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A Pilot Study of Nutrition Management in the Department of Pediatric Oncology Department of a Hospital in Kazakhstan

Zhandulla Nakipov[1], Anar Tursynbekova[2], Gaukhar Dauletova[1], Akmaral Mussakhanova[1], Gulzhan Dossybayeva[3], Zakira Kerimbayeva[1], Gaukhar Saurbayeva[1], Aigul Kaliyeva[4], Assiya Turgambayeva[1]*, Mei Yen Talamona Chan[5]

[1]Department of Public Health and Management, NJSC "Astana Medical University", Nur-Sultan, Kazakhstan; [2]Clinical Hospital, Almaty, Kazakhstan; [3]Department of General Practitioner N2, South Kazakhstan Medical Academy, Shymkent, Kazakhstan; 4Corporate Fund, University Medical Center, Nur-Sultan, Kazakhstan; 5School of Medicine, Nazarbayev University, Nur-Sultan, Kazakhstan

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***Correspondence:** Assiya Turgambayeva, Tashenov str.17-85, Nur-Sultan, Kazakhstan. E-mail: tak1973@mail.ru
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Abstract

BACKGROUND: Maintaining optimal nutritional status is important for children with cancer because it can affect clinical outcomes. At present, there are no unified and harmonized protocols for assessing the nutritional status and nutritional support of children in pediatric wards in Kazakhstan. According to the WHO research, most of the children admitted to hospitals already have significant nutritional status disorders, such as exhaustion and malnutrition, lipid metabolism disorders, hypovitaminosis, and anemia.

AIM: This study aimed to prospectively study clinical practices in children's cancer departments to improve the nutritional health of children and adolescents receiving cancer treatment.

METHODS: 200 children with cancer aged 6 months to 17 years (n = 200) were recruited. Dietary data and other relevant anthropometric and biochemical data were collected using a data collection form validated and developed by the researchers. Data processing is still in progress. They were randomly allocated either to a treatment group or a control group (age-matched and gendermatched). The treatment group received nutritional advice and support and the control group received the standard treatment.

RESULTS: A significant decrease in the intake of protein and energy with the consumed diets, which are prescribed by doctors in daily practice, was revealed, which is a risk factor for the development of severe nutritional disorders ($p > 0.5$). Patients who were assigned nutritional support in addition to the general diets during the study had higher nutrient intake. Comparing week zero with subsequent weeks of nutritional support, children in the main group showed significant improvements in the thickness of the triceps skin fold ($p < 0.001$), the circumference of the middle shoulder ($p < 0.001$), and the circumference of the arm muscles ($p < 0.001$), showing that performing nutritional support is better for the evolution of nutrition ($p < 0.01$).

CONCLUSION: Proper use of nutritional support in children with cancer can prevent the development of nutritional deficiencies and associated risks. To improve nutrition management, attention should be paid to nutrition education and assessment tools for doctors and nurses.

Introduction

Modern WHO studies have shown that at the time of hospitalization in specialized hospitals, most children are admitted with pre-existing nutritional status disorders, which is manifested by exhaustion, malnutrition or overweight, as well as hypovitaminosis, anemia of varying severity, and metabolic disorders [1].

In Kazakhstan, in 2019, more than 1000 children were diagnosed with malignant neoplasms for the 1st time. The total incidence in 2019 was 12.5/100 thousand children, while in 2018 this figure was 11.5.

World experience proves that early detection of nutritional status problems in children with malignant tumors and timely adequate nutritional support is mandatory components of complex treatment of cancer patients. Providing nutritional support for children of oncological profile allows avoiding pronounced asthenization of patients, improving the tolerability of antitumor treatment, increasing survival, improving the quality of life [2], [3], [4].

A number of international studies have shown that there is a wide range of indicators that are used to assess the nutritional status of children with cancer, while body weight is the only uniform indicator. It should be noted that body weight is not an adequately sensitive marker for detecting nutritional disorders in children with oncological diseases [5], [6]. This indicator may be distorted due to the large volume of tumor tissue, in diseases such as neuroblastoma, nephroblastoma, soft-tissue sarcoma and others, hydration during chemotherapy, and edema. In children with adequate or overweight, the true loss of muscle mass may be hidden, since fat decreases or remains unchanged while skeletal muscles are depleted. Such children may

be mistakenly left without adequate nutrition correction, which can lead to a fatal outcome [7], [8].

As part of the international initiative to improve the assessment of the nutritional status and therapy of children with cancer, the working group on nutrition of the International Society of Pediatric Oncology, the Committee on Pediatric Oncology in Developing Countries, presented a report with scientifically based recommendations for supportive therapy of children with cancer [9], [10], [11]. In the presented article, the authors point out the importance of assessing the nutritional status as a key to the success of basic cancer therapy. To assess the nutritional status, experts recommend using parameters such as weight, height, weight-to-height ratio, body mass index (BMI) and the circumference of the middle part of the shoulder as a simple indicator of the nutritional status of children with cancer. The combination of the circumference of the middle third of the shoulder mid-upper arm circumference (MUAC) and the thickness of the triceps skin fold (TSFT) provides a more complete assessment of the nutritional status, since both instruments do not depend on ethnicity, are not affected by a large tumor mass, and provide information about body muscle mass (MUAC) and fat mass (TSFT) [12], [13].

In the first prospective cohort study to study the nutritional status of children with cancer in Scotland, the authors use such indicators as weight, height, BMI calculation according to the centile program, the index of the triceps skin – fat fold and the circumference of the middle third of the shoulder (measured as standard using a caliper). The reference values were taken from the Frisancho table. The energy value was estimated using the WinDiets program, and the energy needs were calculated using the Henry equation [14], [15].

