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Cerebral Palsy in Childhood: Possible Relationship Between Nutritional Status and Gestational Age

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Abstract: Cerebral palsy (CP) is a term employed to define different physical disability syndromes. Children's nutritional status is highly related to their growth and general development. Gastrointestinal symptoms (GIS) are frequent and have influence on nutritional status (NS). It's necessary to evaluate and treat these symptoms adequately to improve the NS. Generally, pre and perinatal risk factors are 85% of the causes and 35% of the cases are premature newborn. In this analytical, observational and cross-sectional study with retrospective data. It was included patients under 18 years with CP with GMFCS V with exclusive enteral nutrition, ambulatory patients in Hospital Nacional Profesor Alejandro Posadas from January to June 2021. The sample consisted of 36 patients with a median age of 66 months (pc 25 32-pc 75 133). 61% of the patients were born at term. 42% with a prenatal cause. The most frequent SGIs were constipation (33%) and GER (19%). The median for the P / E according to WHO was -2.7 SD (CI: -3.41 - 1.97) (underweight). 50% of them presented a P / E < 25th percentile (higher risk of morbidity and mortality). We conclude that patients with postnatal CP had a nutritional diagnosis of underweight, in comparison with the CP diagnosed pre and perinatally. It was evidenced that the severe underweight, which was evaluated using WHO tables, coincides with the low percentiles of the Brooks table, indicating a higher risk of morbidity and mortality in underweight patients.

Keywords: Cerebral Palsy, Nutrition Assessment, Nutrition Therapy, Malnutrition

1. Introduction

Cerebral palsy (CP) is a term used to define various physical disability syndromes, including abnormal control of movements and posture caused by an impaired brain development. [1, 2] It is classified as a multiple disability. [3] It represents the most common physical disability in childhood. In Argentina there is no PC registry. [4] Approximately 17 million people in the world live with this disability and it affects 2 to 3.5 per 1,000 live births per year. [5] Although not progressive, symptoms persist into adulthood and can have consequences for body functions and structures as well as for activities and participation as the child grows. [6, 7]

It is a multi-factorial syndrome and it's very difficult to identify the precise cause of its origin. Pre- and perinatal risk factors are generally 85% of the causes. On the other hand, perinatal births include premature births (35% of CP cases are premature babies at birth and the risk is 30 times higher in those with a birth weight less than 1.5kg). 15% of causes are post-natal. [8, 9]

Table 1. *Etiological factors of PCs.*

Prenatal factors	Perinatal factors	Postnatal factors
Changes in coagulation	Premature childbirth	Head injuries
Toxemia	Pre-natal asphyxia	Meningoencephalitis
Untreated maternal hypothyroidism	Hyperbilirubinemia	Intracranial hemorrhage
Corioamnionitis	Pre-natal infection	Cerebral infarction
Placental infarction	Low weight	Hydrocephalus

Prenatal factors	Perinatal factors	Postnatal factors
Multiple pregnancies	Maternal fever during childbirth	Intracranial tumor
Autoimmune diseases	Systemic or CNS infection	Convulsive status
High blood pressure	maintained Hypoglycemia	Respiratory cardio attack
Cerebral arterial infarction	Intracranial hemorrhage	Poisoning
Intrauterine infection		Severe dehydration
Trauma		
Genetic factors		
Exposure to toxins and drugs		

Source: adapted from [8-10].

There are different classifications to determine the type of CP: -According to motor failure (spastic, athetotic, ataxic, hypothonic, dystonic or mixed); -According to the location of motor failure or compromised limbs (quadriplegia, hemiplegia, diplegia and monoparesia). [11] -Mild, moderate and severe, depending on gross motor function, intended for the organization or structuring of voluntary movements. [12] With respect to this last one, there is a Coarse Motor Function Classification System, also known as the GMFCS Gross Motor Function Classification System, is the gold standard of classifications to describe the level of functionality of a person with PC. [6, 13-15]

Table 2. *Description of GMFCS levels.*

Level I	Level II	Level III	Level IV	Level V
Walks without limitations	Walks with limitations	Walks using a mobility device with manual restraint in most interior spaces	Use mobility methods that require physical assistance or motorized mobility in most environments	Transported in wheelchairs in all environments

Source: Adapted from Ruiz Brunner [6].

