Nutritional status of children with CNS diseases

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Research article

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Abstract

Background Children with neurological disorders are frequently subject to malnutrition, stunted growth or underweight. These are accompanied with oral cavity motility disorders, swallowing disorders and gastroesophageal reflux. Frequently, there is growing insufficiency of the body mass caused by the loss of adipose tissue, decreasing BMI and muscular atrophy, which leads to increased risk of complications and deaths due to nutrition disorders The aim of this research was to examine the state of nutrition of children with central nervous system damage, depending on age, a neurological disorder and the degree of dysphagia.

Materials and methods The research encompassed 74 children diagnosed with damage of the central nervous system and sent to the Pediatric Clinic of the Silesian University in Katowice. The children were between 2 and 16 years old and they were subject to the examination from August 2012 to November 2014. The research made use of the prospective method with the help of medical examination, documentation analysis, anthropometric measurements and laboratory tests of patients divided into groups depending on their age, a neurological disorder and the degree of dysphagia.

Results Using cut-off values of BMI for the population of children according to the WHO reference grids, 62.16% of children showed significant underweight, and 4.06% of children were affected by overweight or obesity. Having analysed the anthropometric measurements, it was possible to prove the connection between BMI, the thickness of the skin fold over the three-headed and the two-headed muscle and the degree of dysphagia and a neurological disorder. On the other hand, there was no connection to the patients’ age.

Conclusions Children with cerebral palsy and encephalopathy are more frequently affected by malnutrition than with other causes of central nervous system damage. Children with a higher degree of dysphagia are more frequently affected by underweight and insufficient growth. The patients' age does not influence malnutrition in a substantial way.

Keywords: malnutrition, neurological disorders, status of nutrition

Introduction

Nutrition of children and adolescents is very important for their physical and mental development. This is the group most vulnerable to the negative effects of inappropriate nutrition. Proper nutrition can also help to reduce the risk of developing civilization diseases in adulthood, such as obesity, atherosclerosis, type 2 diabetes, allergy, cancer, or milder conditions. [1]

Malnutrition according to The European Society for Clinical Nutrition and Metabolism (ESPEN) is related to insufficient food supply or nutrient abnormalities leading to changes in body composition, to the physical and mental impairment, and adversely affects the outcome of the underlying disease. It is the most common cause of growth failure during childhood. Early diagnosis of malnutrition is of great importance in developmental age medicine due to the continuous development of the young organism.

[2].Children with CNS disorders are a particular group of patients at risk of inadequate nutritional status. [3] This is due to progressive weight loss caused by loss of body fat, muscle and decreased body mass index (BMI). In addition, growth disorders in children with neurological disease are influenced by factors independent of nutrition, including the type and severity of damage to the nervous system, mobility, and intellectual ability. Damage to the nervous system in children with accompanying motor disorders of the oral cavity, swallowing (dysphagia), or gastroesophageal reflux contributes to the difficulty of properly estimating nutritional needs and can therefore lead to progressive malnutrition and growth disorders. [4] Children with neurological disorders are generally shorter and weigh less than healthy children and rarely reach 3 percentile. The incidence of malnutrition increases with age. However, a small proportion of children (8–14%) may be overweight. [5] The occurrence of overweight may be understated due to the incorrect distribution of adipose tissue or a small body dimensions occurring in certain neurological disorders which may result in omission of increase in proportion of weight to height ratio. [6] Assessing the nutritional status of ill children is relatively difficult to interpret. This may result from the impact of various symptoms of the disease unit on selected anthropometric parameters. In children with CNS damage, there is an increased risk of complications and deaths due to nutritional disorders.

Material And Methods

Studies were conducted prospectively using interviews, medical records, anthropometric and laboratory tests. In order to detect statistically significant differences between groups, obtained results were analyzed statistically. The study covered 74 patients aged 2-16 years (mean age 8.96 years) including 30 (40.54%) girls and 44 boys (59.45%) with diagnosed central nervous system disorders .

Characteristics of the study group

The study included 74 children divided into the following groups:

1. age:

AI group from 2 to 8 years of age - 38 children (51.35%), including 14 girls and 24 boys;

AII group from 9 to 16 years old - 36 children (48.64%), including 16 girls and 20 boys;

2. neurological disorder:

NDI group - cerebral palsy and progressive / non-communicable encephalopathy -55 children - (74,32%) including 22 girls and 33 boys;

NDII - genetic, metabolic, CNS defects and unknown causes - 19 children (25.67%), including 8 girls and 11 boys;

3. degree of dysphagia:

DI group - II and III degree of dysphagia -31 children (41.89%) including 11 girls and 20 boys;

DII group - IV and V degree of dysphagia -43 children (58.10%), including 19 girls and 24 boys.

