Managing the Adult Patient With Short Bowel Syndrome

Carol Rees Parrish, MS, RD, and John K. DiBaise, MD

Ms Parrish is a nutrition support specialist at the University of Virginia Health System's Digestive Health Center in Charlottesville, Virginia. Dr DiBaise is a professor of medicine in the Division of Gastroenterology and Hepatology at the Mayo Clinic in Scottsdale, Arizona.

Address correspondence to:
Dr John K. DiBaise
Division of Gastroenterology and Hepatology
Mayo Clinic
13400 East Shea Boulevard
Scottsdale, AZ 85259
Tel: 480-301-6990
Fax: 480-301-6737
E-mail: dibaise.john@mayo.edu

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Abstract: Short bowel syndrome (SBS) is a malabsorptive disorder associated with significant morbidity and mortality, reduced quality of life, and high health care costs. Managing the patient with SBS requires an understanding of gastrointestinal anatomy and physiology; a dedicated multidisciplinary team; and the coordination of dietary, fluid, pharmacologic, and comorbid disease management. This article provides an overview of the current state of management of SBS, including a practical approach to optimizing the care and quality of life of the adult patient with SBS.

Short bowel syndrome (SBS) is a challenging and often disabling malabsorptive condition associated with significant morbidity and mortality, reduced quality of life, and high health care costs.[1] In patients with SBS who are receiving long-term home parenteral nutrition (PN), 2- and 5-year survival rates have been reported to be up to 80% and 70%, respectively.[2,3] Factors affecting survival with SBS include the anatomy and function of the remaining bowel, the age of the patient, the primary disease process, comorbid diseases, the presence of chronic intestinal obstruction, and the experience of the management team.[4]

A functional definition of SBS is necessary due to the wide variation in small bowel length in adults (300-800 cm) and the ability of the remaining bowel to compensate for the lost length. Thus, SBS is defined as the inability to maintain nutritional, fluid, and/or electrolyte homeostasis while consuming a normal, healthy diet following a bowel resection.[5] Although the cause of SBS varies (Table 1), the multiple physiologic alterations and associated clinical complications are similar (Table 2).[6] The use of PN, which is often required in the management of SBS, has its own complications, high cost, and impairment in quality of life.[7] Dependency on PN at 1, 2, and 5 years in patients with SBS was reported in 74%, 64%, and 48% of patients, respectively.[8] The presence of a colon and the remaining length of functional small bowel (<50-70 cm with the colon in continuity or <100-150 cm when the colon is absent) are the most critical factors predicting permanent need of PN.[9] Management goals include reducing the dependence on PN, the severity of SBS symptoms, and the development of complications associated with SBS.

Table 1. Causes of Short Bowel Syndrome in Adults

• Complications from abdominal surgery – Occur more often in laparoscopic vs open procedures – Bariatric surgery (volvulus)
• Malignancy (ie, tumor resection, radiation enteropathy)
• Mesenteric ischemic events
• Crohn's disease
• Trauma
• Other

Table 2. Clinical Complications Associated With Short Bowel Syndrome

Central Venous Catheter–Related Complications	• Infection • Occlusion • Breakage • Central vein thrombosis
Parenteral Nutrition–Related Complications	• Hepatic complications (ie, steatosis, cholestasis, fibrosis, cirrhosis) • Biliary complications (ie, gallstones)
Bowel Anatomy–Related Complications	• Malabsorptive diarrhea • Malnutrition • Fluid and electrolyte disturbances • Micronutrient deficiency • Essential fatty acid deficiency • Small bowel bacterial overgrowth • D-lactic acidosis • Oxalate nephropathy • Renal dysfunction • Metabolic bone disease • Acid peptic disease • Anastomotic ulceration/stricture