A child's nutritional status is highly related to his or her growth and overall development. In children with CP, nutritional assessment becomes a challenge because the relationship between weight, height, growth and body composition differs from that of children with typical development. Deficit malnutrition is more common than overweight and obesity in children with PCs in our country. [16]

The nutritional approach is an integral part of multidisciplinary treatment with the aim of contributing to improve the survival and quality of life of patients, due to the high incidence of nutritional effects such as malnutrition, failure in growth, micronutrient deficiencies and osteopenia. (12) This occurs with high frequency in patients with GMFCS IV or V, due to insufficient intake of food because of immobility, disability, lack of signaling hunger-satiety, less physical activity or endometrial alterations, and a greater degree of malnutrition is observed in these patients. [13, 14].

The gastrointestinal alterations are frequent and very important in this disease; within them it is observed the oral motor dysfunction, with the secondary difficulty to feed, risk of aspiration by dysphagia, sialorrea, gastroesophageal reflux, gastroparesis, intestinal dysmotility and constipation. [15, 16] These gastrointestinal alterations influence the nutritional status of the child. Evaluating and treating them properly benefit an improvement in nutritional status achieving weight gain, better linear growth, fat deposition (subcutaneous folds) and a decrease in mainly infectious morbidity. [17, 18].

People with CP have a different body composition than children with typical development and stunting that is strongly influenced by functional severity and feeding capacity. This is why it is difficult to assess their nutritional status due to lack of benchmarks. For this reason, specific tables have been developed for this population with stratification according to the functional capacity defined with the GMFCS. The author identified that children with low weight/age had a higher risk of comorbidities and mortality, with a higher risk of mortality in levels I and II when they had a percentile less than 5 and in levels III to V when the percentile was less than 25. [19]

Bearing in mind that the assessment of nutritional status and the provision of adequate nutrition are crucial components in the management of children during the disease, because malnutrition is frequent and affects their normal growth and development, the general objective of this study was to describe the nutritional status in patients with GMFCS V using the WHO tables to determine the diagnosis and the Brooks tables performed in patients with CP to determine the risk of morbidity-mortality; with respect to the specific objectives, it was considered to analyze whether there is a relationship with nutritional status and gestational age at birth, the cause of CP and the presence of gastrointestinal symptoms.

2. Materials and Methods

Analytical, observational and cross-sectional study with retrospective data, whose inclusion criteria were patients under 18 years with cerebral palsy with GMFCS V that are exclusively enteral-fed, which were treated on an outpatient basis in the outpatient nutrition clinic of the Professor Alejandro Posadas National Hospital from January to June 2021. Moreover, the exclusion criteria were medical records with incomplete data recording.

The total sample was 36 patients, recruited by medical history. A form was used to record their personal data such as age, weight, height, body mass index (BMI) and their respective indices: weight/age (P/E), BMI/age (BMI/E) and

diagnosis. As for the variables, data were collected on sex, gestational age (Premature 37 weeks and at full term 38), current age (months). Age corrected up to 2 years was used in premature patients and chronological age in full-term newborns and those premature with an age greater than 2 years. The etiology of cerebral palsy (prenatal, natal and post-natal) will be recorded [1].

On the other hand, the type of feeding was established either enteral nutrition by Naso-Gastric Tube (SNG), gastrostomy (GTT) or feeding jejunostomy (YT).

Finally, the most frequent gastrointestinal symptoms (vomiting, gastro-esophageal reflux disease, constipation and diarrhea) were recorded.

