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Enteral Nutrition in the Adult Short Bowel Patient: A Potential Path to Central Line Freedom

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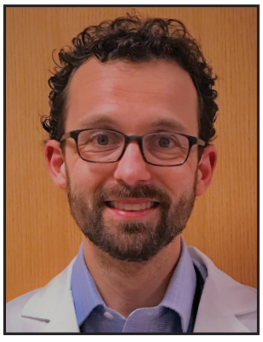

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Short bowel syndrome/intestinal failure (SBS/IF) is characterized by patients who have lost absorptive surface area in the gut either due to structural (e.g. surgical) or functional (e.g. mucosal disease) changes and demonstrate an inability to maintain both hydration and nutritional well-being while eating and drinking a normal diet. While the use of enteral nutrition is part of primary therapy in the pediatric SBS population, it is underutilized in adult patients trying to transition off parenteral nutrition. Instead, adult SBS patients are sometimes left on chronic parenteral hydration or nutrition. This article will address how one institution orchestrates an enteral feeding trial in the adult SBS patient trying to achieve enteral autonomy from parenteral support.

INTRODUCTION

Short bowel syndrome/intestinal failure (SBS/IF) is best defined as an inability to maintain adequate nutrition and/or hydration through oral intake due to insufficient gut surface area either from surgical resection or a significantly defunctionalized bowel surface (e.g. radiation injury, etc.). Many patients require parenteral nutrition (PN) or hydration due to the severity of malabsorption and/or dehydration present. Not only does this pose significant lifestyle and financial challenges, but the medical risks of catheter infection, thrombosis, and gradual loss of vascular access are also significant. Effective and aggressive care of the SBS patient requires a thoughtful approach to maximizing GI tract function and eliminating the need for parenteral support whenever possible.

While enteral nutrition (EN) is widely used in pediatric SBS patients[1-4] in an attempt to transition from PN to enteral autonomy, it appears to be rarely used in adult SBS patients. Getting the most out of a shortened bowel means not only providing luminal nutrients to maximize absorption and the adaptation process,[5] but also means incorporating creative strategies such as using the GI tract at a time when it would normally be in disuse (i.e., during sleep). This allows delivery of nutrients at a slower pace for gradual absorption without overwhelming the vulnerable GI tract. This article will address how one institution orchestrates an EN trial in the adult SBS patient trying to achieve enteral autonomy from parenteral support.

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Adaptation Phase After Loss of Bowel

After a massive loss of bowel, the remaining bowel attempts to boost absorption of nutrients and fluids through hypertrophy of the villous mucosa. While maximal adaptation is usually reached within the first 6 months after resection, some bowel adaptation will continue for up to two years. During the adaptation phase, enteral nutrients directly stimulate:

- Enteral blood flow
- Epithelial cells
- Production of trophic hormones
- Pancreaticobiliary secretions

In so doing, mucosal atrophy is prevented, mucosal barrier function is preserved, and the mucosal immune system is downregulated.[5-7] Recognizing that nutrients in the GI tract stimulate this process is key to understanding intestinal adaptation. To maximize intestinal adaptation, it is important to provide early introduction of whole, enterally delivered nutrients (either as food or polymeric formula). Whole nutrients help maximize the functional workload of the intestinal epithelium which drives intestinal adaptation (think use it or lose it). Utilizing the gut overnight may have the added benefit of avoiding overstimulation of the bowel by presenting nutrients slowly via a pump maximizing uptake at the brush border.

It is absolutely critical in caring for the newly minted SBS patient to allow time for adaptation before committing a patient to "long-term or PERMANENT TPN." Patients may see significant improvements in bowel function as the adaptation window closes which could facilitate weaning of previously necessary parenteral support. As with any post-op GI patient, oral/enteral nutrients should be started as soon as feasible, to initiate the intestinal adaption process, even if oral intake is not sufficient, or needs to be kept to a minimum to prevent high output. Oral intake enlists the cephalic phase of digestion activating salivary glands and stimulation of epidermal growth factor secretion and other trophic agents in saliva that also may play a role in adaptation.[2,8] Finally, oral intake is a very important component in the quality of life of our patients. For our institution's written SBS diet education materials for patients go to: **med.virginia.edu/ginutrition/patient-education**.

