000*
Partial or independent	29 (80.6%)	7 (19.4%)		

Significant difference between CP children with and without undernutrition ($p<0.05$).

Table 5. Logistic Regression Analyses of Patients' Characteristics Associated with Undernutrition

Characteristics	Percentage of patients in category	Percentage with undernutrition	Adjusted odds ratio (95% CI)	p
Female	37	53.6	8.409 (1.841 - 38.399)	0.006*
Male	63	34		
Duration per meal				
<20min	27	60	5.316 (1.276 - 22.153)	0.022*
≥20min	73	35.8		
Feeding problem				
≥2	51	52.6	5.037 (1.320 - 19.224)	0.018*
<2	49	29.7		
Communication ability				
Voicing/Word	53	60	9.557 (2.479 - 36.837)	0.001*
Sentences	47	20		

food loss during eating, having more than one feeding problem, and variety of food texture ($p=0.026$, 0.044, <0.001 respectively). Any other single oral-motor problem (except for food loss during eating) and the number of meals per day did not differ significantly between the children with and without undernutrition (Table 3).

It was shown that undernutrition was significantly associated with the following poor functional status, including severe motor involvement, poor locomotion ability, poor communication ability, and dependence on caretaker for feeding ($p=0.009$, 0.013, <0.001, <0.001, respectively) (Table 4).

Table 5 showed the variables proved to be independent predictors of undernutrition of children with spastic CP through multivariate analysis. The predictors were being a girl, duration per meal less than 20 minutes, having more than one feeding problems and poor communication ability ($p=0.006$, 0.022, 0.018, 0.001, respectively).

DISCUSSION

The assessment of nutritional status in our study was accomplished by comparing various anthropometric measurements with published standards. In children with spastic CP, comparisons based on weight-for-age and length-for-age provide only a rough estimation of the degree of undernutrition, because of the in deviation in growth patterns. Skin fold thickness may lead to an overestimation of body fatness because there may be more fat folds in paralyzed limbs of children with CP. Weight-for-length may be a more reliable indicator of current nutritional status, and this measurement is relatively independent of age and ethnic group.[20,21] In this study, we used the weight-for-length method to assess the individual nutritional status of children with CP.

Accurate measurements of height or length in children with joint contractures or scoliosis are often difficult to obtain. Recent studies have indicated that limb length (including upper-arm length, tibial length, and knee height) provide an estimation of stature in these children.[8,15,22] We used the formula based on knee height, according to the description of Stevenson,[15] as an alternative measurement to estimate the length for the children with severe involvement. We chose this method because the data that was derived from a study of 211 CP children, age from birth to 12 years, was compatible with the age range of the children in our study group. In addition, this was a quick, reliable method that easily applied to our study.

There is no universally accepted anthropometric diagnostic criteria for measuring the nutritional status in children with cerebral palsy. Brizee et al. suggested that children with weight-for-height below the 10th percentile and above the 90th percentile were of concern.[23] Johnson and Maeda defined CP children with a weight-to-height ratio between the 5th and 10th or 90th and 95th percentile on the NCHS growth charts as being "at nutritional risk", and those with a weight-to-height ratio of less than the 5th or above the 95th percentile as having "poor nutritional status".[24] Pinyerd suggested the optimal "weight-for-length ratio" for each child with CP should be equated with a point that falls within the 10th to 75th percentiles on the NCHS graphs.[21] Krick et al. suggested that the ideal body weight for children with quadriplegic cerebral palsy was at the 10th percentile weight-for-height on the NCHS charts.[25] Shapior chose the 10th percentile weight-for-height as the outcome criteria, since this would indicate that the children were adequately nourished.[10] Based on the above references, we defined "undernutrition" as the values of "weight-for-length" below the 10th percentile, while those above the 90th percentile were defined as "overnutrition". According the definition, we found that undernutrition was a very common problem for children with spastic CP (31 of the 75 children fulfilled the criteria for undernutrition). This result is similar to that of previous research on representative material for children with various types of CP.[13,24,26,27]

We found that girls with spastic CP were significantly associated with undernutrition. No similar results have been presented before. This phenomenon may be explained by the traditional concept of Taiwanese parents. Most of the parents, especially in Southern Taiwan, have the idea that their sons belong to them forever; the daughters will belong to others after they growing up, so they take care of their sons more carefully than they take care of their daughters.

