Chapter 59

Short Bowel Syndrome

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"Who needs such a long intestine, anyway?"
Moshe Dayan

CLINICAL IMPORTANCE

Short bowel syndrome is a malabsorptive state that may develop after massive resection of the small intestine (Vanderhoof and Langnas, 1997). Short bowel syndrome is an important clinical entity in people but is uncommon in dogs and cats. This difference probably reflects the relative frequency with which predisposing conditions occur. In people, the most common reasons for extensive bowel resection are inflammatory and neoplastic conditions in which the residual bowel is often compromised. In dogs and cats, a number of intestinal conditions may warrant the removal of large segments of the bowel, including linear foreign bodies, intussusception, volvulus, infarction, neoplasia, entrapment, gastrointestinal (GI) surgical site dehiscence and fungal infections. In many of these conditions, the remaining intestine is healthy. The syndrome is characterized by malabsorption due to lack of gut surface area resulting in diarrhea, malnutrition and weight loss. Short bowel syndrome may occur whenever large segments of the small intestine (≥50%) are excised surgically (Gorman et al, 2006; Yanoff and Willard, 1989; Yanoff et al, 1992; Pawlusiow and McCarthy, 1994; Williams and Burrows, 1981; Joy and Patterson, 1978; Feldman et al, 1976; Uchiyama et al, 1996). However, one retrospective study was unable to correlate the percentage of resected bowel with the development of short bowel syndrome (Gorman et al, 2006).

PATIENT ASSESSMENT

History and Physical Examination

Dogs with short bowel syndrome typically develop diarrhea one or more days after a large portion of the small bowel is resected (Gorman et al, 2006; Yanoff et al, 1992). The diarrhea may be intermittent or persistent. Stools range from soft, cowpie consistency to explosive, watery diarrhea. In longstanding cases, the patient may have weight loss, polyphagia and evidence of malnutrition.

Occasionally, patients present weeks to months after surgery with small bowel diarrhea, flatulence and borborygmus. A delayed onset of clinical signs is associated with small intestinal bacterial overgrowth, which can develop as a sequela to resection of the ileocolic valve. Physical examination findings are usually unremarkable. Body condition assessment may demonstrate poor condition (body condition score 1/5 or 2/5). Most patients are bright, alert and active with an increased appetite.

Laboratory and Other Clinical Information

Hematologic and biochemical findings are variable, often reflecting the underlying condition that led to the bowel resection. Hypoproteinemia and hypoalbuminemia may be present in long-term cases. Mild, normocytic, normochromic nonregenerative anemia may be recognized as a consequence of chronic disease. Patients in which the ileum has been resected

