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Original

Nutritional status, dietary intake and serum levels of vitamin C upon diagnosis of cancer in children and adolescents

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Abstract

Introduction: **The prevalence of malnutrition upon diagnosis, together with reduced food intake secondary to disease and treatment, make the periodic assessment of nutritional status (including the intake of antioxidant nutrients) of considerable importance to the follow up of patients with cancer.**

Objectives: **Assess the nutritional status and frequency of inadequate vitamin C levels among children and adolescents with cancer at the beginning of treatment and determine associated factors.**

Methods: **A cross-sectional study was carried out with 30 patients under 18 years. Nutritional status was assessed using laboratory methods and anthropometric measurements. Vitamin C adequacy was assessed through its serum concentration and dietary intake.**

Results: **In the sample, 10% were short for their age and 13.3% were underweight. The triceps skinfold measurement revealed fat depletion in 68% and the arm muscle circumference measurement revealed muscle depletion in 32.0%. Seventy percent of the patients had vitamin C deficiency and had greater weight loss, lower Z scores for all anthropometric indicators analyzed, lower serum albumin and higher C-reactive protein than those without vitamin C deficiency, but these differences were not statistically significant.**

Conclusions: **Children with cancer may have nutritional deficits upon diagnosis. Further studies are needed on the association between serum levels of antioxidant and nutritional status in order to offer safe, effective nutritional support.**

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Key words: *Childhood cancer. Nutritional status. Vitamin C.*

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EL ESTADO NUTRICIONAL, LA INGESTA ALIMENTARIA Y LOS NIVELES SÉRICOS DE VITAMINA C EN EL MOMENTO DEL DIAGNÓSTICO DE CÁNCER EN NIÑOS Y ADOLESCENTES

Resumen

Introducción: **La prevalencia de desnutrición al momento del diagnóstico junto a la reducción de la ingesta de alimentos secundaria a la enfermedad y el tratamiento, condicionan que la evaluación periódica del estado nutricional, incluso la evaluación de los nutrientes antioxidantes, sea de gran importancia en el seguimiento del paciente con cáncer.**

Objetivo: **Evaluar el estado nutricional y la frecuencia de los niveles inadecuados de vitamina C en niños y adolescentes con cáncer, en etapas tempranas del tratamiento, y determinar los factores asociados.**

Métodos: **Se realizó un estudio transversal con 30 pacientes menores de 18 años para evaluar el estado nutricional y la frecuencia de los niveles inadecuados de vitamina C en los pacientes de oncología pediátrica al momento del diagnóstico de la enfermedad. Se evaluó el estado nutricional por métodos de laboratorio y mediciones antropométricas, y se evaluó la vitamina C en su concentración sérica y el consumo de fuentes de alimentos.**

Resultados: **Se obtuvo 10% de baja estatura, 13,3% de bajo peso, 68% de disminución de los pliegues cutáneos del tríceps (PCT) y 32,0% de la circunferencia muscular del brazo (CMB). El setenta por ciento de los pacientes presentaron una deficiencia de vitamina C. Estos mostraron una mayor pérdida de peso y menor puntuación Z para todos los indicadores antropométricos estudiados, media menor de albúmina sérica y media mayor de proteína C reactiva en comparación con las personas que no tienen deficiencia de vitamina C, pero las diferencias no fueron estadísticamente significativas ($p > 0,05$).**

Conclusión: **Los niños con cáncer pueden presentar importantes déficits nutricionales al momento del diagnóstico de la enfermedad. Se necesitan más estudios sobre la asociación entre los niveles séricos de antioxidantes y el estado nutricional, a fin de apoyar el soporte nutricional seguro y efectivo.**

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Palabras clave: *Cáncer infantil. Estado nutricional. Vitamina C.*

Abbreviations

%WL: Percentage of weight loss.
AC: Arm circumference.
AMC: Adequacy of arm muscle circumference.
BMI/A: Body mass index for age.
CRP: C-reactive protein.
FAPE/IMIP: Fundação de Apoio à Pesquisa/IMIP.
H/A: Height for age.
HW: Habitual weight.
IMIP: Instituto de Medicina Integral Prof. Fernando Figueira.
TSF: Triceps skinfold.
W/A: Weight for age.
WHO: World Health Organization.

