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Home Enteral Nutrition in children – 6 years of clinical experience

Żywienie dojelitowe dzieci w warunkach domowych – 6 lat doświadczeń klinicznych

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Słowa kluczowe

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**Konflikt interesów
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S u m m a r y

Introduction. In the last years there was an intensive development of Home Enteral Nutrition (HEN).

Aim. The aim of the study was the presentation of our clinical experience in Home Enteral Nutrition in children.

Material and methods. 148 patients treated in HEN since 1st October 2007 till 30th September 2013 were characterized according to age, indications for enteral nutrition, nutritional status, access to gastrointestinal tract, type of diet, complications, duration of HEN and reasons for discontinuation the Program.

Results. The main indications for enteral nutrition were neurological diseases (n = 71) and gastrointestinal disorders (n = 34). At the time of introducing HEN the undernutrition was stated in 65% of patients. 60 children were fed by nosogastric tube, 87 by gastrostomy and 1 by jejunostomy. 129 patients received the polymeric industrial diet, in 97 cases the hypercaloric formula was used and in 27 the diet was enriched in fiber. Diet was given in bolus in 130 patients, 13 were fed by continuous infusion and 5 by mixed method. The complications of enteral nutrition were reported in 98 patients. The main problems included: peristomal inflammation (n = 63), mechanic damages of gastrostomy (n = 53) and intolerance of industrial diet (n = 38). In 67 children the HEN was interrupted and the main reason was obtaining an anticipated effects of the therapy (n = 29).

Conclusions. HEN is safe and well tolerated method of nutrition for children suffering from chronic diseases, when the effective oral feeding is impossible or the risk of nutritional deficiencies is high due to the higher energy requirements.

S t r e s z c z e n i e

Wstęp. Ostatnie lata to czas intensywnego rozwoju terapii żywieniowej w warunkach domowych.

Cel pracy. Celem pracy było przedstawienie doświadczeń własnych w domowym żywieniu dojelitowym (HEN) dzieci.

Materiał i metody. 148 pacjentów włączonych do HEN w okresie od 1 października 2007 r. do 30 września 2013 r. scharakteryzowano pod kątem wieku, wskazań do żywienia dojelitowego, stanu odżywienia, dostępu do przewodu pokarmowego, rodzaju diety, powikłań, czasu trwania oraz przyczyn zakończenia programu.

Wyniki. Najczęstszymi wskazaniami do żywienia dojelitowego były zaburzenia neurologiczne (n = 71) oraz schorzenia gastroenterologiczne (n = 34). W dniu zakwalifikowania do programu niedożywienie stwierdzono u 65% chorych. 60 dzieci żywionych było przez sondę nosowo-żołądkową, 87 przez gastrostomię i jedno dziecko przez jejunostomię. 129 pacjentów otrzymywało przemysłową dietę polimeryczną, w 97 przypadkach wykorzystywano preparaty wysokokaloryczne, a dla 27 dzieci dieta wzbogacana była w błonnik pokarmowy.

U 130 chorych preparaty przemysłowe podawane były w bolusach, 13 pacjentów żywiono metodą wlewu ciągłego, a 5 metodą łączoną. Powikłania żywienia dojelitowego stwierdzono w sumie u 98 dzieci, a do najczęstszych należały: stany zapalne wokół stomii (n = 63), uszkodzenia mechaniczne gastrostomii (n = 53) oraz nietolerancja diety przemysłowej (n = 38). 67 dzieci zakończyło HEN, a najczęstszym powodem było uzyskanie oczekiwanych efektów terapii (n = 29).

Wnioski. HEN jest bezpieczną i dobrze tolerowaną metodą żywienia u dzieci cierpiących na choroby przewlekłe, kiedy skuteczne żywienie doustne nie jest możliwe, lub ze względu na duże zapotrzebowanie na energię i składniki odżywcze wysokie jest ryzyko niedożywienia.

INTRODUCTION

Treatment with liquid diets delivered through the other way than oral have its origins in the ancient times (1). In 1598 the first attempts of supplying the liquid food directly into the esophagus were taken (2) and first descriptions of gastrostomy and jejunostomy placement methods have already come from the nineteenth century (3). The placement of gastrostomy by inoperable method – percutaneous endoscopic gastrostomy (PEG) has started in the 70s of the 20th century and was a milestone in the area of enteral nutrition. The second half of the last century was also the time of significant progress in the production of enteral preparations, modifications of their composition and recipes as well as widening the range of their applications in different clinical conditions (1).

According to the ESPGHAN Committee on Nutrition statement, the term of enteral nutrition (EN) includes feeding of patients with specialized industrial preparations, both by the tube/stomy and orally (4). However in Poland, EN is recognized as the administration of enteral diet through any other than oral way (5, 6). This form of therapy is intended for patients with at least partially functioning digestive tract, in whose the effective oral feeding is impossible or the standard diet does not cover the individual requirements for energy and nutrients (1).