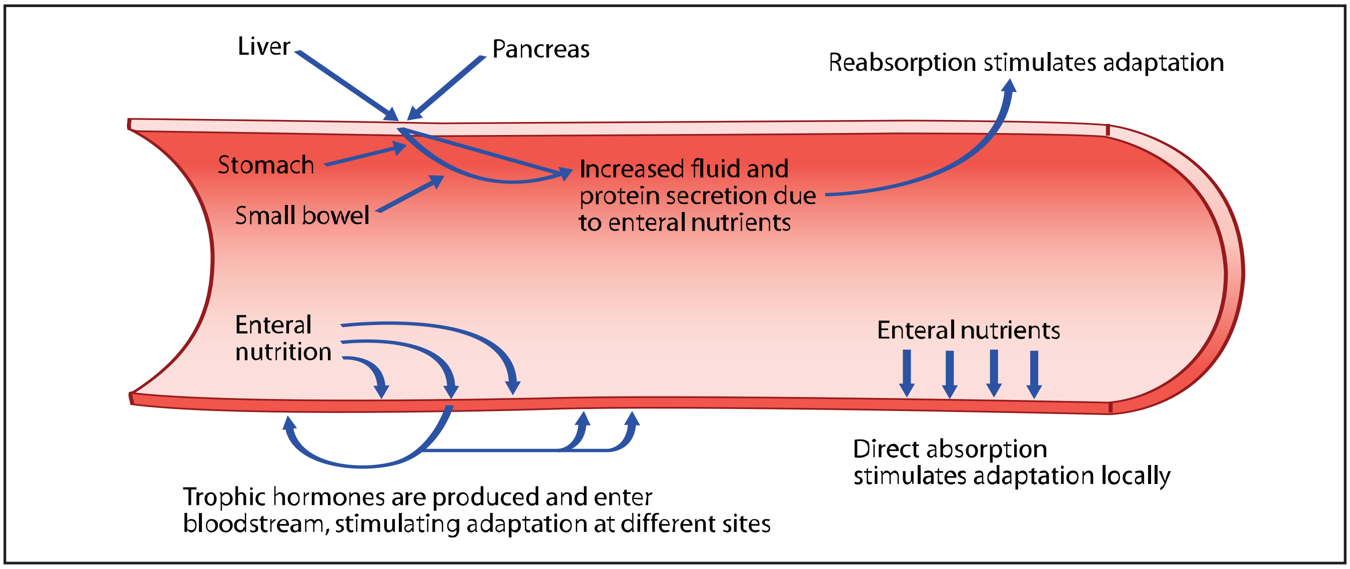

Figure 59-1. Schematic representation of the pathways by which enteral nutrients stimulate intestinal adaptation. (Adapted from Vanderhoff JA, Langnas AN. Short-bowel syndrome in children and adults. Gastroenterology 1997; 113: 1767-1778.)

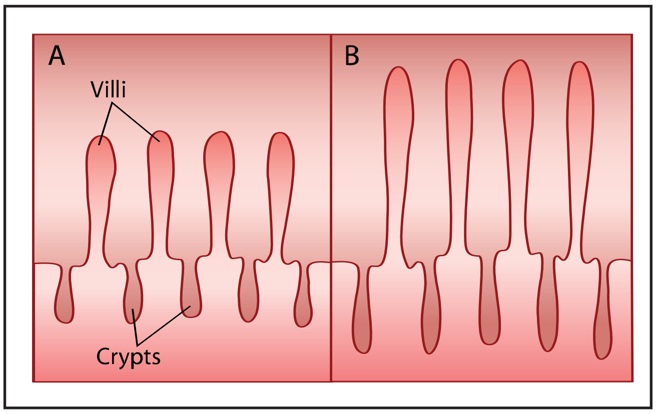

Figure 59-2. Diagrammatic comparison of normal (A) and adapted (B) gastrointestinal epithelium in patients with short bowel syndrome. Note the increased villous length and crypt depth. Increased muscle mass may also be observed. (Adapted from Vanderhoff JA, Langnas AN. Short-bowel syndrome in children and adults. Gastroenterology 1997; 113: 1767-1778.)

may have microcytic anemia consistent with that caused by cobalamin deficiency.

Radiographic findings are usually not helpful. Contrast films may demonstrate rapid transit of ingesta from the stomach to the colon. Contrast radiography can also be used to estimate the length of bowel remaining. In normal dogs, the small intestinal length is approximately four times the distance from the crown of the head to the rump. The percentage of small intestine remaining can be calculated by comparing the length of bowel remaining to this standard (Yanoff et al, 1992).

Risk Factors

Puppies and young adult dogs are most likely to suffer from GI conditions that may require extensive small bowel resection. Young cats, in particular, are at risk for linear foreign bodies (Gorman et al, 2006). GI conditions that may require resection include intestinal intussusception, volvulus, fungal infections (e.g., histoplasmosis), neoplasia and foreign bodies. Larger breeds, especially German shepherd dogs, are more likely to suffer from intussusception and mesenteric volvulus.

Etiopathogenesis

A surgeon may be faced with the need to resect a large portion of the small intestine in the management of a number of obstructive small intestinal diseases. Generally, as mentioned above, the potential for the syndrome exists any time 50% or more of the small bowel is resected. Remarkably, dogs with as little as 30 to 40 cm and cats with 18 to 20 cm of residual small intestine may achieve nutritional autonomy (Yanoff and Willard, 1989; Yanoff et al, 1992). Short bowel syndrome arises due to a lack of sufficient mucosal absorptive surface area. The reduced gut surface results in incomplete digestion and absorption of nutrients. Unabsorbed nutrients in the gut lumen lead to osmotic diarrhea. In addition, unabsorbed bile acids and fatty acids may result in secretory diarrhea in the large bowel.

Massive intestinal resection causes morphologic and functional adaptation in the remaining small bowel. Adaptation is stimulated by: 1) exposure to luminal nutrients, 2) endogenous GI secretions, 3) trophic effects of gut hormones, especially epidermal growth factor, enteroglucagon and gastrin, 4) intraluminal polyamines, 5) neural factors and 6) changes in blood flow to the remaining bowel (**Figure 59-1**) (Kouti et al, 2006; Chan and Klein, 1997). During adaptation, the intestine dilates and hyperplasia occurs in villi and crypts; however, the absorptive capacity of individual enterocytes does not change (Kouti et al, 2006; Williamson and Chir, 1978; Dowling, 1988). Therefore, the net increase in absorptive function in the remaining small bowel occurs because of increased total surface area.

In general, jejunal resections are tolerated better than removal of the ileum or the ileocolic valve. An intact ileum markedly enhances fluid, bile acid, cobalamin and electrolyte resorption. Loss of the ileocolic valve removes the physical barrier that separates the profuse bacterial flora of the colon from the relatively sparse population of the small bowel. Loss of the valve predisposes patients to development of small intestinal bacterial overgrowth or colonization of the remaining small bowel with bacterial pathogens.

