

## Short bowel syndrome – experience from a home parenteral nutrition centre

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In healthy people, a significant amount of nutrients is absorbed in the first 100–150 cm of the jejunum, but the absorption of water, sodium, and bile salts is most effective in the ileum and colon. In patients with short bowel syndrome (SBS), this function is disturbed.

SBS is a medical term defining metabolic disturbances occurring after extensive resection of the small intestine as a result of the reduction of the surface area for nutrient absorption. A vast majority of people with SBS demonstrate persistent diarrhoea, water–electrolyte balance disorders, weight loss, and deficiency of proteins, carbohydrates, fats, vitamins, bile salts and trace elements [1–5].

The most important aetiological SBS factors are: mesenteric ischaemia, Crohn's disease, radiation enteropathy, malignant tumour, complications of surgical procedures, injuries, etc. [1, 4].

There are 3 types of SBS: type I – end enterostomy, type II – jejunocolic anastomosis and type III – jejunoileocolic anastomosis [4].

Patients with SBS type I are provided parenteral nutrition (PN) if the remnant bowel is shorter than 115 cm. Patients with SBS type II with the remnant small intestine longer than 50 cm and the colon in continuity are largely independent of PN. Patients with SBS type III are PN dependent if the small intestine is shorter than 35 cm [1–9].

PN for many patients with short bowel syndrome is a life-saving procedure.

The study was conducted among 64 patients (45 women, 19 men), aged 29–92 years (mean: 61.75 ± 14), divided into three groups, depending on the type of SBS. Each of the patients required long-term nutritional treatment provided by the Clinical Nutrition Department. The patients were intravenously administered individually selected compositions of a nutritional mixture, depending on the nutritional status, SBS type and laboratory results.

Over the period 2012–2017, every 3 months, selected laboratory parameters were evaluated in each patient during control medical visits. This procedure was conducted in accordance with the National Health Fund guidelines for patients receiving home parenteral nutrition (HPN).

Statistica (version 12, StatSoft Inc.) was used for the purpose of data management and statistical calculations. The following statistical meth-

ods were used in the study: the Kruskal-Wallis test in order to check whether there are statistically significant differences between the types of groups of patients with SBS in the (mean) concentration of the studied laboratory variables and the  $\chi^2$  test in order to show a significant relationship between the type of SBS and the value of a measurable variable in laboratory tests, together with multiple comparisons. *P*-values < 0.05 were considered statistically significant.

The most common causes of short bowel syndrome in the study group were: mesenteric embolism in 16 (25%) patients, cancer in 13 (19%) and Crohn's disease in 11 (17%) patients (Figure 1).

The average length of the small intestine of patients with SBS type I was  $95 \pm 72.29$  cm; type II  $75.57 \pm 50.43$  cm and type III  $96.53 \pm 40.28$  cm. The average length of the large intestine of patients with type I was  $60 \pm 56$  cm, type II  $88 \pm 32$  and type III  $104 \pm 25$  cm ( $p < 0.05$ ).

The average duration of parenteral nutrition was  $51.38 \pm 46.01$  months. The mean volume of intravenous nutrition was  $2184.78 \pm 161.26$  ml.

Composition of the PN: the average content of amino acids intake was  $0.83 \pm 0.26$  g/kg/day, glucose  $4.16 \pm 1.37$  g/kg/day and lipid  $0.31 \pm 0.19$  g/kg/day (Table I). The mean caloric content of PN in patients with SBS was  $1336.81 \pm 167.13$  kcal/day. The average body mass index (BMI) of our patients was  $21.83 \pm 4$  kg/m<sup>2</sup>, which indicates a proper nutritional status. Patients with all types of SBS were underweight as well as overweight. Twenty-two percent of patients with SBS type I, 9% with type II and 22% with type III were underweight (BMI < 18.5 kg/m<sup>2</sup>). A body composition analysis was not included in the study, because the study was retrospective, and according to the guidelines for patients receiving HPN measuring the body composition of patients is not required.

Nutritional recommendations and amounts of oral fluids were adjusted to the type of SBS. None of the patients received enteral nutrition. Each of the patients included in the study drank oral rehydration solutions (ORSs), which contained appropriate proportions of sodium, water and carbohydrates. Patients took commercial ORSs or prepared them at home, according to the given prescription. During hospitalization, patients are given 5% glucose solution and 0.9% NaCl in a 2 : 1 ratio to drink. We estimate that approximately 80% of patients follow the recommendations at home.

