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NUTRITION AND OBESITY (S MCCLAVE, SECTION EDITOR)

Controversy in Nutrition Recommendations for Short Bowel Syndrome: How Type of SBS Impacts Response

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Abstract

Purpose of Review This review examines the current recommendations for dietary management of patients living with short bowel syndrome (SBS) and outlines the need for future research to provide optimal care for this unique group of patients.

Recent Findings Providers caring for patients with SBS lack sufficient data to help guide recommendations regarding diet. The majority of studies are conducted at a single medical institution on a small number of anatomically diverse patients. Multi-center studies would allow for inclusion of a larger number of patients and may lead to more individualized dietary recommendations.

Summary Patients with short bowel syndrome should be evaluated on an individual basis by a multidisciplinary team including physicians, dieticians, pharmacists, and nurses specializing in the care of these complex patients. Tailoring both medical and nutritional therapy will help realize the overarching goal for these patients of maintaining adequate nutrition with diet and medications, and achieving independence from parenteral support.

Keywords Short bowel syndrome · Nutrition recommendations · Parenteral nutrition

Introduction

In a healthy patient, the length of the small bowel ranges between 300 and 800 cm [1, 2]. A 2003 review from the American Gastroenterological Association defines severe short bowel syndrome (SBS) as a condition in which less than 200 cm of functional small bowel remains [2]. Clinically, any resection of small bowel resulting in nutrition deficiency can be treated as short bowel syndrome as well. Within this definition, patients are divided into three types to better characterize the clinical course and natural history of the disease based on an individual patient's anatomy:

- Type 1: patients with an end jejunostomy
- Type 2: patients with a jejuno-colonic anastomosis
- Type 3: patients with a jejuno-ileo-colonic anastomosis

The etiology of SBS in the adult population is most frequently related to acute mesenteric vascular disease, trauma, Crohn's disease, motility disorders, or surgical complications [1]. However, as cancer treatment becomes more aggressive, a higher percentage of patients with SBS secondary to resection from cancer-related disease or radiation enteritis has emerged [3].

Dietary recommendations for SBS have been limited by small studies, heterogeneous patients and poor methodology. This article will outline the data available on dietary guidance for patients with SBS and their providers.

Physiologic Response to Resection Across SBS Types

In the post-resection period, monitoring a patient's response to surgery can be divided into the acute phase and the adaptation phase. The acute phase occurs in the immediate post-operative period and can last several months following surgical resection [4]. This period is characterized by poor nutrient and fluid absorption with higher risk of dehydration and electrolyte imbalances. Frequent vital signs, daily electrolytes, and daily intake and output monitoring is required as aggressive fluid and electrolyte repletion are often needed in the post-operative

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patient [4]. A patient can be started on parenteral nutrition (PN) when stable from a cardiopulmonary standpoint, generally around post-operative day 2 or 3 [4]. When daily electrolytes are stable and ostomy output is less than 2 L daily, oral nutrition can be started [5]. Oral intake helps facilitate the adaptation phase through enteral stimulation [5].

The adaptation phase begins within 24 to 48 h after surgical resection and may last 1 to 2 years [4]. The remaining bowel undergoes multiple physiologic changes to compensate by increasing the length and diameter through villous hypertrophy as well as increasing intestinal transit time [6, 7].

Type 1 SBS Type 1 SBS is the most severe disease, characterized by massive fluid and electrolyte losses due to severely impaired capacity for intestinal adaptation [8, 9]. These patients have the highest risk for dependence on permanent parenteral nutrition (PN) support if they have less than 115 cm of small bowel [8, 9]. Physiologic consequences unique to type 1 SBS include accelerated small intestinal transit from the loss of peptide YY (PYY) production within the terminal ileum (TI) and colon, and hypomagnesemia due to the loss of normal physiologic absorption within the colon [10].