Poor nutritional status is one of the most common problem among children suffering from chronic diseases (7). In many cases the inability to provide the adequate amounts of energy and nutrients by oral feeding refers not only to the disease's exacerbation, but can also be maintained during the convalescence period or even through the whole life. In these patients, nutritional therapy has usually the long-term character, contributes to the reduction of the quality of life and generates the high costs of treatment (3). For these reasons, in the 80s of the last century the USA and Canada started the Home Enteral Nutrition (HEN), and since then we observed a rapid development of this kind of nutritional treatment around the whole world (8). Experiences of other centers showed, that in children suffering from chronic diseases HEN is safe and effective method of feeding, that reduces the degree of malnutrition and allows to normal participation in family and social life (3, 4).

AIM

Until recently, in Poland (mostly due to the high costs) the prevalence of HEN was relatively low. However, this procedure has started to be reimbursed by the Public Health Care in 2007 (7) and since then it has become an important alternative for an inpatient enteral nutrition. Over these past six years the significant progress in the area of HEN has been seen in our country. Nevertheless, the availability of the data in this method of therapy among pediatric patients is still very limited. Therefore the aim of the study was the multi-dimensional analysis of clinical experiences in HEN in

children and the assessment of safety and efficacy of this method of nutritional treatment.

MATERIAL AND METHODS

We retrospectively analyzed the data from all patients younger than 18 years who entered HEN Program in our Department, since its beginning, on the 1st October 2007, till 30th September 2013. A total of 148 patients (75 males) were studied, all by the same nutritional team.

The data (including age, gender, indications for enteral feeding, nutritional status, access to gastrointestinal tract, type of diet and methods of delivery, complications, duration of HEN and causes of any discontinuation the Program) were obtained from the HEN computerized data-base, and from the medical and dietetic charts of all patients. The indications for Home Enteral Nutrition were classified as neurological diseases (including cerebral palsy), genetic congenital malformations, gastrointestinal diseases, cystic fibrosis, hepatic diseases, metabolic disorders and congenital heart malformations. In most patients the nutritional status was assessed based on BMI index referred to the WHO standards. Diet was given by naso-gastric tube (NG), gastrostomy (GT) or jejunal access (JA). The methods of delivery included: continuous EN (> 16 hours per day), overnight EN (< 12 hours per day), day time bolus EN and day time bolus with overnight EN. For continuous EN peristaltic pumps were used and for overnight EN the industrial diet was given both, in gravity infusion and by pumps. Commercially available diets were analyzed according to 3 features: type of contained protein – polymeric or hydrolyzed-protein paediatric formula, energy density – normocaloric (≤ 1 kcal/1 ml) or hypercaloric (> 1 kcal/1 ml) industrial diet and content of the dietary fiber – with or without addition of fiber formula. All this products were adapted to the age and disease. The number of patients (in first year of life) were fed with hydrolyzed-protein infant formula because of lack of hydrolyzed-protein industrial diet for patients under first year of life – in this cases diet may have eventually been concentrated or enriched in supplements feeds (like additionally sources of energy/carbohydrate or fat units). Complications of HEN were considered as: peristomal inflammation, mechanic damages, intolerance of industrial diet and constipation. Reasons of discontinuation of the Program were divided into the following groups: obtaining an anticipated effects of therapy, death of the child, intolerance of industrial diet and changing the HEN center.

Results are presented as means and standard deviations.

RESULTS

Population

The mean age of patients at the beginning of HEN was 5.26 years \pm 5.52 (the range from 6 weeks to 17 years) with the median of 2.8 years. 42 children (28%) were

under 1st year of life and 34 (23%) were older than 10 years. The age varied from 0.66 ± 0.55 in patients with congenital heart malformations to 7.4 ± 6.44 in children with gastrointestinal diseases (fig. 1). Among patients still in HEN on 30th September 2013 ($n = 81$) the mean age was 7.85 ± 5.76 (the range from 3 months to 18.5 years) with a median of 6.32 years; 6 children (7.4%) were under 1st year of life and 29 (36%) were older than 10 years.

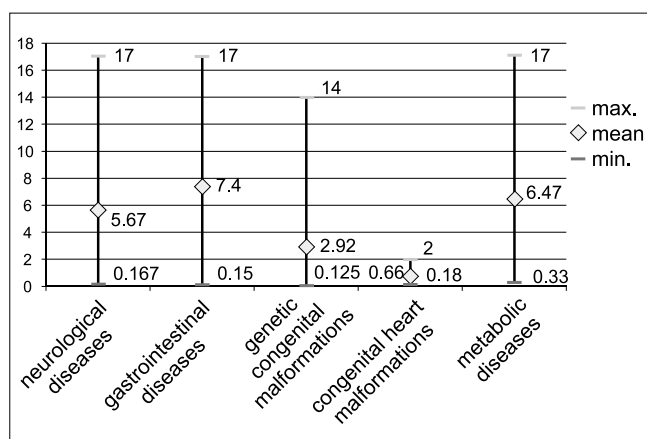


Fig. 1. Mean age of patients at the time of introducing HEN, according to the underlying disease

The mean duration of HEN was 397.31 ± 371.66 days (the range from 10 to 1545 days) with the median of 282 days. 10 children (7%) received HEN for less than 30 days and 28 patients (19%) for more than 2 years. The duration of HEN range from 130.83 ± 96.21 days (the range from 21 to 245 days) among children with metabolic diseases to 498.38 ± 400.89 days (the range from 16 to 1545 days) in patients with neurological diseases (fig. 2).