The average values of renal function parameters – urea and creatinine – in our patients on their first visit to the Clinical Nutrition Department were: SBS type I urea  $50.57 \pm 17.47$  mg/dl, creatinine  $1.19 \pm 0.60$  mg/dl; for type II urea  $37.41 \pm 19.05$  mg/dl, creatinine  $0.82 \pm 0.43$  mg/dl and for type III

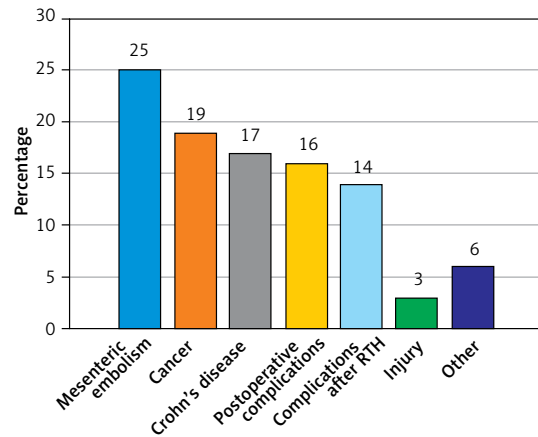


Figure 1. Etiology of SBS patients

urea  $35.84 \pm 21.98$  mg/dl, creatinine  $1.06 \pm 0.62$  mg/dl and gradually were normalized.

An analysis of the groups of SBS patients and studied variables showed that there were significant differences in the laboratory parameters. The patients with SBS type I demonstrated higher levels of blood alanine aminotransferase (ALT), aspartate aminotransferase (AST), urea, creatinine, and potassium concentration ( $p < 0.05$ ) in comparison with patients with type II and III of SBS. The mean values of renal function parameters, calculated throughout the study period, were as follows for SBS type I patients: urea  $47.41 \pm 20.53$  mg/dl, creatinine  $1.28 \pm 0.56$  mg/dl. The lowest urea concentration was observed in patients with SBS type III, i.e.  $34.70 \pm 8.26$  mg/dl. The creatinine level observed in SBS type II patients was  $0.96 \pm 0.41$  mg/dl. Almost a quarter of the patients with end enterostomy demonstrated elevated urea concentration.

A vast majority of the studied patients demonstrated elevated liver enzymes. Other investigators have also observed liver dysfunction, which may be associated with long-term parenteral nutrition. Ławiński *et al.* noted high values of liver function parameters in patients with type I short bowel syndrome receiving parenteral nutrition. Nanji AA and Anderson FH observed elevated  $\gamma$ -glutamyltranspeptidase (GGTP) levels, which returned to normal after a complete withdrawal of parenteral nutrition [7, 8].

Long-term parenteral nutrition carries a risk of developing intestinal failure-associated liver disease (IFALD). According to guidelines of the European Society for Clinical Nutrition and Metabolism (ESPEN), appropriate oral or enteral nutrition as well as optimal composition of PN play a key role in prevention and treatment of this complication. It is particularly important to avoid excessive consumption of long chain fatty acids (LCFA) and polyunsaturated fatty acids and totally eliminate phytosterols [9–12].

Table 1. Demographic and anatomical features and laboratory test results for the study population