Type 2 SBS Patients with type 2 SBS generally require more than 60 cm of small bowel to maintain adequate nutrition off PN and generally has less severe diarrhea and weight loss than type 1 SBS [3, 4]. Common complications seen in type 2 patients include vitamin B12 deficiency, increased diarrhea, fat malabsorption, loss of the ileal brake, and loss of the ileocecal valve [10, 11]. Vitamin B12 deficiency results from loss of specialized B12 receptors in the TI. Increased diarrhea in type 2 SBS is partially caused by the loss of bile salt transporters and by the loss of the ileum-mediated fluid absorption leading to greater strain on the colon [10]. Fat malabsorption from loss of ileum-mediated bile salt absorption leads to fat-soluble vitamin deficiencies, steatorrhea, and oxalate-induced nephrolithiasis. Nephrolithiasis occurs secondary to calcium binding to mal-absorbed fatty acids within the lumen of the colon while the excess free oxalate is absorbed [10]. Loss of the ileal brake decreases small bowel transit time through impaired synthesis of PYY and glucagon-like peptide-1 (GLP-1) [11]. If the colon remains in continuity, it can compensate and increase synthesis of PYY and GLP-1 to preserve small bowel motility [11]. Additionally, the colon compensates with enhanced absorption by increased synthesis of glucagon-like peptide-2 (GLP-2) [11]. Loss of the ileocecal valve allows bacterial colonization within the remaining small intestine, resulting in small intestinal bacterial overgrowth (SIBO) [11].

Type 3 SBS Type 3 SBS is relatively uncommon and has a low probability for PN dependence due to the adaptation of the intact TI and colon [10, 11]. Type 3 patients generally need only 35 cm of small bowel to maintain their nutritional status off PN [3, 4]. Jejunal resection can result in unique management considerations secondary to decreased production of the negative feedback hormones, cholecystokinin and secretin, that regulate gastrin production [11]. Loss of the negative feedback results in gastric acid hypersecretion and subsequent impaired digestion through denatured pancreatic enzymes [11]. This phase is usually transient, resolving within months, and can be treated successfully with acid-suppressing medication [10]. The intact TI adapts by slowing small intestine transit time through the ileal brake and maintaining hydration with the tight junctions of the ileal lumen [10, 11]. The remaining colon can increase absorption from the normal 1 L daily up to 5 L to help decrease output [4, 12]. Furthermore, the colon serves a pivotal role in digestion through increased small chain fatty acid production provided by undigested carbohydrates reaching the colon [13].

General Dietary Recommendations in SBS

Given the loss of absorptive capacity and alterations in nutrient absorption described above in patients with SBS, hyperphagia is needed to meet nutritional needs. Specific caloric requirements will vary across patients; however, observational studies have found that patients with SBS will consume between 35 and 58 kcal/kg/day in order to meet their nutritional needs [14–16]. If a more specific recommendation is desired, and resources are available to measure resting energy expenditure (REE), Crenn et al. found that the majority of SBS patients consumed two to three times their REE. While likely not necessary for all patients, measurement of REE may help some patients better understand their specific needs and tailor their oral intake plans.

Carbohydrates Further studies looked at the digestion of each macronutrient and found that carbohydrates were the most readily used in SBS patients and represent nearly 50% of the calories some patients consume. However, the type of carbohydrate consumed is very important. Simple sugars should be avoided as they can contribute to osmotic diarrhea and thus decreased ability to use the energy consumed. In addition, soluble fiber such as pectin is frequently utilized to help thicken stools and is generally not well fermented in patients without a colon [17, 18].

Protein Determining the optimal protein intake for patients with SBS is difficult. Prior studies show that protein absorption depends on the length of small bowel remaining and may increase over time as the bowel adapts, ranging from 61 to 80% [14, 16, 19]. Based on these findings, Woolf et al. recommended SBS patients consume 80–100 gm of protein per day, though these recommendations should be modified for

each patient based on initial weight and bowel length remaining, and may decrease over time as bowel adapts.

Fat As with the general population, fat calories should provide about 30% of the calories of patients with SBS [20•, 21]. Jeppesen previously found that enterally provided essential fatty acids were better able to maintain physiologic levels to prevent deficiency [22]. In patients with a colon, it is important to limit the intake of fat to 20–30% of calories to help reduce the risk of nephrolithiasis from calcium oxalate stones [23]. These patients are also better able to utilize medium chain triglycerides for nutrient absorption without increasing the volume of stool and decreasing calcium and magnesium absorption [15, 24].

Nutrition Recommendations Based on Remaining Anatomy

When discussing nutrition recommendations for patients with SBS, the presence of a colon decreases the need for hydration support and salvages calories that would otherwise be lost [8, 23, 24]. Therefore, this section divides nutrition recommendations into end jejunostomy and colon-in-continuity categories, rather than discussing the literature based on the classic types of SBS.