Methods:

The interview consisted of a medical and nutrition history, growth progress and diet. [7]

Anthropometric tests consisted of:

- body weight, height / body length,
- BMI,
- thickness of the fold above the triceps, biceps and over shoulder, middle arm circumference, and shoulder muscle circumference.

Due to the heterogeneous groups in terms of sex and age, the obtained results were converted to standard deviation values using Z-score. Data were compiled using the WHO centile charts.

All patients underwent the following laboratory :

- peripheral blood morphology with smear,
- serum albumin concentration,
- serum urea concentration,
- concentration of sodium, potassium, phosphorus, and magnesium. [8]
- In addition to the assessment of nutritional status, ferritin serum concentrations and vitamin 25 (OH) D levels were determined.

Results

Using body mass index (BMI) for the children's population, according to WHO centile charts, 62.16% of patients had significant weight deficiency and 12.16% weight deficiency. In contrast, 4,06% were found to be overweight or obese. Normal body weight was observed in 21.62% of the examined children. (Table1).

Table 1 Nutrition status of the examined group by gender.

		Boys	*Girls*
Significant weight deficiency	*62,16%*	*56,82%*	*70%*
Weight deficiency	*12,16%*	*15,91%*	*6,67%*
Normal body weight	*21,62%*	*25%*	*16,67%*
Overweight or obesity	*4,06%*	*2,27%*	*6,67%*
Total	*100,0%*	*100,0%*	*100,0%*

Based on the WHO centile charts; BMI ≥ 85 centile – overweight or obesity, BMI < 3 centile – significant weight deficiency, BMI=3-15 – weight deficiency ,BMI = 15-85 centile – normal body weight.

Biochemical parameters of nutritional status

Anemia was reported in 8 (10%) patients, in 66 (90%) children the hemoglobin level was normal. Incorrectly low values of ferritin, the basis for the diagnosis of iron deficiency, were observed in 13 patients (17.56%).

Albumin deficiency was present in 13 (17%) children, in 54 (72%) was correct, and in 7 patients (9%) the level of albumin was not determined. One third of children were found to have vitamin 25 (OH) deficiency. The other children had a normal vitamin D value or slightly above normal. There were no statistical differences between biochemical measurements and patients' gender.

Data from the interview

Based on an interview, in each group the usage of neurological and anti-reflux medications (affecting appetite) was evaluated. The method of feeding (oral or tube / PEG), food calories and patient environment were assessed.

Used drugs

The total number of children who take neurological medications was ¾ (75.67%) of the patients, 43% are girls and 57% are boys.

There were 25 (33.78%) children using anti-reflux drugs (48% of girls and 52% of boys).

There is no statistical significance between sex and the drugs used.

Method of feeding and calorie of meals.

44 (almost 60%) of children were fed orally (31% of girls, 69% of boys), and 30 (40%) of patients were fed enterally - by nasogastric tube or PEG (girls - 53%, boys - 47%).

Only 35 (47.29%) children had a correct calorie intake for their age and gender.

No statistically significant relationship between gender and food calorie intake was demonstrated.

Assessment of nutritional status and age of examined children

On the basis of the WHO centile charts 22 (57.89%) patients among younger children (AI) had significant weight deficiency and 24 (66.67%) in the group of older children (AII). In contrast, weight deficiency (BMI 3-15) in both groups was comparable (in the AI group 5-13.16% and in AII 4-11.11).

BMI values in both groups were similar. There were no statistical differences between the groups.

Table 2 Nutritional status of the examined group by age

	AI	AII
Significant weight deficiency	57,89%	66,67%
Weight deficiency	13,16%	11,11%
Normal body weight	26,32%	16,67%
Overweight or obesity	2,63%	5,56%
Total	100,0%	100,0%

Table 3 Anthropometric measurements (BMI) and age of examined children

		Group AI	Group AII	p
BMI	Mean SD	14,06±2,37	15,22±4,30	
	Median	13,67	13,30	NS
	Min - Max	10,6-21,76	8,14-25,70	p>0,05
BMI	Mean SD	-1,43± 1,35	-1,58 ± 1,59	
(z-score)	Median	-1,81	-1,91	NS
	Min - Max	-4,10 – 2,15	-4,02-2,37	p>0,05

Biochemical parameters of nutritional status and age

Serum hemoglobin concentration below the reference standard was observed in 4 (10.53%) patients in AI group and 4 (11.11%) in AII group.