Whereas:

1) Diarrhea: >4 liquid stools/day
2) Constipation: Negative catharsis >48 hours
3) Vomiting: 2 or more daily episodes.
4) Gastro-Esophageal Reflux Disease: Diagnosis of Esophageal pH or Monitoring of pH / Multichannel Intraluminal Impedance and/or Upper Gastrointestinal Endoscopy. [20, 21]

For anthropometric measurement, weight, height and BMI were recorded. The weight was obtained by difference (subtracting the weight of the child from that of the companion or the wheelchair). Nutritional diagnosis was made using World Health Organization (WHO) tables: P/E and height/age (T/E) were used in children younger than one year, BMI/E and T/E. [22] (Table 3). Brooks tables were used to compare with the population of children with PCs [19].

Table 3. *Nutritional diagnosis according to WHO.*

Diagnosis	<1 year		>1 year	
	Weight/age	Heigh/age	BMI/age	Heigh/age
Above 3 SD	Pacient may have a growth		OBESITY	
Above 2 SD	problem. Evaluate in relation to		OVERWEIGHT	
Above 1 SD	body length		POSSIBLE RISK OF OVERWEIGHT	
0 (Median)	Normal weight		EUTRÓPHIC	
Under -1 SD				
Under -2 SD	UNDERWEIGHT	STUNING	WASTED	STUNING
Under -3 SD	SEVERE UNDERWEIGHT	SEVERE STUNING	SEVERE WASTED	SEVERE STUNING

Source: [22].

*WHO tables were used as it has developed prescriptive growth standards from a sample of children with typical development from six countries, in the Multicenter Growth Reference Study (EMRC) which was designed to provide data that describes how children should grow up around the world and allows a nutritional diagnosis to be made. [23]

Brooks' tables, on the other hand, were used to compare the growth of the child with other children with cerebral palsy and to establish risk zones for weight. The international guides described the above mentioned references. [20, 24]

All measurements were converted to z-scores based on age and sex reference patterns of the World Health Organization using the WHO software, Anthro Plus V1.0.4. #Malnutrition will be defined according to the World Health Organization as wasting (low weight for height), low height (low height for age) and low weight (low weight for age), and will be classified as moderate or severe malnutrition according to Z scores. [4, 23, 24]

For the quantitative variables, central trend measurements with their respective dispersions were used according to the sample distribution, mean and standard deviation (SD) for those with normal or median distribution and interquartile range for abnormal distribution data. For qualitative variables, absolute count and percentage were used. Parametric/non-parametric tests were used to make comparisons between quantitative variables according to their distribution. To compare the qualitative ones, the CHI2 or Fisher Exact test was used according to the conformation of the double-entry table.

To determine risk, the odds ratio and its confidence interval were calculated.

A p value<0.05 was considered statistically significant.

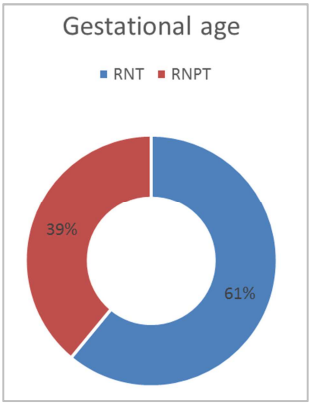
3. Ethical Considerations

The participating researchers are committed to comply with Law 26529/2009 and its amendment 26742/2012 "Patient rights in relation to health professionals and institutions", ensuring the confidentiality of participants' data. For this purpose, all personally identifiable information will be removed from the study records after health data has been compiled and stored in encrypted electronic formats that will be available for review by the nosocomial research ethics committee.

4. Results

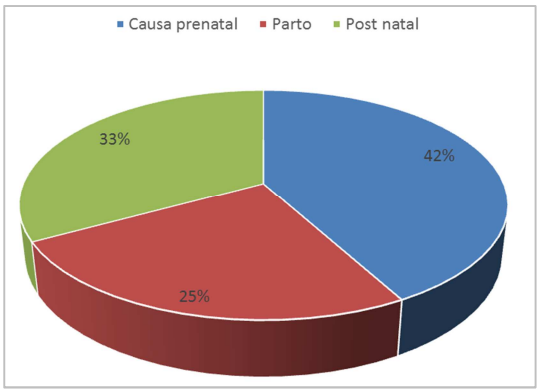
The total sample was 36 patients. The median age was 66 months (pc 25 32-pc 75 133). The distribution by sex was 58% male and 42% female. From the sample it was observed that the highest percentage of patients were born to term (61%), as shown in figure 1.