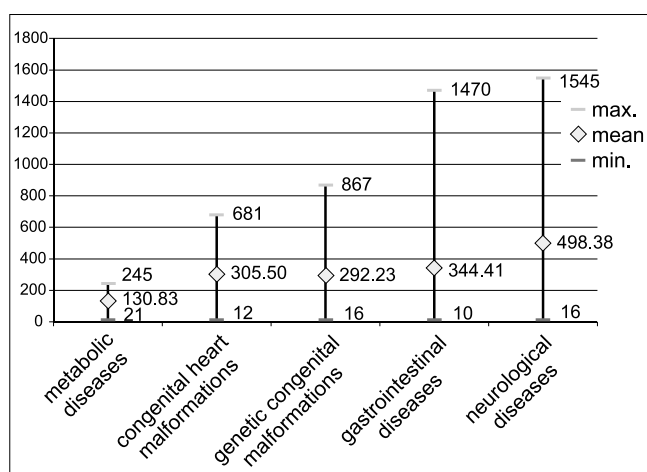


Fig. 2. Mean duration of HEN, according to the underlying disease

Indications

Indications for HEN administration were: neurological diseases in 71 (48%) children, including cerebral

palsy in 36 (24%); gastrointestinal disorders in 34 patients (23%); genetic congenital malformations in 27 (18%); congenital heart malformations in 10 (7%) and metabolic diseases in 6 (4%). Most heterogeneous was the group of gastrointestinal diseases and included: cystic fibrosis in 10 children (29%), hepatic diseases in 8 (23%), feeding disorders in 6 (18%), Crohn's disease in 4 (12%), burned esophagus in 2 (6%), congenital esophageal atresia in 2 (6%) and single cases of esophageal stenosis and recurrent pancreatitis.

Nutritional status

In 96 (65%) of patients commencing HEN the undernutrition was stated in 74 cases (77%) based on BMI status referred to the WHO standards ($BMI < 3$ pc). In the rest of children the health condition resulting from underlying disease did not allow to measure the growth and thus to calculate the BMI index. Among them the nutritional status was assessed using both the information included in medical charts (that are filled up for each patient on the day of the HEN introduction) and the laboratory tests. Most often the undernutrition was confirmed among patients with congenital heart malformations and metabolic diseases ($n = 9$; 90% and $n = 5$; 83%, respectively). Also in 3 other groups the poor nutritional status constituted the important problem in more than the half of children – malnutrition was claimed in 22 patients with gastrointestinal diseases (65%), 17 with congenital genetic malformations (63%) and 39 who suffer from neurological disorders (55%).

Made of administration

At the time of introducing HEN the industrial diet was delivered by NG in 60 (40.5%) children, GT in 80 (59%) and JA in 1 (0.5%). NGT was the most common enteral access among patients with congenital heart malformations ($n = 8$; 80%), whereas GT was preferred in children with neurological diseases ($n = 52$; 73%). In the three remaining groups the equal distribution on children fed by NG and GT was observed (fig. 3). Initially, only one boy with Down's syndrome was fed by the jejunal access.

In the group of children commencing HEN with NG, in 34 (57%) cases this kind of enteral access was used

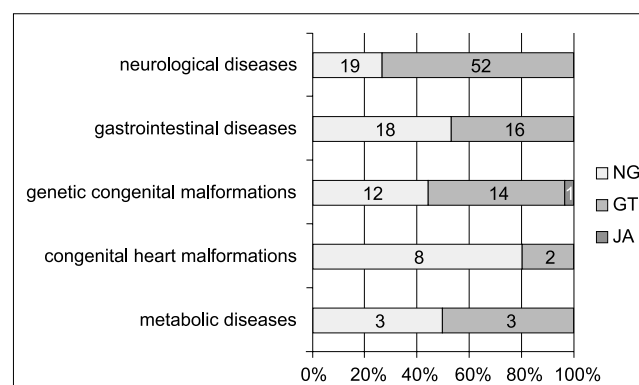


Fig. 3. Type of enteral access, according to the underlying disease

during the whole time of treatment in the Program. The NG was sufficient method of feeding in around half of patients with gastrointestinal disorders and congenital heart malformations ($n = 16$; 47% and $n = 3$; 50%, respectively). It was also an only way of food administration among 2 children with metabolic diseases (33%) and 6 patients with congenital genetic malformations (22%). In children with neurological disorders NG was used during the entire time of therapy only in 5 children (7%). The mean duration of HEN in this group of patients was 105.09 ± 98.01 days (the range from 10 to 338 days) with the median of 56 days. The duration of HEN range from 83.5 ± 88.39 days in children with metabolic diseases to 144.4 ± 135.28 in patients suffering from congenital heart malformations (tab. 1). The percentage of cases, in which the feeding by NG was continued longer than 6 weeks, was 65% ($n = 22$).