Enteral Feeding Considerations in the Adult Short Bowel Patient

Available supportive evidence for using EN in adult SBS patients with varying lengths of small bowel consists of case reports, case series and small observational studies.[9-20]

Feeding Route

Gastric delivery is favored over jejunal feeding, not only to stimulate pancreaticobiliary secretions to assimilate nutrients, but to encompass the greatest amount of surface area for absorption and to better regulate flow across the pylorus into the small bowel. Jejunal feeding should be reserved for those patients with functional or mechanical gastric outlet obstruction, severe ongoing gastric reflux, or anatomy that prevents gastric feeding. However, this would only be appropriate in those patients with adequate jejunal/ileal surface area below the jejunal feeding tube ports to absorb infused nutrients.

Continuous vs. Bolus Enteral Infusion

Pump feeding is preferred to bolus feeding to present nutrients slowly over time to maximize nutrient contact and saturation of mucosal receptors resulting in overall improved absorption per unit length of small bowel.[1] Delivery of EN via a pump is vastly slower than the slowest/smallest amount of food or fluid taken orally; consider: 60mL/hour = 1mL/minute (a teaspoon [5mL] infused over 5 minutes). Several studies have shown improved outcomes (nutrient absorption, weight gain, less diarrhea, less divalent cation loss), with continuous infusion in both pediatric and adult SBS populations.[4,13-16,18,21,22] In the patient consuming a short bowel diet over the course of the day, nocturnal pump feedings over 8-12 hours at night have the advantage of using the GI tract when there is no competition for the mucosal receptors, leaving nutrients their very own contact time. For those who want to infuse during the day and tolerate the increased daytime enteral workload, an enteral backpack can be used to carry the infusion pump so patients can continue their normal activities as desired ("infuse and cruise" as it were).

Enteral Product Selection

In the early studies of enteral feeding in pediatric SBS, elemental or semi-elemental formulas were often used based on the assumption that the injured, shortened intestinal tract needed help to absorb nutrients by having them partially or fully broken down. While there is evidence in animal studies that more complex nutrients promote adaptation, human studies have been small, hence clear benefit of polymeric vs. elemental formulas is not available at this time.[13,14,20,23,24] Elemental-type formulas tend to be more osmotic and costly. The whole nutrients in polymeric formulas also provide the necessary "workload" to maximally stimulate adaptation.[5] See Table 1 for a comparison of various standard polymeric vs. elemental-type formulas.

Fiber-containing products may be useful in those SBS patients with a colon segment as colon metabolism generates useful free fatty acids. However, patients with concurrent small intestinal bacterial overgrowth may find that fiber exacerbates gas and distension. This can be worsened in some patients by the addition of fructo-oligosaccharides (FOS) in some of the enteral products.[25,26]

As enteral formulas are known to be relatively low in sodium content, SBS patients with end jejunostomies or ileostomies may need additional salt added directly to their EN prior to infusion[27] if they do not get enough salt in their diet. Those with a colon should not need this as even a small colon segment avidly absorbs sodium from the gut.

Finally, there may be a few patients who only need hydration rather than additional nutrition support. Oral rehydration infused over time via a gastrostomy tube may effectively hydrate and allow freedom from the risks of a central line.[28]

Table 1. Fat Content of Elemental, Semi-Elemental and Low Fat Enteral Formulas

Formula	Calories/ mL	g Fat/ Liter	% MCT	g fat/ 1000 kcal	g fat/ 2000 kcal	mOsm/ Liter
Elemental						
Peptamen®	1.0	39	70	39.0	78	270
Peptamen 1.5®	1.5	56	70	37.3	74.6	550
Peptamen AF 1.2®	1.2	54	50	45	90	390
Peptamen Intense 1.0 HP®	1.0	38	50	38	76	345
Perative®	1.3	37.3	40	28.6	57.2	385
Vital 1.0®	1.0	38.1	47	38.1	76.2	411
Vital AF 1.2®	1.2	54	45	29	58	459
Vital 1.5®	1.5	57.1	47	38	76	610
Vital HP®	1.0	23.2	50	23.2	46.4	419
Vivonex RTF®	1.0	11.6	40	11.6	23.2	630
Vivonex T.E.N. Powder	1.0	3	0	3	6	630
Vivonex Plus Powder	1.0	25	0	25	50	650
Standard Polymeric						
Promote®	1.0	26	19	26	52	340
Replete®	1.0	34	20	34	68	300
Isosource 1.0 HP®	1.2	40	20	32	64	330
Osmolite 1.5®	1.5	49	19	32	64	525
Nutren 1.5, unflavored®	1.5	60	20	40	80	530