Abnormally low serum ferritin concertation was observed in 6 patients (16.6%) in the AI group and in 7 (20%) patients from the AII.

Decreased albumin levels were observed in 8 (25%) children in the AI group and in AII group in 5 (15%). Mean serum albumin concentrations in both groups was similar.

Vitamin D deficiency has been reported more frequently among older children (14 children -38%). There was no statistically significant difference between the reported parameters and the age of the examined children.

Assessment of nutritional status and neurological disease

Parameters, the results of which were consistent with normal distributions are: a body weight, body height, BMI, BMI (Z-score), thickness of the triceps, biceps and under the shoulder, middle arm circumference and muscle circumference.

Body weight and body height in both groups were not statistically different.

BMI values for two standard deviations below mean were more frequently observed in NDI patients than in NDII, the difference was statistically significant (P <0.05).

Using standard BMI cut points for children, according to WHO centile charts, in 69.09% of children from NDI group a significant body weight loss was observed and 42.11% in the DII group. However, a weight deficiency (BMI 3-15 pc) occurred in 7.27% of children from the NDI group and in the NDII group in 26.32%.

Figure 1 BMI relationship (percentiles) in DI and DII

Biochemical parameters of nutritional status and neurological disease

Anemia was reported in 7 (12.73%) patients in NDI and 1 (5.26%) patients in the NDII group. Mean hemoglobin levels in both groups were comparable. The ferritin level in the NDI group was slightly higher than in the NDII group. However, no statistical significance was found.

The level of albumin below the reference standard was found in 11 (20%) of patients in the NDI group and 2 (12%) in the NDII group. Albumin values were comparable in both groups.

Vitamin D deficiency was reported in 20 (36.35%) patients in NDI group and in NDII group in 3 patients (15.78%).

Assessment of nutritional status and degree of dysphagia

Parameters, the results of which were consistent with normal distributions are: a body weight, body height, BMI, BMI (Z-score), thickness of the triceps, biceps and under the shoulder, middle arm circumference and muscle circumference.

Body weight and body height in both groups were not statistically different.

BMI values for two standard deviations below mean were more frequently observed in DI patients than in DII, the difference was statistically significant (P <0.05).

In 54.84% of children from DI group a significant body weight loss was observed and 67.44% in the DII group.

Table 4 Nutritional status of the test group according to the degree of dysphagia

	DI	DII
Significant weight deficiency	54,84%	67,44%
Weight deficiency	12,90%	11,63%
Normal body weight	25,81%	18,61%
Overweight or obesity	6,45%	2,33%
Total	100,0%	100,0%

Biochemical parameters of nutritional status depending on the degree of dysphagia

Anemia was observed in 8 (18.60%) patients in the DII group. group DI all children have hemoglobin values within the reference standards. It has been demonstrated statistical significance between groups.

Abnormally low levels of ferritin were observed in 3 (9.68%) patients in the DI and in 10 (23.26%) patients in the DII, and showed no statistical relationship between groups.

Decreased albumin levels were only observed in 13 (31%) children in the DII group. Statistical significance was demonstrated between the groups.

Vitamin D deficiency was observed in 10 (32.26%) children in the DI group and in the DII group in 13 (30.23%). There was no statistically significant difference between the groups.

Discussion

Malnutrition is a common problem in hospitalized children with central nervous system disorders. This may be due to a neurological disorders, feeding difficulties and inadequate supply of calories. [9]

Immobilization of patients, neurological disease itself and its metabolic consequences are factors which deepening malnutrition [10]

The consequences of malnutrition and the consequences of neurological disease are an important factor in extending hospitalization and increasing the cost of treating children with CNS disorders. [11]

Knowledge of the causes, symptoms, methods of diagnosing malnutrition and effective therapies is a key element of therapeutic success.

BMI is the most commonly used nutritional status indicator, as monitoring of body weight is a simple and available method of assessing the imbalance between supply and demand and which allows, in case of indications, targeted intervention.

Malnutrition is a common problem among children with cerebral palsy, as documented in literature [12,13].

