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CLINICAL STUDY

Effect of home parenteral nutrition in malnourished patients

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ABSTRACT

OBJECTIVE: The goal of our research was to determine the impact of clinical nutrition in the form of home parenteral nutrition (HPN) in patients with nutritional disorders, most often caused by diseases of the digestive tract, with the risk of developing malnutrition.

PATIENTS AND METHODS: We retrospectively evaluated 39 patients from the Gastroenterology Clinic and the Home Parenteral Nutrition Center of the University Hospital Bratislava, whose nutritional status was evaluated based on the determination of the body mass index (BMI), the completed nutritional risk screening (NRS) questionnaire and the determination of performance status. Subsequently, after fulfilling the criteria for HPN, the initiation of parenteral nutrition (PN) followed, implemented in a domestic environment for the following two years as HPN. During this period, we did a monthly check-up of the objective condition and laboratory parameters of the enrolled patients, which were the basis for adjusting the nutritional treatment. We also evaluated the occurrence of infectious and thrombotic complications clinically and on the basis of laboratory parameters focused on culture and hemocoagulation examination. After two years, we performed control exit examinations, which we compared with the entrance examinations and statistically evaluated the success of the treatment. We evaluated the obtained data using standard statistical methods.

RESULTS: During HPN, there was a statistically significant elevation of the individual monitored values (BMI, absolute lymphocytes count, cholesterol, cholinesterase, total proteins, albumins), which clearly proves correctly indicated and managed HPN. We recorded vein thrombosis in v. subclavia and v. jugularis in 6 (15 %) patients. Subsequent catheter extraction was necessary after unsuccessful catheter insertion. In 13 (33 %) patients, tunneled catheter replacement was required due to infection. The mortality rate in our group was 8 % (3 patients). These were female patients aged 39, 42, and 66 years. The cause of death in all of these patients was the underlying diagnosis (oncohematological disease, systemic connective tissue disease, and repeated resections of the digestive tract for inflammatory GIT disease with the development of severe malnutrition). We recorded a positive effect of applied HPN in all three patients until death.

We did not register any factors that would have a relevant influence on the success of administered HPN.

CONCLUSION: Based on our results, we can conclude that the patients included in the HPN were correctly indicated, and all of them, based on the monitored parameters (regardless of gender, age, initial diagnosis, or BMI value), benefited from the applied treatment, which was correctly chosen based on their individual needs. Our results clearly document the irreplaceable role of HPN in the management of patients with nutritional intake disorders leading to the development of malnutrition *(Tab. 2, Fig. 10, Ref. 44)*. Text in PDF *www.elis.sk*

KEY WORDS: malnutrition, nutritional risk screening, clinical nutrition, home parenteral nutrition, complications.

Introduction

The nutritional treatment represents treatment with all the attributes of pharmacotherapy, and its non-administration or incorrect application is non-lege artis.

Home parenteral nutrition (HPN) is a set of medical actions performed in a home environment by an educated patient in whom it is not possible to ensure adequate nutritional needs per vias naturales even with the addition of a medically defined diet – enteral nutrition (EN). It is applied in the form of „all in one" bags with a defined amount of fats, sugars, proteins as well as electrolytes, trace elements, and vitamins (1). It enables the indicated spectrum of patients to positively influence the quality and length of their life. On the other hand, the HPN process is demanding in terms of both the administrative burden and personnel, as it is accompanied by lengthy communication with the health insurance company and requires practical training of the patient, as well as the solution to possible complications (2, 3).

Indications for HPN include dependence on long-term parenteral intake of nutrients without the need for hospitalization due to

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the underlying disease, diseases of the gastrointestinal tract (GIT), malabsorption – short bowel syndrome (SBS), chronic intestinal pseudo-obstructions, cystic fibrosis with severe malnutrition, severe intestinal involvement in Morbus Crohn, oncological diseases with the development of malnutrition.

In Slovakia, patients are included in the HPN program on the basis of meeting the criteria set out in the Clinical Nutrition Organization's Professional Guidelines no. 13163/2006 as amended by Professional Guideline no. 06242/2008-OZS, published in the Journal of the Ministry of Health, section 1–3/2009 (4).

The objective of our observation was to determine the impact of clinical nutrition in the form of HPN on the prognosis of the clinical condition in malnourished patients.

Patients and methods

Set characteristics

We retrospectively evaluated patients from the Gastroenterology Clinic and the Home Parenteral Nutrition Center of the University Hospital Bratislava, who were included in HPN predicated on the assessment of their nutritional status evaluated based on the determination of the body mass index (BMI), the completed nutritional risk screening (NRS) questionnaire and the determination of performance status.

The inclusion criteria for participation in the HPN program included: age over 15 years, minimal oral intake with deepening signs of malnutrition, use of EN without clinical effect, intestinal failure with the development of secondary malabsorption syndrome, with the need for parenteral substitution of basic nutrients, primary malabsorption syndrome accompanying various other diagnoses.

Exclusion criteria consisted of conditions where the risk of using HPN exceeded the benefit (e.g., the presence of multiresistant strains, repeated thrombotic events).

All of the examined patients were informed about their health status and the diagnostic and therapeutic procedures and signed informed consent.

Process of observation

Indicated patients with malnutrition started receiving parenteral nutrition (PN), implemented in a domestic environment for the following two years as HPN. During this 2-year period, we did a monthly check-up of the objective condition and laboratory parameters, which were the basis for adjusting the nutritional treatment. We also evaluated the occurrence of infectious and thrombotic complications clinically and on the basis of laboratory parameters focused on culture and hemocoagulation examination.

After two years, we performed control exit examinations, which we compared with the entrance examinations and statistically evaluated the success of the treatment.

Ethics committee approval

The implementation of the research was approved by the Ethics Committee of the University Hospital and Polyclinic Bratislava, St. Cyril and Methodius Hospital.

Methods

For all patients, a nutritional risk screening questionnaire was used, the aim of which was to determine the occurrence of malnutrition in the hospital as well as the outpatient setting. We used anthropometric and laboratory data obtained during the entrance examination to fill out the questionnaire.

From the laboratory parameters, using classic laboratory methods, we determined parameters of the blood count (BC) with a differential count of leukocytes, biochemical parameters: glycemia, albumin, total proteins (TP), C-reactive protein (CRP), creatinine, sodium (Na), potassium (K), chlorides (Cl), calcium (Ca), phosphorus (P), magnesium (Mg), cholinesterase (CHE), cholesterol (CHOL), triacylglycerols (TG), and gamma-glutamyl transaminase/alkaline phosphatase ratio (GMT/ALP).

We evaluated the state of the risk of developing malnutrition according to the questionnaire used and the state of performance based on scoring according to the World Health Organization (WHO). The score, according to the WHO, divides patients into categories 0–4 based on mobility, performance, and self-sufficiency. Category 0 includes a fully active patient performing all activities as before the disease, and category 4 includes a patient who is completely incapable of self-care and completely confined to a bed or chair (5).

Statistical methods

To compare the values of continuous random variables in two samples, we used the two-sample t-test or two-sample Mann–Whitney test, depending on whether we rejected the hypothesis of a normal distribution of the values of the compared variables or not.

To compare the values of continuous random variables in more than two samples, we used a simple analysis of variance or the Kruskal–Wallis test depending on whether we rejected the hypothesis of a normal distribution of the values of the compared variables or not.

To compare the values of continuous random variables before and after therapy, we used the paired t-test or paired Wilcoxon test, depending on whether we rejected the hypothesis of a normal distribution of the differences between the values of the compared variables before and after therapy or not.

To determine the closeness of the relationship between two continuous random variables, we used Pearson or Spearman correlations depending on whether we rejected the hypothesis of a

Tab. 1. Characteristics of the group of patients on home parenteral nutrition.