When estimating the effect of medical problems on the nutritional status, we found that neither seizure nor pneumonia correlated with nutritional status. This finding is consistent with the results by Kurowski et al, who have suggested that the use of

common anticonvulsant medication was not a confounding variable in the growth of children with CP.[28]

When focusing on the relationship between the feeding problems and nutritional status, in 1993, Stallings et al. found that children with more than one feeding problem were more likely to have low adipose stores in the triceps muscle.[8] The poor nutritional status of those children was probably due to inadequate food intake because of severe feeding problems. Our results showed that the children who had more than one feeding problem were at higher risk of undernutrition than those who had none or just one feeding problem. In addition, no single feeding problem had a significant influence on the nutritional status of the children with spastic CP. Based on our results, it was observed that the severity of the feeding problems had negative effects on the nutritional status of children with spastic CP. When the children had only a mild feeding problem, the caretaker might use some compensatory ways to maintain an adequate dietary intake for the children.

Some researchers suggested that offering food of low caloric density might have been the cause of failure to thrive in the young CP children.[29] We found that the majority of the undernourished children were fed proprietary baby foods, which have relatively low caloric density.[30] In our study, children who were fed liquid or soft food tended to be undernourished, but this factor may be related to other factors such as duration of per meal. The consistency of the food did not show significant influence on the nutritional status in the multivariate analysis. We also found that the frequency of meals offered was not associated with nutritional status, but the undernourished children took significantly shorter duration of time during meal. The children who took less than 20 minutes per meal were significantly associated with undernutrition status. In a study that correlated the feeding efficiency in children with severe CP and growth failure, researchers found that these children required 2 to 12 times longer to chew and swallow a standard amount of pureed food and 1 to 15 times longer to chew solid food than did the weight-matched control subjects.[2] It appears that long feeding time is required for children with CP to meet their nutritional needs.

In addition to the feeding problems and feeding habits, several researchers mentioned that the functional status may influence the nutritional status of CP.[8,26,31,32] Stallings et al. noted that there were no differences in the growth and nutritional status patterns of children with diplegic CP compared with those with hemiplegia.[31] However, there were differences between the groups of children with quadriplegic CP and those with diplegia or hemiplegia.[8] In our study, the differences between the groups of children with quadriplegic CP and those with diplegia or hemiplegia were significant in the univariate analysis but not in the multivariate analysis. The notable association between limbs involving and nutrition status may be related to the severity of feeding problems. We also noted that those who had poor ambulatory skills, poor communication skills, or were more dependent on a caretaker for feeding tended to be undernourished, but only the poor communication ability was an independent predictor. These phenomena can be explained by the following. The three factors were closely related, most children with poor communication skills also had poor ambulatory skills and were more dependent on a caretaker for feeding. The children with communication difficulties may not be able to ask for food or express their preferences[32]. Although the disabled children cannot forage for food in the kitchen or buy snacks at the sweet shop as readily as able-bodied children, they can get help if they can express clearly.

In view of the methodological problems that are inherent in the study of spastic CP children, our results need to be interpreted with caution. First, the children with spastic CP in this study were not necessarily representative of the general spastic CP population in Taiwan. However, the present data can be considered representative of those children with spastic CP served by large interdisciplinary referral centers. Second, the prevalence of undernutrition was dependent on the criteria used. Because there are no universally accepted anthropometric diagnostic criteria for measuring the nutritional status in children with CP, it should be cautioned to compare the results of this study with others using different definitions.

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痙攣型腦性麻痺兒童營養不良之危險因子

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背 景： 本研究目的在於探討痙攣型腦性麻痺兒童之營養狀況，進而找出與營養不良相關的危險因子。

方 法： 我們總共收集了75位痙攣型腦性麻痺的兒童，47位男性、28位女性，年齡在5個月至10歲之間，他們都接受人體測量，包括體重、身高及膝高來評量其營養狀態。我們另外也記錄了他們的功能狀況、內科問題及餵食狀態，這些資料將分別統計分析各因子是否對痙攣型腦性麻痺兒童營養狀態造成影響。

結 果： 在75位痙攣型腦性麻痺兒童中，有31位 (41.3%) 其重高比低於同年齡兒童的10百分位，符合我們定義爲處於營養不良狀態，另有3位 (4%) 則高於90百分位，符合過度營養狀態。在多因子分析中，我們發現營養不良的兒童，以女孩居多，他們有較多的餵食問題，餵食時間較短，同時語言溝通能力較差，以上各點均有統計學上顯著的差異 ($p=0006, 0.018, 0.022, 0.001$)。

結 論： 對於有危險因子之腦性麻兒童應定期的檢測其營養狀態，以便能早期發現營養不良狀態，更進一步給予營養相關諮詢或餵食的處理及建議，將可提升其營養狀態且促進他們的生長發育及功能的進步。

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關鍵字：腦性麻痺，痙攣型，營養狀況。

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