Implementing Dietary Modifications and Assessing Nutritional Adequacy of Diets for Inflammatory Bowel Disease

Nicolaus Nazarenkov, Kristina Seeger, MD, Lori Beeken, RD, Ashwin N. Ananthakrishnan, MBBS, MPH, Hamed Khalili, MD, MPH, James D. Lewis, MD, MSCE, and Gauree Gupta Konijeti, MD, MPH

Mr Nazarenkov is an undergraduate student at the University of California, Davis in Davis, California, and clinical research assistant to Dr Konijeti in the Division of Gastroenterology and Hepatology at Scripps Clinic in La Jolla, California. Dr Seeger is a clinical fellow, Ms Beeken is a registered dietitian, and Dr Konijeti is a gastroenterologist and director of the Inflammatory Bowel Disease Program in the Division of Gastroenterology and Hepatology at Scripps Clinic. Dr Ananthakrishnan is an assistant professor of medicine in the Division of Gastroenterology at Harvard Medical School and medical co-director at the Massachusetts General Hospital Crohn's and Colitis Center in Boston, Massachusetts. Dr Khalili is an assistant professor of medicine in the Division of Gastroenterology at Harvard Medical School. Dr Lewis is a professor of medicine and epidemiology, senior scholar in the Center for Clinical Epidemiology and Biostatistics, and associate director of the Inflammatory Bowel Disease Program at the Perelman School of Medicine at the University of Pennsylvania in Philadelphia, Pennsylvania.

Address correspondence to:
Dr Gauree G. Konijeti
Scripps Clinic, Division of Gastroenterology and Hepatology
10666 N. Torrey Pines Road
La Jolla, CA 92037
Tel: 858-554-8880
Fax: 858-554-8065
E-mail: konijeti.gauree@scrippshealth.org

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Abstract: Guidelines for dietary recommendations and nutritional therapy for patients with inflammatory bowel disease (IBD) are lacking, and patients are moving toward popular defined diets for relief of symptoms and inflammation. However, many proposed diets involve elimination of specific foods or food groups and may exacerbate or inadequately replete micronutrient deficiencies that are prevalent in patients with IBD at baseline. Further, limited data are available to guide clinicians on the use of dietary protocols for IBD. This article reviews dietary risk factors for IBD and common beliefs about diet among patients with IBD, and how these aspects may inform general dietary recommendations for this patient population. Additionally, this article reviews dietary interventions used in the management of active IBD, with a focus on whole food diet–based therapies rather than enteral or parenteral nutrition, as well as their nutritional adequacy. This article also highlights various dietary concepts and approaches among patients with IBD, along with the potential for nutritional inadequacy of popular defined diets for IBD. Partnerships with registered dietitians are needed to guide patients with IBD in nutrition and dietary intervention. Larger randomized studies are needed to support evidence-based dietary recommendations for IBD.

Inflammatory bowel disease (IBD), including Crohn's disease (CD) and ulcerative colitis (UC), is a chronic inflammatory disease of the intestine that can result in significant gastrointestinal symptoms, hospitalization, and surgery. Goals of therapy include corticosteroid-free clinical and endoscopic remission, which can help reduce the risk of flares, hospitalization, and surgery.[1] Despite diet being implicated in the pathogenesis of IBD, data are lacking regarding dietary recommendations that may reduce the risk of IBD. Further, limited data are available to guide the use of dietary therapy as either primary or adjunctive treatment for CD and UC.[2] Conventional medical therapy for IBD is increasingly relying on the use of targeted immunosuppressive drugs, yet response rates continue to remain suboptimal. Thus, there is an important need to study dietary factors that may not only help improve response to conventional

treatment, but also potentially be utilized as primary or maintenance therapy for patients with IBD. This article reviews dietary risk factors for IBD and common beliefs about diet among patients with IBD, as well as how these aspects may inform general dietary recommendations for these patients. This article also reviews dietary interventions used in the management of active IBD, with a focus on whole food diet–based therapies rather than enteral or parenteral nutrition, as well as their nutritional adequacy. Included in this article is an outline of key aspects of dietary change that are important for providers to understand and discuss with their patients. Often, diets are tried based on online information in conjunction with a naturopathic provider or dietitian, but not necessarily in coordination with a medical provider. Although dietary change can be useful, it is important to recognize the need for nutritional assessment to understand the impact of nutrition therapy.

Dietary Components as a Risk Factor for Inflammatory Bowel Disease

The first described cases of IBD were published in the 1850s, a time period following the Agricultural Revolution and paralleling the beginning of the Industrial Revolution in the Western world.[3] During this time, as the Western world developed, the incidence of CD and UC increased. These conditions now affect approximately 1.6 million Americans and 2 million Europeans.[3] Over the last century, the incidence of IBD has increased in newly industrialized, or developing, countries.[3] This rise in incidence similarly parallels their rapid urbanization, industrialization, and Westernization of culture. The global increase in incidence is not unique to IBD; the incidence of other autoimmune disorders, such as multiple sclerosis, asthma, and type 1 diabetes mellitus, has also increased in the past century.[4]