The analysis of most literature sources shows that at present, for a comprehensive assessment of the nutritional status of children with oncological diseases, it is better to use a holistic approach – to start with a study of the anamnesis, the somatic status of the child, followed by an assessment of somatometric and clinical and laboratory parameters. To determine the maximum permissible values of these indicators, centile tables are used. These indicators determine the protein reserves of the body [16].

In different countries, with different frequency, in addition to the methods described above, functional tests are used to assess the nutritional status: Manual dynamometry, which is able to detect initial changes in muscle strength, vital capacity of the lungs – the volume of forced exhalation and peak volume velocity, which depend on the state of the respiratory muscles.

In a comprehensive assessment of the nutritional status of children, along with the above indicators, laboratory data are also used. The list of indicators that fully determine the nutritional status of the patient is still being discussed. The most common biochemical indicators that are used to determine the actual nutritional status of patients with tumor processes are such laboratory indicators as total serum protein, albumin, transferrin, prealbumin, and retinol-binding protein. These values determine the status of the visceral protein [10].

Very often, nutritional insufficiency in children with oncological diseases is accompanied by psychological problems, since difficulties in eating due to pain can lead to the development of psychogenic anorexia [17]. Based on the above, we came to the conclusion that metabolic disorders associated with the tumor process, complications of chemotherapy and radiation therapy, lead to the development of severe forms of malnutrition in children with malignant neoplasms. Moreover, as a result, the effectiveness of treatment decreases, the prognosis of the disease worsens, and the quality of life of patients decreases. The purpose of our study was to determine the principles of nutrition organization in the department of pediatric oncology of local hospitals to improve the nutritional status of children with oncological diseases receiving antitumor treatment.

Materials and Methods

Participants

The study was performed on the basis of the Department of Pediatric Oncology of the Corporate Fund “University medical center” of the National Scientific Center for Motherhood and Childhood in Nur-Sultan.

Our study involved one hundred children with oncological diseases who were hospitalized for specialized treatment in the department of pediatric oncology in the period from 2019 to 2020 and processed one hundred medical records of inpatient patients of the Department of Pediatric Oncology of the Corporate Fund «University Medical center» of the National Scientific Center for Motherhood and Childhood (n = 200). The age of the children who took part in the study is from 6 months to 17 years. The average age of the children under observation was 6–10 years. Boys predominate in 55% of the total number of patients. The distribution of children by gender and age is shown in Table 1.

Table 1: Distribution of patients by gender and age

Age (years)	Group I (main) (n = 100)		Group II (control) (n = 100)	
	Boys (n = 55)	Girls (n = 45)	Boys (n = 55)	Girls (n = 45)
0–3	6	8	6	7
4–7	20	10	21	12
8–12	16	18	16	17
13–17	13	9	12	9

According to the nature of the tumor location, 53% of children were diagnosed with tumors of the central nervous system, 17% of children were diagnosed with tumors of lymphoid organs, 13% were nephroblastomas and neuroblastomas, 11% were bone sarcomas, and 6% were soft tissue sarcomas. The structure of the observed nosologies is presented in Table 2.

Table 2: Distribution of patients depending on the morphological type and localization of the tumor

Localization	Central nervous system	The lymphoid system	Bone	Parenchymal organs	Soft tissues
Morphological type of tumor					
Embryonic tumors	84				
Gliomas	22				
Lymphomas		34			
Sarcomas			22		12
Netphro/ neuroblastomas				26	

All the observed patients received courses of polychemotherapy or radiation therapy, according to the Clinical Protocols approved by the Ministry of Health of the Republic of Kazakhstan. Treatment was started under the condition of optimal hematopoiesis indicators and a satisfactory somatic status of the child.

Parents and guardians of patients who participated in the study were informed about the purpose and tactics of conducting a clinical trial before signing an informed consent to participate in the study. This study was approved by the Local Bioethical Committee.

Procedures

The study consisted of several types - prospective, comparative medical observation and retrospective analysis of medical records of inpatient patients who were treated in the department of pediatric oncology. The control group was recruited from archival histories in compliance with all the criteria for inclusion in the study. The observation group was recruited as patients were admitted to the department.

To control the intake of nutrients, micronutrients and assess the quality of the products consumed, caregivers were asked to keep a food diary indicating the name of the dish, the volume. The calculation of protein and energy requirements (calories), the need for micro-and macronutrients, was carried out according to the standards of the European Society of Pediatric Gastroenterology, Hepatology, and Nutritionology.

All children of the main group, after assessing the initial state of nutrition, for the correction of nutritional insufficiency, in addition to correcting the energy composition of the dishes consumed, enteral and parenteral mixtures were used according to the indications. To ensure the administration of mixtures to children, nasogastric probes and central venous catheters are installed. There were no children with stomas among the observed patients. The mixtures used for enteral and parenteral nutrition were selected taking into account the following requirements:

1. A balanced composition with a complex content of micro-and macronutrients
2. High energy value
3. The mixture should not contain products of high allergenization, for example, lactose or gluten
4. Easy-to-use and control packaging.

The volume of the mixture for oral/parenteral administration was prescribed in accordance with age, taking into account the food obtained from the main diet, the physiological need for nutrients, losses due to gastrointestinal disorders or chemotherapy. Children from the control group received diet No. 11 according to Pevsner, traditionally used in pediatric oncology departments. Diet No. 11 is characterized by hypercaloric content when dieting 5 times a day. The number of calories increases due to the protein component. There are no special requirements for machining.

Nutritional risk screening using proven tools is vital to identify patients at risk of malnutrition to avoid adverse outcomes. At present, there is no approved tool for this purpose in Kazakhstan. Therefore, we have developed a questionnaire called KZNUTPEDY © to routinely conduct nutrition screening in pediatric departments. The questionnaire contains three questions and allows you to identify what problems with nutrition the child has at the time of admission to the department. The parents of the patients were asked to fill out a questionnaire after signing the consent to participate in the study. Furthermore, during the study to track the nutrition of children, parents were asked to keep a food diary, where they recorded the date, time of meals, the food composition of the dish, the amount of additional nutrition of enteral/parenteral mixtures. Here, in the food diaries, complaints and symptoms in the form of nausea, vomiting, constipation, and diarrhea were recorded.