Characteristic	All patients (n = 64)	Group I (n = 23)	Group II (n = 23)	Group III (n = 18)	Kruskal-Wallis	$\chi^2$
<b>Patients demographics:</b>						
Age	61.75 ±14	67.91 ±12.89	62.78 ±12.96	52.72 ±12.33	NS	NS
BMI [kg/m <sup>2</sup> ]	21.83 ±4	22.90 ±4.83	21.83 ±3.46	20.41 ±3.15	NS	NS
<b>Anatomic features:</b>						
Remnant small intestine length [cm]	88.75 ±56.21	95 ±72.29	75.57 ±50.43	96.53 ±40.28	NS	NS
Remnant large intestine length [cm]	77 ±47	60 ±56	88 ±32	104 ±25	NS	< 0.05
<b>Parenteral nutrition:</b>						
Nutrition volume [ml]	2184.78 ±161.26	2312.63 ±817.99	2238.10 ±490.81	2003.61 ±491.07	< 0.05	NS
Parenteral amino acid intake [g/kg/day]	0.83 ±0.26	0.81 ±0.28	0.86 ±0.27	0.82 ±0.24	NS	NS
Parenteral glucose intake [g/kg/day]	4.16 ±1.37	4.17 ±1.27	4.49 ±1.63	3.82 ±1.23	NS	NS
Parenteral lipid intake [g/kg/day]	0.31 ±0.19	0.34 ±0.19	0.29 ±0.18	0.31 ±0.19	NS	NS
Energy [kcal/db] [kcal/day]	1336.81 ±167.13	1266.68 ±291.43	1527.58 ±1124.92	1216.18 ±262.67	NS	NS
Parenteral infusion intake [days/week]	6.11 ±0.97	6.04 ±1.07	6.30 ±0.93	5.96 ±0.92	NS	NS
<b>Laboratory test:</b>						
Sodium (136 – 145 mmol/l)	139.37 ±2.55	138.88 ±2.63	139.71 ±1.67	139.56 ±3.34	NS	NS
Potassium (3.5–5.1 mmol/l)	4.71 ±1.23	4.96 ±1.3	4.35 ±0.68	4.88 ±1.60	< 0.05	< 0.05
Calcium (8.4–10 mg/dl)	9.33 ±0.44	9.32 ±0.35	9.36 ±0.54	9.30 ±0.42	NS	NS
Magnesium (1.50–2.60 mg/dl)	1.92 ±0.18	1.93 ±0.22	1.90 ±0.15	1.95 ±0.17	NS	NS
Chloride (98–107 mmol/l)	102.56 ±4.31	101.35 ±6.13	103.72 ±1.92	102.01 ±3.57	NS	< 0.05
Phosphates (2.5–4.5 mg/dl)	3.59 ±0.42	3.57 ±0.36	3.56 ±0.57	3.67 ±0.27	NS	NS
Urea (16.6–48.5 mg/dl)	40.70 ±16.04	47.41 ±20.53	38.68 ±13.50	34.70 ±8.26	< 0.05	< 0.05
Creatinine (0.5–0.9 mg/dl)	1.09 ±0.47	1.28 ±0.56	0.96 ±0.41	1.04 ±0.37	< 0.05	< 0.05
Triglycerides (≤ 150 mg/dl)	135.24 ±57.4	141.46 ±60.94	124.97 ±44.84	140.44 ±67.74	NS	NS
ALT (0–33 U/l)	52.27 ±48.16	54.45 ±24.31	49.27 ±24.31	53.33 ±70.22	NS	NS
AST (0–33 U/l)	36.83 ±20.41	38.60 ±18.51	35.29 ±12.73	36.53 ±29.73	NS	NS

In the Nutrition Treatment Centre, among patients with elevated liver function parameters their glucose content is individually adjusted in parenteral nutrition. Besides, when indicated, LCFA fat emulsion is replaced with medium chain triglycerides.

In a study by Guohao Wu, patients with IFALD received glucose in PN in the amount of  $3.21 \pm 0.08$  g/kg/day, which was lower than in our patients, whereas the fat emulsion content, i.e.  $0.89 \pm 0.09$  g/kg/day, was higher than in our patients [13].

Our analyses confirmed a significant relationship between the type of SBS and the concentrations of the renal function parameters serum urea and creatinine. The mean levels of urea and creatinine in the studied patients at their first visit to the Nutrition Treatment Centre were: in SBS type I: urea 50.57 mg/dl, creatinine 1.19 mg/dl; in SBS type II: urea 37.41 mg/dl, creatinine 0.82 mg/dl and in SBS type III: 35.84 mg/dl and 1.06 mg/dl, respectively. Electrolyte disturbances were compensated during the patient's hospitalisation for the first 2–3 weeks. For the purpose of HPN, the nutrition team prepared the composition of the nutritional mixture, which was individually adjusted on the basis of results of tests performed during follow-up visits.

Delayed implementation of adequate nutritional treatment after major bowel resection was the most important cause of renal failure in the analysed patients. A large number of patients had spent several weeks at home without adequate treatment before they were referred to the Nutritional Treatment Centre. Failure of patients to follow the centre's recommendations, i.e. to consume adequate oral fluids, especially ORS instead of water or sugary drinks, may be another cause of renal dysfunction.

A high-output stoma (HOS) that secretes more than 2,000 ml per day is a major challenge for both healthcare professionals and patients. A jejunum length < 100 cm is associated with greater fluid and electrolyte loss than patients can take orally [14].

Dehydration and renal failure in patients with end enterostomy can be a huge challenge for the treatment team. Patients who have undergone a small intestine resection should be under the care of medical professionals who are highly experienced in treating such patients. There are patients who will readily accept their disease and those who will fight it. An adequate choice of nutrients, electrolytes and water in parenteral nutrition, an individually adjusted diet, proper care of vascular access and constant monitoring of patients are the keys to proper functioning in SBS [15].

The study was conducted in accordance with the guidelines of the 1975 Declaration of Helsinki

and Good Clinical Practice. The study protocol was approved by the Bioethics Committee (Consent No. 3/2017).

In conclusion, patients with short bowel syndrome are at risk of exacerbations of liver and kidney functions and electrolyte imbalances. Patients with end enterostomy (SBS type I) are particularly at risk of renal failure. A proper composition of parenteral nutrition and a special diet enable patients to maintain proper hydration status, biochemical, metabolic and energy balance of the human body.

### Conflict of interest

The authors declare no conflict of interest.

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