	Patients on HPN (n=39) (average±SD)
Age	49 ± 16.5 (15–89 years)
Gender	Women 23/59 % Men 16/41 %
BMI (kg/m2)	15 ± 3 (12–22)
RNS (n/ %)	Low grade 3/7.69 % Intermediate grade 17/43.58 % High grade 19/ 48.71%

SD – standard deviation, RNS – risk of nutritional screening, BMI – body mass index

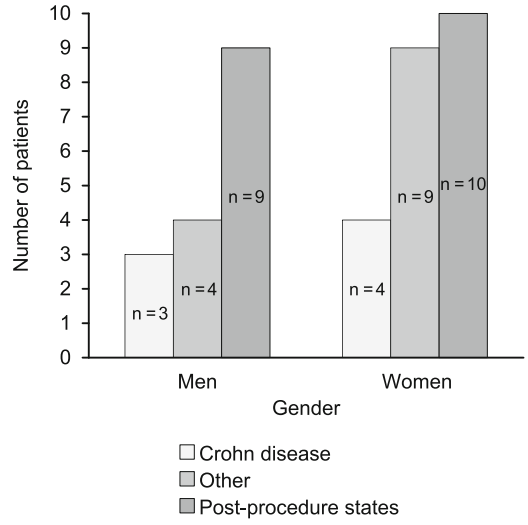

Fig. 1. Characteristics of patients according to gender and basic diagnosis. N – number.

normal distribution of the values of the monitored variables or not. To determine the relationship between two discrete variables, we used the chi-squared test in contingency tables and, in the case of low expected frequencies, Fisher's exact test.

We used decision trees to determine which variables influence performance status and BMI after therapy. We used a general linear model to determine which variables influence post-therapy BMI. We used binary logistic regression to determine which variables influence post-therapy performance status.

We worked in the IBM SPSS 21 statistical software. We performed all tests at the significance level $\alpha = 0.05$.

Results

Set characteristics

We retrospectively evaluated a set of 39 patients from the Gastroenterology Clinic and the HPN Center at the University Hospital Bratislava who were treated with HPN over the course of two years.

The group consisted of 23/59 % women and 16/41 % men, with an average age of 49 years.

On the basis of determining BMI, filling out the NRS questionnaire, and determining the performance status, we evaluated the patient's nutritional status and then started the application of clinical nutrition.

The average value of BMI before inclusion in HPN was 15 kg/m^2, ranging from 12–22 kg/m^2. 3 (7.69 %) patients were at low, 17/43.58 % at medium, and 19/48.71 % at high risk of malnutrition (Tab. 1). The characteristics of the set are in Table 1.

Patients with multiple diagnoses affecting nutrition were included in the set. Postoperative conditions (19/48.72 %), Crohn's disease (7/17.95 %), and others (13/33.33 %) prevailed. In the group of men, there were post-procedural conditions in 9 (60 %), Crohn's disease in 3 (20 %), and other diagnoses in 4 (26.67 %). There were post-procedure conditions in 10 (41.67 %), Crohn's disease in 4 (20 %), and other diagnoses in 9 (33.33 %) women (Fig. 1).

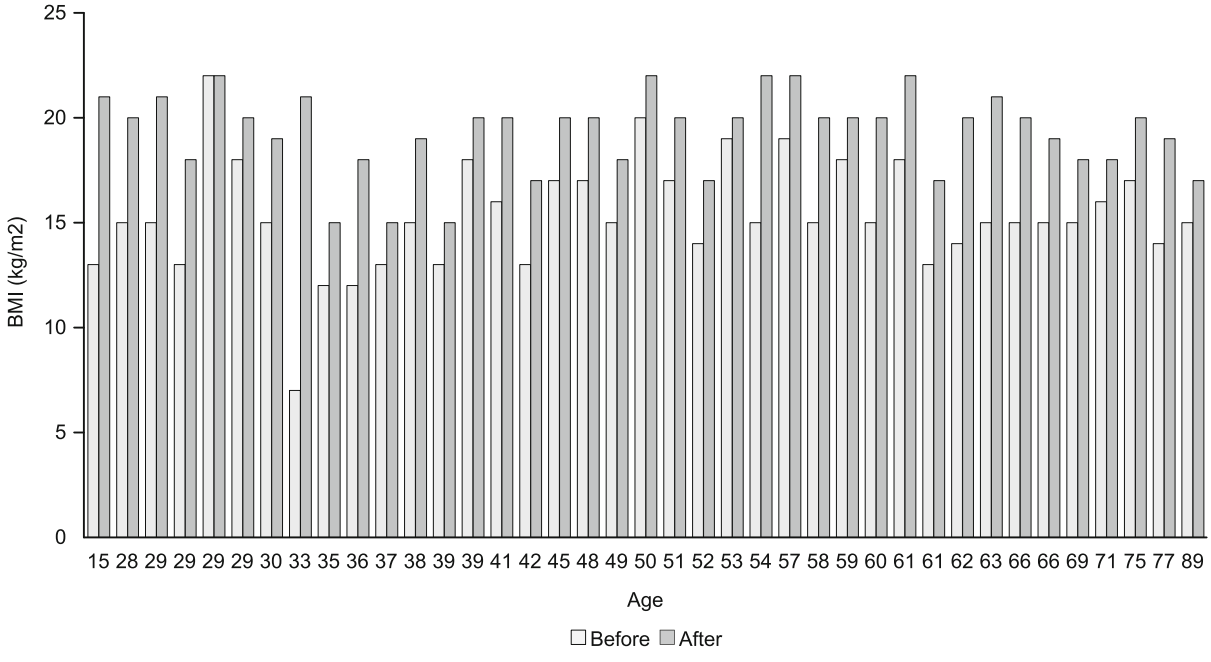

Fig. 2. Changes in BMI in individual patients before HPN and after 2 years of its application. BMI – body mass index, HPN – home parenteral nutrition.

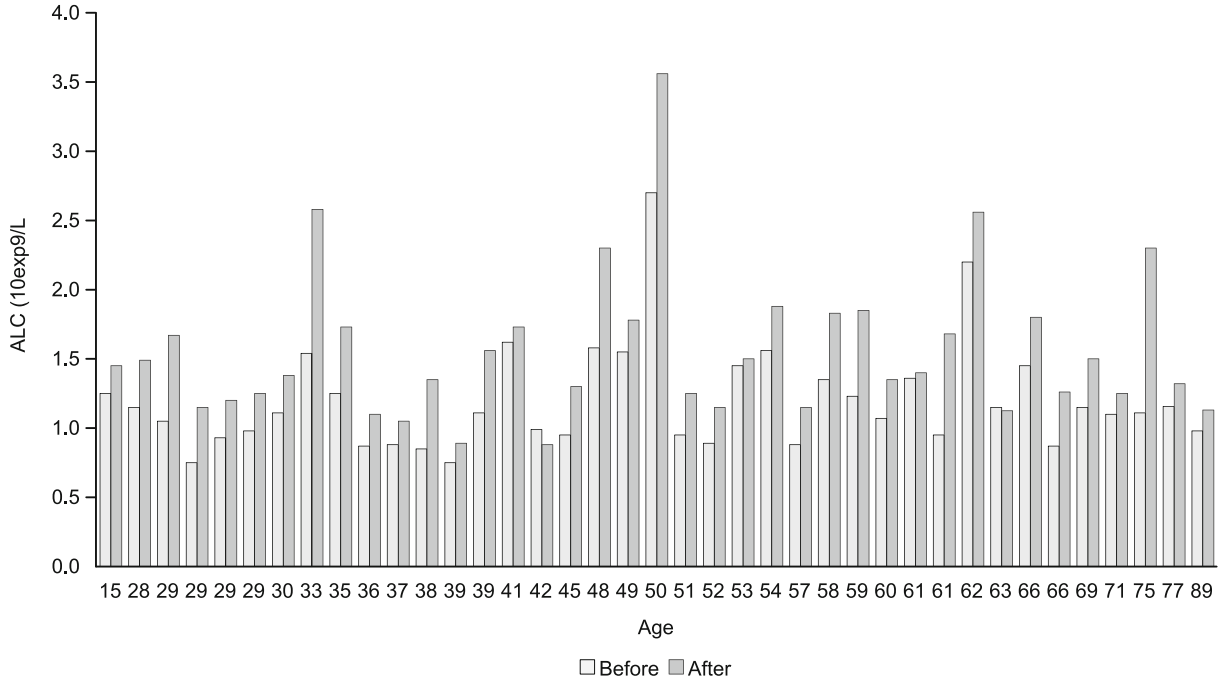

Fig. 3. Changes in the absolute lymphocytes count in individual patients before HPN and after 2 years of its application. HPN – home parenteral nutrition, ALC – absolute lymphocytes count.