Appetite was assessed on a five-point scale, where children and caregivers noted the current state of appetite. 0 points corresponds to a lack of appetite, 5 points-the child has a good appetite.

Measures

The measurement of body weight and height was carried out in the oncology department, on an empty stomach, using lever floor scales with a VAMED height meter.

Depending on the weight of the child, the degree of malnutrition is determined:

- I degree of malnutrition - body weight deficit of 10–19%
- Grade II malnutrition - body weight deficit 20–29%
- III degree of malnutrition - a body weight deficit of 30% or more.

BMI or Quetelet index.

It was calculated using the formula:

BMI = body weight (kg)/height $(m)^2$.

BMI values were determined according to the tables of centile values (WHO, 2006; American Society for Parenteral and Enteral Nutrition [ASPEN], 2008).

- BMI = 25–75 centiles - the norm
- BMI <25 centiles - reduced nutrition
- BMI <10 centiles - I degree body weight deficit
- BMI <5 centiles - body weight deficit of the II degree
- BMI <3 centiles is a third-degree body weight deficit.

A centimeter tape was used to measure the Shoulder circumference. The support is determined at the level of the middle third of the shoulder of the left (non-working) bent arm. The Shoulder circumference standards are also taken from the tables of centile values (WHO, 2006; ASPEN, 2008).

If the shoulder circumference in children is <10 centiles, this corresponds to a mild degree of malnutrition, <5 centiles - medium degree, and <3 centiles-severe degree of malnutrition. Determination of the thickness of the skin-fat fold of the triceps (TSFT, mm) was carried out using caliperometry. The tables of centile values (WHO, 2006; ASPEN, 2008) were used as the standard of the TSFT.

Measurements of the circumference of the shoulder muscles (MUAC) are calculated by the formula:

MUAC (cm) = Shoulder circumference (cm) - 0.314 × TSFT (mm)

Shoulder circumference in cm,

TSFT - skin-fat fold of the triceps, mm

Tables of centile values served as the standard of BMI.

- BMI <10 centiles - a mild degree of nutritional insufficiency
- BMI <5 centiles - average malnutrition
- BMI of <3 centiles is a severe degree of nutritional insufficiency.

General clinical blood test: The emphasis was on the hemoglobin content. The study was conducted using a UNICEL ® DXH 800 analyzer (Beckman Coulter, USA). Biochemical blood analysis: The content of total protein, albumin and vitamin D. The study was conducted using standard methods using the Architect c8000 analyzer (Abbott, USA).

All patients were divided into two equal groups of 100 people:

I – the main (observation group), which included children who underwent nutrition correction and nutritional support, and II - the control group-archived medical histories selected according to the inclusion criteria, who received only a dietary table, according to nosology.

Statistical processing of the results was carried out using the statistical package of computer programs SPSS 20, which allows using parametric and nonparametric analysis. To compare the indicators in the groups, the T-Criterion of pairs for dependent (paired) samples and the Wilcoxon sign rank criterion were used, since these methods are used to compare dependent groups. The paired t-test for dependent (paired) samples will be applied with a normal distribution of data in the group. The Wilcoxon sign rank criterion is for data whose distribution differs from normal.

According to the results of the calculation, attention was paid to the indicators “Significance (2-sided)” and “Asymptotic. Significance (two-sided)” - these indicators are p-value, that is, in our case, the significance of the data differences between at the “beginning” and “after.”

If $p < 0.05$, then we can talk about statistically significant differences in the average indicators between the two data. If $p > 0.05$, then the average values between the indicators do not significantly differ.

Statistical analysis

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Results

The analysis of the state of the existing catering organization in the departments of pediatric oncology revealed many problems:

1. One of the main drawbacks is the absence of a dietitian and a diet nurse (according to order No. 238 of April 7, 2010 “On approval of standards for the provision of medical workers,” there is 1 rate of a dietitian and 1 rate of a diet nurse for 5 oncological departments)
2. There is no single standard for conducting

nutrition screening for incoming children

3. The actual nutritional status is not evaluated. There is no mandatory condition for conducting anthropometry upon admission
4. A single diet is prescribed, without taking into account age, needs, nosology, localization of the process, and existing eating disorders
5. The medical staff in the department have a high workload, and given the specifics of the department, the severity of the condition of children with oncological diseases, due attention is not paid to ensuring adequate nutrition of patients. Correction of already developed disorders is carried out by prescribing symptomatic therapy
6. Most often, doctors resort to prescribing full or partial parenteral nutrition to children with severe infectious complications who completely refuse to eat

The data of patients of the main group were analyzed according to questionnaires filled out by their parents. Hundred questionnaires were filled in. The data of the control group were taken from the passport data of the medical history. 35% of the children included in the study are rural residents.

According to ethnicity, 59% were Kazakhs, 27% were Russians, and the remaining 14% were representatives of other nationalities. About 74% of caregivers have a higher education, the remaining 26% have specialized secondary or incomplete higher education. The analysis of the nutritional status of children with oncological diseases receiving antitumor treatment, according to the results of the questionnaire, revealed nutritional disorders. Thus, 67% of children had problems that made it difficult to eat (e.g., abdominal pain, nausea, vomiting, surgery, behavioral problems, and problems with swallowing). About 72% of patients have a loss of appetite against the background of the existing disease. And 76% of the children of the main group lost weight before hospitalization.