Blended Whole Food Formulas

In a small study of 10 pediatric patients with intestinal failure (80% with colon in continuity), transition from an elemental to a commercial blended formula (Compleat Pediatric®) resulted in more formed stools and appropriate weight gain after one year.[24]

Lower Fat Formulas Might be Worth a Try in Some Patients (especially those with a colon)

In general, avoid restricting fat intake because of the caloric density fat provides. However, some patients with SBS have significant fat malabsorption, which may be worsened by a coexisting bile salt insufficiency, or the increasingly more common pancreatic exocrine asynchrony from altered upper gut anatomy such as a Roux en y gastric bypass. Using a lower total fat formula in these cases may improve overall absorption, particularly in patients with colon in continuity. Case in point:

> 32 year-old male with history of SBS due to necrotizing enterocolitis as an infant (~ 30cm proximal SB anastomosed to ~ 50cm of distal colon); transferred to the adult service when he was 24 years of age. Therapy at that time included: PN, nocturnal semi-elemental EN via gastrostomy tube, and an oral short bowel diet (followed fairly well). His usual body weight fluctuated for years between 95-105 lbs (height 4' 10"). After numerous central line septic episodes, he was transitioned off PN to daily nocturnal IV fluids/electrolytes alone (he could not hydrate himself without), nocturnal EN, and optimized oral SBS diet and fluids during the day. When teduglutide became available, he was started on it in an effort to get him off IV fluids. His weight increased over time to an all-time high of 124 lbs (goal weight was 110 lbs., but patient started working out and wanted to weigh 120 lbs.). Urine and stool output averaged 900-1100mL (never a kidney stone), and 1500-2000mL, respectively. Given his weight gain, and the fact it was over goal, it was decided to switch him from Peptamen® 1.5 @ 110mL/hr x 6 cans for years to a lower fat polymeric formula: Replete @ 110mL/hr x 6 cans. While this dropped his total daily EN calories from 2250kcal to 1500kcal, it also reduced the total fat content from 84g to 50g/day; his weight stabilized at 120 lbs and he experienced a decrease in his 24-hour stool output, demonstrating improved absorption on less total fat.

Be wary of exchanging medium chain triglycerides (MCT) for long chain triglycerides (LCT). Too much MCT can overwhelm a SBS patient's ability to passively absorb it and still result in significant fat malabsorption. In our experience, the use of MCTs should be reserved for SBS patients with colon in continuity, and then only if clear clinical benefit is demonstrated in an individual patient.

In a patient with SBS, lower osmolality products may be helpful, but this benefit is often minimal given the extensive dilution effect of both baseline gastric and intestinal secretions with any gastric formula infused. The bottom line is any enteral product that clearly drives stool/ostomy output above what is tenable for an individual patient is not sustainable.

Additionally, poorly absorbed osmoles are significant contributors to diarrhea in any patient, especially patients with SBS. Liquid medications containing sugar alcohols (see Table 2) and enteral products containing FOS have been shown to increase stool volume.[25,26,29]

Who Needs an Enteral Feeding Trial?

Once out of the adaptation phase, every SBS patient that is PN-dependent as well as every SBS patient that is struggling with nutrition/hydration on oral intake alone, should be considered for novel approaches to maximize current function of their GI tract.

Although there are some patients that have a low probability of success, there is no downside to trying to liberate a patient from PN or IV fluids and central line access. Situations that may be considered relative "contraindications" are high output fistula on maximum medication therapy (antidiarrheals, antisecretory, etc.), chronic dysmotility, chronic obstruction, and severe (>2000mL/day) diarrhea output.

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Indications for an enteral feeding trial begins with a careful examination of the patient and their gut function. The patient is assessed to ensure that they:

1. Are willing to undergo an enteral feeding trial
2. Do not have potential contraindications or complexities associated with enteral access
3. Do not have other untreated GI disorders (e.g. significant dysmotility, bowel fistula, active Crohn's disease, etc.)