The clinical manifestations, prognosis, and treatment of SBS vary depending upon the remaining bowel anatomy and its residual function. Three bowel anatomies occur with SBS: jejunocolonic, jejunoileocolonic, and end jejunostomy. The length and region of the remaining small bowel and the presence of even a part of the colon are particularly important factors determining outcome.[9] Because of differences in the ability to undergo adaptation, patients with an ileal remnant have a better prognosis of survival than patients with only a portion of the jejunum remaining.[4] The presence of the colon is beneficial in SBS given its ability to absorb water, electrolytes, and fatty acids; slow intestinal transit; and stimulate intestinal adaptation. SBS patients with an end jejunostomy are generally the most difficult to manage and are the most likely to require permanent parenteral support.[4]

The treatment of SBS has evolved in recent years such that the reduction or elimination of PN requirements in formerly PN-dependent patients is now a reality. Attaining independence from PN can sometimes be accomplished by incorporating a multidisciplinary approach that includes alterations in diet and fluid intake in order to stimulate intestinal adaptation and optimize intestinal absorption, the use of pharmacologic agents to control symptoms and improve quality of life, and the strategic application of novel intestinotrophic agents and surgery when appropriate.[10] This article describes a practical approach to optimizing the care and quality of life of the adult patient with SBS.

Physiologic Alterations and Clinical Complications of Short Bowel Syndrome

The physiologic alterations in SBS lead to many potential clinical complications (Table 2). Diarrhea tends to be the most bothersome and debilitating symptom for the majority of patients with SBS. A study involving patients with SBS found that chronic, uncontrolled diarrhea has a more negative impact on quality of life than home PN therapy.[11] Therefore, effective management of diarrhea is of primary importance to this patient population. It is imperative to recognize that the diarrhea that is experienced does not occur solely from loss of gut surface area. Understanding this may help target therapies for individual patients. Gastric hypersecretion occurs during the early months following massive intestinal resection and adds a significant volume of secretions to the upper gut. Additionally, the acidity denatures and destabilizes pancreatic enzymes and bile salts, respectively, which contributes to maldigestion and malabsorption. A diminished bile salt pool resulting from distal ileum resection further aggravates malabsorption. Due to resection of their sites of production, reduced gut hormone feedback mechanisms (eg, peptide YY, glucagon-like peptide-1) permit accelerated dumping into the upper gut with rapid intestinal transit, causing poor mixing of pancreaticobiliary secretions with food. Active bowel disease (eg, Crohn's disease, radiation enteritis), *Clostridium difficile* infection, and small bowel bacterial overgrowth (SBBO) may also contribute to the diarrhea seen in SBS.

Multidisciplinary Treatment

The care of SBS requires the use of a variety of treatments. Thus, a multidisciplinary approach consisting of physicians, surgeons, dietitians, nurses, and social workers

Table 3. Diet Guidelines

General Tips	• Patients should consume 6-8 small meals or snacks per day and start with a 3-day diet record. • Tailor the diet to the patient, and outline what they can eat. • Patients should chew foods well. • Written diet materials for short bowel syndrome are available at www.ginutrition.virginia.edu.
Protein	• Patients should consume a high-quality protein at each meal and snack.
Carbohydrates	• Generous complex carbohydrate intake (eg, pasta, rice, potato, bread) is recommended. • Limit simple sugars and sugar alcohols in both foods and fluids; lactose may be tolerated and does not always need to be avoided. • Do not use supplemental nutrition drinks.
Fat	• Limit fat to <30% in patients with a colon; may need to limit in patients without a colon. • Include oils with essential fatty acids (eg, sunflower, soy, walnut).
Oxalate	• Limit if the colon is present; guarantee adequate urine output first.
Fluids	• Consider oral rehydration solutions. • All fluids may need to be limited in some patients and intravenous fluids given.
Salt	• Increase salt intake in patients without a colon; continue usual intake in patients with a colon.
Fiber	• Encourage some soluble fiber (in food) in patients with a colon segment.

Adapted from Parrish CR, DiBaise JK.[14]

experienced in the care of patients with intestinal failure is helpful for the optimal management of this patient population.