Introduction

Childhood cancer accounts for 0.5% to 3% of malignant tumors in the majority of populations.[1] In developed countries, following accidents, cancer is the second leading cause of death among individuals under 15 years of age and has become the leading cause of death in developing countries.[2,3] In Brazil, it is estimated that 9,386 new cases of childhood cancer will occur in 2010.[4]

Childhood tumors are a highly specific, generally embryonic group that affects cells of the hematopoietic system and supporting tissues, whereas, in adults, tumors affect the epithelial cells that cover the different organs.[3] Moreover, childhood tumors tend to have a shorter latency period, generally grow rapidly and become quite invasive, but respond better to treatment and, for many, the prognosis is good.[3] In most populations, the most common type of childhood cancer is leukemia, followed by lymphoma, central nervous system tumor, neuroblastoma, Wilms' tumor, rhabdomyosarcoma, bone tumor and retinoblastoma.[4]

The prevalence of malnutrition upon diagnosis ranges from 6% to 50%, depending on the type of tumor, its location, malignity and stage as well as the criteria adopted for the assessment of nutritional status.[5] Malnutrition may be caused by different mechanisms involving the tumor itself, cytokine production in response to the tumor and cancer treatment.[6] Patients with cancer often have a reduced food intake due to symptoms such as anorexia, nausea and vomiting. In some circumstances, poor nutrient absorption may occur. These conditions predispose cancer patients to nutrient deficiency, especially with regard to antioxidants, which can lead to the buildup of free radicals and consequent oxidative stress, thereby affecting the tolerance to treatment.[7,8]

There are a number of mechanisms that may lead to oxidative stress in cancer patients. The redox system, which includes antioxidant enzymes (superoxide dismutase, catalase and glutathione peroxidase) and low molecular weight antioxidants, may be deregulated in these patients and this imbalance can facilitate the progression of the disease. Moreover, there is a growing body of evidence regarding the association between oxidative stress and neoplastic cachexia.[8]

Compounds such as vitamins A, C and E act as antioxidants, inhibiting the formation of free radicals, minimizing cell damage and toxicity caused by these reactive species and having a positive effect on the response to treatment.[9,10] Vitamin C has been tested *in vitro* and *in vivo* and seems to be the most versatile and effective of the water-soluble antioxidants, exhibiting a capacity to prevent the adverse effects of treatment and enhance the effects of chemotherapy.[11,12] However, there is little information in the literature regarding serum levels of vitamin C among children and adolescents and less still regarding cancer patients.

Objectives

The aim of the present study was to assess the nutritional status and frequency of inadequate vitamin C levels among children and adolescents with cancer at the beginning of treatment and determine associated factors.

Methods

A prospective cross-sectional study was carried out between may and august 2009 involving male and female children and adolescents under 18 years of age admitted with a confirmed diagnosis of cancer at the pediatric oncology ward of the Instituto de Medicina Integral Professor Fernando Figueira (IMIP, Recife, Brazil) for treatment. The following were the exclusion criteria: previous chemotherapy or radiotherapy; infusion of blood products in the 30 days prior to data collection; and impossibility to undergo nutritional assessment (patients in intensive care or those with comorbidities that preclude nutritional evaluation). The data were obtained from electronic patient files and an interview with the parent or guardian of the child.

A structured questionnaire was used for the socioeconomic characterization, containing data on the caregiver (age, schooling), *per capita* monthly household income (R$) and number of residents in the home. The following aspects referring to housing conditions were investigated: number of rooms in residence; destination of trash; type of sewage disposal; type of home construction; and water supply conditions.

The following data were gathered during the clinical evaluation: age in years at time of admission categorized in three age groups (0|-5, 5|-10 and 10|-18 years); type of cancer; presence and duration of signs and symptoms associated to cancer. For analytical purposes, two groups of patients were considered: those with hematological malignancies (leukemia and lymphoma) and those with solid tumors (nephroblastoma, neuroblastoma, central nervous system tumor, rhabdomyosarcoma, etc).