End Jejunostomy Few studies compare the macronutrient composition of diets for patients with SBS. Early studies combined patients with and without a colon and did not account for fluid or fiber intake, making conclusions about recommendations between groups difficult. Early data suggested SBS patients maintain a low-fat, high-carbohydrate diet given concerns of losing divalent ions bound to fat (including magnesium, calcium, and zinc) through steatorrhea and excess diarrhea [25, 26].

Clinical experience pushed Woolf et al. to perform a crossover study evaluating the role of high-fat vs high-carbohydrate diets in SBS. A total of 8 patients were included, 5 of whom had end jejunostomies. Results showed no difference in fecal water excretion, divalent ion absorption or excretion, and ultimately total calorie absorption [27]. As expected, patients excreted a higher amount of fecal fat, though a linear relationship emerged with more fat being absorbed in these patients as well.

McIntyre et al. evaluated 7 patients with end jejunostomy length ranging 60–150 cm. Seven patients followed a liquid diet of varying fat content via an elemental and polymeric diet. No significant differences were found between the two diets with regard to energy absorbed or output. Four patients then completed a solid diet portion of the study comparing high-fat/high-fiber vs low-fat/high-fiber vs low-fat/normal fiber. The authors found no need to limit fat in this patient population as they did not find an increase in diarrhea or mineral losses. This study was limited on several accounts including the actual fat intake among participants in the high-fat portion ranging from 68 102 gm. Additionally, the three diets were not isocaloric, varying up to 600 kcal in one patient [28].

Ovesen et al. studied 5 patients with end jejunostomies ranging from 35 to 125 cm of small bowel remaining, and looked at both high-fat vs high complex carbohydrate diets as well as the composition of fat, specifically polyunsaturated vs saturated fats. All patients required daily parenteral vitamins, trace elements, and fat emulsions to prevent essential fatty acid deficiency. All were maintained on their normal PN formula ranging from 0 to 3000 kcal daily and daily oral intake was recorded, ranging from 600 to 3300 kcal. Patients were given three isocaloric diets for 7 days and served as their own controls: high-carbohydrate (55%) and low-fat (30%) vs two high-fat (60%) and low-carbohydrate (25%) diets. The two high-fat diets were further broken down into equal ratio (1:1) of polyunsaturated:saturated as fatty acids vs 1:4. Overall, patients on a high-fat diet had higher volume output. Fat output varied depending on the amount ingested but mean fat absorption remained fairly constant regardless of intake at approximately 40–45%. The type of fat, polyunsaturated vs saturated, did not have any effect on output including volume or electrolytes. Increases in the amount of divalent ion losses, including magnesium, zinc, calcium, and copper, suggested that patients with these deficiencies may benefit from decreasing their fat intake [29].

A follow-up study in the SBS population was performed by Nordgaard et al. comparing a high-fat (60% of energy), low-carbohydrate (20%) diet vs a low-fat (20%), high-carbohydrate (60%) diet in SBS patients with and without a colon [13]. Six patients with end jejunostomies and residual small bowel ranging from 100 to 250 cm were admitted for dietary manipulation and monitoring. On the high-fat diet, patients absorbed roughly the same percentage (48%) of energy as on the low-fat diet (55%) and had no difference in the amount of calories excreted on the high-fat vs high-carbohydrate diet [13].

Colon-in-continuity In contrast to patients with an end jejunostomy, patients with colon-in-continuity may benefit from limiting the amount of dietary fat and instead focusing on increased complex carbohydrates. A study by Andersson et al. compared fat intake of 100 to 40 gm in patients with SBS. Eleven of 13 patients studied had ileal Crohn's disease and 9 of those had ileal resection. In the 11 patients that had some or all of their colon intact, all had improvement in diarrhea with a fat-reduced diet. Bile acids are absorbed in the distal ileum and have been linked to diarrhea in those with ileal resection [30]. Therefore, diets lower in fat and bile acids may contribute to the physiology of improvement in diarrhea in these patients. This is further supported by the finding that

patients with a functional gallbladder had an even greater improvement in diarrhea on a low-fat diet [26].