Among 26 (43%) children with NG the GT (PEG in 13 cases and surgical gastrostomy in 13) was placed on average after 108 days from the beginning of HEN (the range from 27 to 262 days). Most often the placement of GT was necessary in children with neurological diseases ($n = 14$; 74%) and genetic congenital malformations ($n = 6$; 50%). Because of persisting feeding's problems the further holding of NG was impossible in around one third of patients with congenital heart malformations and metabolic diseases, $n = 3$ (38%) and 1 ($n = 33$), respectively. However, only in 11% of children with gastrointestinal diseases, NG was not sufficient type of enteral access during the entire duration of HEN.

The mean time between introduction of HEN with NG and placement of GT was 107.5 ± 76.47 days (the range from 27 to 262 days) with the median of 82.5 days. This time range from 72 days among children suffering from congenital health malformations to 234 days in patients with metabolic diseases (tab. 2).

The percentage of cases in which the feeding by NG was continuing longer than 6 weeks in this group was 80% ($n = 20$).

Diets

Techniques of infusion regime included day time bolus in 130 children (88%), overnight EN in 8 (6%), continuous EN in 5 (3%) and mixed method (day time bolus with overnight EN) in 5 (3%). Day time bolus was the most common way of diet's delivery in all groups of patients – in 70 children with neurological disorders (99%), 20 with gastrointestinal diseases (59%), 25 with genetic congenital malformations (93%), all children with congenital heart diseases ($n = 10$) and 5 with metabolic problems (83%). Other methods of diet's infusion were mainly used in patients with gastrointestinal diseases ($n = 14$; 41%), and only in single cases in the remaining groups of children (fig. 4). In all patients with continuous EN the peristaltic pumps were used, whereas 2 children (25%) with overnight EN and 4 (80%) with mixed method was fed trough gravity infusion.

Industrial diets used in the studied group were polymeric industrial formula in 129 children (87%) and

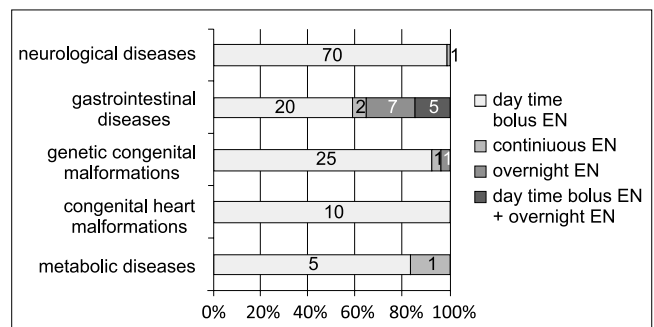


Fig. 4. Type of infusion regime, according to the underlying disease

Tab. 1. Profile of patients in whose the NG was used as an only method of diet's delivery during the whole duration of HEN, according to the underlying disease

Indication	Total number of patients with NG	Number of patients fed by NG during the whole therapy in HEN	%	Mean duration of HEN	Number of patients fed by NG longer than 6 weeks	%
Neurological diseases	19	5	26	89.00	2	10.5
Gastrointestinal diseases	18	16	89	96.63	10	62.5
Genetic congenital malformations	12	6	50	115.50	5	41
Congenital heart malformations	8	5	62.5	144.40	4	50
Metabolic diseases	3	2	67	83.50	1	33

Tab. 2. Profile of patients with NG at the day of introducing HEN in whose the GT was placed, according to the underlying disease

Indication	Total number of patients with NG	Number of patients in whom the gastrostomy was placed	%	Mean time between introduction of HEN and GT placement	Number of patients fed by NG longer than 6 weeks	%
Neurological diseases	19	14	74	100.79	9	47
Gastrointestinal diseases	18	2	11	130.5	2	11
Genetic congenital malformations	12	6	50	112.17	6	50
Congenital heart malformations	8	3	38	72	2	25
Metabolic diseases	3	1	33	234	1	33

hydrolyzed-protein enteral diet in 16 patients (11%). Over the study period there was no hydrolyzed-protein industrial preparation for children younger than 1 year commercially available in Poland. Because of that 3 children (2%) in 1st year of life, who needed this kind of diet's modification were fed with hydrolyzed-protein standard infant formula. The polymeric industrial diet was generally prescribed for the most children in all patients' groups. No children with congenital heart malformations required the implementation of hydrolyzed-protein formula. Also in the remaining groups, the introduction of this type of diet was necessary only occasionally – in 9 children (13%) with neurological problems, 5 (18.5%) with genetic malformations, 4 with gastrointestinal disorders (12%), and 1 with metabolic diseases (17%) (tab. 3).

The analysis of the diet with respect to the energy density showed that normocaloric formula was used more often than hypercaloric enteral diet in the studied group (81 patients; 55% and 67 patients; 45%, respectively). According to the clinical diagnosis the high-energy formula was preferred only in children with congenital heart malformations (n = 10; 100%). Among children suffering from gastrointestinal problems and genetic diseases, the hypercaloric preparations were prescribed also quite often (n = 16; 47% and n = 12; 44%, respectively). In 2 remaining groups this type of diet was used in around one third of patients (tab. 3).