Similar problems were identified in the control group based on the analysis of the records of supervising doctors. About 66% of patients who have difficulties with nutrition. 70% have lost their appetite and 75% have weight loss at the pre-hospital stage. According to the presented data, it is clear that children have pronounced nutritional disorders against the background of nutrition problems that are caused by the course of the underlying disease. One of the most common symptoms for cancer is a decrease in appetite. This symptom was detected in almost all patients of both groups before the start of treatment. Violation of appetite is associated with tumor intoxication and a psychological factor (hospital stay as a traumatic factor).

Every day, in the “Patient’s Diary,” children and caregivers assessed the state of appetite in points. If there was no appetite at all, 0 points were set, and a good appetite was marked with 5 points. Below, in Figure 1, the number of children of the main and control groups with different degrees of severity of appetite disorders is presented.

A good appetite (5 points) is observed in a small group of patients – 5% of the main group and 3% of the control group. A moderate violation of appetite (3-4 points) was indicated by the majority of children – 33% and 35% of the main group, 40% and 30% of the control group. And poor appetite (1-2 points) is noted in 15% and 12% of the main, 12% and 15% of the control group.

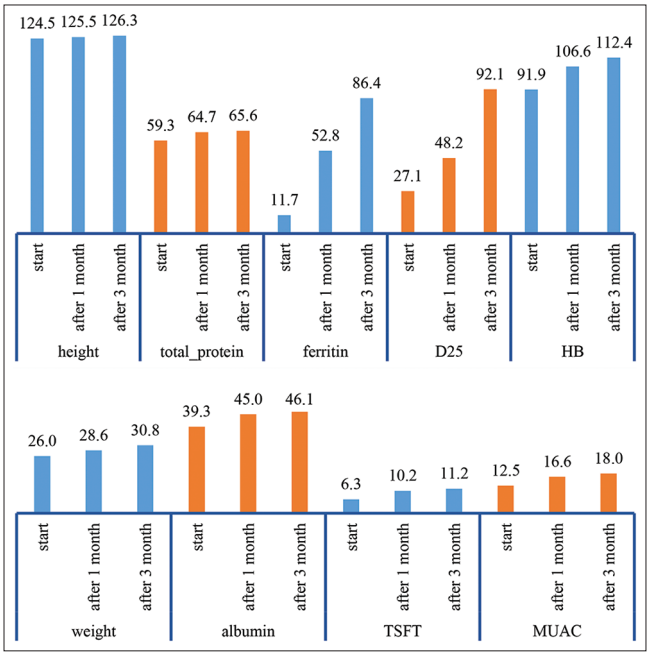

Figure 1: Dynamics of indicators of the main group

About 72% of the main group and 68% of the control group had gastrointestinal disorders, which were manifested by abdominal pain, nausea, vomiting, constipation, or diarrhea. The severity of symptoms in the vast majority of cases (45% and 47% of the main and control groups, respectively) was average (that is, the manifestation of symptoms 3–4 times a day).

The measurement of body weight and height was carried out in the oncology department, on an empty stomach, using lever floor scales with a VAMED height meter. To assess the compliance of mass-growth indicators, centile tables were used.

In accordance with the centile tables, the degree of malnutrition in children at the beginning of the study was established. Almost all children of both groups had some degree of malnutrition. Thus, 21% of patients in the main group and 23% of patients in the control group had Grade 1 insufficiency at the time of admission to the round-the-clock hospital. Nutritional insufficiency of the II degree was determined in the largest group - in 54% of children of the main and 58% of the control group. Severe malnutrition was recorded in 10% of the main and 12% of children of the control groups ($p > 0.5$).

The calculation of the BMI confirmed the presence of nutritional insufficiency in the overwhelming number of patients of both groups, only a small part of the children did not have nutritional disorders ($p > 0.5$). The majority of patients with oncological diseases have a BMI of <5 centiles, which determines the second degree of eating disorders and accounts for 54% of the total number of children in the main group and 58% of patients in the control group. 21% and 23% of cancer patients of the first and second groups, respectively, showed a Quetelet index of <10 cents. About 10% of the main group and 12% of the control group with Grade III malnutrition have a BMI of <3 centiles. Only a small proportion of children do not have eating problems or minor eating disorders.

Measurement of the shoulder circumference in children of the main and control groups also confirmed nutritional insufficiency. According to the degree of malnutrition, patients were distributed as follows:

- A decrease in the shoulder circumference of <10 centiles, which corresponds to mild or 1 degree of malnutrition, was registered in 21% of patients of the main group and in 23% of patients of the control group
- Shoulder circumference below 5 centiles was recorded in 54% and 58% of children of the main and control groups, respectively, which corresponds to the 2nd degree of (average) nutritional inaccuracy
- The shoulder circumference index is <3 centiles or 3 (severe) degree of eating disorders is observed in 10% of patients of the first and 12% of patients of the second group ($p > 0.5$).

The measurement of the skin-fat fold above the triceps was carried out by a caliper. The analysis of the obtained measurements of FGM revealed different degrees of malnutrition in both groups. Based on the obtained data of the CRF and the shoulder muscle circumference of children of the main and control groups, it was found that only 15% of children of the first group and 7% of the second group had no nutritional abnormalities (OMP >10 centile). The first degree of malnutrition (OMP <10 centile) was observed in 21% of children of the main group and 23% of patients of the control group. The second or average degree of nutritional insufficiency (OMP <5 centiles) was registered in 54% of the observation group and 58% of the children of the comparison group. Three the degree of malnutrition (OMP <3 centiles) was observed in 10% and 12% of patients of the main and control groups.

The analysis of anthropometric data showed that both groups initially had problems with nutrition. There were no significant differences in the degree of malnutrition in both groups. The analysis of the initial hemogram revealed the presence of anemia of varying severity in children of both groups. The normal hemoglobin content was registered only in a small number of patients, and in the main group there were more such children ($p < 0.01$). About 32% of the observation group and 38% of the comparison group suffer from Grade 1 anemia. Two the severity of anemia was found in 50% of children in the main group and 54% of patients in the control group. Four patients of the first and four patients from the second group had a severe degree of anemia against the background of the oncological process. The normal hemoglobin content according to the blood test was shown by 14 cancer patients from the main and 4% of the control group.