The assessment of nutritional status was performed within 48 hours after admission. Weight, height, arm circumference (AC) and triceps skinfold (TSF) were measured. For children under two years of age, weight was determined using an electronic scale (Kratos®) with a precision of 0.1 kg and 15-kg capacity and height was determined in the horizontal position using a infantometer with a length of 1.20 m and precision of 0.1 cm. Children over the age of two years were weighed on a digital scale (Filizola®) with a precision of 0.5 kg and 150-kg capacity and height was determined using the anthropometer coupled to the scale. The parent/guardian supplied data on habitual weight (HW) for the calculation of the percentage of weight loss (%WL) using the following formula: %WL = (HW-current weight)/HW x 100%.

The following anthropometric indices were employed: height for age (H/A) and body mass index for age (BMI/A); weight for age (W/A) was calculated for children under ten years. The curves recommended by the World Health Organization (WHO) were adopted as reference.[13] For the nutritional assessment, the Z scores of these indices were calculated with the aid of the WHO AnthroPlus® program (WHO, Geneva, Switzerland), for which children under two standard deviations were considered as exhibiting nutritional deficit and those over one standard deviation were considered as having excess weight.

For the assessment of body composition, a measuring tape was used to determine AC and a scientific skinfold caliper (Lange®, Beta Technology Incorporated, Cambridge, MD, USA) was used to measure the TSF, with a constant pressure of 10 g/mm^2. The measurements were made on the mid point between the olecranon and acromion on the non-dominant arm. From the AC and TSF measurements, the adequacy of arm muscle circumference (AMC) and TSF were determined for the assessment of muscle and fat mass, respectively, using the Frisancho reference values.[14] Analysis was performed using the adequacy percentage in relation to the 50 percentile, with < 90% denoting depletion, ≥ 90% and < 110% denoting normal range and ≥ 110% denoting overweight.

Blood collection for biochemical analysis preceded the beginning of any radiotherapy or chemotherapy. Blood was collected in the morning following 12 hours of fasting. A 5-ml aliquot of serum was obtained by centrifugation and sent to the laboratory (Laboratório Álvaro, PR, Brazil) for the analysis of serum vitamin C.

Albumin was analyzed using the colorimetric method with bromocresol green and measured automatically using the Architec® analyzer. The following cutoff points were used for references values based on age group: < 2.5 g/dL for 0 to 11 months; < 3.0 g/dL for 1 to 5 years; < 3.5 g/dL for 6 to 17 years. C-reactive protein (CRP) was determined quantitatively using the immunoturbidimetric test, measuring the antigen-antibody reaction. CRP values ≥ 1.0 mg/L were considered high.

Serum vitamin C was determined using high-performance liquid chromatography. Values above 0.2 mg/dL were considered normal. This method allowed obtaining serum levels in a continuous fashion only when the values were greater than 0.2 mg/dL. Lower results were obtained in a categorized manner (< 0.2 mg/dL). A food frequency questionnaire was used for the assessment of dietary vitamin C. Habitual dietary vitamin C intake was determined by the intake frequency of food groups with significant vitamin C content in the previous six months.

The data were entered on the Excel program for Windows®. The analyses were performed on the SPSS program version 13.0. The Kolmogorov-Smirnov test was used to test the normality of the continuous variables. For variables with normal distribution, the Student's t-test was used to compare two independent groups and one-way analysis of variance (ANOVA) was used for comparisons of more than two groups. For variables with non-normal distribution, the Mann-Whitney test was used to compare two groups. The level of significance was set at 5%.

The IMIP bioethics committee approved the study (process n.º 1372). All procedures involved are in compliance with the ethical standards of the committee responsible for experiments involving human subjects.

Results

A total of 42 patients were admitted in the study period, but 12 (28.6%) were not included for fulfilling the exclusion criteria. Thus, the final sample was made up of 30 children and adolescents, the majority of whom were male (60%) and under five years of age (60%) (table I).

Table I displays the data on socioeconomic status and clinical characteristics of the sample. Average mother's schooling was 7.43 ± 3.18 years and *per capita* monthly household income was US$ 85.34 ± 47.59. Regarding housing conditions, all homes were made of brick and had flooring; most had access to basic public services, such as water supply (73.3%), trash collection (83.3%) and sewage system (70.0%).