Eighty-nine per cent of the sample live with their families and 11 per cent in children's homes orphanage. Figure 2 shows the possible causes of CP, they were divided according to whether they were recognized before, during or after childbirth during the process of brain development. The greatest number of cases was diagnosed before childbirth (42%).



Source: Author's own creation

Figure 1. *Distribution according to gestational age.*



Source:: Author's own creation

Figure 2. *Distribution of CP cases.*

56% were fed through an SNG and the remaining 44% with GTT, no patient was fed through YT. The most frequent gastrointestinal symptoms were 33% constipation, 19% GERD, 6% diarrhea 3% vomiting 3% constipation and GERD. The mean for P/E according to WHO was -2.7 SD (CI: -3.41 - 1.97) (low weight). We evaluated 80% of the patients through the Brooks tables, which met the evaluation criteria (>24 months), of which 50% had a percentile <25 P/E (higher risk of morbidity-mortality) The mean T/E according to WHO was -3.12 SD (CI: -3,92, -2,33) (severe short). The average BMI/E according to WHO was -1.62 SD (CI: -2.23 - -1.02) (eutrophic), BMI/E WHO 33% severe emaciation, 22% emaciation, 38% eutrophic, 5% overweight.

The Brooks tables for T/E showed that 11% of patients had PC 5-10, 19% PC 10-25, 17% 25-50, 16.7% 50-75, 6% 75-90 and 8% >95. Both P/E, T/E and BMI/E had a normal distribution. These data are outlined in Table 4.

Table 4. *Sociodemographic characteristics.*

Characteristics	Description
Age in months (median± pc 25-75)	66 months (pc 25 32-pc 75 133)
Male gender (%)	58,3%
Etiology CP	Prenatal 41,7% Childbirth 25% Posnatal 33,3%
Mortality	5%
Nutritional Assessment	
WHO (Weight/age)	Normal weight 21,7% Low weight 39,1% Severe low weight 39,1% Severe stuning 19,4%
WHO >1 year (BMI/age)	Stuning 27,8% Eutrophic 47,2% Overweight 5,6%
Weight/age (Brooks)	no morbidity and mortality risk 30% morbidity and mortality risk 50% Not evaluated (<24 months) 20%
Type of feeding	NGT 55,6% Gastrostomy 44,4% Yeyunostomy 0%
Gastrointestinal symptoms	None symptom 36,1% Constipation 33,3% GER 19,4% Diarrhea 5,6% Vomiting 2,8% Constipation y GER 2,8%

Source: Author's own creation.

No significant differences were found in relation to the diagnosis, according to BMI, gestational age or place of residence. A statistically significant difference ($p<0.05$) was found in severely wasted patients and the diagnosis of postnatal CP, with no differences in diagnosis in those diagnosed prenatal or at the time of childbirth.

A statistically significant relationship was found in those patients with a diagnosis of severe low weight, according to P/E of the WHO, and evaluated with the Brooks tables in risk of morbidity and mortality, identifying association between these parameters.

5. Discussion

The adverse consequences of malnutrition among children with cerebral palsy are manifold. A study of Karim T [25] in children with CP showed an inversely significant relationship between age and low weight (the older the patient, the lower the weight). Among children under two years of age, 25.3% (n=106) were found to be underweight, according to the Brooks tables. On the other hand, those with feeding difficulties were found to be 3 to 10 times more likely to be underweight, compared to those children with PC without difficulty to feed. These risk factors are likely to intensify due to their complex interaction with socio-economic factors. In our country, a study by Ruiz Brunner showed a high prevalence of severe malnutrition of 59.3% in the GMFCS group level V, while in our study 33% presented severe malnutrition. [4]