We then assess gut function via:

- 72 hour fecal fat – to assess degree of malabsorption
- Small bowel follow through – to assess transit time and gross assessment of bowel anatomy if unknown
- 24hr I and O – to assess baseline oral fluid intake, stool/ostomy and urine output

Patients with the Highest Potential for Success:

1. Eating and drinking a very high calorie short bowel diet and despite this, cannot gain weight
2. Stool output increases considerably if patient tries to eat or drink more
3. Too full to eat or drink the amount they need in order to meet needs or gain weight
4. Cannot maintain consistent high calorie intake (> 3000kcal/day) day after day as it consumes the entire day leaving no time to have a life, and a grocery bill that may not be sustainable

Table 2. Common Liquid Medications Containing Sugar Alcohols

Medication Oral Suspension	Sugar Alcohol Content
Acetaminophen (Tylenol) 160 mg / 5 ml	Sorbitol
Amoxicillin / clavulanate (Augmentin) 200 mg / 28.5 mg / 5 ml	Mannitol
Codeine 30 mg / 5 ml	Sorbitol
Diphenoxylate and Atropine (Lomotil) 2.5 mg / 0.025 mg / 5 ml	Sorbitol
Furosemide (Lasix) 10 mg / ml	Sorbitol
Gabapentin (Neurontin) 250 mg / 5 ml	Xylitol
Glycopyrrolate (Robinul) 1 mg / 5 mL	Sorbitol
Guaifenesin (Mucinex) 100 mg / 5 ml	Sorbitol
Ibuprofen (Motrin) 100 mg / 5 ml	Maltitol
Lansoprazole (Prevacid) 3 mg / ml	Mannitol
Levetiracetam (Keppra) 100 mg / ml	Maltitol
Metoclopramide (Reglan) 5 mg / 5 ml	Sorbitol
Mycophenolate mofetil (CellCept) 200 mg / ml	Sorbitol
Ondansetron (Zofran) solution 5mg / 5mL	Sorbitol
Oseltamivir phosphate (Tamiflu) 6 mg / ml	Sorbitol
Potassium chloride oral solution 20% (40mEq K / 15mL)	Sorbitol
Simethicone (Gas relief) 20 mg / 0.3 ml	Maltitol
Valproic acid (Depakene) 250 mg / 5 ml	Sorbitol

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Based on above information along with patient centered decision making, we embark on a formal enteral feeding trial. This is often conducted in an inpatient setting to ensure adequate measurements, facilitate rapid changes if needed, and to monitor for clinical issues such as refeeding syndrome.

The Architecture of an Inpatient Enteral Feeding Trial

Conducting an EN trial is often a challenge to orchestrate given the unpredictability and fast pace of modern inpatient medicine. Despite this, with careful planning and appropriate communication, it can be executed smoothly and efficiently. A 3-4 day hospitalization is usually expected, although caution the patient that this could be shorter or longer depending on the circumstances. For smooth initiation of an EN trial, complete as much as possible prior to admission such as a small bowel follow through and baseline 24-hour urine and stool outputs for comparison purposes when enteral trial begins (see Table 3).

Planning and coordination is everything. It is important to be very clear with the involved teams that ALL intake (food, fluid, fluid with medications) and output (urine, stool, external drains) should be accounted for; also that urine and stool should be measured separately (for some female patients this is difficult and might require temporary placement of a Foley catheter). In our experience, more than one patient has reported high ostomy/stool output only to find out they were unable to separate urine and stool and the volume recorded/reported was a high percentage of urine volume and not stool/ostomy output.

The EN regimen initiated is a nocturnal run with a lower fat, standard polymeric formula or a semi-elemental product (see Table 1) via a pump, which can be delivered slowly over time to maximize absorption. Typically, a set volume of 2-3 cans (~ 500-1000 calories) over 10-14 hours is infused. A conservative volume is chosen initially to avoid drastically increasing the stool volume; only increase rate once tolerance is demonstrated ensuring the patient is not up all-night stooling/emptying ostomy appliance. Monitoring any alteration to laboratory values is necessary as well. While refeeding syndrome is a serious clinical issue that is often evident in the lab work, significant diarrhea can also result in electrolyte changes and biochemical signs of volume depletion (e.g. rising BUN/Creatinine ratio).