Hematological malignancies were the most prevalent (36.7% leukemia and 10.0% lymphoma). A total of 36.7% of the children had a family history of cancer. Median time of the perception of signs and symptoms on the part of the family was eight days (inter-quartile interval: 2.75 to 30.0). Figure 1 displays the most prevalent signs and symptoms upon diagnosis, the most frequent of which were fever (43.3%), abdominal mass (36.7%), pain (33.3%) and weight loss (20.0%).

Regarding nutritional status, the H/A and W/A indices revealed that 10% of the sample was short for their age and 3.3% were underweight for their age. The BMI/A index revealed that 13.3% were underweight

Table I
Socioeconomic and clinical characteristics of children and adolescents with cancer admited to a referral hospital in Pernambuco, Brazil (2009)

	n (%)
Sex	
Male	18 (60%)
Female	12 (40%)
Age (y)	
0 ⊢5	18 (60%)
5 ⊢10	6 (20%)
10 ⊢18	6 (20%)
Diagnosis	
Leukemia	11 (36.7%)
Nefroblastoma	5 (16.7%)
Rhabdomyosarcoma	4 (13.3%)
Lymphoma	3 (10%)
Neuroblastoma	3 (10%)
Ganglioneuroblastoma	2 (6.6%)
Adrenocortical carcinoma	1 (3.3%)
Germ cell tumor	1 (3.3%)
Socioeconomic conditions	*Mean ± SD*
Maternal age (y)	30.91 ± 9.01
Maternal education (y)	7.43 ± 3.18
Number of people at home	1.73 ± 0.45
Per capita income (US$)†	85.34 ± 47.59
Number of child	2.47 ± 1.59

SD: Standard desviation; †Exchange rate on 30 July 2010: US$1.00 = R$1.75.

and 23.6% were overweight. Weight loss had occurred in more than half of the sample (60%), with 23.3% having lost more than 10% of their habitual weight. The data on body composition revealed a greater prevalence of malnutrition. There was a greater depletion of fat tissue (68.0%; TSF < 90% adequacy) than muscle reserve (32.0%; AMC < 90% adequacy). The AC parameter indicated that 16.7% of the sample was overweight, whereas the TSF parameter indicated that 20.0% was overweight.

Table II displays the mean values of the anthropometric variables according to age group. The mean H/A, W/A and BMI/A values in the different age groups were within the range of normalcy (≥ -2 standard deviations). Children under five years of age had a greater percentage of weight loss, lower Z scores for W/A, AC and TSF adequacy. However, those over 10 years of age had lower Z scores for H/A and BMI/A. There were statistically significant differences only for H/A, W/A and TSF adequacy ($p < 0.05$).

The patients with solid tumor had higher mean Z scores for W/A, H/A and BMI/A, but had a greater percentage of weight loss and lower mean body composition values (AC, TSF and AMC), serum albumin and CRP in comparison to those with hematological malignancies (table III). However, these differences did not achieve statistical significance ($p > 0.05$). Among the overall sample, 4.0% had hypoalbuminemia and 60.0% had high CRP levels.

Twenty-one (70%) of the children had vitamin C deficiency. Thirty percent reported the use of vitamin

Table III
Clinical, anthropometric and biochemical variables second type of cancer in children and adolescents with cancer admited to a referral hospitan in Pernambuco, Brazil (2009)

Variables	*Solid tumor Mean ± SD*	*Hematologic neoplasia Mean ± SD*
N	16	14
Duration of symptoms (days)†	4.0 (2.0-17.0)	25.5 (3.0-30.0)
Weight loss (%)‡	-12.63 ± 10.44	-10.86 ± 10.78
Weight-for-age Z- score‡	0.017 ± 1.25	-0.456 ± 1.57
Height-for-age Z-score‡	0.091 ± 1.28	-0.535 ± 1.21
BMI-for-age Z-score‡	-0.232 ± 1.42	-0.250 ± 1.62
Adequation of AC (%)‡	93.4 ± 17.0	95.97 ± 14.07
Adequation of TSF (%)‡	73.19 ± 46.87	104. 96 ± 5.09
Adequation of AMC (%)‡	97.12 ± 12.03	97.29 ± 12.15
Albumin (g/dL)‡	3.97 ± 0.77	4.11 ± 0.43
C-reactive protein (mg/L)‡	4.91 ± 5.83	8.09 ± 9.07

†Mann-Whitney test; Values are expressed as median and interquartile range; ‡T-Student test. †Not significant (p > 0,05).