Over time, the colon may begin to play an important role in maintaining nutritional homeostasis in patients with short bowel syndrome (Aghdassi et al, 1994; Nightingale et al, 1992). Following massive small bowel resection, colonic fermentation of malabsorbed carbohydrate may provide significant calories in the form of short-chain fatty acids. Short-chain fatty acids also promote mucosal hyperplasia. The mechanisms that lead to intestinal adaptation are not completely understood. However, a number of GI hormones including enteroglucagon, gastrin, cholecystokinin and secretin are involved, as are other pancreatobiliary secretions. Intraluminal foodstuffs including protein, protein hydrolysates, fats and glutamine stimulate release of these substances. Thus, intestinal adaptation appears to rely on exposure of the remnant bowel to intraluminal nutrients.

Intestinal adaptation is marked by enterocyte hyperplasia and increases in bowel diameter, villous height, crypt depth and number of enterocytes per length of the villous/crypt unit (**Figure 59-2**). Ideally, these physical changes will increase the bowel's absorptive capacity. Mucosal changes begin to occur within one to two days and can result in a fourfold increase in mucosal surface area within 14 days, if intraluminal nutrients are provided (Vanderhoof et al, 1992).

Key Nutritional Factors

Key nutritional factors for patients with short bowel syndrome are listed in **Table 59-1** and discussed in more detail below.

Table 59-1. Key nutritional factors for foods for dogs and cats with short bowel syndrome.*

Factors	Recommended levels
Digestibility	≥87% for protein and ≥90% for fat and digestible carbohydrate
Fat	12 to 15% for dogs 15 to 25% for cats
Fiber	≤5% (soluble or mixed fiber)
Carbohydrate	Lactose free
Food form	Dry foods are preferred due to slower gastric emptying vs. moist foods

*Nutrients expressed on a dry matter basis.

Digestibility

Because this is a malassimilative condition, highly digestible foods (fat and digestible [soluble] carbohydrate ≥90% and protein ≥87%) are recommended. The use of monomeric foods has been investigated in people with the syndrome; however, clinical evidence suggests that these foods are no more effective than polymeric foods (McIntyre et al, 1986). In addition, use of monomeric foods has been associated with villous atrophy (McIntyre et al, 1986; Levy et al, 1998). Polymeric foods are preferred because of their cost, palatability and trophic effects on the gut.

Fat

There are sound reasons for including fat in foods for dogs and cats with short bowel syndrome. Many patients with longstanding short bowel syndrome are underweight at the time of evaluation (Yanoff and Willard, 1989; Yanoff et al, 1992). Therefore, high-fat, energy-dense foods are recommended. Dogs and cats readily use most fats and oils of either animal or plant origin; therefore, fat should be included in the food for animals with short bowel syndrome up to the point of causing steatorrhea. Dietary fat levels of 12 to 15% dry matter (DM) in dogs and 15 to 25% DM in cats are often well tolerated. Intraluminal fat is probably the most influential nutrient in stimulating small bowel adaptation. Fat exerts profound effects on enterocyte growth, villous morphology, mucosal enzyme activity and segmental absorptive functions (Lentze, 1989). Fat also slows gastric emptying of digesta, which may better match the nutrient load to the compromised digestive capabilities of the shortened small bowel.

Replacing 50 to 75% of dietary fat with medium-chain triglycerides (MCT) has been reported to improve nutritional status in human patients with short bowel syndrome (Bochenek et al, 1970). Unfortunately, use of MCT in veterinary patients is limited due to cost, reduced palatability and poor GI tolerance. For these reasons, it is uncommon for MCT to be incorporated in excess of 30% of calories in homemade foods and 10% of calories in commercial foods. Whether MCT in foods are beneficial at these levels in veterinary patients is unknown.

Fiber

Although highly digestible foods are generally recommended for patients with short bowel syndrome, foods with moderate levels (10 to 15% DM) of insoluble fiber (e.g., cellulose) have been successfully used in refeeding patients with short bowel syndrome. Insoluble fiber included in foods at these levels is thought to help modulate intestinal motility and better control fecal water. Maintaining intraluminal bulk may stimulate the adaptive process through the release of GI trophic factors, including enteroglucagon, gastrin, cholecystokinin, secretin and other pancreatobiliary secretions.