It is not uncommon to see an increase in stool output requiring escalation of antidiarrheal agents (e.g. crushed loperamide, codeine, etc.), especially at the start of nocturnal EN infusion. If the stool volume increases such that a patient's ability to sleep or generally function is compromised, then the EN plan is untenable.

During the EN trial, the goal is to maintain a stool output of ideally less than 1500mL and a urine output of greater than 1200mL, without evidence of metabolic disarray or progressive volume depletion. If success is achieved, proceed with a more permanent form of enteral access (e.g. gastrostomy tube) ideally prior to discharge. Some patients may require continued PN for a time with a plan to wean as home EN continues to be advanced. See section below on EN coverage options.

Enteral Access after Successful Enteral Feeding Trial

The principles behind enteral access in the SBS patient emphasize maximizing the length of gut involved in enteral feeding. For most patients, this means consideration of a gastrostomy tube. We recommend avoiding jejunostomy extension arms and jejunostomy tubes if possible since they:

1. Divert past valuable mucosal surface area
2. Bypass the important function of the stomach to control emptying into the duodenum
3. Cause asynchrony of EN infused with normal pancreaticobiliary secretions

Placement of a gastrostomy tube depends on local expertise, but most hospitals have access to teams from GI endoscopy, surgery, or radiology, who can safely perform these procedures. In general, we attempt to endoscopically place a gastrostomy tube prior to discharge if long-term EN is the plan.

If there is hesitation on the part of the patient or the medical team, a reasonable plan at the time of discharge would be a short-term trial at home with a nasogastric tube to clearly demonstrate the enteral feeding/hydration plan is successful before placing

Table 3. Considerations Before Embarking on an Enteral Feeding Trial

Day	Interventions/Orders

Pre-admission	• If anatomy unknown, obtain either:
	  ○ Small Bowel Follow Through (make sure patient is made NPO at midnight the night before procedure)
	  ○ Abdominal CT
	• Baseline 24-hour urine and stool/ostomy volume
	• Check C. difficile just to be sure
	• Baseline comprehensive metabolic, magnesium
	• NG tube placement in fluoroscopy (or clinic with x-ray verification) day before or day of admission so enteral feeding can be started night one

Day of admission	• Start measured urine and stool/ostomy output
	  ○ In female patients who cannot separate urine and stool output (no ostomy), a short term foley catheter may be necessary
	• Baseline CMP, magnesium if not already done recently, then daily basic metabolic and magnesium (phosphorus only if needed)
	• Ensure correct oral diet order is in
	• Initiate EN via NG tube with set volume such as 2-3 cans (~ 500-1000kcal) over 10-14 hours at night—a reasonable amount to get an idea of whether the plan has a chance of success
	  ○ Example: Perative @ 50mL / hr from 1800 (1900 is change of shift) overnight until 500mL (2 cans) infused (~ 10 hours)—set pump to dose delivery (if facility pumps have that option)
	• Order 48-hour (72-hour if Medicare) fecal fat stool collection at time of EN initiation
	  ○ Make sure stool collection containers are available on the unit
	  ○ Ensure nurse/PCA are aware—involving charge nurse or nurse manager may be helpful also—a lot is riding on this
	  ○ Ensure careful documentation of all EN infused
	• Ensure all medications are ordered at correct dose, frequency and timing
	  ○ If antidiarrheals are used, make sure they are given 30-60 minutes before meals and right at bedtime—all hospitals have a set time that meal trays are to arrive on the floor—find out what time that is for the unit the patient is on and order meds accordingly

Day 2/3	• STRICT I/O's (it takes a village—all parties should be aware of the importance of keeping these records—a lot is depending on it) • Continue stool collection for fecal fat • Daily basic metabolic, magnesium • Escalation of gut slowing agents with nocturnal enteral feeding ○ Patient may need a higher dose at start of nocturnal EN • Alert case manager for discharge planning: enteral pump, supplies, etc. (if this can be done prior to admission even better)
Day 4	• Planning permanent enteral access (e.g. gastrostomy) vs. 2-3 week home trial on nasogastric feedings to ensure the patient does well clinically and the plan is sustainable for patient. ○ In some patients, waiting for fecal fat results is prudent to ensure the plan will be a success before more permanent access is placed.