In 27 cases (25%) the industrial preparations were supplemented with dietary fiber. This type of diet was

indicated mainly in patients with neurological diseases (n = 18), in other groups fiber enriched formula was prescribed only sporadically (tab. 3).

Complications

The complication of HEN were generally reported in 98 patients and appeared most often among children with neurological problems and congenital genetic malformations (n = 57; 80% and n = 19; 70%, respectively). In the remaining groups in around half of patients the problems resulting from feeding therapy in HEN were observed. The most common complication was peristomal inflammation (n = 63; 43%). Mechanical damages of PEG or tube and intolerance of industrial diet were stated more rarely – in 53 (36%) and 38 (26%) children, respectively. Among children with gastrointestinal disorders the mechanical damages were observed in the higher percentage of patients, whereas in 4 remaining groups the most common complication of HEN were peristomal inflammations. Constipation was diagnosed only in 15 cases (10%), mainly in patients with neurological problems (n = 12) (tab. 4).

In 54 patients the anti-reflux surgery was necessary, mainly among children with neurological problems (n = 34) and genetic congenital malformations (n = 12). Among 20 of them the postoperative intolerance of industrial diet was observed (tab. 5). Methods of proceeding in this group of children are shown on figure 5. In 8 patients (40%) the symptoms

Tab. 3. Type of diet, according to the underlying disease

Indication	Type of diet													
	Energy density						Type of contained protein						Enriched with dietary fibre formula	
	Normocaloric (≤ 1 kcal/1 ml)		Hypercaloric (> 1 kcal/1ml)		Mixed		Polymeric industrial diet		Hydrolyzed-protein industrial diet		Hydrolyzed-protein infant formula			
	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%
Neurological diseases	45	63.5	25	35	1	1.5	62	87	9	13	0	0	18	25
Gastrointestinal diseases	18	53	16	47	0	0	30	88	2	6	2	6	3	9
Genetic congenital malformations	15	56	12	44	0	0	22	81	4	15	1	4	4	15
Congenital heart malformations	–	0	10	100	0	0	10	100	0	0	0	0	1	10
Metabolic diseases	3	50	2	33	1	17	5	83	1	17	0	0	1	17
Total	81		65		2		129		16		3		27	

Tab. 4. Number and kinds of complication of HEN, according to the underlying disease

Indication	Number of patients with complication in each group	% of patients with complication in each group	Type of complication							
			Peristomal inflammation		Mechanic damages		Intolerance of industrial diet		Constipation	
			Number	%	Number	%	Number	%	Number	%
Neurological diseases	57	80	40	56	31	44	18	25	12	17
Gastrointestinal diseases	15	44	7	21	9	27	5	15	2	6
Genetic congenital malformations	19	70	10	37	8	30	10	37	1	4
Congenital heart malformations	4	40	3	30	3	30	3	30	0	0
Metabolic diseases	3	50	3	50	2	33	1	17	0	0
Total	57	–	40	–	31	–	18	–	12	–

subsided only after the implementation of normal purred diet.

Tab. 5. Profile of patients with intolerance of industrial diet after anti-reflux surgery, according to the underlying disease

Indication	Patients who required anti-reflux surgery		Patients with intolerance of industrial diet after surgery	
	Number	%	Number	%
Neurological diseases	36	51	12	33
Gastrointestinal diseases	4	12	2	50
Genetic congenital malformations	12	44	5	42
Congenital heart malformations	0	–	–	–
Metabolic diseases	2	33	1	50

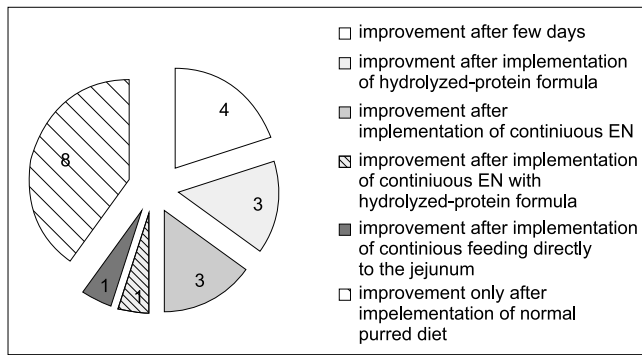


Fig. 5. Methods of proceedings among patients after the anti-reflux surgery with the intolerance of industrial diet

Discontinuation of HEN

In 67 patients the HEN was interrupted. The causes of HEN discontinuation included: obtaining an anticipated effects of therapy in 29 (43%) patients, death of the child in 15 (22%), intolerance of industrial diet in 12 (18%) and changing the HEN center in 11 (17%). Among these patients the mean duration of HEN was 252 days (the range from 12 to 1470 days). Return to the effective oral feeding was the reason of discontinuing the treatment in the Program mainly in children with gastrointestinal problems ($n = 16$; 76%), whereas the death of the child was the most common cause of HEN discontinuation in patients with metabolic diseases ($n = 3$; 50%) (fig. 6).

