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Spectrum of Short Bowel Syndrome in Adults: Intestinal Insufficiency to Intestinal Failure

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Abstract

Short bowel syndrome (SBS) refers to the malabsorptive state caused by physical or functional loss of portions of the small intestine, most commonly following extensive intestinal resection. Such resections hinder absorption of adequate amounts of macronutrients, micronutrients, electrolytes, and water, resulting in malnutrition, diarrhea, and dehydration. Clinical features of SBS vary along a continuum, depending on the extent and anatomy of intestine lost and the ability of the patient and the remaining intestine to compensate for the loss. The impact of SBS can be extensive, leading to diminished health-related quality of life because of its many physical and psychological effects on patients. SBS is associated with decreased survival; risk factors for SBS-related mortality include very short remnant small bowel, end-jejunal remnant anatomy, and arterial mesenteric infarction as primary cause. Although parenteral nutrition and/or intravenous fluid (PN/IV) is a life-saving measure for many patients with SBS, patients with the most severe malabsorption (ie, dependent on PN/IV) are at risk for severe, chronic complications and death. Patients' treatment needs vary depending on disease severity and resection type; thus, each patient should be individually managed. This review discusses the spectrum of disease in patients with SBS and presents common complications encountered by these patients to highlight the importance of individualized management and treatment. (*JPEN J Parenter Enteral Nutr*. 2014;38(suppl 1):8S-13S)

Keywords

gastroenterology; parenteral nutrition; adults; home nutrition support; venous access

Short Bowel Syndrome: Overview

Short bowel syndrome (SBS) refers to the malabsorptive state caused by physical or functional loss of significant portions of the small intestine. In adults, physical losses usually result from extensive intestinal resection for recurrent Crohn's disease, mesenteric vascular events (eg, embolism, thrombus), trauma, volvulus, malignancy, and complications from previous abdominal surgery.[1–5] Functional losses are less common and occur in the presence of an intact small intestine that is not adequately performing its normal digestive and absorptive functions; causes include inflammatory bowel disease, radiation enteritis, recurrent intestinal pseudo-obstruction, and congenital villus atrophy.[1,2] Conditions leading to SBS most commonly affect the jejuno-ileal segment, although the colon may also be affected.[2]

Types of Intestinal Resection

Three types of intestinal resection may lead to SBS.[6] In patients with jejuno-colic anastomosis, all or most of the ileum is removed with at least part of the colon remaining. In contrast, patients with an end-jejunostomy retain some jejunum, but the ileum and colon are completely removed, and the jejunum forms the end of the intestines. The third type of intestinal resection is the jejuno-ileal anastomosis, predominantly a jejunal resection, leaving ≥10 cm of terminal ileum remaining and the entire colon intact. The impact of each of these resections is discussed in more detail in the review on remnant bowel pathophysiology by Tappenden[7] in this issue and in a recent review by Jeppesen et al.[8]

Incidence and Prevalence

The true incidence and prevalence of SBS in adults are unknown because no reliable patient database exists.[1,5,9] Best estimates are based on numbers of patients receiving long-term

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parenteral nutrition and/or intravenous fluid (PN/IV) support and do not account for patients who did not receive or who were weaned off PN/IV. Approximately 40,000 U.S. adults received home-based PN/IV in 1992, according to a U.S.-based patient registry; of these, approximately 10,000 had diagnoses consistent with SBS.[1,10] In Europe, the incidence and prevalence of PN/IV dependence have been estimated at 2–3 per million and 4 per million, respectively.[11,12] According to more recent results from a Spanish registry, the prevalence of PN/IV dependency is 5 per million adults in that country.[13] Based on data indicating that patients with SBS constitute 35% of the European PN/IV population,[12] the prevalence of SBS can be approximated at 1.4 per million.

However, the prevalence of SBS in Europe varies by region, from 0.4 per million in Poland to approximately 30 per million in Denmark.[12,14] The prevalence of SBS tends to be lower in regions lacking major intestinal rehabilitation centers and strong home PN/IV programs, likely because of underreporting and inability to adequately treat these patients. Nonetheless, this patient population is growing; a leading intestinal rehabilitation center in Denmark reported a >2-fold increase in the number of patients with PN/IV-dependent SBS per decade over the past 40 years.[15]

Patient Demographics

The lack of a comprehensive database of patients with SBS also limits efforts to accurately characterize demographic characteristics; these can only be inferred from published data. In a large multicenter survey of 688 adult patients receiving long-term PN/IV support for nonmalignant chronic intestinal failure, approximately 75% of the patients had SBS.[16] In this survey, the mean ± SD age was 52.9 ± 15.2 (range, 18.5–88.0) years, most patients were women (57%), and the most common primary conditions were mesenteric ischemia (27%), Crohn's disease (23%), and radiation enteritis (11%). However, patient demographics can vary widely across different geographic regions and among treatment centers.