Soluble fiber in foods may also benefit patients with short bowel syndrome by modulation of intestinal transit rate, absorption of intestinal water and production of short-chain fatty acids, which stimulate mucosal hyperplasia. Gel-forming fibers (e.g., pectins, gums) may slow gastric emptying rates (Russell and Bass, 1985; Prove and Ehrlein, 1982; Sandhu et al, 1987). Fermentable fiber supplementation (e.g., pectins, green banana) increases gut mass and colonic villous length, resulting in increased capacity for water reabsorption (Rabbini et al, 2001; Sales et al, 1998; Koruda et al, 1986). The most desirable approach is highly digestible, low-fiber foods with no more than 5% of a mixed fiber source DM. Mixed fiber sources include combinations of soluble (citrus and apple pectins and most gums) and insoluble (cellulose and peanut hulls) fiber

Table 59-2. Key nutritional factors in selected commercial veterinary therapeutic foods for dogs with short bowel syndrome compared to recommended levels.*

Dry foods	Protein digestibility (%)	Fat digestibility (%)	Carbohydrate digestibility (%)	Fat (%)	Fiber (%)**	Primary sources of fiber**	Lactose free (Yes/No)
Recommended levels	**≥87**	**≥90**	**≥90**	**12-15**	**≤5**	**–**	**Yes**
Hill's Prescription Diet i/d Canine	92	93	94	14.1	2.7	Cellulose, beet pulp	Yes
Iams Veterinary Formula Intestinal Low-Residue	na	na	na	10.7	2.1	Beet pulp	Yes
Medi-Cal Gastro Formula	na	na	na	13.9	1.9	Flax meal, pea fiber	Yes
Medi-Cal Low Fat Formula	na	na	na	6.6	5.2	Beet pulp, cellulose	Yes
Purina Veterinary Diets EN GastroENteric Formula	84.5	91.4	94.4	12.6	1.5	–	Yes
Royal Canin Veterinary Diet Digestive Low Fat LF 20	na	na	na	6.6	2.3	Beet pulp, cellulose	Yes
Royal Canin Veterinary Diet Intestinal HE 28	na	na	na	22.0	1.6	Beet pulp, psyllium husks	Yes

Moist foods	Protein digestibility (%)	Fat digestibility (%)	Carbohydrate digestibility (%)	Fat (%)	Fiber (%)**	Primary sources of fiber**	Lactose free (Yes/No)
Recommended levels	**≥87**	**≥90**	**≥90**	**12-15**	**≤5**	**–**	**Yes**
Hill's Prescription Diet i/d Canine	88	94	93	14.9	1.0	Soy fiber	Yes
Iams Veterinary Formula Intestinal Low-Residue	na	na	na	13.2	3.9	Beet pulp	Yes
Medi-Cal Gastro Formula	na	na	na	11.7	1.0	Oat bran, guar gum, flax meal	No
Medi-Cal Low Fat Formula	na	na	na	9.0	3.1	Cellulose, beet pulp, guar gum, carrageenan	Yes
Purina Veterinary Diets EN GastroENteric Formula	85.1	95.6	92.2	13.8	0.9	Gum arabic	Yes
Royal Canin Veterinary Diet Digestive Low Fat LF	na	na	na	6.9	3.0	Cellulose, guar gum	Yes
Royal Canin Veterinary Diet Intestinal HE	na	na	na	11.8	1.4	Oat bran, guar gum, carrageenan, flaxseed	No

Key: Fiber = crude fiber, na = information not available from manufacturer.
*Manufacturers' published values; nutrients expressed as % dry matter; dry foods are preferred because they have slower gastric emptying compared to moist foods.
**Foods with soluble or mixed fiber sources are best (see text).

sources or mixed fiber sources (rice, oat and wheat brans; soy fibers; soy hulls and beet pulp). Patients that have undergone ileal resection do not absorb bile acids well, which may cause secretory diarrhea. In such cases, dietary intake of mixed fibers may bind bile salts. Several manufacturers include small amounts of a mixed fiber source in their highly digestible foods intended for GI diseases. This is the most desirable option if it can be done without negatively affecting digestibility. Lower levels of fiber (≤5% [DM]) are generally recommended and facilitate high digestibility and higher energy density while providing the benefits described above.

Digestible Carbohydrate
The digestible carbohydrate fraction of the selected food should be highly digestible (≥90%). Lactose-containing ingredients should be avoided because extensive small bowel resection results in loss of lactase and other brush border disaccharidases.

Food Form
Dry foods may be preferred because they may increase gastric retention time; it takes longer to lower the digesta osmolality of dry foods compared to moist foods.

Other Nutritional Factors
Prebiotic Fibers
Fructooligosaccharides and other prebiotic fibers have been proposed for use in the management of dogs with small intestinal bacterial overgrowth and, therefore, may be useful in cases of short bowel syndrome in which the ileocolic valve has been resected. However, clinical evidence to support use of these ingredients remains sparse in dogs and cats.