Diet Therapy

Diet therapy is an important intervention not only for the sake of nourishment, but also as a means for affecting intestinal adaptation and symptom control. The cornerstone of diet therapy is manipulation of food intake to maximize nutrient and fluid absorption, thereby decreasing stool output. Luminal, complex nutrient therapy initiated early after bowel resection is critical for optimal intestinal adaptation, as the higher workload stimulates and recruits all of the processes involved in digestion and absorption, including stimulation of mucosal hyperplasia and secretion of intestinotrophic gastrointestinal hormone and pancreaticobiliary enzyme secretion.[12,13] Long-chain fat enhances the secretion of both peptide YY and glucagon-like peptide-2 (GLP-2), which are responsible for mediation of the jejunal and ileal brake mechanisms.

Although there are basic tenets to diet therapy that apply to all patients with SBS (Table 3), tailoring the diet to each patient's remaining bowel anatomy and explaining to the patient the importance of diet and fluid modifications are essential to optimize adherence and successful outcomes.[14] Starting with a 3-day diet record of the patient's usual intake is a good idea. Periodic evaluation and adjustment of diet, particularly during the adaptation period, is critical for ongoing success. Table 3 provides specifics regarding diet therapy for SBS, but 4 nutrients warrant special comment: fat, oxalate, fiber, and salt.

Fat and Oxalate Fat, a significant calorie source, is the most difficult nutrient to digest and absorb. Excess fat in some patients with SBS may exacerbate steatorrhea and diarrhea, resulting in significant nutrient and water loss. Furthermore, in the patient with a remaining colon segment, too much fat can displace calcium from oxalate, allowing the unbound oxalate to be absorbed in the colon. In marginally hydrated patients, enhanced oxalate absorption may lead to oxalate nephropathy. Fat restriction is most important in the SBS patient with a remaining colon, severe steatorrhea, and/or a history of oxalate nephrolithiasis. Restricting oxalate in known kidney stone formers is also important; however, the clinician should first ensure that the patient is adequately hydrated.

Fiber Soluble fiber may benefit some patients with SBS, particularly those with a colon segment remaining, as the bacterial fermentation of undigested carbohydrate can generate between 500 to 1000 kcal per day from the short-chain fatty acids that are produced, which can be used as energy by the host.[15] Soluble fiber can also slow gastric emptying and potentially improve diarrhea. Therefore, a moderate intake of soluble fiber is often encouraged. However, its use should not be at the expense of the patient with a poor appetite who has difficulty meeting his or her most basic nutrient needs. Avoidance of bulk-forming agents such as insoluble fiber is advised.

Although insoluble fiber may appear to decrease stool loss by thickening the consistency of stool or ostomy effluent, it may also result in the net loss of minerals and fluids.[16,17]

Salt SBS patients with high stool output, primarily those with end jejunostomy, are at a significant risk of sodium depletion. Daily sodium losses can be as high as 105 mEq (2430 mg) per liter of stool output.[18] In patients with fatigue, failure to thrive, and high stool output, an assessment of sodium status is advised (eg, by maintaining a 24-hour urinary sodium concentration of >20 mEq/L).[19] Salty snacks are encouraged, and liberal use of salt can help replace the sodium lost in stool. For patients on enteral feedings, salt can be added directly to the feeding or bolused as part of the water flush.