In the Nordgaard study referenced above, eight patients with colon-in-continuity were evaluated on a high-fat (60%)/low-carbohydrate (20%) vs low-fat (20%)/high-carbohydrate (60%) diet. Patients had a significant increase in energy absorption in the low-fat/high-carbohydrate diet of 69% vs the high-fat diet of 49% [13]. See Table 1 for summary of current recommendations.

Monitoring Patient Response to Diet

Clinical response is measured through monitoring of intake, output, and daily weight. Evaluation of intake and output should involve a baseline 24-h urine and stool output collection. It is crucial to ensure the patient can achieve a urine output of at least 1200 mL to maintain adequate hydration [21]. Monitoring output should continue weekly to biweekly to assess therapeutic efficacy until clinically stable. Additionally, a 72-h quantitative fecal fat assay may be required to assess need for PN. Daily weights are utilized to evaluate if IV fluids are needed or increased if weight loss is greater than 0.5 lb/day or 1 kg/week [31].

Oral Rehydration and Fluids

For patients with SBS, maintaining hydration can be difficult. Those patients with ostomy/stool output greater than 2 L per day are at increased risk for dehydration and potential need for parenteral hydration [32]. As a primary role of the colon is fluid absorption, there is decreased risk of dehydration and generally lower volume of stool output if colon is intact. For those patients with recurrent dehydration, consumption of 1 to 2 L of oral rehydration solution daily may help maintain their volume balance. [21]There are many different potential formulations of oral rehydration solution including commercial products and recipes that can be made from common over-the-counter ingredients. The key factor in the success of these solutions is a sodium concentration between 90 and 120 mmol/L and the addition of some glucose to aid in the absorption of sodium [21, 32]. It is important for these patients to avoid drinking free water as this can lead to worsening electrolyte disturbances by increasing the sodium in their stool output by drinking hypotonic solutions. Conversely, hypertonic solutions such as soda and fruit juice should also be avoided as these hyperosmolar solutions can pull water into the gastrointestinal tract and worsen dehydration.

To help decrease risk of dehydration, medications such as loperamide, diphenoxylate atropine, and tincture of opium can be utilized to help slow GI transit and decrease stool output. In addition, teduglutide may help decrease the hydration support of patients with SBS [33•].

Table 1 Macronutrient recommendations based on anatomy

Macronutrient	End jejunostomy	Colon-in-continuity
Fat	Up to 40%	20%
Carbohydrate	40%	60%
Protein	20%	20%

Next steps

For providers caring for patients with SBS, the current data available to help guide recommendations regarding diet is lacking. The majority of studies are conducted on a small number of patients in a single center. Early studies did not differentiate between those with and those without a colon. Given the known absorption capacity of the colon, this makes any recommendations about dietary intake from these studies difficult. As a group, patients with SBS are diverse in nature. Most studies have a wide range of small bowel length included in the same study and outcomes for a patient with 60 cm of small bowel and an end jejunostomy are likely quite different from one with 150 cm of small bowel and a full colon. Further studies with a larger number of patients from multiple academic centers would be beneficial to better guide our therapy.

Historically, studies have focused on recommendations related to fat and carbohydrate intake in SBS patients. Though studies have analyzed the utility of adjusting the composition of protein intake (e.g., glutamine), no data currently exists to guide adjustments to total protein consumption in this patient population [34]. Current guidelines recommend that protein comprise 20% of total caloric intake for both patients with end jejunostomy and colon-in-continuity. Current trends in nutrition research indicate benefits of high-protein diets for several patient populations including the elderly and critically ill patients [35, 36]; it remains to be seen whether this recommendation holds for the SBS population as well.

Additionally, many of the older studies have a majority of patients with SBS secondary to Crohn's disease as the underlying illness. As our medical therapies and surgical techniques for bowel preservation for Crohn's continue to improve, it is likely that IBD patients will make up a smaller percentage of the SBS population [37]. Crohn's patients pose unique nutritional risks depending on disease activity and location of disease that may limit the generalizability of nutrition recommendations to other SBS patients.

While there are some general recommendations for dietary management for patients with SBS, an individualized, team-based approach is ideal. A multi-disciplinary team including a dietician, physician or advanced practice provider with expertise in SBS, pharmacist, and nurse can best address the

complex needs of these patients especially during the first few years following surgery as adaptation occurs and a patient's needs change.

Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflict of interest.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

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