Table II
Anthropometric variables, according to age of children and adolescents with cancer admited to a referral hospital in Pernambuco, Brazil (2009)

Variable	*0⊢5 y*	*5⊢10 y*	*10⊢18 y*	*p**
N	18	6	6	
Weight loss (%)**	-14.09 ± 12.7	-10.6 ± 7.3	-8.05 ± 5.6	NS
Height-for-age Z-score	-0.447 ± 1.09	1.12 ± 0.68	-0.695 ± 1.48	0.011
Weight-for-age Z- score‡	-0.567 ± 1.20	1.06 ± 1.15	–	0.008
BMI-for-age Z-score	-0.414 ± 1.66	0.560 ± 1.23	-0.520 ± 0.99	NS
Adequation of AC (%)	91.9 ± 13.8	104.0 ± 22.7	92.7 ± 9.0	NS
Adequation of TSF (%)	63.1 ± 17.0	114.5 ± 57.7	117.0 ± 70.8	0.028
Adequation of AMC (%)	99.2 ± 11.3	99.4 ± 13.9	90.6 ± 10.0 NS	

*One-way ANOVA test; **n = 25 (5 patients did not know refer usual weight); ‡Obtained for children under 10 years. NS: not significant (p > 0,05).

Table IV
Clinical, anthropometric and biochemical characteristics, according to serum levels of vitamin C in children and adolescents with cancer admited to a referral hospital in Pernambuco, Brazil (2009)

Variable	*Vitamin C deficiency*	
	Present *Mean ± SD*	*Absent* *Mean ± SD*
N	21	9
Duration of symptoms (days)[†]	4.0 (2.0-18.0)	30.0 (14.0-30.0)
Weight loss (%)	-12.46 ± 12.31	-10.60 ± 5.04
Height-for-age Z- score[‡]	-0.360 ± 0.26	0.160 ± 0.47
Weight-for-age Z-score[‡]	-0.391 ± 1.45	0.401 ± 1.01
BMI-for-age Z-score[‡]	-0.460 ± 0.32	0.260 ± 0.51
Adequation of TSF (%)[‡]	83.23 ± 11.71	99.4 ± 20.62
Adequation of AMC (%)[‡]	94.52 ± 2.42	102.88 ± 4.96
Albumin (g/dL)[‡]	3.91 ± 0.16	4.24 ± 0.22
C-reactive protein (mg/L)[‡]	6.72 ± 8.04	5.64 ± 6.64

[†]Mann-Whitney test (p = 0,040); Values are expressed as median and interquartile range. [‡]T-Student test; Not significant (p > 0,05).

supplements. The patients with vitamin C deficiency had a greater percentage of weight loss and lower mean Z scores for H/A, BMI/A, TSF and AMC adequacy and albumin as well as higher CRP levels in comparison to those without vitamin C deficiency. However, these differences did not achieve statistical significance ($p > 0.05$). Among the variables analyzed, only time of the perception of signs and symptoms on the part of the family was significantly associated to vitamin C deficiency ($p = 0.040$) (table IV).

From the food frequency questionnaire on the intake of fruit and vegetables with vitamin C, the most consumed foods were acerola *(Malpighia emarginata)* (80.0%), orange *(Citrus sinensis)* (73.3%), tomato (Lycopersicon esculentum) (63.3%) and papaya *(Carica papaya)* (50.0%). Among the children for whom the intake of these foods was less then three times a week, there was a greater prevalence of vitamin C deficiency, but this difference did not achieve statistical significance ($p > 0.05$).

Discussion

Based on the results of the present study, the children and adolescents had adequate housing conditions, but a mean *per capita* monthly household income of less than half the minimum salary and caregiver's (in most cases a parent) schooling corresponding to an incomplete high school education. These characteristics may have a negative effect on the prognosis of these patients.

Socioeconomic status exerts a strong influence over adherence to cancer treatment, affecting the survival rate and quality of life of patients.[15] Monthly household income and access to communication, transportation and education affect the space of time between the onset of the disease and diagnosis. Thus, many children begin treatment in advanced stages of the disease, which reduces the chances of successful treatment and further compromises nutritional status at the time of diagnosis.[16]

Moreover, the first signs and symptoms of cancer in children are easily confused with other common childhood illnesses, thereby contributing toward delayed diagnosis.[17] As described in the present study, the most common signs and symptoms are bleeding, an increase in abdominal volume, pain, vomiting and fever.