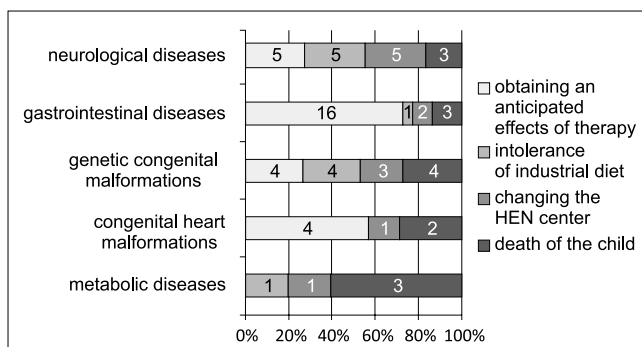


Fig. 6. Reasons for discontinuation of HEN, according to the underlying disease

DISCUSSION

Despite the lapse of 30 years since the first experiences of HEN, its usage in pediatric population has been documented quite rarely till today. Although, in the last ten years some authors have described their experiences on this topic. The study from Daveluy et al. published in 2005 based on 416 children at the University Hospital of Lille (9) appears to be the largest study including only paediatric patients. Practise of HEN in children was also widely described by 3 other authors: in 1996 Salmon and Garbi published their experience in Home Enteral Nutrition of 184 children in Brazil (10), in 1996 the analysis of 156 patients treated in HEN in the Royal Hospital of Sick Children in Glasgow was described by McCarey et al. (11) and recently (2012) Pedrón-Giner et al. published the clinical experience in HEN of 304 children from the Hospital Infantil Universitario Niño Jesús in Spain (12). In Poland the only published study is the summary of the effects of the therapy in 25 children treated in HEN in The Department of Children's Gastroenterology of Medical University of Gdańsk (7). There are also two multicenter studies available: the analysis of 525 paediatric patients treated in HEN in Poland (2012) (13) and the characteristic of 757 children carried out in HEN in Italy (14). Although in these series the largest groups of patients were included, the analysis were conducted in the slightly other way and took into account significantly less aspects of therapy in HEN, than in other studies.

According to our knowledge data presented above is the largest study carried out in Poland, that reports experience in paediatric HEN and underlines various particularities of this method of therapy. It is also important that in our series the widest range of issues connected with HEN provided in children had been considered – some of them had been no analyzed by other authors. The exact comparison between the particular studies is difficult both due to differences in the classification of the pathologies, the type of diseases treated at the various hospitals, the specificities of the healthcare organization in each country and the range of factors that were analyzed by each authors.

The age of children in current series was 5.26 ± 5.52 and was similar to those in the study of Daveluy et al. (5.4 ± 5.3 years) (9) and Borkowska et al. (5.44 ± 4.09 years) (7) but lower than the mean age among the whole polish paediatric population treated in HEN (6 years) (13). On the other hand, patients described by Pedrón-Giner et al. (12) and Salmon and Garbi (10) were younger than in our population, 4.0 ± 4.09 years and 4.11 ± 4.5 years, respectively. However these differences were not appreciable and resulted probably from the varied peculiarity of patients in particular HEN centers.

The age of children varies greatly according to underlying disease and in our study the youngest were patients with congenital heart malformations, while the oldest were those with gastrointestinal problems. The comparison of these observations with other au-

thors was impossible because of the differences in the profile of indications for HEN among particular studies (9, 10, 12) or because of the lack of data (7, 11, 13, 14). However, it can be assumed that the results obtained in our study were related both to the specificity of clinical diagnosis as well as to the heterogeneity and strength of particular patients' groups.

In this series the most frequent pathologies were neurological disorders (48%), similar like in the other studies: 60% in the group described by Borkowska et al. (7), 35% by Daveluy et al. (9) and 30% by McCarey et al. (11). Results from the two multicenter studies showed, that neurological diseases are generally the most common indication for HEN in pediatrics – 49% in Diamanti et al. (14) series and 61% in Szlagatys-Sidorkiewicz et al. (13). In two remaining authors neurological problems were also the frequent medical diagnosis, and constituted respectively the second largest group of patients in Salmon and Garbi (21.2%) (10) study and the third in Pedrón-Giner et al. paper (23%) (12).

It was noticed that in 24% of patients in analyzed group the indication for HEN were gastrointestinal diseases and this rate was significantly higher than the 9.5% stated by Szlagatys-Sidorkiewicz et al. (13). Nevertheless, this study (13) included all pediatric HEN centers in Poland, in whose the range of treated pathologies varies very widely. The specificity of our Department explains the higher percentage of children with gastrointestinal problems than in the whole Polish population.

In compare to our previous description of experience in HEN of 47 children from 2011, although the number of group has been increased significantly, the profile of indications has remained similar (15).

The undernutrition was claimed in almost 2/3 of patients (65%) in current study. The analysis of the nutritional status was conducted only by Borkowska et al. (7) and they stated the malnutrition in 92% of children. However, it is difficult to compare these results because of the small numbers of patients in the series of Borkowska et al. ($n = 25$) and therefore less representativeness of data and secondly because of slightly different profile of indications for HEN than in our studies – they showed neurological problems in 60% of cases, genetical syndromes in 24%, gastrointestinal diseases in 8%, cystic fibrosis in 4% and neoplastic diseases in 4%. All of these pathologies are known as the common reasons of poor nutritional status in pediatrics (1, 6).