Vitamins
Fat-soluble vitamins are malabsorbed in many canine and feline patients with steatorrhea. Although commercial foods are supplemented with fat-soluble vitamins, fat-soluble vitamins may need to be administered by intramuscular or subcutaneous routes until intestinal adaptation occurs and diarrhea resolves. It is simple and cost effective to administer 1 ml of a vitamin A, D and E solution,[a] divided into two intramuscular sites. This should supply fat-soluble vitamins for approximately three months. Vitamin K_1 at a dosage of 0.5 to 1 mg/kg subcutaneously is recommended if a vitamin K-responsive coagulopathy is suspected.

If the distal ileum has been surgically removed, cobalamin

Table 59-3. Key nutritional factors in selected commercial veterinary therapeutic foods for cats with short bowel syndrome compared to recommended levels.*

Dry foods	Protein digestibility (%)	Fat digestibility (%)	Carbohydrate digestibility (%)	Fat (%)	Fiber (%)**	Primary sources of fiber**	Lactose free (Yes/No)
Recommended levels	**≥87**	**≥90**	**≥90**	**15-25**	**≤5**	**–**	**Yes**
Hill's Prescription Diet i/d Feline	88	92	90	20.2	2.8	Cellulose, beet pulp	Yes
Iams Veterinary Formula Intestinal Low-Residue	na	na	na	13.7	1.8	Beet pulp	Yes
Medi-Cal Hypoallergenic/Gastro	na	na	na	11.5	3.1	Beet pulp, rice bran	Yes
Purina Veterinary Diets EN GastroENteric Formula	94.0	93.1	79.7	18.4	1.3	Cellulose	Yes
Royal Canin Veterinary Diet Intestinal HE 30	na	na	na	23.7	5.8	Cellulose, beet pulp	Yes

Moist foods	Protein digestibility (%)	Fat digestibility (%)	Carbohydrate digestibility (%)	Fat (%)	Fiber (%)**	Primary sources of fiber**	Lactose free (Yes/No)
Recommended levels	**≥87**	**≥90**	**≥90**	**15-25**	**≤5**	**–**	**Yes**
Hill's Prescription Diet i/d Feline	91	89	91	24.1	2.4	Beet pulp, cellulose, guar gum	Yes
Iams Veterinary Formula Intestinal Low-Residue	na	na	na	11.7	3.7	Beet pulp	Yes
Medi-Cal Hypoallergenic/Gastro	na	na	na	35.9	1.2	Cellulose, carrageenan, guar gum, flax meal	Yes
Medi-Cal Sensitivity CR	na	na	na	35.1	2.5	Cellulose, guar gum, carrageenan, carob gum	Yes

Key: Fiber = crude fiber, na = information not available from manufacturer.
*Manufacturers' published values; nutrients expressed as % dry matter; dry foods are preferred because they have slower gastric emptying compared to moist foods.
**Foods with soluble or mixed fiber sources are best (see text).

deficiency will develop because this portion of the bowel is solely responsible for B_{12} absorption. In such cases, parenteral supplementation of B_{12} is necessary. In dogs, cobalamin should be administered at 600 µg to 1 mg weekly for six weeks followed by injections every other week for six weeks then monthly doses until serum B_{12} levels normalize.[b] In cats, a dose of 250 µg weekly for four to six weeks is recommended. When short bowel syndrome is complicated by small intestinal bacterial overgrowth, bacterial uptake of vitamin B_{12} may exacerbate cobalamin deficiency.

Glutamine

Glutamine is the preferred fuel for enterocytes (Chan, 2006; Windmueller and Spaeth, 1974, 1978). Enteral administration of 2% glutamine solutions may benefit patients with short bowel syndrome (Frankel et al, 1993). Research in short-term (one-week) rat models has shown that adding glutamine to intravenous nutritional solutions reduces some aspects of disuse intestinal atrophy and enhances intestinal immune function (Burke et al, 1989; Alverdy et al, 1992; Jacobs et al, 1989). Glutamine administered intravenously for six to seven days prevents decreased intestinal weight, DNA content, villous height (O'Dwyer et al, 1989) and prevents decreased sucrase and lactase activities (Grant and Snyder, 1988) in adult rats fed parenterally. However, administering glutamine via foods (Vanderhoof et al, 1992a) and intravenous solutions (Remillard et al, 1998; Scott and Moellman, 1992) to research animals for more than one week was not shown to improve intestinal morphology. Glutamine may be a conditionally essential amino acid only during early periods of physiologic stress to stimulate DNA synthesis and increase mucosal mass early in recovery (Lacey and Wilmore, 1990). For example, rats undergoing abdominal radiation and fed glutamine orally the subsequent eight days had significant increases in jejunal villous numbers and height and an increase in the number of mitoses per crypt. Non-irradiated control rats fed the same glutamine-enriched food had no significant increase in mucosal cell activity (Klimberg et al, 1990). In one study performed in cats with methotrexate-induced intestinal injury, glutamine supplementation of a purified food failed to provide a benefit (Marks et al, 1996). Additional studies are needed to assess the benefits of glutamine supplementation in dogs and cats with GI disease including short bowel syndrome.