Fluids

The hydration status is often neglected in the SBS patient population.[19] However, fluid and electrolyte abnormalities are a major cause of morbidity and hospitalization in patients with ostomies.[20] Maintaining hydration status is a central component in the care of the patient with SBS. Failure to do so can result in dehydration, rapid weight loss, and fatigue. If dehydration is chronic and untreated, it can lead to nephrolithiasis and renal injury that may be irreversible. Educating patients to identify and prevent signs of dehydration should be a priority. The degree of fluid and electrolyte abnormalities occurring in SBS varies depending upon the remaining bowel anatomy, specifically the length, location, and presence of disease in the residual small bowel and the presence of a colon in continuity. To determine hydration status, 24-hour stool or ostomy volume as well as 24-hour urine volume should be measured. Whether a patient with SBS can produce adequate urine volume is critical. Although evidence supporting an optimal daily urine output in SBS is lacking, clinical recommendations often suggest that in patients with normal kidney function, 1200 mL of urine each day is important for long-term renal health, while a daily urine output of at least 1500 mL is preferred in patients who have experienced nephrolithiasis. A good practice for clinicians who are planning to discharge a SBS patient without intravenous (IV) fluids is to stop all IV fluids at least 2 days prior to discharge in order to monitor urine output and ensure that these goals can be achieved.

Oral Rehydration Solution Patients with SBS should avoid sodas, fruit juices, fruit drinks, sweet teas, and liquid nutritional supplements, as the amount of sugar in these drinks is related to the amount of output the patient will experience. A major misconception on the part of the patient is that he or she should drink large quantities of water; this generally leads to an increase in stool output, which further exacerbates fluid and electrolyte disturbances. Instead, SBS patients, particularly those with an end jejunostomy, may benefit from the use of a glucose-electrolyte oral rehydration solution (ORS) to enhance absorption and reduce secretion, whereas most patients with a colon can usually maintain adequate hydration without excessive fluid loss with hypotonic fluids. ORS utilizes the sodium-glucose-coupled transport system, operating primarily in the jejunum, to promote sodium and water absorption. The optimal sodium concentration of ORS ranges between 90 to 120 mEq Na^+/L (with an optimum carbohydrate-to-sodium ratio of 1:1).[19] Due to palatability and cost, ORS is not often preferred by patients. To improve palatability, ORS can be made into ice cubes or popsicles, or sugar-free flavoring can be added. Homemade ORS recipes are also available and equivalent to the more expensive commercial products.[19] Some patients have been able to avoid IV fluids with the use of gravity or pump-drip ORS administered via a gastrostomy tube overnight.[21] Regardless of how patients try to hydrate themselves, it is important to recognize the patient who needs parenteral fluid support. The clinician should determine which patients are in need based on urine output, hypotension, recurrent dehydration, and acute kidney injury.

Medications

Treatment of SBS requires aggressive use of several medications. Although it is generally recognized that diet and fluids are malabsorbed in patients with SBS, it is important to understand that medications may also be malabsorbed (Table 4). To maximize the efficacy of medications in patients with SBS, clinicians should consider the dose, formulation, frequency, and timing of administration of each drug in relation to meals. Higher doses are typically needed, IV formulations are sometimes necessary, and delayed- or extended-release medications should generally be avoided. The cost and availability of medications at the patient's local pharmacy should also be considered in order to improve medication adherence. A periodic total pill count is also advised, as not only can the prescription medications, over-the-counter medications, and vitamin and mineral supplements add up, but also the osmotic contributions and sheer volume of fluid needed to take these pills can further contribute to stool output. Finally, efficacy should be monitored over a set period of time, and if a goal is not achieved, ineffective medications should be discontinued and alternatives should be tried.

Conventional medications used for SBS are essential for symptom relief. The most commonly used medications, particularly during the period of greatest intestinal adaptation, are antisecretory and antimotility

Table 4. Factors Affecting Medication Absorption in the Patient With Short Bowel Syndrome[23]

• The change to the total surface area, permeability, and integrity of the intestinal epithelia
• The change in orocecal transit time
• The impact on dissolution and release of the drug from the formulation
• Loss of the specific absorptive area in the bowel where the medication is routinely absorbed
• Loss of specific enzymes or epithelial transport proteins needed to activate the drug
• The location of the bowel that acts as the site of action for the medication
• The health of the remaining bowel
• The magnitude of intestinal adaptation
• Other conditions that alter intestinal architecture and lead to impaired absorption (eg, small bowel bacterial overgrowth)

agents. They are often necessary to control gastric hypersecretion and high-volume diarrhea.