A recent study limited to patients with SBS (N = 268) reported a median age of 52.5 (range, 18–89) years, a majority of female patients (52%), and a mean ± SD body mass index of 20.7 ± 3.9 kg/m^2 at baseline.[17] The most common primary conditions were mesenteric infarction (43%), radiation enteritis (23%), surgical complications (12%), Crohn's disease (6%), and soft tissue tumor (6%). Most patients (67%) had jejunocolic anastomoses, 18% had end-jejunostomies, and 15% had jejunoileocolic anastomoses.[17]

Individualized Treatment

As these studies suggest, patients with SBS differ in their underlying pathology, remnant bowel anatomy, and demographic characteristics. Consequently, treatment recommendations also vary.[18] The guidelines from the Small Bowel and Nutrition Committee of the British Society of Gastroenterology recommend that patients with SBS be individually managed because of their heterogeneity.[19]

Clinical Features and Effect of Malabsorption

Absorption Affected by Resection Site

Clinical features of SBS vary, depending on the extent and anatomy of intestinal loss and the ability of the remaining intestine to functionally compensate.[2] In the first 2 years following extensive resection, the remnant bowel can functionally adapt in response to the loss of the resected portion.[18] Patient outcomes are typically better for jejunal, as opposed to ileal, resections because the ileum adapts structurally and functionally, whereas the jejunum can adapt only functionally.[6,9,18] Nutrient entry into the ileum triggers a feedback mechanism, known as the ileal brake, that slows small bowel transit and delays gastric emptying, allowing increased nutrient absorption; no such compensatory mechanism exists for the jejunum.[6] Outcomes are also better in patients with a preserved colon because the colon helps to slow transit of the luminal contents and can compensate for decreased jejunal fluid and carbohydrate absorption.[6,20]

The ileocecal valve, the sphincter connecting the small and large intestine, has been considered an important regulator of intestinal transit speed and a physical barrier to anterograde flow of chyme from the large to small intestine.[18] For example, dogs that underwent construction of an artificial valve following resection of the distal intestine and ileocecal junction exhibited slower intestinal transit time and lower bacterial colony counts in the distal ileum than resected dogs who did not receive artificial valves.[21] However, other animal studies suggest that sphincterectomy does not significantly affect intestinal transit time.[22,23] Unfortunately, evidence from studies conducted in adult humans is sparse due to the rarity of limited ileocecal resections. In one small study, 8 patients who underwent resection of the distal ileum and proximal colon (including the ileocecal valve) had intestinal transit times that were similar to those of healthy volunteers. Furthermore, no instances of anterograde reflux from the colon to the small intestine were observed.[24] Therefore, it is likely that the role and function of the ileocecal valve may have been overestimated. However, the area in which the valve is located represents an important site for hormonal secretion. Feedback hormones, including glucagon-like peptides 1 and 2 and peptide YY, mediate important effects on gastrointestinal secretions, motility, and growth.[7]

Patients with SBS are often classified according to the length of intestine resected. However, because adult intestinal lengths can vary greatly, classifications according to remnant bowel length are usually more informative.[9] Adult patients retaining less than one-third of the jejuno-ileal segment (≤200 cm) typically experience symptoms of SBS.[2] Patients without