FEEDING PLAN

The goals of dietary and medical therapy for patients with short bowel syndrome are to provide adequate nutritional support during the period of intestinal adaptation and to stimulate adaptive changes that increase function in the remaining bowel segments. Diarrhea should be controlled as soon as possible because most pet owners will not tolerate persistent diarrhea. Changes required in the feeding management of short bowel syndrome are primarily determined by the function of the remaining small intestine. The feeding plan is often used in conjunction with medical therapy. (See below.)

Assess and Select the Food

Parenteral nutritional support is often required initially to meet nutritional, fluid and electrolyte needs as patients with short bowel syndrome recover from surgery. This is of particular benefit in situations in which the remaining intestine does not have normal function (e.g., infiltrative disease), in patients that have a low body condition score (1/5 to 2/5) at the time of surgery and in patients with complete or partial anorexia postoperatively. Reestablishing normal intestinal function and stimulating adaptation should begin as soon as the patient tolerates food enterally. Experimentally, intestinal adaptation did not occur in dogs with short bowel syndrome fed only parenterally (Feldman et al, 1976). Intestinal adaptation depends on using the remnant bowel, and not "bowel rest."

Parenteral administration of nutrients can be used in conjunction with enteral refeeding to meet the patient's requirements. The combination of continuous enteral nutrition through a feeding tube (nasoesophageal, esophageal, gastrostomy or enterostomy) and partial parenteral nutrition can be used in anorectic patients. A reduced fraction of the nutrient requirements (typically up to 30%) are given enterally, which provides nutrients and trophic factors for the adapting intestine. The remaining nutrient requirements are provided parenterally. This combination of feeding methods can be used in referral and primary care hospitals.

Continuous enteral nutrition consists of providing the calculated food volume at a constant rate over a prolonged period of time (12 to 24 hours). Studies in normal dogs and cats show that continuous enteral nutrition is well tolerated (Abood and Buffington, 1992; Chandler et al, 1996). Gravity drip, an intravenous infusion pump or an enteral feeding pump can be used to administer the food. The remaining nutrients are provided parenterally. Because only part of the patient's protein and caloric needs are being met parenterally, partial parenteral nutrition solutions are less hypertonic and may be administered through a peripheral vein (cephalic or saphenous) if less than 550 mOsm/l. This technique is less cumbersome and expensive than parenteral nutrition, which provides full caloric and protein needs, but requires central venous access. Partial parenteral nutrition may provide 30 to 70% of the patient's protein and caloric requirements assuming the remaining requirements are met through enteral nutrition. The solutions used in partial parenteral nutrition are similar to those used for parenteral nutrition, but more dilute glucose solutions are required. Providing 20% calories as glucose and 80% as lipid reduces the osmolality of the final solution and thus reduces endothelial irritation. Studies evaluating the use of partial parenteral nutrition demonstrate that complications are infrequent (Chan et al, 2002).

Refeeding should begin with a food that has the appropriate levels of key nutritional factors for patients with short bowel syndrome. **Tables 59-2** and **59-3**, provide the key nutritional factor content of selected veterinary therapeutic foods marketed for malabsorptive-type GI diseases in dogs and cats, respectively. These tables also include recommended levels of key nutritional factors for comparison. Appropriate formulations will be energy dense enough to meet the daily energy requirement of the patient in a reasonable volume of food and stimulate adaptation of remaining small bowel segments. Dry foods may be preferred because they may increase gastric retention time; it takes longer to lower the digesta osmolality of dry foods compared to moist foods (Chapter 54).

A liquid monomeric food containing glutamine and soluble fiber can be mixed with dry food during the first few days of recovery (Chapter 25). Such foods contain nutrients in readily absorbable forms and glutamine to fuel enterocyte hyperplasia.

Assess and Determine the Feeding Method

In contrast to feeding frequency commonly recommended for healthy animals (i.e., once or twice daily), patients with short bowel syndrome usually require multiple smaller meals per day to improve digestibility and prevent intestinal overload. Multiple (i.e., six to eight) small meals per day are recommended during the period of intestinal adaptation.