Antisecretory Agents Gastric acid hypersecretion occurs for 6 to 12 months after the resection of more than 50% of the small bowel.[22] Hypersecretion causes an increase in acidic fluid volume entering the small bowel and contributes to diarrhea and fat maldigestion for the reasons stated previously. However, gastric acid hypersecretion can be managed in most patients with the use of readily available antisecretory agents. Table 5 lists key considerations for the use of available antisecretory agents, which include histamine-2 receptor antagonists, proton pump inhibitors, octreotide, and clonidine.[23] Importantly, somatostatin analogues are rarely needed in the long-term management of diarrhea in the SBS patient and may have negative effects on intestinal adaptation if used earlier in the course following massive bowel resection.

Antimotility Agents Control of diarrhea using antimotility agents is a cornerstone of SBS therapy (Table 6). Opioid derivatives used as antimotility agents can be categorized as locally acting agents with low systemic effects (eg, loperamide, diphenoxylate with atropine) or as systemic agents (eg, codeine, tincture of opium). Loperamide is the most commonly used antidiarrheal medication and is generally preferred over diphenoxylate, as the latter may produce systemic effects at the higher doses needed to treat SBS. Despite a lack of high-quality evidence supporting the use of these medications, loperamide and diphenoxylate are considered first-line antimotility agents in SBS given their extensive clinical experience. For SBS, an initial dose of loperamide is typically 2 capsules or tablets (30 mL) taken 30 to 60 minutes prior to a meal and again at bedtime. Whereas the maximal recommended daily dose is 8 tablets in generally healthy individuals, a dose of up to 4 tablets taken 4 times daily may be needed in patients with SBS. Use of the crushed tablet form may improve bioavailability and increase efficacy over the capsule form.

Codeine and tincture of opium should be considered in patients with SBS who have failed therapy with loperamide or diphenoxylate, although codeine may have

Table 5. Antisecretory Agents[23]

Agent	Form	Clinical Considerations
Histamine-2 receptor antagonists	Oral or IV	• Compatible with parenteral nutrition solution • Loss of efficacy with long-term use
Proton pump inhibitors	Oral or IV	• Requires adequate small bowel surface area for oral absorption. If efficacy is in question, try IV route (and stop oral route). • Cannot be added to parenteral nutrition • Increased risk of *Clostridium difficile* • Potential for hypomagnesemia • Reevaluate need at 6 months
Octreotide (somatostatin analogue)	SC or IV	• Overused in clinical practice; reserve for secretory diarrhea, not osmotic. (Make the patient nil per os for 24 hours to determine the difference.) • Risk of hyperglycemia and cholelithiasis • Painful and expensive • May inhibit intestinal adaptation
Clonidine	Oral or patch	• Risk of hypotension

IV, intravenous; SC, subcutaneous.

Table 6. Antimotility Agents[26]

Agent	Form	Clinical Considerations
Loperamide	Oral: liquid, tablet, capsule	• Limited effects on the central nervous system • Enterohepatic circulation of loperamide can be disrupted with extensive ileal resection.
Diphenoxylate/ atropine	Oral: liquid, tablet	• Atropine crosses blood-brain barrier; careful use in elderly patients • Atropine discourages drug abuse by anticholinergic events if >10 tablets
Codeine	Oral: liquid, tablet	• Avoid use of codeine/acetaminophen combinations due to the risk of acetaminophen toxicity. • CYP2D6 genotyping may need to be considered.
Tincture of opium	Oral: liquid	• Not available in all pharmacies • Not always covered by insurance • Always dose in mL (not drops); caution should be taken when eyesight is poor. • Costly • Patients dislike the taste.

synergistic effects when combined with loperamide.[24] Although codeine is generally a safe and effective treatment option for most patients, 5% to 10% of the population are poor metabolizers, and 1% to 2% are ultra-rapid metabolizers.[25] Therefore, unless pharmacogenomic testing is available, clinicians should initiate the use of codeine cautiously and monitor closely for side effects. Much misconception remains regarding the use of opioids in the management of SBS; however, our experience suggests that a carefully executed management plan with opioid therapy may reduce PN use and unnecessary hospitalizations.[26]