We considered the nutritional status also according to the underlying diseases but this issue has never been analyzed in previous studies. There is also no data available about the general rate of nutritional status of children treated in the Polish paediatric hospitals. Nevertheless, in current series the malnutrition was stated most often in children with congenital heart malformations and metabolic diseases. It appears that these results are related more to the number of patients in particular groups and thus to the differences in

the strength of data than to the medical diagnosis – all of these pathologies are recognized as a common cause of malnutrition in children (1).

We are also aware of the limited representativeness of the obtained results due to the lack of data on the measurement of growth and BMI index in all patients.

The NG was used more frequently as an enteral access than GT in the studied group. These results were comparable to the most other authors (9, 11, 12, 14). Only in the series of Borkowska et al. (7) and Szlagatys-Sidorkiewicz et al. (13) patients were mainly fed by stomy (80 and 88%, respectively). However, in these studies the neurological disorders, genetic syndromes and cystic fibrosis constituted altogether 88 and 85% of all indications for HEN – these pathologies are related to the need of long-term nutritional therapy and therefore to the necessity of GT placement (1, 6, 16).

According to the ESPGHAN Committee on Nutrition (4) and to the Polish guidelines (6) the duration of feeding by NG should be no longer than 6 weeks in children (4). Taking into account these recommendations and analyzing the duration of HEN in our patients, it was expected that among 60 children who commencing HEN with NG in 48 cases the gastrostomy should have been placed. The number of patients fed by NG during the whole therapy in HEN was 34 and among these children the frequency of holding this kind of enteral access for longer than 6 weeks was 65% ($n = 22$). The explanation of these results seems to be the specificity of underlying disease. Feeding by NG during the whole treatment in HEN and for longer than recommended 6 weeks was mainly used in patients with gastrointestinal disorders ($n = 10$; 30%) and congenital heart malformations ($n = 4$; 40%). In the first group of patients, 23% of children presented with hepatic diseases in whose the EN is used mainly only as a method of improving the nutritional status before the liver transplantation. Additionally, the placement of GT considering the upcoming surgery is contraindicated. In 18% patients the indication for HEN were feeding disorders – in these cases EN has often been only temporary application and the rapid return to the effective oral feeding is highly plausible. Finally, for 12% of children suffering from Crohn's disease – according to the current guidelines (17-19) in these patients EN with industrial diet is indicated for 8 weeks, also among them the using of gastrostomy is unreasonable.

The peculiarity of the second group (heart congenital disorders) can be related both to the existing of contraindications for GT (such as previous/planned surgery) as well as to the claiming of real opportunity for the return to sufficient oral feeding. Therefore the longer hold of NG than it is supported by ESPGHAN guidelines is often under the consideration in this group of children.

Among the rest of patients ($n = 26$) in whose the GT finally was placed, the percentage of cases in which the NG was used longer than 6 weeks was even higher (80%). This method of proceeding was mainly stated in children with genetic congenital malformations and

neurological problems. In both these pathologies a relative short return to effective oral feeding is theoretically possible, but usually the long-term nutritional support is necessary and the final GT used is inevitable. Rationale of longer feeding by NG in these patients is usually not clear and depends mainly on three factors: the patient's condition, the current oral feeding skills and the safety of oral feeding. Therefore these issues are always evaluated individually, by the all members of our nutritional team.

The other explanation of above observation can be the influence of family and social factors – most often the lack of parents' approval on the GT placement. However, the exact frequency of these incidences was not defined in the studied population because the lack of data.

In the presented study the most common method of infusion regime was day-time bolus feeding (83%) and it was consistent with the current guidelines (4). This rate varied from one study to another, depending on the profile of indications for HEN. Nevertheless, in the most series the continuous infusion was recommended for the majority of children (9, 11, 12, 14). Among patients fed in another way than day-time bolus, the one regularity was stated – in all cases of cystic fibrosis the overnight EN was used. This method of proceeding is consistent with literature and recommendations (20-23).

Considering the type of prescribed formula, the most common diet in current study was polymeric industrial preparations. This rate was compatible both with all other series, in which this issue was analyzed (7-12, 14) as well as with current guidelines (4). The analysis of the type of diets according to the underlying disease has not demonstrated any correlations between the medical diagnosis and the necessity of introduction of the hydrolyzed-protein formula. The comparison of these results with literature was not possible due to the lack of such information in the most series (7, 8, 10-13) or the different specificity and way of classification the indications for HEN, given by other authors (9, 14).

Regarding to the energy density the normocaloric industrial diets were prescribed more often (55%) than the hypercaloric preparations (45%) in the current group. The analysis of the type of diet according to the energy density was included only by Daveluy et al. (9) by Borkowska et al. (7). However, considering the different profile of underlying diseases between the particular series, and therefore the different frequency of indications for the introduction of high-energy formula, the comparison of these data with the results obtained from studied population was unreasonable.