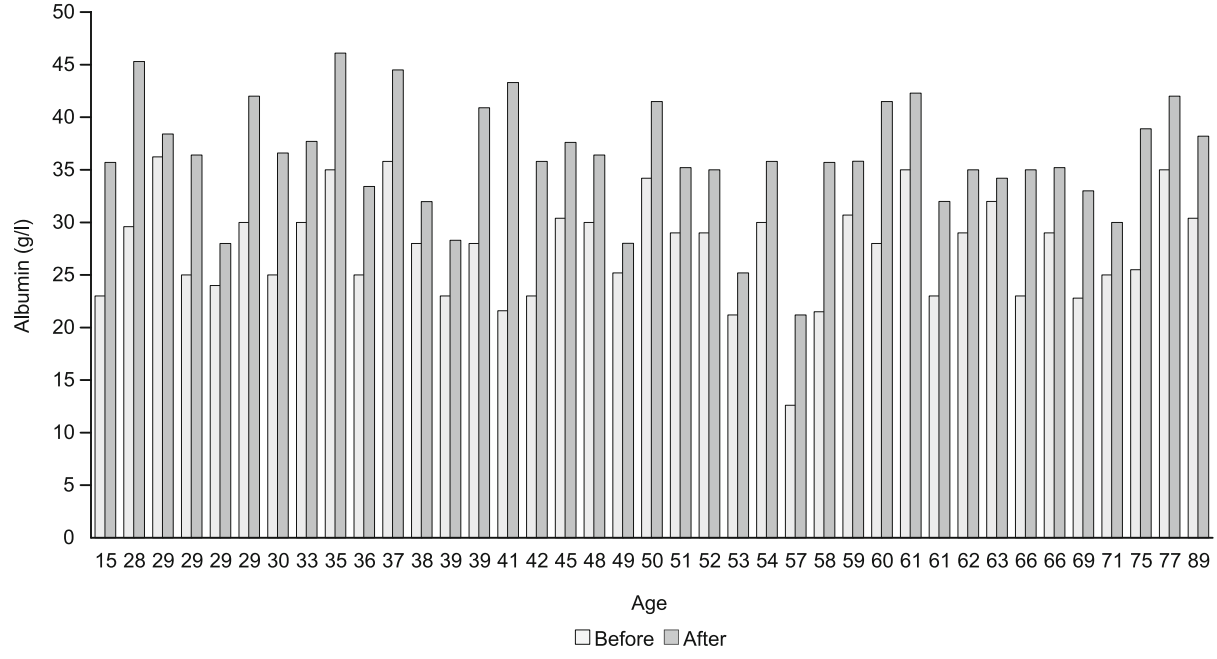

Fig. 4. Changes in the albumin level (g/l) in individual patients before HPN and after 2 years of its implementation. HPN – home parenteral nutrition.

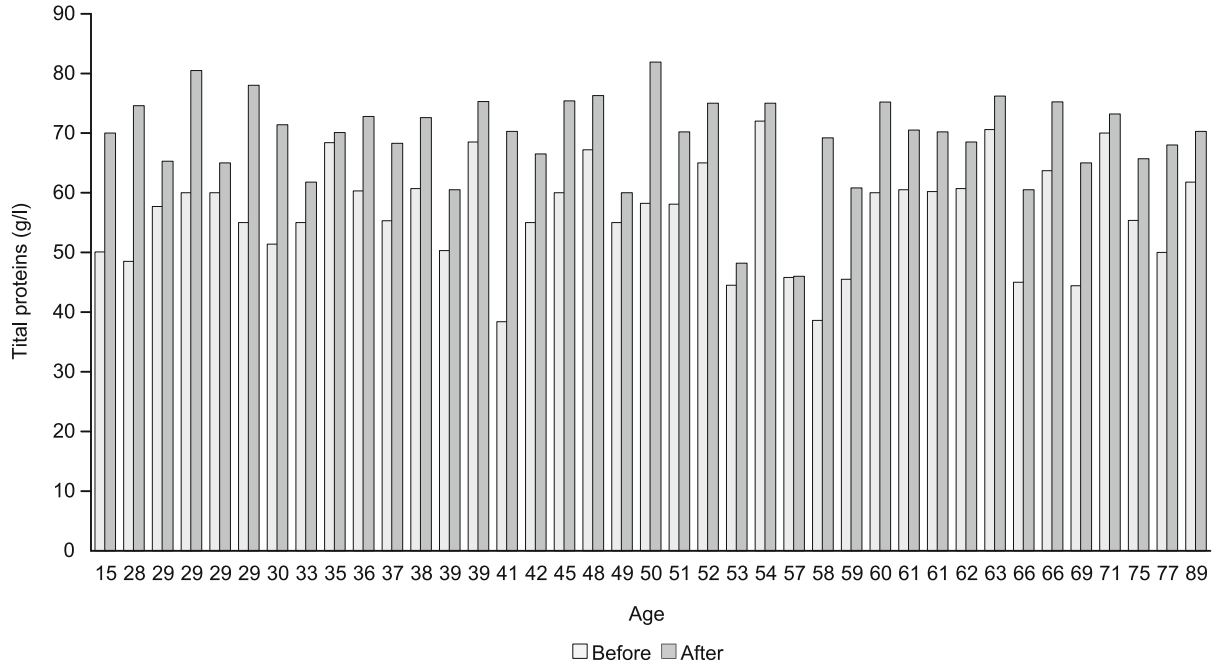

Fig. 5. Changes in the level of total proteins (g/l) in individual patients before HPN and after 2 years of its implementation. HPN – home parenteral nutrition.