Bile Acids and Bile Acid Binders Resection of more than 100 cm of terminal ileum affects the reabsorption of bile acids into the enterohepatic circulation and, over time, reduces the ability of the liver to synthesize an adequate replacement.[27] This decreased bile acid pool results in impaired micelle formation and fat digestion, and manifests clinically as steatorrhea and fat-soluble vitamin deficiencies. At present, there are no suitable, commercially available bile acid replacers that facilitate fat digestion without also aggravating diarrhea. Use of bile acid sequestrants in this setting may result in a further reduction in the bile salt pool, worsening steatorrhea and fat-soluble vitamin loss. Instead, bile acid binders should be reserved for SBS patients with a colon and clinically significant diarrhea who fail other first-line agents.[27]

Glutamine The use of glutamine in combination with growth hormone and optimized diet has been suggested to have an additive effect on PN weaning compared to the use of growth hormone alone.[28] Nevertheless, in a small, randomized, controlled, crossover study that used glutamine by itself, no difference in stool output, small bowel morphology, intestinal transit time, or D-xylose absorption was observed.[29]

Pancreatic Enzymes Pancreatic enzyme secretion is only reduced in SBS when there is no concomitant enteral or oral diet. The function of pancreatic enzymes, however, may be impaired during the hypersecretory period that occurs in the first 6 to 12 months after massive resection if no antisecretory medication is used. Although there may be concern about a mismatch of pancreatic enzymes mixing with ingested nutrients due to the alterations in anatomy and faster small bowel transit, evidence supporting the usefulness of pancreatic enzyme supplementation in SBS is lacking.

Antibiotics and Probiotics for Small Bowel Bacterial Overgrowth The combination of bowel dilatation and altered transit frequently seen in patients with SBS is thought to facilitate the development of SBBO.[30] SBBO can cause a number of gas-related symptoms, aggravate diarrhea (leading to a reduction in oral intake), induce inflammatory changes in the gut, deconjugate bile acids (resulting in further fat maldigestion), and consume vitamin B12 (leading to deficiency). Because of limitations in the tests used to diagnose SBBO (eg, small bowel aspirate/colony count, hydrogen breath test) in patients with SBS, diagnosing SBBO is challenging. As such, empiric antimicrobial treatment is often provided. A variety of oral broad-spectrum antibiotics can be used, with success being judged on improvement in symptoms and/or oral intake, reduction in stool output, and/or weight gain. The

continuous use of a low-dose, rotating cycle of antibiotics for SBS may be necessary in some patients.

High-quality evidence supporting the use of prebiotic, probiotic, and synbiotic agents in SBBO in adults is lacking; however, their benefit in the pediatric SBS population has been described.[31] Further research of these agents is needed before they can be recommended for routine use in SBS.

Intestinotrophic Agents An overarching goal when treating a patient with SBS who requires parenteral support is to reduce or, whenever possible, eliminate its use. Whereas more than 50% of adults with SBS are able to be weaned completely from PN within 5 years of diagnosis, fewer than 6% will wean from PN using conventional methods if independence is not achieved in the first 2 years following resection.[8,9] Intestinal adaptation is the process occurring mainly during the first 2 years following intestinal resection whereby the remaining bowel undergoes macroscopic and microscopic changes in response to a variety of internal and external stimuli in order to increase its absorptive capacity.[12] Two intestinal growth factors (somatropin [Zorbtive, Serono Inc] and teduglutide [Gattex, Shire]) are now available for use in patients with SBS who have been unable to wean themselves from parenteral support after the period of maximal intestinal adaptation.