The assessment of biochemical parameters revealed protein deficiency due to the albumin fraction in children of both groups. Protein deficiency is one of the indicators of metabolic disorders that patients with a tumor process have. Thus, only 30% of the main and 32% of the control groups had a normal content of total protein (65–85 g/l) and albumin (the norm is 35–52 g/l). Hypoproteinemia and hypoalbuminemia were recorded by tests in 70% of patients of the main group and 68% of the comparison group. A decrease in the protein pool in the body is fraught with the development of asthenization, a decrease in the mass of skeletal muscles.

In addition to the participation of Vitamin D in phosphorus-calcium metabolism, the vitamin supports muscle tone, promotes the normal activity of the nervous and cardiovascular systems, is one of the key elements of the regulation of carbohydrate and lipid metabolism, and also has a pronounced immunomodulatory property. Vitamin D deficiency was detected in 67% of the main group of patients and 60% of the comparison group.

The estimated initial indicators of the actual state of nutrition, appetite, anthropometric and laboratory data revealed eating disorders in the majority of children of both groups. That is, at the beginning of the study, all patients need nutritional support.

It was found that children receive food that is not able to cover the physiological needs of the child and does not make up for the existing deficit. The initial protein and vitamin deficiency in the observed patients averaged 70%. Insufficiency is primarily associated with the tumor itself, as well as the presence of such problems as decreased appetite (68% had a moderate decrease in appetite and 27% complained of a very poor appetite), gastrointestinal symptoms (nausea, vomiting, which made it difficult to eat or diarrhea, which increased the lack of nutrients, had 72% of patients).

Analyzing the obtained initial data of anthropometric and somatometric indicators, we confirm that the vast majority of children have a pronounced nutritional deficiency. Before starting treatment, a severe degree of nutritional insufficiency was recorded in 11% of children, 63% of children have a second degree of eating disorders, and 22% of patients suffer from mild insufficiency. The results of hematological tests revealed the presence of anemia of varying severity in children. Children who needed replacement therapy at the time of admission were 4%. In 52% of patients with oncological profile, the 2nd degree of anemia was

Table 3: Nutritional requirements by age

Nutrients	Basic needs			Moderate needs			High needs		
	0–1 years	1–8 years	8–15 years	0–1 years	1–8 years	8–15 years	0–1 years	1–8 years	8–15 years
Water (ml)	100	100–70	70–30	125	125–100	100–50	125–200	150–100	125–100
Energy (Kilocalories)	110–90	80–60	60–40	125	100	75–50	150	125	100–60
Nitrogen (g)	0.3	0.2	0.15	0.45	0.3	0.5	0.5	0.45	0.3–0.4
Amino acid (g)	2.5	2.0–1.5	1.5–1.0	3.5	2.5	2.1	4.0	3.5	2.5–3.0
Glucose (g)	12.0	12.0–10.0	10.0	15.0–20.0	15.0–12.0	12.0	20.0–150	18.0–20.0	12.0–15.0
Fats (g)	1.0–4.0	2.0–4.0	4.0	4.0	6.0	3.0–4.0	6.0	5.0	4.0

recorded. And 35% of children suffered from anemia of the 1st degree.

In addition to oxygen deficiency, the children also had a deficiency in the protein substrate. This fact is confirmed by biochemical indicators, because 69% of children had an initial deficiency of total protein and albumin. The revealed violations are an indisputable indication for conducting nutritional support.

After receiving the initial data on the state of actual nutrition, anthropometric indicators and laboratory data, nutrition correction was carried out for children from the main group – a table was assigned taking into account the qualitative composition of food, the deficiency of macro - and micronutrients was replenished with enteral and parenteral mixtures, taking into account the anthropometric data of the child, his age needs and filling the deficit against the background of gastrointestinal disorders and chemotherapy. After determining the degree of malnutrition, children from the main group were assigned a treatment Table 11, but the dishes were selected taking into account the patient's needs in calories. The Harris – Benedict equation and online calculators were used to calculate the energy demand. The nutritional needs of children with oncological diseases undergoing specialized treatment are determined according to Table 3.

After calculating the necessary calories, the volume of proteins, carbohydrates, fats, the nutritional value of the dishes was determined. But given the initial malnutrition, the necessary needs cannot be covered only by traditional food, and therefore, nutritional support was prescribed to children. Hypercaloric mixtures were used to provide adequate nutritional support. Of the 100 children under observation, 92 children received enteral nutrition through a nasogastric probe, using the sipping method. Partial parenteral nutrition was carried out for eight children, since the severity of mucositis and the associated pain syndrome made it impossible to eat food through the mouth. And the severe degree of insufficiency of these children required more intensive nutritional support. Nutritional support was carried out during the entire observation period.

An objective examination of patients receiving nutritional support revealed a slight but positive trend in improving appetite, reducing the manifestations of gastrointestinal symptoms. If at the time of admission, only a small number of patients (5% of the main group) demonstrated a good appetite (5 points), then in dynamics after 1 month, and the group of children with a good appetite was 15%. In a larger number of children (52%), appetite remained moderately reduced (3 points). This fact is explained by the receipt of active antitumor treatment (non-adjuvant courses of chemotherapy), since the children were initially diagnosed, tumor intoxication also affected the decrease in appetite. But these facts did not affect the well-being and activity of children. All children during the observation period indicated 100% good health. All patients of the main group (100%) received chemotherapy courses within the time limits regulated by clinical treatment protocols. That is, the child's somatic status, hematological and biochemical parameters met the criteria for the beginning of the course of chemotherapy. This is confirmed by the dynamics of the studied indicators presented below.