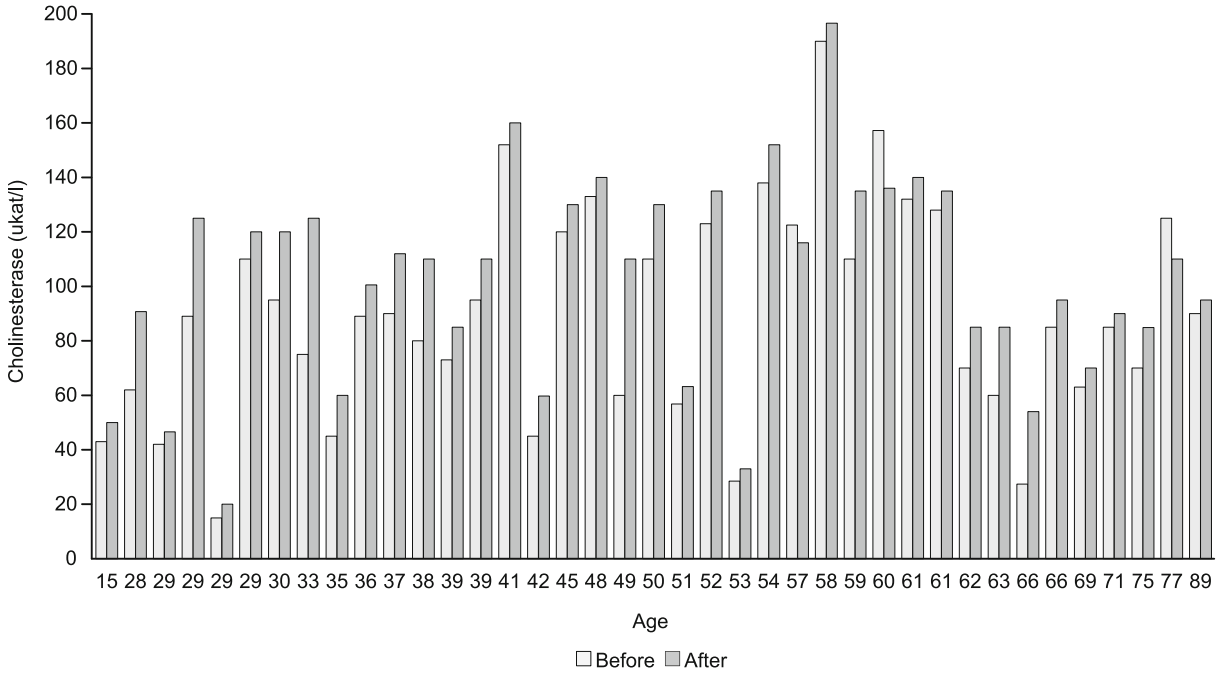

Fig. 6. Changes in the level of cholinesterase (ukat/l) in individual patients before HPN and after 2 years of its implementation in individual patients. HPN – home parenteral nutrition.

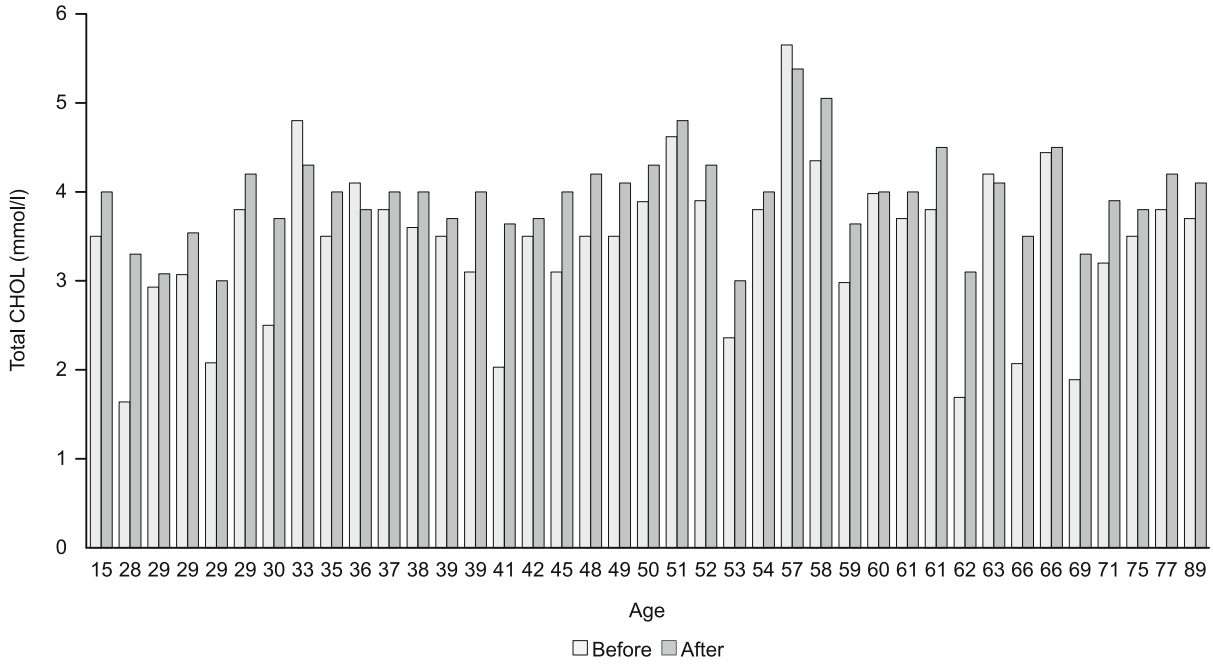

Fig. 7. Changes in the level of total cholesterol (ukat/l) in individual patients before HPN and after 2 years of its implementation in individual patients. HPN – home parenteral nutrition, CHOL – cholesterol.

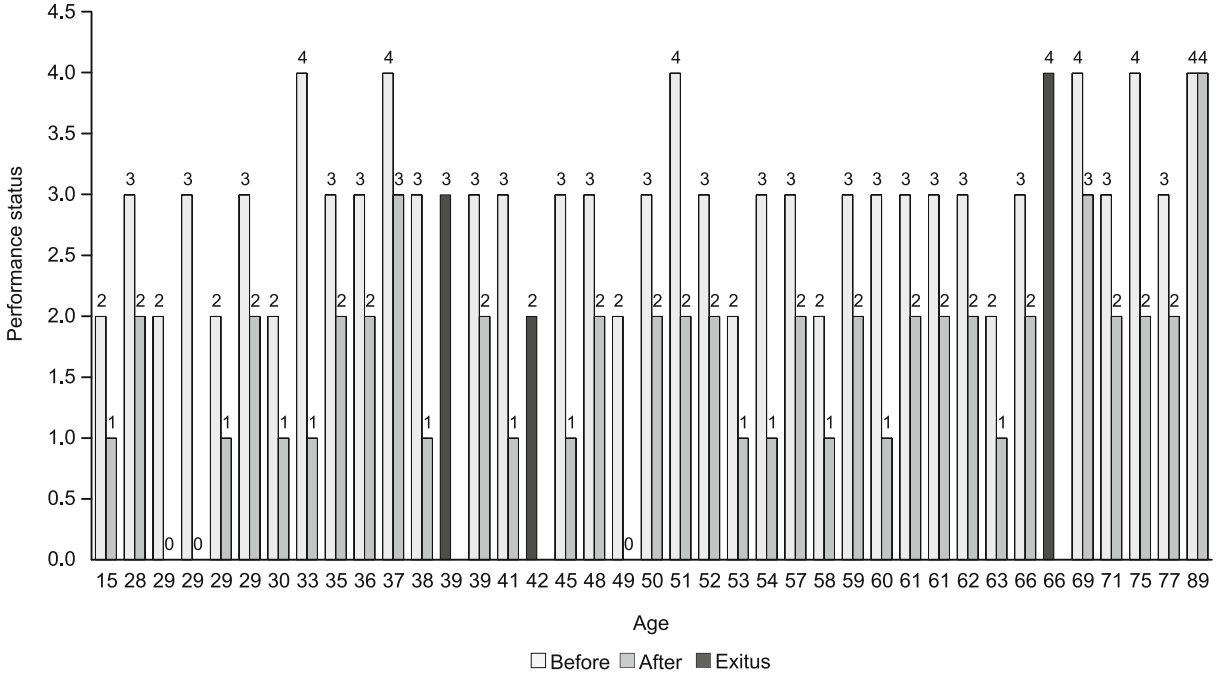

Fig. 8. Individual performance scores for individual patients before HPN and after 2 years of its implementation (black column – exitus). HPN – home parenteral nutrition.

Tab. 2. The effect of administered HPN on monitored parameters.