Based on the H/A, W/A and BMI/A, there was a low prevalence of weight and height deficit in the sample. However, the body composition measures revealed greater frequencies of inadequacy, with a greater depletion of fat reserves upon diagnosis. It should be pointed out that the presence of palpable mass in 36.7% of the sample may have masked the results of the W/A and BMI/A indices. The majority of children (60.0%) had experienced weight loss, but only 20.0% of the parents/guardians reported this sign at the time of diagnosis. This is an indication of the poor perception on the part of caregivers and families with regard to changes in weight in the child.

Despite the aforementioned results, the BMI/A indicated that there were nearly twofold more overweight than underweight children (23.6% and 13.3%, respectively). According to Sgarbieri et al. (2006), children with a recent diagnosis of cancer have a similar nutritional status to that of the general pediatric population in cases in which the diagnosis is determined in the early stages of the disease.[18] It is suggested that the low prevalence of nutritional deficit upon diagnosis stems from the decline in childhood malnutrition in Brazil in recent decades. The underlying causes of this reduction in the prevalence malnutrition seem to be improved coverage of essential public services and an increase in household income.[19]

The comparison of these results with those of previous studies is limited due to the different indicators, cutoff points and reference curves used as well as the characteristics of the population studied, such as the type of cancer and phase of treatment. In a study carried out on children with solid tumor and hematological malignancies in the first month of treatment (phase of disease remission induction), Garófalo, Lopez and Petrili (2005) found a greater prevalence of deficit than that described in the present study for the BMI/A indicator (18.9% *vs* 13.3%) and AMC inadequacy (35.4% *vs* 32.0%) as well as a lower prevalence of TSF inadequacy (40.2% *vs* 68.0%).[20]

In a study carried out in the pediatric oncology ward of the Instituto de Medicina Integral Prof. Fernando Figueira (IMIP, Recife-PE, Brazil) involving 292 patients with leukemia and solid tumors in early treatment between 1995 and 1998, Pedrosa et al. (2000) also found a greater prevalence of deficit for the H/A, W/A and BMI/A indicators (18.5%, 20.9% and 14.9%, respectively).[21] The same study analyzed a database of 151 children diagnosed with leukemia at the Niños Benjamin Bloom Hospital (San Salvador, El Salvador) that also reported higher frequencies of these deficits (31.1%, 28.5% and 17.3%, respectively).[21]

Weight measurements may underestimate the prevalence of malnutrition. The results of the present study corroborate data found in the literature demonstrating that body composition measures, such as TSF, AC and AMC, are more sensitive for detecting nutritional deficit in children and adolescents with cancer in comparison to indicators that use weight and height.[22] Lean and fat mass depletion in children with cancer is generally progressive, leading to severe malnutrition in many cases and characterizing cachexia. It is likely that cachexia is mediated by cytokines that alter the metabolism of carbohydrates, proteins and fats, leading to a poorer prognosis for such patients.[23] This condition can often be identified upon the diagnosis of cancer.[24]

Although the mean anthropometric values were within the normal range for weight, the adolescents had significantly lower mean Z scores for the H/A indicator. This indicator measures the linear growth and its deficit is related to cumulative long-term changes in nutritional status and general health. The growth and final height of an individual depend on the interaction between genetic potential and the influence of a large number of environmental factors. Poor housing and sanitation, low income and low parental education have been suggested as determinants of the stunting.[25]

The Z scores value found for the H/A indicator may be related to poor socioeconomic status as well as changes in metabolism, presence of infection and inadequate food consumption found among oncology patients.[5-8] As 20 to 25% of an individual's stature is acquired in adolescence, gonadal hormone secretion may be inhibited by insufficient amounts of nutrients, thereby slowing the onset of puberty, which can compromise the gain in stature.[26] In Brazil, a study carried out in order to characterize the process of sexual maturation with 6765 adolescents, between 10 and 19 years, residents of Santo André (São Paulo) showed that the development of sexual characteristics occurs later in lower socioeconomic classes.[27] The data for nutritional assessment of adolescents included in the sample of this study are limited since it was not possible to analyze the stage of sexual maturation in these patients.