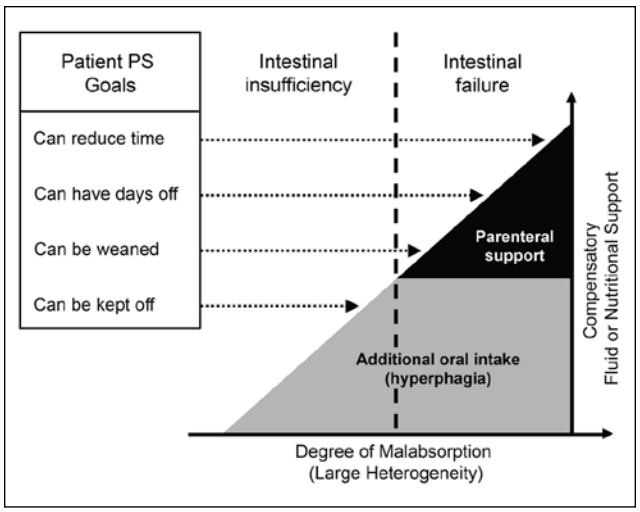

Figure 1. Spectrum of short bowel syndrome ranging from intestinal insufficiency to intestinal failure. PS, parenteral support. Reproduced with permission from Jeppesen PB. Short bowel syndrome—characterisation of an orphan condition with many phenotypes. *Expert Opinion on Orphan Drugs*. 2013;1:515-525.

a functional colon whose remnant small intestinal length is <100 cm and patients with a functional colon and <60 cm of small intestine remaining will usually be dependent on PN/IV, but this varies depending on the patient's ability to increase oral intake and the absorptive capacity of the remnant bowel.[1,18]

An alternative classification considers the proportion of ingested nutrients and fluids that are absorbed, and may better characterize the extent of intestinal insufficiency or failure than classifications based solely on remnant intestinal length (Figure 1).[1] Patients with intestinal insufficiency are able to compensate for malabsorption by increasing oral nutrient intake or using pharmacotherapies (eg, antimotility agents), resulting in sufficient net absorption of fluid and nutrients.[5,25,26] In contrast, patients with intestinal failure are unable to compensate with diet or drugs and are PN/IV-dependent.[1,5,25]

Clinical Consequences

The clinical impact of SBS is far-reaching because these patients report lower health-related quality of life than the general population.[27,28] Extensive resections can lead to malabsorption of macronutrients, micronutrients, electrolytes, and water, resulting in malnutrition, diarrhea, and dehydration.[2,9,18,29,30] The consequent undernutrition leads to weight loss, and low-weight patients report symptoms typical of undernutrition, including confusion, difficulty concentrating, somnolence, and weakness.[6,18,31] Many of these patients also report feelings of apathy, depression, and irritability, which may impair recovery.[6] Patients with SBS may exhibit physical signs of undernutrition, such as low body temperature, impaired growth and sexual development, and premature aging.[6,31]

SBS can also lead to hypotension and early kidney failure because of water and sodium deficiencies, especially in patients with a resected colon.[6] These patients are susceptible to magnesium deficiency, which can contribute to increased fatigue and depression and may also cause muscle weakness and dysfunction, cardiac arrhythmia, and possibly seizure.[6] Importantly, patients with SBS are at increased risk for infection and experience impaired wound healing because of malnutrition.[31] For example, vitamins A and C and the trace elements zinc, copper, and selenium contribute to wound healing through a variety of mechanisms.[32–34] Patients with SBS, particularly those patients who are dependent on PN/IV support, can manifest deficiencies in these specific nutrients or a more generalized protein-calorie malnutrition, which may result in delayed wound healing.[6,32,35]

Classification of Patients With Intestinal Failure Based on Parenteral Support Requirements

Based on their need for parenteral support, patients with SBS can be classified into multiple groups depending on disease severity and resection type (Table 1).[36] Because the jejunum absorbs more nutrients than fluids, patients with end-jejunostomy typically require IV fluid supplementation; however, their need for nutrition support increases with disease severity. In the most severe cases, these patients are PN/IV-dependent. In contrast, the colon absorbs water preferentially to nutrients, so patients with remnant colon-in-continuity (ie, jejuno-colic or jejuno-ileal anastomoses) require more energy than fluid. Similar to patients with end-jejunostomy, patients with colon-in-continuity require fluid and additional nutrition support with increasing disease severity and may eventually become PN/IV-dependent.