Parameter	Before HPN				After 2-years of implementation of HPN				p
	average	median	SD	min–max	average	median	SD	min–max	
BMI (kg/m2)	15.33	15.00	2.6	7–22	19.31	20.00	1.9	15–22	<0.001
Hb (10 exp12/l)	114	120	17.1	75–135	125.92	128	10.40	99–145	<0.001
ALC (10 exp9/l)	1.20	1.11	0.38	0.75–2.7	1.56	1.40	0.52	0.88–3.56	<0.001
Albumin (g/l)	27.53	28.00	5.0	12.60–36.23	36.13	35.80	5.5	21.20–46.10	<0.001
Total proteins (g/l)	56.59	58.10	8.64	38.40–72.00	69.22	70.20	7.57	46.00–81.90	<0.001
CHE (ukat/l)	89.34	89.00	39.4	15.00–190.0	102.95	110.00	37.38	20.00–196.60	<0.001
Cholesterol (mmol/l)	3.41	3.50	0.89	1.64–5.65	3.94	4.00	0.52	3.00–5.38	<0.001
TG (mmol/l)	1.25	1.10	0.58	0.50–3.50	1.49	1.40	0.47	0.89–2.96	<0.001
Creat (umol/l)	122	85	97	35–509	104	88	51	43–245	0.895
Na (mmol/l)	133.20	133.90	5.68	116.00–144.10	137.52	138.20	3.47	130.70–143.20	<0.001
K (mmol/l)	3.66	3.75	0.61	1.39–4.80	4.34	4.22	0.37	3.66–5.38	<0.001
Cl (mmol/l)	96.70	99.80	9.25	62.00–104.20	104.60	104.20	3.43	98.30–112.08	<0.001
Ca (mmol/l)	2.00	2.00	0.34	0.92–2.58	2.21	2.29	0.29	1.40–2.60	<0.001
P (mmol/l)	1.02	1.05	0.28	0.28–1.63	1.16	1.16	0.21	0.70–1.80	<0.001
Mg (mmol/l)	0.95	0.80	0.34	0.19–9.00	0.99	0.94	0.16	0.75–1.50	<0.001
GMT/ALP	0.62	0.43	0.86	0.10–5.31	0.48	0.44	0.23	0.18–1.12	0.093
Performan-ce status	3				2				<0.001

p – statistical significance, SD – standard deviation, min–max – minimal–maximal value, TG – triacylglyceroles, Creat – creatinin, Mg – magnesium, K – potassium, Na – natrium, Cl – chlorides, BMI – body mass index, Hb – hemoglobin, CHE – cholinesterase, GMT/ALP –gammaglutamyltranferase to alkaline phosphatase ratio, ALC – absolute lymphocytes count

After two years of applied HPN, there was a statistically significant elevation of the BMI value after two years of HPN from 15.33 kg/m^2 vs 19.31 kg/m^2 ($p < 0.001$), while we also noted an individual increase in BMI in each patient, which clearly confirmed correct selection of HPN nutritional support for each enrolled patient (Fig. 2).

During the administration of HPN, we recorded a statistically significant increase in the concentration of the absolute lymphocytes count (ALC; 1.20x10 exp^9/l vs 1.56x10 exp^9/l; $p < 0.001$), which we also confirmed by evaluating the individual effect of HPN on ALC values (Fig. 3), which proves a positive impact of the applied nutritional support.

Another proof of the positive effect of HPN in patients with malnutrition is a statistically significant elevation of the albumin concentration from 27.53 g/l before the start of treatment to 36.13 g/l after the application of HPN ($p < 0.001$), as well as TP from 56.59 g/ l to 69.22 g/l ($p < 0.001$). We also noted this effect in the individual evaluation of HPN for albumin and TP concentrations in each enrolled patient (Figs 4 and 5).

During HPN, we also noted a statistically significant elevation of CHE levels from 89.34 μkat/l to 102.9 μkat/l ($p < 0.001$), as well as its individual increase in individual enrolled patients (Fig. 6).

During HPN, we recorded a statistically significant elevation of the level of total CHOL from 3.41 mmol/l to 3.94 mmol/l ($p < 0.001$), as well as an individual elevation of its concentration in individual patients (Fig. 7).

In the monitored set of patients, there was an improvement in the state of performance in all but one patient (Fig. 8). The average value of the score decreased from the value of 3 to 2 ($p < 0.001$), which clearly documents the improvement of the performance status of the patients.

The effect of HPN administration on BMI monitored laboratory parameters and performance status in our observed set is shown in Table 2.

The most frequent complications occurring during HPN are of thrombotic and infectious nature, with the risk of developing catheter-related sepsis. In our group, we recorded vein thrombosis in v. subclavia and v. jugularis in 6 (15 %) patients, in which subsequent catheter extraction was necessary after unsuccessful catheter insertion (Fig. 9). In 13 (33 %) patients, the tunneled catheter had to be replaced due to infection (Fig. 10). The most common causes of infection were gram-positive bacteria (*Staphylococcus aureus, St. epidermidis*), but we also cultivated gram-negative bacteria (*Klebsiella pneumonia, Pseudomonas species*) and yeast (*Candida albicans, Candida parapsilosis*).

In our set, we recorded a mortality rate of 8 % (3 female patients) in patients aged 39, 42, and 66 years. The cause of death

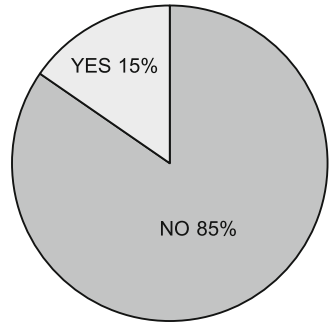

Fig. 9. Incidence of thrombotic complications during HPN. HPN – home parenteral nutrition.

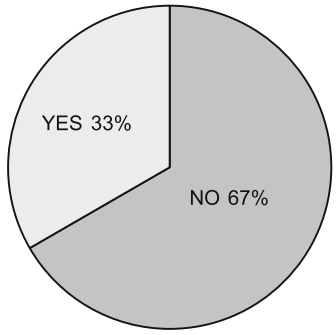

Fig. 10. Incidence of infectious complications during HPN. HPN – home parenteral nutrition.

in all three was the underlying diagnosis. It was an oncohematological disease, a systemic connective tissue disease, and repeated resections of the digestive tract due to an inflammatory disease of the GIT with the development of severe malnutrition. We recorded a positive effect from applied HPN in these female patients until their death.

We did not register any factors that would have a relevant influence on the success of administered HPN. Based on our results, we can conclude that the patients included in the HPN were correctly indicated, and all of them, based on the monitored parameters (regardless of gender, age, initial diagnosis, or BMI value), benefited from the applied treatment, which was correctly chosen based on their individual needs.

Discussion

Undernutrition (malnutrition) represents a serious worldwide medical, social, and economic problem that does not only affect developing countries. In developed European countries, up to a third of patients suffer from various forms of malnutrition. 30–35 % of patients are at risk of developing so-called iatrogenic malnutrition during hospitalization, while in acutely hospitalized patients, this risk is up to 55 %, and several factors participate in it (6). In addition, in up to 70 % of patients with pre-existing malnutrition, the degree of malnutrition worsens significantly during hospitalization. The mortality rate of severe untreated malnutrition is 3–4 %. It should be remembered that if in a 1000-bed hospital, 30–40 patients are not provided with artificial nutrition daily, there is a risk that patients in such a hospital will die from insufficient nutrition. Multicenter studies from European countries document the prevalence of malnutrition in hospitalized patients between 20–60 % (7).

The published EN and PN guidelines clearly point to the necessity of screening for malnutrition and the need for rapid nutritional intervention in outpatients as well as hospitalized patients. It is also recommended to determine the initial risk of malnutrition when the patient is hospitalized, which is the basis for the subsequent comprehensive treatment depending on the underlying disease and nutritional status (8, 9, 10, 11).

By starting HPN in cases of benign diseases, it is possible to achieve reversibility of intestinal failure within 1–2 years in up to 20–50 % (12). In cases of advanced cancer, the initiation of HPN is controversial (13). In cancer cachexia syndrome, PN is administered only at a stage when excessive catabolism is not present, and it is assumed that there is a modality of treatment that could prolong the patient‘s life but is contraindicated precisely for cachexia (administration of chemotherapy, surgery) (14, 15). They confirmed through observation that the correct indication of HPN as a part of palliative health care to oncology patients in good condition who do not require other hospital care apart from parenteral hydration and nutrition, can significantly contribute to improving their physical performance as well as to improving the quality of life.