An association between PC and intrauterine growth restriction has been suspected for some time, but it is difficult to prove since as information on prenatal growth is generally not available in cohort studies large enough to evaluate CP as a result. In contrast, low birth weight according to population tables is what is generally used as a substitute for growth restriction. A case-control study in Sweden assessed the association between the state of growth at birth and the

subsequent development of PCs in premature and full-term newborns, demonstrating that the risk of developing it is related to the severity of low weight for gestational age. [26] In premature babies, the relationship has so far been less clear, and some studies suggest a low-weight association for gestational age between 34 and 36 weeks, and others an association in gestations <32 weeks only. In our study, 39% of children were preterm and 78% had low weight according to the WHO nutritional diagnosis.

The decision of food route to ensure sufficient intake is very important since the decrease in the ability to feed, directly influence the lower intake of energy and nutrients, exposing children and adolescents with CP to a nutritional risk. [20]. This feature is further accentuated in patients with GMFCS V, included in our work, who cannot feed themselves and need exclusive enteral nutrition for their diet.

An article recently published in our country, about the nutritional status of patients with CP, mentions that patients with GMFCS V were 14 times more likely to have severe malnutrition and 4 times more likely to have moderate malnutrition, compared with patients with GMFCS I-III. [4] They agree with the study carried out in the United States a few years ago in which the specific graphs were made for this population, concluded that in these children, weight percentiles for age are lower than in the general population. This is especially true in children with more severe motor dysfunction. In turn, low weight causes them more important medical conditions and are at greater risk of death, which is why the Brooks tables serve as detection of risk zone to avoid morbidity and mortality. These results are consistent with those of this study.

For clinical practice, according to international guidelines, in the absence of strict criteria for the identification of malnutrition in these children, it is important to observe the presence of warning signs of malnutrition, such as physical signs, //pressure ulcers, skin problems and poor peripheral circulation; weight for age (z score < 2); thickness of the cutaneous fold of triceps <10 percentile for age and sex; mean or upper arm fat or muscle area <10 percentile; and wavering or unsuccessful weight. [16] The results of our work report that the population attended had an average of P/E according to WHO of -2.7 SD (low weight), coinciding with what was exposed in the previous studies. Several studies agree that socioeconomic factors have also been associated with nutritional status and prognosis in children with CP. However, there is little information on the relationship between CP and malnutrition in developing countries, where poverty could accentuate the vulnerability of these children. [14, 28]

Some papers present the discussion that children with higher GMFCS level have higher percentage of fat mass and lower muscle mass than children of the same weight with typical development, probably due to inadequate calorie intake and low physical activity, therefore they suggest that the weight measurement and BMI are insufficient for the evaluation of body composition and it is necessary to add more anthropometric parameters such as skin folds or circles. [19, 29] According to the ESPHGAN Guidelines, finding a low body mass index (BMI) or low P/T may involve low muscle mass, but an increased fat mass. For this reason, they recommend the measurement of skin folds as a routine component in the nutritional assessment of these children. [20] It was a limitation on our work due to lack of equipment.

Children with CP have several risk factors and complications that can make an adequate nutritional status difficult. Complications associated with feeding include oropharyngeal dysphagia, aspiration pneumonia, constipation, and gastro-esophageal reflux disease. The presence of one or more complications of these ones, can cause serious nutritional disorders. In the present study, the predominant gastrointestinal symptomatology was constipation in 33% of the cases. Similar results showed Tavares de Sousa et al with 39% of cases of constipation.

The limitations of this study that can be mentioned are the size of the sample and the lack of equipment for the complete anthropometric measurement, a situation that should be taken into account for future research.

6. Conclusion

According to our study, patients diagnosed with postnatal CP had a low-weight nutritional diagnosis, compared to those diagnosed with pre- and perinatal CP. It was also evident that the low severe weight evaluated by WHO tables coincided with the low percentile of the Brooks table, indicating a higher risk of morbidity and mortality in patients under weight. There was no relationship between gestational age and nutritional status. More work with a greater number of patients is needed to verify the conclusions observed.

Conflict of Interest

The authors declare that they have no conflict of interest.

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