Role of Parenteral Nutrition and/or Intravenous Fluid

PN/IV support provides the nutrition, fluid, and electrolytes necessary to maintain health and normal body weight.[31] In the immediate postoperative period, all patients with SBS require PN to make up for nutrition losses and minimize osmotic diarrhea by avoiding oral food intake.[37,38] IV fluids and electrolytes are also required because extensive fluid loss can lead to severe dehydration, hypotension, and electrolyte imbalances.[18]

Although some patients can gradually decrease dependence on PN/IV support and may eventually be weaned, others require long-term parenteral support.[37,39] Patients absorbing less than one-third of their oral intake and those with very short intestinal remnants typically require long-term PN/IV.[18,40] Additional improvement after the 2-year adaptation period is uncommon and is limited to a further 5%–10% increase in absorptive capacity at most. The likelihood of permanent intestinal failure after 2 years of PN/IV dependence is 95%.[18,41] Two years after resection, PN/IV dependence is 49%, decreasing only slightly at 5 years to 45%.[41]

Table 1. Suggested Grading of Intestinal Failure According to the Absolute Average Daily Need for Parenteral Support.[36]

	Severity of Intestinal Failure				
Parenteral Support	Grade 1 (Borderline)	Grade 2 (Mild)	Grade 3 (Moderate)	Grade 4 (Severe)	Grade 5 (Very Severe)
Volume, mL/d [mL/kg/d]	<1000 [<17]	1000–2000 [17–34]	2000–3000 [34–51]	3000–4000 [51–68]	≥4000 [≥68]
Energy, kJ/d [kJ/kg/d]	<1000 [<17]	1000–3000 [17–51]	3000–5000 [51–83]	5000–7000 [83–117]	≥7000 [≥117]
Sodium, mmol/d [mmol/kg/d]	<100 [<1.7]	100–200 [1.7–3.4]	200–300 [3.4–5.1]	300–400 [5.1–6.8]	≥400 [≥6.8]
Potassium, mmol/d [mmol/kg/d]	<25 [<0.4]	25–50 [0.4–0.8]	50–75 [0.8–1.2]	75–100 [1.2–1.7]	≥100 [≥1.7]
Magnesium, mmol/d [mmol/kg/d]	<5 [<0.08]	5–10 [0.08–0.17]	10–15 [0.17–0.25]	15–20 [0.25–0.33]	≥20 [≥0.33]
Calcium, mmol/d [mmol/kg/d]	<4 [<0.07]	4–6 [0.07–0.10]	6–8 [0.10–0.13]	8–10 [0.13–0.17]	≥10 [≥0.17]

Values given in brackets represent conversions for a 60-kg person.
Reproduced with permission from Jeppesen PB. Short bowel syndrome—characterisation of an orphan condition with many phenotypes. *Expert Opinion in Orphan Drugs*. 2013;1:515-525.

The ability to receive home PN/IV (HPN) allows patients requiring long-term support to resume some aspects of normalcy.[42] Patients on HPN are advised to consume a hyperphagic diet, defined as a ≥1.5-fold increase in caloric intake over resting energy expenditure.[43] Selected patients may be able to increase calorie consumption to 300% over presurgery levels.[39] Animal studies suggest that hyperphagia stimulates structural and functional intestinal adaptation.[44] In humans, adaptive hyperphagia is associated with decreased risk of dependence on PN/IV for patients with SBS as a result of chronic radiation enteritis.[45] In addition, patients receiving HPN are frequently advised to use oral rehydration, ideally with isotonic solutions with a high sodium content, to minimize daytime dehydration; however, because of the low palatability of isotonic formulations, these recommendations are hard to implement.[38,40] Vitamin and mineral status should be monitored regularly, and supplementation should be customized for each patient.[1] Common supplements include calcium, magnesium, iron, selenium, zinc, bicarbonate, and vitamins A, B_{12}, C, D, E, and K.[1,39]

Pharmacological management of symptoms associated with SBS may include antidiarrheals to avoid excess fluid loss; H_2 receptor antagonists and proton pump inhibitors to reduce gastric secretions and stool losses; and antibiotics, prebiotics, and probiotics to combat bacterial overgrowth.[9,39,46] Two drugs have been approved by the U.S. Food and Drug Administration for the treatment of adult patients with SBS, somatropin and teduglutide. Clinical data supporting the use of these agents are extensively reviewed in the accompanying supplement article by Jeppesen.[47]

Complications

Although PN/IV is a life-saving measure for many patients, several complications are common (Table 2).[1,42,48,49] Many of these are related to the PN/IV catheter, PN/IV composition, and malabsorption due to the reduced remnant intestinal anatomy.