The frequency of using the hypercaloric formula was quite high in our patients. However, it was due to the fact, that among 67 children fed with this type of enteral preparation in 43 cases (64%) the industrial formula intended for children under the first year of life was used. Although this product contains 1 kcal/1 ml, because of the significantly higher energy density as compared

to standard infant formulas (≈ 0.67 kcal/1 ml), it is recognized as hypercaloric preparation. The high-energy formulations are recommended in cases when the covering of current nutritional needs with normocaloric diet is not possible. These are mainly children with resulting from underlying disease higher energy and nutrients requirements or with the intolerance of sufficiently portion's size and therefore with the higher risk of malnutrition. These guidelines were confirmed in the studied group – preparations with the energy density higher than 1 kcal/1 ml ($n = 24$) were mainly used in children suffering from neurological diseases ($n = 12$; 50%) and cystic fibrosis ($n = 8$; 33%).

The industrial formulas enriched with dietary fibre were used in 25% of studied population, most often among children with neurological disorders – in this group of patients the high frequency of constipation was also reported. Our results were generally similar to those reported by Daveluy et al. (9) and by Borkowska et al. (7). In remaining series this information was not available. In our practise the enteral diets supplemented in fibre were often worse tolerated than the standard formulas. However, currently available preparations contain the specialized mixture of dietary fiber and seems to increase the degree of assimilation and also have a therapeutic effect both, in the treatment of diarrhea and constipation (24). Therefore, their use in some clinical conditions will probably become more frequent, but still the further studies to evaluate the tolerance and the benefits of such diets in pediatric practice are necessary.

Unlike in other studies, in our series the analysis of complications of HEN was also included. Only Borkowska et al. (7) considered the problems resulting from therapy in HEN, however due to the differences in patients profile between these series, the comparison of obtained results was difficult to conduct.

According to the literature, the most common complication of HEN are nutritional and mechanical problems (3). These data have been reflected in the analyzed group – mechanic damages and symptoms of intolerance the industrial diet/enteral nutrition constituted in total 49% of all cases of HEN's complication. Only the peristomal inflammations were claimed more often, mainly among children with neurological problems – probably due to the largest strength of this group and the highest rate of children fed by GT. However, despite of the quite high frequency of complications stated in studied population, these problems were usually not serious and had only periodical character. In most cases the change of diet/infusion regime or the introduction of proper treatment allows to the continuation of therapy in the Program. Only in 11 patients (7%) the intolerance of enteral diet was the reason of HEN interruption.

The novelty in current study was the observation of the relatively high rate of intolerance of industrial diet among patients after anti-reflux surgery – this issue have never been analyzed by other authors. However,

there is one paper published in 2012, in which authors focused on this issue (25). According to the authors, the common problems of children after fundoplication are gagging and retching and they seem to be intensified by giving the industrial diet. They also showed out that feeding these patients with the specially designed normal diet allows both to cover the all nutritional needs as well as to reduce the frequency of postoperative symptoms of diet's intolerance. In our studies different proceeding in this group of patients were undertaken, but also in most cases the improvement was achieved only after changing the industrial formula on purred diet. However, these findings need to be further analyze to find the reasons and the best solutions of such problems, with the greatest emphasis on the exact composition of diet that should be used in these patients.

The profile of causes of HEN discontinuation in our population was generally comparable to this reported by Daveluy et al. (9). In other studies this data was not given. We did not find out any correlation between the underlying disease and the causes of therapy interruption, despite the one observation – among patients with gastrointestinal problems the return to sufficient oral feeding was stated among 76% of all children whose finished the treatment in HEN. It was due to kind of medical diagnosis included in this patients' group, exactly to the high percentage of children with hepatic diseases, feeding disorders and Crohn's disease.

The quite high rate of deaths reported in our population as well as in this described by Daveluy et al. (22 and 27%, respectively) can be explained by the general high mortality rate in patients suffering from such disorders like congenital genetic malformations and

metabolic diseases in our series and cancer in the French population.

CONCLUSIONS

Over the 6 year period a large group of children suffering from variety of chronic diseases was treated in HEN. After the summary of our experience it can be concluded, that this kind of therapy is a safe and well tolerated technique of nutritional support in pediatrics, that can be carried out in at early age and can be prolonged over the long time. Alarming is the fact, that still the high number of patients referred to our center are undernourished. It means that nutritional therapy is implemented too late and shows the necessity for further spread of knowledge about the significance of adequate nutritional status among the pediatric medical staff. We find innovative the observation of the intolerance of industrial diet among children after fundoplication surgery. This findings point to the need of further studies, to recognize the causes and to find the best solutions for this complication.

This is the first study in Poland including children carried out in HEN in which the profile of patients was analyzed in the such multifactorial way. We are aware both to the certain limitations of our study (such as the method of assessment the nutritional status) as well as of the existence of areas in the HEN practise that could be improved (f.e. the frequency of complications). Further studies are needed in our country to design the maximally effective and safe strategies for children treated in Home Enteral Nutrition.

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