HPN allows the entire spectrum of patients to improve not only the quality but also the length of their life (16, 17); however, in addition to the beneficial effect on the health of the patient with digestive tract failure, there are unfortunately several complications associated with its application; therefore this form of nutritional nourishment requires a multidisciplinary approach and compliance of the patient and his family members (10, 3).

The first European multicentric study evaluating HPN published in 1996 reported a prevalence of HPN of 4.6–12.2 patients per 1 million (mil.) of European population (18). Later studies from Italy (from 2005) report a prevalence of 31.7 HPN/1 mil. inhabitants (19). In the USA in 2013, the prevalence of HPN was 79/1 mil. inhabitants (20). In 2013, 2016, and 2018, the prevalence of HPN in Spain increased (4.22 vs 6.16 vs 6.61/1 mil. inhabitants) (21, 22, 23), and the indication of HPN also doubled in the UK in 2015 (40/1 mil. inhabitants) compared to 2005 (24). In Switzerland, five patients per 1 mil. inhabitants/1 year are reported on HPN (25), and in Poland, 53.26/1 mil. inhabitants/1 year (17).

In Slovakia, the prevalence of patients on HPN is reported as 4.07/100,000 inhabitants (26), and in absolute numbers, as of September 30, 2019, there were a total of 127 adult and child patients on HPN in Slovakia (27).

HPN centers record a trend of a decrease in younger patients (18–54 years old) on HPN and an increase in the number of patients older than 65 years (17, 18, 24, 28). In Slovakia, by evaluating 391 patients treated with HPN in the years 2017–2020, most patients on HPN were determined to have been between the ages of 50 and 69. Younger patients aged 35–39 (15.4 %) were the most represented in our monitored set, followed by 25–29, 50–54, and 60–64 years old (7.5 % each).

In general, among the most frequent primary diagnoses leading to the need to start HPN are cancer diseases, the incidence of which has an increasing trend (17, 24, 29, 30, 31, 32).

In the study by Slezáková (26), the reason for starting HPN was an intestinal failure in malignant diseases (63.17 %), and in 32.99 %, it was a benign disease. Short bowel syndrome was found in 23.74 % of cases. The most common malignancy was cancer of the stomach, colon, pancreas, and gynecological malignancies. In the study of Ondrušová et al (27), in patients with SBS enrolled in HPN, the most common diagnoses were Crohn‘s disease (40 %) and non-neoplastic surgical conditions (25 %), and tumors (20 %). In the study by Reber et al (25), SBS was the cause for HPN in 30 % of patients. In a study by Fowarski et al (17), the most com-

mon cause of HPN indication was malnutrition, intestinal diseases with intestinal malabsorption, post-procedural GIT conditions, and tumors. In our observed set of patients, the most common reason for inclusion in HPN was post-procedural GIT conditions (19/49 %), followed by Crohn's disease (7/18 %).

The BMI value is the most commonly used indicative examination of a patient's nutritional status to identify malnutrition. On the other hand, its use is limited in obese patients and in patients with swelling conditions. A reduced BMI confirms malnutrition with a telltale value of 100 %, but an increased BMI does not rule out malnutrition. Average BMI values in our set of patients statistically increased in a significant way (15.33 kg/m^2 vs 19.31 kg/m^2; $p < 0.001$). The goal of treatment of malnutrition is to achieve and maintain a physical condition in which full activity in life is possible, or there are as few limitations as possible. Evaluation of the state of performance in patients with nutritional disorders and the development of malnutrition is a parameter that can be used to evaluate the progression of the disease, or the success of the applied therapy, as well as the quality of life and the subsequent course of the disease.

The performance rating scale, according to the Karnofsky score or WHO, is most often used to assess physical condition (33, 34). We used the WHO score, which divides patients according to the degree of mobility, performance, and self-sufficiency into categories 0–4. Category 0 includes a fully active patient, performing all activities as before the disease, and on the other hand, category 4 includes a patient who is completely incapable of self-care and completely confined to a bed or a chair (5). With the exception of one patient, we noted an improvement in the performance of all patients. The average value decreased from 3 to 2 ($p < 0.001$). Even the patients themselves assessed their condition as improved, while they managed and were capable of several activities.

Determination of ALC in peripheral blood is a sensitive indicator of deterioration of cellular immunity, while values lower than 900x10^9/l are a prediction of infectious complications, early onset of pressure ulcers, and impaired wound healing (5), and in oncology patients, a decrease below 1,500x109/l is associated with 1.8 times the risk of complications and four times the risk of death (35). In our observed set of patients, we recorded a statistically significant increase in ALC (1 200x10^9/l vs 1 560x10^9/l; $p < 0.001$), which may predict a beneficial effect of HPN. The lowest ALC values before the start of treatment were 750x10^9/l in our group and 880x10^9/l after two years of HPN application.

The examination of circulating TP and albumin is of limited use for the basic diagnosis of malnutrition, as normal values of TP or albumin do not rule out malnutrition. According to Evans et al (36), albumin/prealbumin are even mislabeled as nutritional proteins. However, given the strong association between inflammation and malnutrition, visceral proteins correlate well with the risk of adverse effects, and while not specifically reflecting the patient's current nutritional status, they are useful for determining the risk of malnutrition by identifying patients who are likely to be at increased risk of malnutrition if adequate nutrition will not be initiated. On the other hand, its elevation in malnourished patients achieved by complex PN was proven as an independent factor leading to a shorter hospitalization of patients (37). Albumin determination is also used as a supplementary examination in swelling conditions to confirm hypoprotein malnutrition in patients with chronic stress metabolism. Because of their long biological half-life, they are not suitable for the diagnosis of acute malnutrition, in which the examination of proteins with a short biological half-life is preferred, e.g., determination of transferrin with a biological half-life of 7 days or transthyretin with a half-life of 1.5 days (5). In our 2-year observation, we noted a statistically significant elevation of TP concentration (56.59 g/l to 69.22 g/l; $p < 0.001$) and albumin (27.53 g/l to 36.13 g/l; $p < 0.001$). The two-year HPN led to the normalization of albumin and TP concentration in several patients, and while the lowest albumin level before the start of nutritional support was only 12.6 g/l, after treatment, no patient had an albumin concentration below 21.2. Similarly, the lowest TP concentration after treatment was 46 g/l, while before starting the treatment, it was only 38 g/l. Albumin levels below 35 g/l are associated with a 4-fold higher incidence of complications and 6-fold higher mortality. If this decrease is also combined with lymphopenia up to 1500x10^9/l, it is associated with up to a 20-fold risk of death in oncology patients (35). A decrease in ALC, together with decreased serum albumin levels and an increased SGA (subjective global assessment), malnutrition score, and a decrease in the volume of the neck above the triceps are predictors associated with nutritional risk and the development of postoperative complications (38).

To assess the proteosynthetic capacity of the liver and the capacity of the functional liver parenchyma, we determined CHE, which is significantly reduced in hepatopathies, acute catabolic conditions, and chronic malnutrition. Its increased concentrations can be observed in nephrotic syndrome or in alcoholics. CHE levels are used as a predictor in several diseases associated with nutritional disorders (39). During HPN, there was a statistically significant elevation of the CHE level 89.34 μkat/l vs 102.9 μkat/l; ($p < 0.001$).