The children of the control group received a standard Table 11 according to Pevsner, without correcting the existing deficits. Against the background of the treatment of appetite disorders and the degree of severity of gastrointestinal disorders not only did not decrease, but on the contrary, it tended to progress. If initially 70% of children had a moderate decrease in appetite, and 27% had a poor appetite, then in dynamics already 40% have an appetite disorder of 1–2 points, and 75% - 3–4 points. About 73% of children indicated emetogenic disorders and a problem with a chair, when initially they had only 47%. Due to ongoing problems, 30% of children in the control group had to postpone the planned course of chemotherapy as symptoms of intoxication, the accession of infectious complications, decrease in hematological parameters ($p < 0.05$).

Table 4: The criterion of the paired samples

Indicator	Paired differences					t	St.in	Significance (two-sided)
	Medium	SD	SE of the average	95% CI of the mean difference				
				Lower bound	Upper bound			
Couple 1								
Height_before - height_after	−0.18000	0.51991	0.05199	−0.28316	−0.07684	−3.462	99	0.001
Couple 2								
Weight_before - weight_after	−0.30000	0.59459	0.05946	−0.41798	−0.18202	−5.046	99	0.000
Couple 3								
HB_before - HB_after	−3.10000	9.14363	0.91436	−4.91430	−1.28570	−3.390	99	0.001
Couple 4								
Albumin_before - albumin_after	2.97690	6.93659	0.69366	1.60053	4.35327	4.292	99	0.000
Couple 5								
D25_before - D25_after	−2.15000	7.19620	0.71962	−3.57788	−0.72212	−2.988	99	0.004

SD: Standard deviation, SE: Standard error, CI: Confidence interval, Hb: Hemoglobin.

Comparative analysis of the actual nutrition in patients of the main group after 1 and 3 months showed significant differences in favor of improvement (Table 4). While in the control group, these indicators remained almost unchanged.

The improvement of anthropometric indicators indicates an improvement in the actual nutritional status. Accordingly, the distribution of children according to the degree of insufficiency has changed. If initially, the normal state of nutrition was recorded only in 5% of children, then against the background of nutritional support, this indicator increased 4.5 times and amounted to 22%. About 10% of the children of the main group had a reduced diet when the insufficiency had not yet developed at the time of the start of the study, in dynamics this group was 21% of children. Against the background of nutritional support, the first degree of malnutrition was present in 37% (initially it was noted in 21%) of children, this was the largest group, whereas during hospitalization in the department of pediatric oncology, the most numerous degree of malnutrition was II-54%, now it is recorded in 18% of children. Moreover, finally, 2% of the patient remained with a severe degree of insufficiency, which is 5 times less compared to the initial data, when this indicator was 10%. The severe degree in 2% of children was associated with a diagnosis (Burkitt's lymphoma) and surgical problems (the presence of a colostomy), which was associated with high losses of nutrients, fluid, and energy.

Table 5: Wilcoxon's criterion of sign ranks

Parameters	TSFT_after - TSFT_before	MUAC_after - MUAC_before	Total_protein_after - total_protein_before
Z	−5.162	0.000	−1.768
Asymptotic knowledge (two-way)	0.000	1.000	0.077

TSFT: Thickness of the triceps skin-fat fold, MUAC: Mid-upper arm circumference.

To compare the indicators between the control and the observation group, the T-criterion was used for independent groups, since the comparison groups are independent of each other. Comparative characteristics of such anthropometric indicators as the skin-fat fold of the triceps, the circumference of the shoulder muscles, as well as laboratory data (hemoglobin content, protein fraction, and Vitamin D level) showed significant differences in the average values, since $p < 0.05$ (Table 5).

Table 6: Group statistics

Group	Medium	SD	SE of the average
Height			
At the time of the start	121.9	26.58579	2.65858
After 1 month	122.1	26.31330	2.63133
Weight			
At the time of the start	25.9	14.44313	1.44431
After 1 month	26.2	14.16832	1.41683
HB_gl			
At the time of the start	88.6	12.59169	1.25917
After 1 month	91.7	7.69633	0.76963
Albumin			
At the time of the start	39.3	7.90640	0.79064
After 1 month	36.3	6.06479	0.60648
D25(OH)			
At the time of the start	27.1	12.22584	1.22258
After 1 month	29.2	11.07212	1.10721
TSFT			
At the time of the start	6.3	1.09816	0.10982
After 1 month	7.1	1.29689	0.12969
MUAC			
At the time of the start	12.5	1.62990	0.16299
After 1 month	12.5	1.62990	0.16299
Total_protein			
At the time of the start	59.3	9.10347	0.91035
After 1 month	57.5	7.05316	0.70532

SD: Standard deviation, SE: Standard error, HB: Hemoglobin, TSFT: Thickness of the triceps skin fold, MUAC: Mid-upper arm circumference.

The analysis of these tables shows that children from the observation group have positive dynamics in terms of TSFT and MUAC (Table 6). In children with nutritional support, the indicators of TSFT and MUAC after 3 months indicated a decrease in the number of children with a body weight deficit, now only 2% had the 3rd degree of body weight deficiency, and 2–18%, whereas initially these figures were 10% and 54%, respectively. Such dynamics indicates an improvement in the nutritional status of children.

The average hemoglobin content in the main group receiving enteral/parenteral nutrition increased from 91.9 g/l to 112.4 g/l. Protein insufficiency on the background of the correction power grew 3.5 times (from 70% to 20.0%) ($p < 0.05$). In children of the main group against the background of nutritional support, also decreased the deficiency of Vitamin D – the average has increased from 27.1 ng/ml to 92.1 ng/ml ($p < 0.05$).