The amount of food may need to be increased to help animals regain or maintain ideal body condition. Aggressive nutritional support is recommended for patients with body condition scores less than 3/5. Additionally, supplemental parenteral feeding should be considered if the patient continues to lose weight despite consumption of what would normally be adequate calories. If parenteral support is used, infusion rates should be calculated to meet the patient's total caloric needs (Chapter 26). In some cases, total or partial parenteral nutritional support should be considered as an interim feeding method until the patient can meet its needs orally. Parenteral nutrition can be withdrawn gradually as intestinal function recovers and enteral feeding provides at least 70% of the patient's caloric needs. As mentioned above, intestinal adaptation did not occur in experimental dogs with short bowel syndrome when they were fed only parenterally (Feldman et al, 1976). Oral feedings or enteral infusions of glutamine-containing foods should continue throughout the parenteral feeding period to facilitate intestinal adaptation.

CONCURRENT MEDICAL THERAPY

Drugs commonly used in patients with short bowel syndrome include opiate antidiarrheal agents (e.g., loperamide, diphenoxylate), antibiotics (e.g., tetracycline, tylosin) and bile salt binding agents (e.g., cholestyramine, ursodeoxycholic acid). In addition, octreotide, a long-acting analogue of somatostatin (Nehra et al, 2001) has been recommended for use by some physicians in short bowel syndrome. This agent inhibits GI secretions and prolongs intestinal transit thus reducing diarrhea and fecal fluid loss. Glucagon-like peptide 2 has also been recommended due to its trophic effect on the GI mucosa (Jeppesen et al, 2001). The use of these compounds has not been investigated in veterinary patients with short bowel syndrome.

REASSESSMENT

Weekly determinations of body weight and condition and stool evaluations are useful for assessing dogs with short bowel syndrome. Medical therapies mentioned above should be considered if dietary therapy alone does not sufficiently improve stool quality and maintain body weight. Well-compensated patients should be evaluated immediately if a decline in body condition is noted. This presentation suggests concurrent GI disease or the onset of small intestinal bacterial overgrowth in dogs without an ileocolic valve.

The prognosis for recovery from short bowel syndrome is variable and cannot be based solely on the extent of resection (Gorman et al, 2006; Yanoff et al, 1992). The patient's preoperative condition, the functional integrity of the remnant bowel, degree of intestinal adaptation and the site of the resection are also important (Yanoff et al, 1992). For example, secondary complications (i.e., small intestinal bacterial overgrowth and large bowel diarrhea due to bile acid overload) may be avoided if the ileocolic valve can be preserved. In cases of surgical excision of intestinal neoplasia, adjuvant cytotoxic chemotherapy may be detrimental to remaining mucosa. In general, intestinal adaptation occurs in most dogs within one to two months and diarrhea may resolve in that time (Guilford and Strombeck, 1996). However, adaptation may continue for years; thus, stool quality may improve with time. In the meantime, the veterinarian and owner must work closely together to ensure optimal postoperative care.

ENDNOTES

a Vital E-A+D containing 100 IU of D and 300 IU of alpha-tocopherol per ml. Schering-Plough Animal Health Corp., Kenilworth, NJ, USA.

b. Steiner J. College of Veterinary Medicine, Texas A&M University, College Station, TX, USA. Personal communication. 2006.

REFERENCES

The references for **Chapter 59** can be found at www.markmorris.org.

CASE 59-1

Vomiting in a Labrador Retriever Crossbred Dog

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Patient Assessment

An 18-month-old neutered male Labrador retriever crossbred dog was examined for a 12-hour period of vomiting. The dog had no previous medical problems. The night before presentation, the dog ate a rawhide chew and began to vomit several hours later. The vomitus initially contained undigested food but then rapidly changed to a more liquid consistency. The dog weighed 22.3 kg (body condition score [BCS] 3/5) and was extremely depressed and weak. Rectal body temperature was 37.2°C (99°F). Mucous membranes were pale gray and the capillary refill time was three seconds. The heart rate was 180 beats/min. and femoral pulses were fair to poor. The dog's abdomen was tense and extremely painful. Significant clinical pathologic abnormalities included hyperglycemia (glucose 217 mg/dl, normal 65 to 110), thrombocytopenia (19.0 x 10^3/µl, normal 122 to 475) with clotting dysfunction (i.e., prolonged prothrombin time [8.7 sec., normal 4.5 to 7.6] and activated partial thromboplastin times [19.8 sec., normal 10.3 to 17.0]). Changes consistent with a small intestinal obstruction were apparent radiographically.

Exploratory celiotomy performed within two hours of presentation revealed a mesenteric volvulus involving the jejunum. Most of the jejunum was purple to black due to occlusion of mesenteric vessels. Resection of all questionable bowel was performed resulting in a final anastomosis of the remaining 10 cm of proximal jejunum to the ileum. The duodenum, pancreatic/bile duct, ileum and ileocecal junction were preserved.

Assess the Food and Feeding Method

The dog was normally fed a commercial dry grocery brand food (Purina Dog Chow[a]) once daily. Water was available free choice. Treats, snacks and table foods were given to the dog occasionally.