Cholesterol is a sensitive indicator of energy malnutrition. Its disadvantage is genetic determination, influenced by medication, thyroid, and hepatic functions. A reduced level of total CHOL and especially its HDL fraction has recently been often associated with acute malnutrition, induced by inflammation, and is associated with the severity of the condition. In several clinical studies, the reduced level of HDL CHOL or an increased ratio of total CHOL/HDL-CHOL is associated with visceral obesity as well as with a deficiency of some micronutrients, such as vitamins of class A, B3, B12, zinc, calcium (40). Similarly, several studies, mainly carried out in patients with cardiovascular diseases, clearly point to the so-called cholesterol paradox, which leads to insufficient benefit in reducing cardiovascular mortality by low non-HDL-CHOL levels due to malnutrition in these patients (41, 42). In our observed set, we noted an increase in total CHOL from 3.41 mmol/l to 3.94 mmol/l ($p < 0.001$), while the lowest concentration before treatment was 1.64 mmol/l and after treatment, 3.0 mmol/l. The TG level also increased in a statistically significant manner from 1.25 mmol/l to 1.49 mmol ($p < 0.001$).

The incidence of catheter thrombotic and infectious complications in published studies is reported to be 0.13–0.86 cases per

1000 catheter days (25, 26, 43). In patients with PN in intensive care units, the risk of catheter sepsis is significantly higher (6.47 cases/1000 catheter days) and is associated with the length of hospitalization, length of PN, length of catheterization and its introduction, as well as procedures performed in the intensive care unit (44). In our observed set of patients, thrombotic complications occurred in 15% and infectious complications in 33 %. The most common causes of infection in our group were gram-positive bacteria (*St. aureus, St. epidermidis*), as well as gram-negative bacteria (*Klebsiella pneumonia, Pseudomonas species*) and yeast (*Candida albicans, Candida parapsilosis*). Galvao et al (43) observed the most frequently cultivated *St. epidermidis* and *Serratia marcescens.*

The eight percent mortality recorded in our observed set is comparable to the published 7 % (25). It is known that the risk of death increases with the duration of HPN application as well as with age above 75 years (17).

The main reason for the inclusion of patients in the HPN program was the failure of effective nutrition in a natural way with a progressive decline in physical condition, with increasing dependence on assistance for self-care (5). In our group, there was a statistically significant decrease in the impaired performance score from 3 to 2 ($p < 0.001$). The improvement in performance status was related to the modification of nutrition in the patient's underlying disease. However, we also noticed an improvement in the quality of life for all of them. Our results are in agreement with the improvement in quality of life found in patients with EN and PN after surgical intervention in 98 patients with esophageal tumors. The Karnofsky score increased statistically significantly after 4, 8, and 12 days compared to the control group. They also recorded a statistically significantly lower incidence of complications (34).

Conclusion

Proper management of patients requiring HPN enables the entire spectrum of patients to significantly improve their health status and quality of life. The duration of HPN administration depends on the basic diagnosis, the initial nutritional status of the patient, and their comorbidities. We set the patient's parenteral regimen according to the current need, with the possibility of not only central but also peripheral PN application, with a preference for a gradual, as early as possible, transition to EN and a natural way of eating.

When enrolling a patient in the HPN program, one of the important criteria is also a good/suitable social background and proper, sufficient education of the patient. During the administration of HPN, regular clinical and laboratory monitoring of the patient is essential Since every PN, including HPN, is accompanied by acute and chronic complications, it is necessary to regularly monitor all risk factors and early manifestations of developing complications after starting such treatment. This will enable the application of relevant and rapid intervention with the elimination of the development of serious complications worsening the overall condition of the patient and participating in the increased morbidity and mortality of these patients.

Correctly applied clinical nutrition, whether EN, PN, or their combination, can significantly influence morbidity and mortality in patients with malnutrition or the risk of its development. Unfortunately, Slovakia still lags behind developed countries in its implementation as part of complex patient treatment. Our results clearly document the irreplaceable role of HPN in the management of patients with nutritional intake disorders leading to the development of malnutrition. In Slovakia, it will be necessary to intensify the activity of all those involved in regular monitoring of the risk of developing malnutrition, which will bring benefits not only for patients but also to the health system.

References

1. Itzhaki MH, Singer P. Advances in Medical Nutrition Therapy: Parenteral Nutrition. Nutrients 2020; 12: 717. DOI: 10.3390/nu12030717.

2. Fojtová A, Norek B, Zamborský T, Bátovský M. Domáca parenterálna výživa – význam a využitie v klinickej praxi. (Home parenteral nutrition – significance and use in clinical practice. Gastroent Hepatol 2015; 69 (5): 449–452.

3. Fojtová A, Norek B, Gazdíková K. Význam domácej parenterálnej výživy v klinickej praxi – vlastné skúsenosti z nášho centra. Gastroent Hepatol 2022; 76 (1): 1–7.

4. Vestník Ministerstva zdravotníctva SR z roku 2009 – Odborné usmernenie MZ SR č. 06242/2008-OZS, ktorým sa mení a dopĺňa odborné usmernenie MZ SR č. 13168/2006 OZS organizácie klinickej výživy. Journal of the Ministry of Health of the Slovak Republic from 2009 – Expert guidance of the Ministry of Health of the Slovak Republic no. 06242/2008-OZS, amending and supplementing the professional guideline of the Ministry of Health of the Slovak Republic no. 13168/2006 OZS of clinical nutrition organizations [online]. https: //sspev.sk/manual-a-video-pre-pacientov-na-dpv/.Cited 15.3.2021.

5. Fojtová A, Gazdíková K. Skríning a diagnostika malnutrície. Screening and diagnosis of malnutrition. Lek Obz 2021; 70 (11): 400 – 408.

6. Barker LA, Gout BS, Crowe TC. Hospital Malnutrition: Prevalence, Identification and Impact on Patients and the Healthcare System. Int J Environ Res Public Health 2011; 8: 514–527. DOI: 10.3390/ijerph8020514. cited 15.3.2021.

7. Sorensen J, Kondrup J, Prokopowicz J et al. An international, multicentre study to implement nutritional risk screening and evaluate clinical outcome. Clin Nutr 2008; 27: 340–343.

8. McClave S, Taylor BD, Martindale RG et al. Guidelines for the Provision and Assessment of Nutrition Support Therapy in the Adult Critically Ill Patient: Society of Critical Care Medicine (SCCM) and American Society for Parenteral and Enteral Nutrition (A.S.P.E.N.). J Parenter Enter Nutr 2016; 40 (2): 159–211. https://www.researchgate.net/publication/290605265, cited 15.2.2019.

9. Volkert D, Beck AM, Cederholm T et al. ESPEN guideline on clinical nutrition and hydration in geriatrics. Clin Nutrition 2018; 1–38. https://doi.org/10.1016/j.clnu.2018.05.024.

10. Pironi L, Boeykens K, Bozzetti F et al. ESPEN guideline on home parenteral nutrition. Clin Nutrition 2020; 39: 1645–1666. https://doi.org/10.1016/j.clnu.

11. Gramlich L, Hurt RT, Jin J, Mundi MS. Home Enteral Nutrition: Towards a Standard of Care. Nutrients 2018; 10 (8): 1020. DOI: 10.3390/nu10081020. www.mdpi.com/journal/nutrients.

12. NHS National Commissioning Group for highly specialised services. 2019. Strategic Framework for Intestinal Failure and Home Parenteral Nutrition Services for Adults in England 2019 [online]. www.specialisedservices.nhs.uk/library/28/ Strategic_Framework_for_Intestinal_Failure_and_Home_Parenteral_Nutrition_ Services_for_Adults_in_England_1.pdf.

13. Bozzetti F, Santarpia L, Pironi L et al. The prognosis of incurable cachectic cancer patients on home parenteral nutrition: a multicentre observational study with prospective followup of 414 patients. Ann Oncol 2014; 25 (2): 487–493. DOI: 10.1093/ annonc/mdt549.

14. Škripeková A. Výživa pacientov s pokročilým nádorovým ochorením (Nutrition in patients with advanced cancer. Farmakoterapia 2013; 3 (1): 55–59.

15. Voleková M, Popálená J. Domáca parenterálna výživa u onkologických pacientov. (Home parenteral nutrition in oncology patiets. Paliat med liec boles 2018; 11 (1–2e): 61–65.