In the control group, against the background of specific therapy, according to the results of a comparative analysis, anthropometric data and laboratory indicators remained almost unchanged, which indicates that malnutrition persists, despite receiving hyper-calorie meals. Gastrointestinal symptoms on the background of ongoing chemotherapy also contributed to the preservation of nutritional deficiencies. The average indicator of Vitamin D deficiency remains almost unchanged – 27.1 ng/ml initially and 29.2 ng/ml in dynamics.

Table 7: Comparative characteristics of the main and control groups after 1 month

Indicator	Medium	p
Height		
Control group after 1 month	122.1	0.377
Main group after 1 month	125.5	0.377
Weight		
Control group after 1 month	26.2	0.244
Main group after 1 month	28.6	0.244
TSFT		
Control group after 1 month	7.1	0.000
Main group after 1 month	10.2	0.000
MUAC		
Control group after 1 month	12.5	0.000
Main group after 1 month	16.6	0.000
HB_gl		
Control group after 1 month	91.7	0.000
Main group after 1 month	106.6	0.000
Albumin		
Control group after 1 month	36.3	0.000
Main group after 1 month	45.0	0.000
Total_protein		
Control group after 1 month	57.5	0.000
Main group after 1 month	64.7	0.000
D25(OH)		
Control group after 1 month	29.2	0.000
Main group after 1 month	48.2	0.000

HB: Hemoglobin, TSFT: Thickness of the triceps skin fold, MUAC: Mid-upper arm circumference.

The analysis of the results in the course of the study found that the nutritional status of children improved against the background of nutritional support, which is confirmed by an improvement in the state of appetite, a decrease in gastrointestinal disorders, an increase in body weight and height, BMI, TSFT, MUAC, and shoulder circumference (Tables 7-9). Thus, the distribution of

Table 8: The criterion of Wilcoxon's landmark ranks of the main group in 1 and 3 months

Parameters	TSFT_after_1 month_2 - TSFT_start_2	MUAC_after_1 month_2 - MUAC_start_2	HB_after_1 month_2 - HB_start_2	Total_protein_after_1 month_2 - total_protein_start_2
Z	−8.765	−8.734	−8.198	−6.680
Asymptotic knowledge (two-way)	0.000	0.000	0.000	0.000
	TSFT_after_1 month_2 - TSFT_after_3 months_2	MUAC_after_1 month_2 - MUAC_after_3 months_2	HB_after_1 month_2 - HB_after_3 months_2	Total_protein_after_1 month_2 - Total_protein_after_3 months_2
Z	−8.210	−8.664	−7.682	−2.887
Asymptotic knowledge (two-way)	0.000	0.000	0.000	0.004

HB: Hemoglobin, TSFT: Thickness of the triceps skin fold, MUAC: Mid-upper arm circumference.

children by degrees of malnutrition changed with an increase in the number of patients with a normal state of nutrition by almost 4.5 times from 5% to 22% ($p < 0.05$). Practically unchanged anthropometric indicators in children of the control group left unchanged the distribution of children according to the degree of malnutrition.

Table 9: Analysis of control group data

Group	Medium	SD	Standard average error
Height			
Start	121.9	26.58579	2.65858
After 3 months	122.1	26.31330	2.63133
Weight			
Start	25.9	14.44313	1.44431
After 3 months	26.2	14.16832	1.41683
HB_gl			
Start	88.6	12.59169	1.25917
After 3 months	91.7	7.69633	0.76963
Albumin			
Start	39.3	7.90640	0.79064
After 3 months	36.3	6.06479	0.60648
D25(OH)			
Start	27.1	12.22584	1.22258
After 3 months	29.2	11.07212	1.10721
TSFT			
Start	6.3	1.09816	0.10982
After 3 months	7.1	1.29689	0.12969
MUAC			
Start	12.5	1.62990	0.16299
After 3 months	12.5	1.62990	0.16299
Total_protein			
Start	59.3	9.10347	0.91035
After 3 months	57.5	7.05316	0.70532
Ferritin			
Start	11.7	6.97912	0.69791
After 3 months	11.8	5.74470	0.57447

SD: Standard deviation, HB: Hemoglobin, TSFT: Thickness of the triceps skin fold, MUAC: Mid-upper arm circumference.

The results of hematological and biochemical studies, even against the background of systemic polychemotherapy in children with nutritional support, showed an improvement in such hematological indicators as the level of hemoglobin and total protein due to the albumin fraction ($p < 0.05$). The number of children with normal hemoglobin levels increased almost 2 times ($p < 0.05$). While in the control group, even after 3 months, there were patients (8%) with severe anemia requiring replacement blood transfusion therapy ($p < 0.05$).

Discussion

This is the first study to study the nutritional status of children with cancer receiving antitumor treatment in local hospitals. A review of the literature data and the current experience of foreign researchers allow us to draw the following conclusions:

- The nutritional status of children should be determined at the time of initial hospitalization in the hospital
- Nutritional support should be provided to children, both with existing risks for the development of eating disorders, and children at the stage of nutritional insufficiency
- The most physiological method of supporting nutrition is the method of enteral nutrition with the preservation of the function of the gastrointestinal tract
- Prescribe parenteral nutrition with the confidence that it is impossible to conduct enteral nutrition
- The appointment of adequate nutritional support with the provision and prevention of undesirable effects is possible with a multidisciplinary approach [18], [19].

World experience shows that the treatment of children with malignant neoplasms should be comprehensive, where adequate nutritional support is one of the main components. The prognosis of oncological diseases and the quality of life of children depend not only on the pathohistological type of the tumor, but also on the fullness of the food received [20]. In different countries, for a comprehensive assessment of nutrition, with different frequency, not only anthropometric and somatometric indicators are used, but also functional tests (manual dynamometry, vital capacity of the lungs, and peak volume velocity), laboratory data. The list of indicators that fully determine the nutritional status of the patient is still being discussed. The most common biochemical indicators that are used to determine the actual nutritional status of patients with tumor processes are such laboratory indicators as total serum protein, albumin, transferrin, prealbumin, and retinol-binding protein [21], [22], [23].