Questions

1. What preoperative, intraoperative and postoperative care is important for this dog?
2. What complications might occur subsequent to intestinal resection in this patient?
3. What are the key nutritional factors and feeding plan for this dog?

Answers and Discussion

1. Most dogs with mesenteric volvulus present in hypovolemic or endotoxic shock and therefore require immediate aggressive fluid therapy and broad-spectrum antibiotics preoperatively. Rapid surgical intervention is required in cases of small bowel obstruction. Intraoperative blood loss and hemorrhage due to coagulopathies may complicate recovery. Postoperative concerns include fluid losses, electrolyte imbalances, infection control and caloric intake. These problems can be addressed through aggressive fluid therapy, electrolyte replacement, continued broad-spectrum antibiotics and assisted feeding.
2. Short bowel syndrome often occurs when a large portion of the small intestine is removed, resulting in maldigestion and malabsorption causing diarrhea, steatorrhea, malnutrition and weight loss. The remaining length of small intestine will hypertrophy and absorptive capability will significantly increase; however, the functional capacity of the remaining intestine is difficult to predict and varies from case to case. Generally, complete adaptation takes months.
3. The key nutritional factors for this dog in the immediate postoperative days are water, electrolytes, energy (fat) and protein. Longer-term management of dogs with short bowel syndrome includes providing nutritional support to the patient until the intestine adapts, the diarrhea is controlled and weight can be maintained. A highly digestible food fed in small frequent feedings (i.e., six to eight meals/day) is recommended. Food characteristics should be individually modified to meet each patient's specific needs. Eventually, the patient may be fed its normal or similar food.

Progress Notes

The packed cell volume decreased to 19% during surgery; therefore, the dog was given one unit (500 ml) of packed red cells and one unit (50 ml) of fresh frozen plasma during surgery. Postoperatively, the dog had large amounts of bloody diarrhea, became hypoproteinemic and continued to have significant fluid losses through vomiting and diarrhea.

Crystalloid solutions supplemented with potassium were administered in quantities sufficient to meet fluid requirements and replace ongoing losses. The dog was given a parenteral mixture designed to meet daily fluid, electrolyte, resting energy and protein requirements. This mixture was administered via a peripheral catheter for the first five days after surgery (Chapter 26). After four days, the vomiting had resolved and a nasoesophageal tube (8 Fr.) was placed for a continuous infusion of a commercial liquid monomeric food (Peptamen[b]). This homogenized food contains protein, carbohydrates and fat in small, readily absorbable forms, has a caloric density of 1 kcal (4.2 kJ)/ml and contains glutamine. To meet the daily energy requirement of this dog, 720 ml of the monomeric food were infused via nasoesophageal tube continuously over 24 hours. This liquid food accounted for approximately 720 ml of the patient's daily water requirement, thus infusion of the intravenous crystalloid fluid was appropriately reduced.

After seven days in the hospital, the patient was discharged with instructions for the owner to feed a mixture of a commercial moist growth food (Science Diet Canine Growth[c]), the monomeric liquid food and small amounts of a moist high-fiber veterinary therapeutic food (Prescription Diet Feline r/d[c]). The moist growth food (521 kcal/can [2.18 MJ/can]) provided a nutrient-dense, highly digestible food to promote nutrient absorption and weight gain or maintenance. The monomeric food provided nutrients that were immediately absorbable with little or no digestion, and was to be used in decreasing amounts as the remaining small bowel adapted. Feline r/d (30% dry matter fiber) was used in small amounts to help control the diarrhea. Initially, the dog went home with instructions for the owner to feed 250 kcal (1.05 MJ) of the monomeric liquid food with each half can (260 kcal [1.09 MJ]) of the growth formula and to add 2 tbs of the high-fiber veterinary therapeutic food as needed to manage diarrhea. This mixture was offered every two to three hours for the first week and then less frequently as the dog tolerated larger meals. The proportions of these foods were varied over the next several weeks, depending on the dog's appetite, body weight and condition and stool quality.

The dog's body weight and condition declined initially; however, as stool quality gradually improved, the body weight and condition improved so that the dog was essentially normal eight weeks after surgery. The dog was fed the moist growth food only until its weight stabilized. After six months, the dog was fed a commercial dry maintenance-type food (Science Diet Canine Maintenance[c]) free choice. Four years postoperatively, the dog continued to do well, was maintaining a normal weight of 22.7 kg and body condition score (BCS 3/5) and had reasonably normal stools. The dog was fed two meals daily.

Endnotes

a. Ralston Purina Co., St Louis, MO, USA.
b. ClinTec, Chicago, IL, USA.
c. Hill's Pet Nutrition Inc., Topeka, KS, USA. These products are available under different names.

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