16. Lee A, Queiroz M, Cunali H et al. Epidemiology and Clinical Outcomes of Chronic Intestinal Failure Patients Undergoing Home Parenteral Nutrition, Experience from A Brazilian Intestinal Rehabilitation Center. Transplantation 2021; 105 (7S): S54.

17. Folwarski M, Klek S, Szlagatys-Sidorkiewicz A, Wyszomirski A, Brzeziński M, Skotnicka, M. Trend Observations in Home Parenteral Nutrition. Prevalence, Hospitalizations and Costs: Results from a Nationwide Analysis of Health Care Provider Data. Nutrients 2021; 13: 3465. https: // doi.org/10.3390/nu13103465. Cited 16.1.2022.

18. Van Gossum A, Bakker H, De Francesco A et al. Home parenteral nutrition in adults: A multicentre survey in Europe in ESPEN – Home Artificial Nutrition Working Group. Clin Nutr 1996; 15: 53–59.

19. Pironi L, Candusso M, Biondo A et al. Prevalence of home artificial nutrition in Italy in 2005: A survey by the Italian Society for Parenteral and Enteral Nutrition (SINPE). Clin Nutr 2007; 26: 123–132.

20. Mundi MS, Pattinson A, McMahon MT, Davidson J, Hurt RT. Prevalence of Home Parenteral and Enteral Nutrition in the United States. Nutr Clin Pract 2017; 32: 799–805.

21. Wanden-Berghe LC, Martín CC, Hernández JA, Paláes RB, Martín PA, Compes CC, Grupo NADYA-SENPE. Registro del grupo NADYA-SENPE de nutrición enteral domiciliaria en España; años 2018 y 2019. Nutr Hosp 2022; 39 (1): 223–229.

22. Wanden-Berghe C, Luengo LM, Álvarez J et al. de nutrición enteral domiciliaria en España, años 2014 y 2015. Nutr Hosp 2017; 34 (1): 15–18.

23. Wanden-Berghe LC Cuerda CC, Maíz JM et al. Home and Ambulatory Artificial Nutrition (NADYA) Group Report. Home parenteral nutrition in Spain, 2018. Nutr Hosp 2020; 37 (2): 403–407.

24. Smith T, Naghibi M. British Artificial Nutrition Survey (BANS) Report Artificial Nutrition Support in the UK 2005 – 2015 – Adult Home Parenteral Nutrition & Home Intravenous Fluids; BAPEN: Redditch, UK, 2016; 27 pp.

25. Reber E, Staub K, Schönenberger KA et al. Management of Home Parenteral Nutrition: Complications and Survival. Ann Nutr Metab 2021; 77 (1): 46–55.

26. Slezáková J. Slovenský register pacientov na domácej parenterálnej výžive. (Slovak register of patients on home parenteral nutrition. Gastroenterol prax 2021; 20 (2): 75–78.

27. Ondrušová M, Maronová M, Slezáková J. Analýza veľkosti cieľovej populácie pacientov so syndrómom krátkeho čreva. Bratislava: Pharm-In 2019: 16 s. https: //doi.org/10.1159/000515057. cited 12.4.2022

28. Daoud DC, Cartagena EMS, Schwenger KJP et al. Home parenteral nutrition in older vs younger patients: Clinical characteristics and outcomes. J Parenter Enter Nutr 2021; 46 (2): 348–356.

29. Wanden-Berghe C, Cunill JLP, Compes CC et al. Informe del Grupo de Nutrición Artificial Domiciliaria y Ambulatoria NADYA. Home and ambulatory artificial nutrition (NADYA) report. home parenteral nutrition in Spain, 2017. Nutr Hosp 2018; 35 (6): 1491–1496.

30. Higuera I, García-Peris P, Camblor M et al.. Outcomes of a general hospital-based Home Parenteral Nutrition (HPN) program; report of our experience froma 26-year period. Nutr Hosp 2014; 30 (2): 359–365.

31. Shaw SA, Rühlin M, Wagener N, Stanga Z, Meier R, Ballmer PE. Home Artificial Nutrition in Switzerland: An Epidemilogical Survey from 2005 to 2009. Ann Nutr Metab 2013; 62: 207–213.

32. Hortencio TDR, Arendt BM, Teterina A et al. Changes in Home Parenteral Nutrition Practice Based on the Canadian Home Parenteral Nutrition Patient Registry. J Parenter Enter Nutr 2015; 41 (5): 830–836.

33. Barthelemy N, Streel S, Donneau A-F, Coucke P, Albert A, Guillaume M. Screening for malnutrition in lung cancer patients undergoing radiotherapy. Support Care Cancer 2014: DOI 10.1007/s00520-013-2116-9. https: //orbi.uliege.be/bitstream/2268/163847/1/Screening%20for%20malnutrition%20in%20lung%20cancer%20patients%20undergoing%20radiotherapy.pdf.

34. Chu L, Ren Y, Zhang L, Yu X. Evaluation of effects of nutritional risk assessment and enteral and parenteral nutritional interventions after esophageal cancer surgery. Int J Clin Exp Med 2018; 11 (5): 5110–5116. www.ijcem.com /ISSN: 1940–5901/IJCEM0074101.

35. Škripeková A. Indikácie parenterálnej výživy u onkologických pacientov a problémy s tým spojené. Paliat med liec boles 2009; 2 (2): 86–89.

36. Evans DC, Corkins MR, Malone A et al. Visceral Proteins as Nutrition Markers: An ASPEN Position Paper. Nutr Clin Pract 2020; 36 (1): 22–28. DOI: 10.1002/ncp.10588 wileyonlinelibrary.com.

37. Yan X, Zhang S, Jia J, Yang J, Song Y, Duan H. Total Parenteral Nutrition Treatment Improves the Nutrition Status of Gynecological Cancer Patients by Improving Serum Albumin Level. Front Med 2022; 8: 759387. DOI: 10.3389/fmed.2021.759387.

38. Rocha NP, Fortes RS. Total lymphocyte count and serum albumin as predictors of nutritional risk in surgical patients. ABCD Arq Bras Cir Dig 2015; 28 (3): 193–196. DOI: /10.1590/S0102-67202015000300012.

39. Seo M, Yamada T, Tamaki S et al. Prognostic Significance of Serum Cholinesterase Level in Patients With Acute Decompensated Heart Failure With Preserved Ejection Fraction: Insights From the PURSUIT-HFpEF Registry. J Am Heart Assoc 2020; 9: e014100. https: //doi.org/10.1161/JAHA.119.014100, cited 8.4.2022.

40. Delisle H, Ntandou G, Sodjinou R, Couillard Ch, Després J-P. At-Risk Serum Cholesterol Profile at Both Ends of the Nutrition Spectrum in West African Adults? The Benin Study. Nutrients 2013; 5: 1366–1383. DOI: 10.3390/nu5041366.Cited 14.1.2021.

41. Wang B, Liu J, Chen S et al. Malnutrition affects cholesterol paradox in coronary artery disease: a 41,229 Chinese cohort study. Lipids Health Disease 2021; 20: 36. https: //doi.org/10.1186/s12944-021-01460-6.

42. Wang B, Guo Z, Li H et al. Non-HDL cholesterol paradox and effect of underlying malnutrition in patients with coronary artery disease: A 41,182 cohort study. Clin Nutrition 2022; 41: 723e730.

43. Galvao F, Lee A, Scavia T, Rocha M, da Cruz M. Catheter Related Infection in Patients with Intestinal Failure Using Home Parenteral Nutrition. Transplantation 2021; 105 (7S): S96.

44. Comerlato PH, Stefani J, Viana MV, Viana LV. Infectious complications associated with parenteral nutrition in intensive care unit and non-intensive care unit patients. Braz J Infect Dis 2020; 24 (2): 137–143.

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