We used the indicators available for measurement in a local hospital. Our results revealed the presence of nutritional insufficiency in children with oncological diseases already at the time of admission to the hospital; almost all children needed nutrition correction.

In the course of the study, a comparative analysis of the state of nutrition and clinical and laboratory indicators found that children who received nutritional support improved their nutritional status, and

in some cases even stopped malnutrition. These facts are confirmed by an improvement in the indicators of body weight and height, TSFT, MUAC, and shoulder circumference. The distribution of children by degrees of malnutrition changed with an increase in the number of patients with a normal state of nutrition by almost 4.5 times from 5% to 22% ($p < 0.05$). The group with reduced nutrition was already 21% of children. I degree of malnutrition was present in 37%, and II - in 18% of children. 2% of the patient remained with a severe degree of insufficiency, which is 5 times less compared to the initial data, when this indicator was 10%.

The average hemoglobin content in the peripheral blood increased in the children of the main group by 1.2 times, which reduced the number of children with anemia. During the treatment, the children from the observation group did not need hemotransfusion therapy. The provision of protein against the background of nutritional support increased by 3.5 times, which proves the effectiveness of the accompanying therapy. A low percentage of infectious complications in children of the main group may be associated with the replenishment of vitamin deficiency – so the average vitamin D index increased from 27.1 ng/ml to 92.1 ng/ml ($p < 0.05$).

All children from the main group (100%) were treated according to the term, according to the Clinical protocols for the treatment of solid tumors. And in pediatric oncology, the timeliness of receiving chemotherapy courses is important, since this significantly affects the prognosis of the disease and the occurrence of relapses. We believe that this was achieved thanks to the implementation of nutritional support. Since 30% of children from the control group who did not receive nutritional support, the breaks between courses of chemotherapy were significantly delayed. The anthropometric indicators and the distribution of children according to the degree of malnutrition in children of the control group receiving a common table have practically not changed. The distribution of children according to the degrees of insufficiency and weight deficit, based on BMI, TSFT, and MUAC remained the same: I degree of malnutrition in 23% of patients; II degree - 58% of the control group; and III degree - 12% of children ($p > 0.05$).

The average hemoglobin content in children in the comparison group also remained virtually unchanged – 88.6 initially and 91.7 after 3 months, the children still suffered from anemia of varying severity. And about 8–10% of children even received substitution therapy throughout the treatment. The protein supply in patients of this group decreased by 1.7 times in dynamics. The development of infectious complications, due to which specialized treatment had to be postponed, is associated not only with malnutrition, but also with immunosuppression, which was aggravated by vitamin deficiency. Thus, the average indicator of Vitamin D deficiency remains almost unchanged – 27.1 ng/ml initially and 29.2 ng/ml after 3 months.

Conclusions

1. The main problem in the organization of nutrition, in particular in the departments of pediatric oncology, is the absence of a dietitian and a diet nurse. Violations related to the untimely conduct of anthropometry were revealed, the assessment of nutritional insufficiency is carried out only on the basis of mass-growth indicators. Nurses are not involved in the process of assessing the nutritional status of patients. Children with a body weight deficit, nutritional insufficiency, regardless of the degree of severity, do not undergo nutrition correction. Severe anemia, protein deficiency are corrected by substitution therapy. If there are problems with eating, doctors resort to parenteral nutrition. In connection with the above facts, we believe that in order to improve the management of catering, attention should be paid to nutrition education and assessment tools for doctors and nurses.
2. It was found that in the department of pediatric oncology, all children had eating disorders that reflect such indicators as: Decreased appetite (71%), difficulty eating (75.5%), body weight deficit, low BMI, decreased circumference of the shoulder muscles, skin-fat fold of the triceps (89%), low hemoglobin content (91%), protein metabolism disorders (69%), and vitamin deficiency (63.5%). The reduction of nutritional disorders significantly improved the quality of life of the child – the well-being of children improved by 4.5 times. The distribution of children by degrees of malnutrition changed with an increase in the number of patients with a normal state of nutrition by almost 4.5 times from 5% to 22% ($p<0.05$). About 2% of the patient remained with a severe degree of malnutrition, which is 5 times less than the initial data. The number of children suffering from anemia has decreased by 1.2 times. The protein supply in children receiving nutritional support is significantly higher, which is confirmed by an improvement in indicators by 3.5 times. Vitamin D deficiency, respectively, immunosuppression, is reduced by 3 times. The improvement of hematological and biochemical parameters confirms the normal direction of metabolism and the provision of micronutrients for children receiving nutritional support.

3. The use of nutritional support made it possible to improve the dynamics of anthropometric, somatometric, hematological indicators by 2.5-3 times, improve protein supply by 3.5 times, reduce vitamin deficiency by 3 times. The quality of life of patients undergoing antitumor treatment has improved by 4 times.

The implementation of nutritional support should be considered as the main part of the accompanying treatment of children with oncopathology during specialized treatment. Since this will improve the quality of life of the child and the tolerability of specialized treatment, it will contribute to the stabilization of hematological and biochemical parameters. It is recommended, if possible, to use the enteral route of administration of specialized mixtures for nutritional support, as a more physiological one.

Author Contributions

Development of a questionnaire for screening nutrition for children with cancer. An algorithm for conducting nutritional support for pediatric oncology departments of local hospitals is proposed. All the authors have read and agreed with the publication of this version.

Institutional Review Board Statement

The study was approved by the Local Bioethical Commission of the NAO “Astana Medical University”, Kazakhstan (Protocol No. 3, 2020-01-16).

Informed Consent Statement

Informed consent was obtained from all subjects participating in the study.

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