The most common of the catheter-related complications is catheter-related bloodstream infection and even sepsis, which is responsible for most of the morbidity and hospital readmissions in these patients.[48–50] In a systematic review, adults receiving HPN experienced catheter-related bacteremia once every 2–3 years (0.34 episodes per catheter-year).[51] In addition to implementation of stringent catheter hygiene, the use of catheter locks containing ethanol or antibiotics (e.g., taurolidine) may decrease infectious complications in these patients.[52,53] The second most common catheter-related complication is occlusion, which can be caused by a thrombus (0.07 episodes per catheter-year), medication-PN precipitate, catheter-related mechanical problems, or lipid build-up.[20,48,49]

Hepatobiliary disorders, including steatosis, cholestasis, gallstones, and hepatic fibrosis, are also associated with PN/IV dependence.[54] Evidence from preclinical and clinical studies suggests that components of PN could be hepatotoxic due to the presence of excess lipids, particularly ω-6 polyunsaturated fatty acids, or high levels of phytosterols.[54] Uncomplicated liver steatosis may be caused by an excess of carbohydrates supplied in PN solution.[55] Several studies of patients receiving long-term PN/IV support have found that cholestasis is most likely to occur in patients with the shortest remnant bowel or in those with moderate-to-high lipid content in the PN emulsion.[49] Other factors implicated in the pathogenesis of PN-associated liver disease include recurrent sepsis, small bowel bacterial overgrowth, choline or taurine deficiencies, and absence of enteral feeding.[54,56]

Mildly abnormal liver function tests are observed in up to 99% of patients receiving PN, but may also be related to the primary pathologic condition.[48,57,58] The incidence of severe liver dysfunction in these patients is much lower. In a study of 107 PN-dependent patients, almost half had deranged liver function tests, but none progressed to decompensated liver disease over a median follow-up of 19 months.[58] Salvino et al[57] reported a severe liver dysfunction rate of 4% among 208 patients on PN support, only 1 of whom had PN-associated liver disease. Furthermore, in adults, death caused by intestinal failure–associated liver disease is rare when patients are managed in specialized centers. In a cohort of 509 PN-dependent SBS patients treated over the course of 4 decades at the

Table 2. Potential Adverse Effects of Parenteral Nutrition.[1,42,48,49]

		Affected System			
Catheter Related	Toxicities	Biliary	Hepatic	Renal	Skeletal
• Catheter-related bloodstream infections • Infectious "metastasis" (endocarditis, osteomyelitis, etc) • Catheter-related central venous thrombosis • Loss of venous access	• Aluminum • Chromium • Manganese	• Sludge • Gallstones • Gallbladder dysmotility • Acalculous cholecystitis	• Steatosis • Cholestasis • Fibrosis • Cirrhosis • End-stage liver disease	• Hyperoxaluria • Kidney stones • Impairment of tubular function	• Osteoporosis • Osteopenia • Osteomalacia

Rigshospitalet in Denmark, the mortality rate from intestinal failure–associated liver disease was 2.6%.[15]

Patients' altered intestinal anatomy may lead to complications. In a normal bowel, various mechanisms, including gastric acid secretions and intestinal motility, ensure an appropriate intestinal bacterial composition; however, SBS-related intestinal resection impairs intestinal motility, resulting in luminal content stasis and excessive bacterial proliferation.[55] Consequences of bacterial overgrowth can include fatty acid and carbohydrate malabsorption as well as sepsis.[20]

Survival

SBS is associated with decreased survival. Actuarial survival probabilities for adults with nonmalignant SBS at 1, 5, and 10 years have been reported as 94%, 70%, and 52%, respectively.[17] Slightly lower survival rates were reported for patients with SBS secondary to radiation therapy for abdominal and pelvic malignancies (83% at 1 year and 68% at 5 years).[59]

A number of risk factors for SBS-related mortality have been reported. A study of 268 adult patients with nonmalignant SBS found 3 independent risk factors: end-jejunostomy, a primary condition of arterial mesenteric infarction, and a history of cancer. In contrast, age <60 years was associated with significantly increased survival.[17] A larger study of patients receiving HPN found that the risk of HPN-related death increases with duration of HPN support.[60] Although 1 or 2 hospital readmissions are attributed to PN/IV per patient each year, PN/IV complications account for only 5%–20% of mortality in these patients.[16,61,62]

Conclusions

SBS is a heterogeneous disorder covering a spectrum ranging from intestinal insufficiency to intestinal failure. Because of the large degree of variability in disease severity and the different types of resection, SBS patients require individualized approaches to treatment that, it is hoped, will minimize complications, improve quality of life, and decrease SBS-associated mortality.

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