The patients with solid tumors had lower mean AC and TSF adequacy values in comparison to those with hematological malignancies, although the difference was not statistically significant ($p > 0.05$). This corroborates the findings of previous studies that report greater muscle and fat depletion among children with solid tumors and further stresses the need to use body composition measures due to the difficulty in obtaining the actual weight of such patients, which is often masked by edema and/or the size of the tumor.[20]

Biochemical methods can be used for the detection and evaluation of malnutrition. Serum levels of some proteins should be assessed in children with cancer. However, it should be stressed that such parameters have little sensitivity and no specificity as markers of nutritional status in cancer patients, as common clinical conditions in cancer may modify the serum concentrations of these proteins, such as alterations in hydration, kidney function and liver function as well as infection, inflammation and the use of medication.[28] In the present study, serum albumin was measured, which is routine at the clinic at which the study took place. Although the mean values were within the range of normalcy in both groups analyzed, the values were lower in the group with solid tumors, which also had a greater percentage of malnutrition, as determined by body composition measures.

The analysis of serum vitamin C revealed that 70.0% of the sample had vitamin C deficiency. There are few studies that address the nutritional status of this micronutrient and most are case studies carried out in a hospital setting on non-cancer patients with severe hypovitaminosis. However, data on children under daycare report a similar prevalence to that described herein. In a study involving 104 preschoolers at daycare centers in the city of João Pessoa (Northeastern, Brazil), Costa et al. (2001) found that 69.2% had vitamin C deficiency.[29] Tone et al. (1991) report a 60% prevalence of vitamin C deficiency in a sample of 28 children with malignant tumors.[30] Rai (2008) studied vitamin C levels in the saliva of adult patients with oral cancer in India and found lower levels in patients in advanced stages of the disease.[31]

Although the patients with vitamin C deficiency had greater weight loss and lower anthropometric indicators, body composition measures and albumin, the only significant association was between vitamin C deficiency and the time when the family perceived signs and symptoms. This finding reveals an association between time of diagnosis and nutritional status in these patients.

There is no consensus in the literature regarding the potential risks and benefits of supplementation with antioxidant vitamins during cancer treatment.[32] A number of randomized clinical trials have demonstrated that the concomitant administration of antioxidants with chemotherapy or radiotherapy reduces the side effects of treatment.[33] Some studies indicate that antioxidants may protect cancer cells as much as normal cells from the oxidative damage caused by the treatment.[34] However, other data suggest that antioxidants may protect normal tissues from the damage caused by chemotherapy or radiotherapy without diminishing the effect of the treatment on the tumor.[35]

Serum CRP was determined in order to investigate its association with the type of cancer and serum vitamin C levels. CRP is a marker of non-specific inflammatory response produced mainly by hepatocytes. It is also described as a marker of the progression and prognosis of cancer.[36] Both groups studied had high mean serum CRP levels. Although the difference was not statistically significant, mean CRP was higher in the group of patients with hematological malignancies and those with vitamin C deficiency, which seems to demonstrate a greater inflammatory state and consequent oxidative stress in these patients. There are few studies in the literature that assess CRP levels in pediatric cancer patients, which limits the comparison of these findings. However, an increase in CRP is likely secondary to tumor necrosis, tissue damage and associated inflammation in patients with malignant diseases. Thus, high CRP levels have been associated with progressive disease and a worse survival rate among patients with such diseases.[37]

Some methodological limitations of the present study should be addressed. The sample size was small due to the exclusion criteria. The fact that the prevalence of childhood cancer ranges from 0.3 to 5% of all malignancies may have contributed to the small sample size. The data were limited to information gathered from patients at the beginning of treatment. However, the results described here stress the importance of a nutritional assessment upon the diagnosis of cancer with the use of weight and body composition measures, along with the assessment of serum levels of antioxidant nutrients, such as vitamin C. Moreover, nutritional deficits may worsen during cancer treatment. Thus, there is a need for future studies to investigate in a more precise manner possible associations between the serum levels of antioxidants, such as vitamin C, and nutritional status in these patients in order to offer safe, effective nutritional support.

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