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more permanent access. This is a temporary option given the risk of displacement of the nasogastric tube, the discomfort associated, and the risk of injury to the sinuses associated with a longer-term NG tube.

If at First You Don't Succeed…Pitfalls Encountered That Alter Success of Plan

- Make sure all orders (medications, diet, fluid, I & O's, etc.) go in correctly the first time and are carefully followed
- Appropriate labs are scheduled at opportune times
- Can patient separate urine and stool when voiding?
    - If not, patient may need a urinary catheter to accurately measure stool/ostomy output during trial

The Converse: Some patients are very unlikely to succeed with an enteral trial

There are certainly cases where an enteral trial is quite unlikely to succeed. We utilize the clinical history and baseline data from studies such as fecal fat collections to help patients understand the likelihood of success. For example:

> 65 year old, 6' 2", 142# male presented to GI nutrition clinic with malnutrition, failure to thrive, and depression with a history significant for: pseudomyxoma peritoni with heated intraperitoneal chemotherapy; exploratory laparotomy with radical intra-abdominal tumor debulking and bowel resection. He was constantly hungry, ate all day long, yet suffered significant osmotic diarrhea despite a 6 month effort to maximize diet and narcotic gut slowing. Neither his hydration status nor his weight had meaningfully improved. A 48 fecal fat collection was completed while he ingested a 100-gram fat diet with the following results: 5220mL total stool volume (2610mL/ daily) and 85 g fat lost per day. This degree of fat malabsorption made the likelihood of success with an EN trial extremely low. After reassurance regarding the risk of PN which had previously been explained to him by another provider as quite dire, he was started on PN. In follow-up his quality of life was markedly improved → back to travelling and deep-sea fishing with a weight of 165 lbs.

Insurance Coverage of Enteral Feeding in SBS

Insurance coverage of EN can vary widely; it is helpful to acquire approval PRIOR to permanent gastrostomy tube placement if needed. Medicare requires patients to have a permanent (>3 months) functional impairment of the upper GI tract making EN via a tube necessary. In patients making the transition from PN, not all insurance carriers will cover both modalities at the same time to facilitate a safe transition.

Getting both EN and PN covered at the same time:

- Medicare patients → not possible as definitive criteria exists for each therapy
- Commercial plans: Patient, prescriber and home provider will have to clear the patient's plan to assess if both EN and PN can be covered. There may or may not be a case manager to work with at the plan and a prior authorization may be required
- The payer may not cover a hospitalization for a trial or initiation of enteral feeding. Check to see if a "home trial" is possible with strong outpatient support
- If patient is weaning off PN and not in any danger of doing a trial at home, discontinue PN temporarily and monitor the EN trial and the patient's clinical status closely
- Some private insurers will not cover the cost of enteral formula but will cover enteral pump and supplies. Insurance and benefits should always be cleared prior to initiating therapy so the patient and family are clear on what the financial responsibility will be
- Medicaid or managed Medicaid plans: Every state is different. Again, benefits should be cleared with the patient's plan prior to initiating therapy to assure the patient will have full EN coverage and there will be a provider willing to take the patient's case

- Consider soliciting product donations from EN manufacturers for at least the trial period
- Oley Foundation Equipment/Supply Exchange Program: (oley.org/page/Equipment_Exchange), however, if shipping is involved, it costs a flat rate of ~$20/case
- Patient is willing to self-pay (for formula and supplies)

CONCLUSION

Clinicians should consider enteral feeding for SBS patients for the maintenance and/or improvement of nutritional status, improvement of residual bowel function (adaptation), freedom from a central line, and improvement of quality of life. EN therapy is not without risk, but it may be a viable, less costly alternative for some patients while minimizing the risks and complexity associated with central venous access and PN therapy. A carefully planned enteral trial often includes brief hospitalization, if covered, clinical monitoring, utilization of polymeric EN formulas, and judicious use of bowel slowing agents. A summary table of considerations when enterally feeding the adult SBS patient can be found in Table 3. ■

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