Growth Hormone Growth hormone has been shown to promote crypt cell proliferation, mucosal growth, collagen deposition, and mesenchymal cell proliferation. A phase 3, prospective, randomized, placebo-controlled trial enrolled 41 PN-dependent SBS patients who were studied in an inpatient-like setting for 6 weeks, with 2 weeks of diet and medication optimization and PN stabilization followed by a 4-week treatment period.[28] Patients were randomized into 3 groups: recombinant human growth hormone (somatropin; 0.10 mg/kg taken subcutaneously once daily) plus glutamine, growth hormone (0.10 mg/kg taken subcutaneously once daily) without glutamine, and placebo plus glutamine. A significant reduction was seen in PN requirements in both groups treated with growth hormone at the end of the 4-week treatment period: 7.7 L per week (4.2 days/week) vs 5.9 L per week (3.0 days/week) vs 2.0 L per week (2.0 days/week), respectively.[28] PN reduction remained significantly reduced during a 12-week observation period only in the group treated with growth hormone plus glutamine. Peripheral edema and musculoskeletal complaints were common in the growth hormone–treated groups. Based in part on these results, the US Food and Drug Administration (FDA) approved the use of somatropin in 2003 as a short-term (4 weeks) aid for PN weaning in patients with SBS. A considerable amount of skepticism surrounding the long-term benefits of this approach, its side effects, and the feasibility of replicating the results of the pivotal trial in an ambulatory setting has limited its adoption into clinical practice. In the United States, the cost of a 4-week course of growth hormone is approximately $20,000,[32] and an economic analysis of health care costs associated with growth hormone use estimated a 2-year savings of $85,474, assuming that 34% of growth hormone–treated patients eliminated PN use within 6 weeks of treatment and 31% remained PN-free after 2 years.[33]

Glucagon-Like Peptide-2 GLP-2 induces gut epithelial proliferation by stimulating crypt cell proliferation and inhibiting enterocyte apoptosis, increases absorptive capacity, and inhibits gut motility and secretion. Teduglutide, a recombinant, degradation-resistant, longer-acting GLP-2 analogue, was studied in two phase 3, multinational, randomized, double-blind, placebo-controlled trials that included parenteral fluid–requiring SBS patients in an outpatient setting.[34,35] In the first study, 83 SBS patients were separated into 3 treatment arms (placebo, 0.05 mg/kg/d of teduglutide, and 0.10 mg/kg/d of teduglutide administered subcutaneously once daily) and treated with the study medication for 6 months following a PN optimization period.[34] PN weaning was the primary endpoint (20% volume reduction at weeks 20-24). Teduglutide was found to be safe and well tolerated; however, only the lower dose significantly reduced PN requirements (46% for 0.05 mg/kg/d vs 6% for placebo).[34] After stopping teduglutide at the end of the 24-week treatment period, some patients (15/37) required an immediate increase in their fluids, whereas others (22/37) seemed to maintain their fluid requirements and body weight.[36] The second trial compared only the lower dose of teduglutide to placebo administered for 6 months in 86 adult SBS patients and utilized the same primary endpoint but a more aggressive PN weaning strategy.[35] Patients receiving teduglutide were more than twice as likely to respond to therapy (63% vs 30%; P=.02). The mean reduction in PN volume after 24 weeks was 4.4 L in the teduglutide group compared with 2.3 L in the placebo group. Fifty-four percent of patients receiving teduglutide were able to reduce their weekly PN infusions by at least 1 day compared with 23% of patients receiving placebo. In a preliminary report from a 2-year extension study, 65 patients (74%) completed the study.[37] Of the 30 patients treated for 30 months with teduglutide, 28 (93%) made additional reductions in parenteral support with a mean decrease of 7.6 L per week, and 21 (70%) eliminated at least 1 infusion day.[37] A total of 15 of the 134 patients (11%) treated in both phase 3 studies and their extension studies were able to