Using the BMI cutoff criteria for deficiency of body weight, overweight and obesity (assumptions as above), a comparison and next the evaluation of disorders were made in the study group. The analysis of the study showed weight deficiency in 75% of children and overweight or obesity in only 4% based on BMI, referring to WHO reference values (two standard deviations). Andrea A. et al. demonstrated weight loss in more than half of children with cerebral palsy. In their work on the basis of anthropometric studies, body composition, food calorie intake they assessed the nutritional status of 30 children with cerebral palsy, showing an increased risk of malnutrition in children with severe CP. [12]. Similar results are reported by Karagiozoglou-Lampoudi et al., who reported weight deficiency in 40% of children during assessing the risk factors affecting the feeding and nutritional status of children with cerebral palsy. They evaluated, in the group of 42 patients with CP, the anthropometric measurements and compared them to the WHO standards and presented the relationship of the diet quality index (DQI), used to evaluate the quality of the diet, to the BMI (z-score). [14] Also, J. Socas Teixeira, M. Martins Gomes, in their work on anthropometric measurements of children with non-communicable encephalopathy, found 71% of children with malnutrition, referring to WHO standards and charts developed by Krick et al. The study involved 20 children who underwent anthropometric measurements - body weight, body length / height, length-to-age ratio, body weight to body length, thickness of the triceps muscle, middle arm circumference, and arm muscle circumference. [15] An important parameter during evaluation of the nutritional status in our study were results of anthropometric tests such as measurement of the skin fold thickness over the triceps, biceps and under the shoulder, measurement of the arm circumference and arm muscle. Comparing these values to the reference values by WHO in more than half of the children fold thickness over biceps and triceps was below 3 percentile. In contrast, the thickness below the 3 percentile was observed in about 60% of children. Circumference of the central arm and arm muscle circumference in 75% of children was two standard deviations according to WHO. The values of the above parameters were similar to values obtained by Andrea A. Garc-Contreras et al. Also, M. Sangermano et al. in their work on nutritional problems in children with neurological disorders report that in about 40% of children with neurological disorders, the thickness of the triceps fold was less than 3 percentile and 10% of children had values above 85 percentile. In addition to measurements of folds, they took weight, body height, BMI and biochemical parameters. [16]

In our observation only less than 3% of children with neurological disorders had triceps thickness over 85%.J.Socas Teixeira et al. found that based only on the thickness over the triceps malnutrition was presented in 80% of children, based on the middle arm circumference - 43%, and based on circumference of the arm - 60%. [15] Frisanho in the 1970s described the arm measurement standards as indicators of nutritional status for the pediatric and adult population that was currently used. We also use biochemical nutritional status indicators to assess nutritional status.Taking into account the biochemical nutritional status, no significant deviations were found in the analysis of the examined children.Anemia was found only in 10% of children with CNS damage.Similarly, M. Sangermano et al., who reported anemia in 13% of patients. M. Santos, T. et al., in their work on the impact of motor dysfunction of the gastrointestinal

tract on the nutritional status of children with cerebral palsy show the correct values for hemoglobin in almost all of 43 examined children. [17]

In case of anemia and iron deficiency, the concentration of ferritin, which is responsible for the storage of iron in the body, should be remembered. In our own studies, abnormal ferritin levels were observed in 18% of children. Similar results are reported by Hillesund, in his work on the nutritional status of children with cerebral palsy based on micronutrients content in the body, reduced ferritin values were found in 13% of patients. [18]

In conclusion, it can be assumed that malnourished children with CNS damage mostly have normal values of hemoglobin and ferritin. A small percentage of these children are diagnosed with iron deficiency anemia.

The analysis of our material showed hypoalbuminemia in 17% of children. Italian authors report albumin deficiency in nearly 40% of the examined children, which is significantly different from our studies. This may be due to a smaller study group, which in Italian researchers included 30 patients. Lark R et al. describe albumin deficiency and pre-albumin in children with cerebral palsy and their lack of influence on nutritional assessment. [19]

The vitamin 25(OH) D3 may prove to be a very important biochemical parameter.

The more authors describe the role of this vitamin in practically all physiological processes.

In a child with CNS damage, muscle weakness and constant non-use of muscle result in reduced bone expansion. This often causes osteoporosis, resulting in an increased number of fractures. Hence, a very important function of vitamin D3 in this group of children.

In our analysis, one third of children had vitamin 25(OH) D3 deficiency, more than 5% had total calcium deficiency and 6% had phosphorus deficiency. Similar results are reported by Tyson Ware et al. in the work on the effect of vitamin D on the bone status of children with CP. They report vitamin D deficiency in 34% of children with cerebral palsy. [20] Hillesund also reported a vitamin 25 (OH) D3 deficiency in 1/3 of patients and total calcium deficiency and phosphorus deficiency in 5%.

Considering the way of feeding and caloric content of meals, it was observed that more than half of the children were fed orally and 40% enteral (tube / PEG), while only less than half of children had proper calorie-related meals for sex and age. Also, other studies have shown that caloric content of meals for children with neurological disorders was too small. M.Sangermano and Rob Rieken et al. also reported abnormal caloric content of meals for half of examined children. [21]

In the study participated a large group of 74 children with central nervous system damage, in which the nutritional status was assessed on the basis of anthropometric, biochemical, and history , in which not only children with CP but also with progressive encephalopathies and metabolic diseases, CNS defects and unknown causes of CNS damage were involved.