Table 7. Short Bowel Syndrome Resources for Clinicians

Professional Text	DiBaise JK, Parrish CR, Thompson JS, eds. *Short Bowel Syndrome: Practical Approach to Management*. Boca Raton, FL: Taylor & Francis Group; 2016.
Extensive Professional and Patient Education Materials for Short Bowel Syndrome	University of Virginia School of Medicine Gastrointestinal Nutrition Support Team website: www.ginutrition.virginia.edu (Under Nutrition Articles link: recent 6-part series on short bowel syndrome from *Practical Gastroenterology*; under Patient Education link: several dietary resources)
Patient Education Guidebooks	Parrish CR. *A Patient's Guide to Managing a Short Bowel*. 4th ed. Overland Park, KS: Intouch Solutions; 2016. Available at no cost to clinicians or patients at: www.shortbowelsyndrome.com/sign-up
The Oley Foundation	www.oley.org; 1-800-776-OLEY
Short Bowel Syndrome Foundation	www.shortbowelfoundation.org; 1-888-740-1666

be completely weaned from parenteral support[38]; most of these patients had a portion of colon in continuity and lower baseline parenteral support requirements. The most common adverse effects of teduglutide include abdominal pain, injection site reactions, and stomal complaints.[39] Teduglutide was approved by the FDA in 2012 for SBS patients as a long-term aid to PN weaning.

The only contraindication to teduglutide is active gastrointestinal neoplasia. However, precaution is necessary due to a number of potential adverse effects, including the potential for fluid overload, increased drug absorption requiring dosage reduction, and the risk for acceleration of neoplastic growth within the gut. Periodic colonoscopic surveillance before and during its use (6 months before, 1 year after, and at least every 5 years thereafter) is advised.[40] Additional monitoring (ie, amylase, lipase, alkaline phosphatase, and total bilirubin levels before and every 6 months while using the agent) for gastrointestinal obstruction and gallbladder, biliary and pancreatic disease is part of the risk evaluation and mitigation strategy program required of prescribers.[40] Given its annual cost of nearly $300,000 in the United States, appropriate patient selection for teduglutide is important to determine the proper place for this therapy in the management of the PN-requiring SBS patient. In the United States, the cost to the individual is generally much lower as a result of insurance coverage and patient support programs that provide financial assistance for out-of-pocket expenses. Similar to growth hormone, the reduction in costs associated with PN use as weaning progresses will also offset some of the cost associated with teduglutide use.

Role of Surgery in Short Bowel Syndrome

Surgeries that recruit additional bowel into continuity, relieve obstruction, repair a fistula, and eliminate diseased bowel may improve residual bowel absorption or function.[41] The restoration of continuity of the small bowel with the colon may be the single most effective operation to facilitate independence from parenteral support and may also improve quality of life and reduce the risk of catheter-related infections. Intestinal tapering to improve the function of dilated bowel, stricturoplasty for benign strictures, and serosal patching for chronic fistulas may prevent the need for resection.

Nontransplant surgical procedures (eg, autologous gastrointestinal reconstruction) have also been devised to maximize the function of the existing intestine.[42] The choice of surgery is influenced by the existing bowel length, function, and caliber, and can be divided into procedures that optimize function (eg, lengthen, taper) or slow transit (eg, reversed segment). These operations serve to enhance the mucosal surface area for absorption, slow intestinal transit to facilitate absorption, or correct stasis and SBBO, which may reduce gastrointestinal symptoms and reduce or eliminate malabsorption. These techniques should only be considered in the stable SBS patient following the initial adaptive period and after medical and dietary management have been maximized.

Summary

Management of the patient with SBS requires patience, persistence, and attention to detail. Risks to these patients are significant, often resulting in major detriments to quality of life and increased consumption of health care resources. An understanding of gastrointestinal anatomy and physiology is essential to recognize the risks to these patients and to optimize their management. A coordinated approach including dietary and fluid modifications, symptom-based conventional medications, selective use of intestinotrophic agents and surgery, and comorbid disease management, ideally by a multidisciplinary team, is important for the successful management of SBS. Additional resources for clinicians are listed in Table 7.

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