Unfortunately, the actual incidence of malnutrition, growth inhibition and overweight is not known in children with CNS damage. So far, only the estimates for cerebral palsy have been published in literature, where malnutrition was found in 29- 46% and overweight in 8-14%.

In order to deepen the assessment of existing disorders, in a group of children with CNS damage selected anthropometric and biochemical parameters have been investigated, whereas the impact on the detailed test results can have neurological disease, the degree of dysphagia and age.

The rationale for conducting a careful assessment and monitoring of nutritional problems in children with severe damage to the central nervous system is introducing early nutritional intervention thereby contributing to improve the quality and extend the life of these patients.

Abbreviations

1. ESPEN- The European Society for Clinical Nutrition and Metabolism
2. CNS-Central Nervus System
3. BMI- Body Mass Index
4. AI group- from 2 to 8 years of age
5. AII group- from 9 to 16 years old
6. NDI group - cerebral palsy and progressive / non-communicable encephalopathy
7. NDII - genetic, metabolic, CNS defects and unknown causes
8. DI group - II and III degree of dysphagia
9. DII group - IV and V degree of dysphagia
10. WHO- World Health Organization
11. PEG-Percutaneus endoscopy gastrostomy

Results

1. Nutritional disorders, primarily in the form of malnutrition, on the basis of anthropometric measurements occur in most children with central nervous system damage, while less frequently performed biochemical studies indicate the characteristics of malnutrition
2. Children diagnosed with nonprogressive encephalopathy / progressive, and high degree of dysphagia are most at risk of malnutrition, as indicated by both anthropometric measurements and biochemical tests.
3. Early dietary intervention should be introduced in children with central nervous system disorders due to insufficient caloric intake.

Declarations

Ethics approval and consent to participate The work described in this article has been carried out in accordance with The Code of Ethics of the World medical Association (Declaration of Helsinki) for experiment involving humans: EU Directive 2010/63/EU for animal experiments.

Number ethics approval KNW/022/KB1/100/12 , Medical University of Silesia w Katowicach (03.07.2012 r). Parent or guardian for participants under 16 years old agreed to take part in the research.. The informed consent obtained was written.

Consent for publication: Not applicable

Availability of data and material: Data sharing not applicable to this article as no datasets were generated or analyzed during the current study.

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Authors' contributions: AFW collected data , participated in the design of the study , performed the statistical analysis drafted the manuscript.. UGC conceived of the study, and participated in its design and coordination and helped to draft the manuscript. All authors read and approved the final manuscript.

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Figures

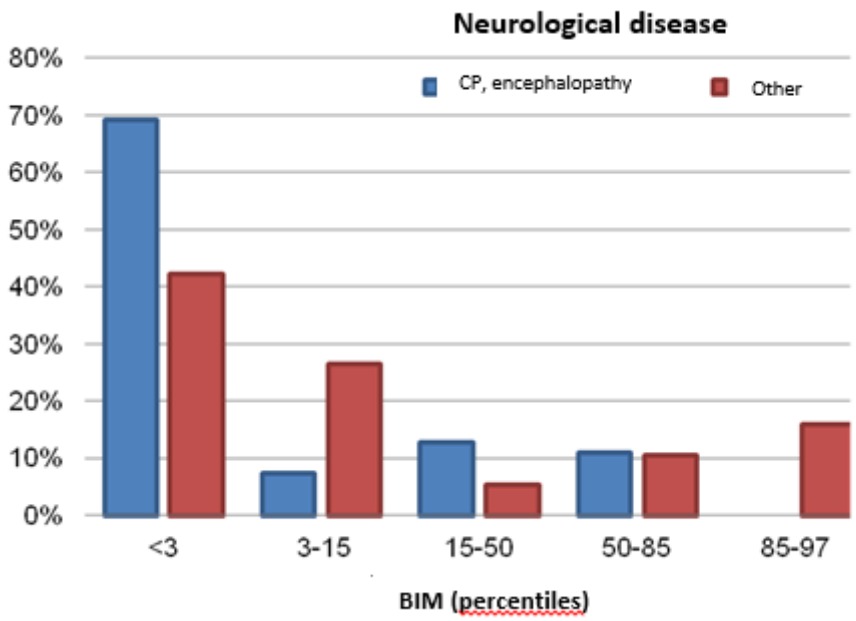

Figure 1

BMI relationship (percentiles) in DI and DII