Societal advancement evolved a Westernized diet, which is also associated with the development of IBD.[5] A Westernized diet is characterized by higher intake of sugars, processed foods, and transunsaturated and saturated fats. It is also low in fruits, vegetables, fiber, and general nutrient density. Multiple epidemiologic studies have demonstrated that diets high in sugars, soft drinks, linoleic acid (ie, polyunsaturated omega-6 fatty acid), and processed meats and low in vegetables, fruits, fiber, omega-3 fatty acids, zinc, and vitamin D are associated with the development of IBD.[6-11] Aside from naturally occurring food components, additives such as emulsifiers and thickeners may also be associated with the development of colitis. Emulsifiers, which are natural or synthetic compounds found in processed foods, are designed to improve the viscosity, texture, and appearance of food. Depending on the type, emulsifiers may also serve as a preservative and prevent mold growth. Examples of synthetic emulsifiers include carboxymethylcellulose and polysorbate 80. An epidemiologic study suggested that the rising incidence of CD may be due to increased emulsifier consumption in foods and beverages.[12] Animal models examining in vivo effects of carboxymethylcellulose and polysorbate 80 identified colitis resulting from emulsifier-induced shifts toward proinflammatory bacteria, erosion of the mucous layer, reduced levels of short-chain fatty acids, altered bile acid levels, and increased fecal levels of lipopolysaccharide and flagellin.[13] Carrageenan, a naturally occurring polysaccharide derived from red seaweed, functions as an emulsifier, thickener, stabilizer, and gelling agent. Animal models suggest that carrageenan may induce colitis through monocyte aggregation, tumor necrosis factor α expression, and decreased abundance of anti-inflammatory bacteria; likewise, a recent randomized, controlled trial of 12 patients with UC in remission found that carrageenan intake contributed to earlier relapse.[14-16] Data are mixed regarding the effects of maltodextrin, a polysaccharide thickener, in IBD. An animal model suggests that maltodextrin-induced expansion of *Escherichia coli* strains and impairment of cellular antibacterial responses are associated with the development of CD,[17] whereas another animal model suggests maltodextrin may have anti-inflammatory and chemopreventive effects on the colon in conjunction with other supplements.[18]

Broad dietary recommendations for patients with IBD, or for patients wishing to potentially reduce the risk of IBD, are to follow a Mediterranean-style or anti-inflammatory diet. These diets emphasize nutrient density through consumption of fruits and vegetables (rich in antioxidants and polyphenols), lean proteins, healthy fats (eg, omega-3 fatty acids, olive oil), and whole grains (rather than refined grains). To avoid consumption of additives, one could also recommend a cleaner diet prepared predominantly from fresh ingredients rather than prepackaged foods. This cleaner diet also minimizes intake of refined sugars, emulsifiers, and other artificial ingredients. Although these general recommendations have not collectively been shown to reduce the risk of IBD, they are associated with a lower risk of obesity, cardiovascular disease, diabetes, and cancer, and are currently recommended by the US Department of Agriculture (USDA).[19-21] Support for dietary change should ideally come from a registered dietitian, who can also help to assess actual nutrient intake and discuss the role of supplements.

Assessment of Malnutrition

The World Health Organization characterizes malnutrition by inadequate or excess intake of protein, energy,

and micronutrients, and the resulting disorders or infections.[22] The American Society for Parenteral and Enteral Nutrition and the Academy of Nutrition and Dietetics advise assessing nutritional status in the context of acute or chronic illness, as well as in social and environmental circumstances, with a focus on energy intake and weight changes.[23] Anthropometric measurements through nutrition-focused physical assessments can be performed by registered dietitians as part of nutrition assessment, but are not required. Single measurements, such as albumin and body mass index, are not reliable measures of nutritional status.[24]

A simple tool to assess the risk of malnutrition is the Malnutrition Universal Screening Tool (MUST),[25] which can be utilized to determine whether further assessment or registered dietitian referral may be warranted. The MUST, developed for multidisciplinary use by the Malnutrition Advisory Group of the British Association for Parenteral and Enteral Nutrition, can be administered by any health care provider in a variety of clinical settings. The tool involves assessment of body mass index, unplanned weight loss in the past 3 to 6 months, and disease severity. In patients with IBD, the self-administered MUST performs essentially as well as when a health care provider performs screening (kappa, 0.85; 95% CI, 0.77-0.93).[26] Once patients are identified as being at risk for malnutrition, the Subjective Global Assessment (SGA)[27] can be performed by a clinician to assess nutritional status. The SGA evaluates gastrointestinal symptoms, functional capacity, physical signs of malnutrition (eg, loss of muscle mass or subcutaneous fat), and changes in dietary intake and body weight. Such measurements can be utilized to both address and monitor malnutrition.

Patients with IBD are at increased risk of malnutrition. Chronicity of disease, severity of inflammation, factors impacting digestion and absorption, complications of disease (eg, stricture, fistula, altered anatomy), and an inadequate or unbalanced diet are all risk factors for malnutrition in this patient population. Malnutrition is also more common among hospitalized patients with IBD (6%-7%) than those without IBD (1%-2%).[28] Indeed, malnutrition increases the risk of hospitalization and is associated with longer hospital stays.[29] It is also associated with an increased risk for infection, venous thromboembolism, nonelective surgery, and mortality.[30,31]

Patient Perceptions of Diet

Patients' dietary perceptions can play an important role in their resultant nutritional status. A majority of patients believe that food causes IBD relapse.[32] Foods associated with worsened symptoms include vegetables, spicy foods, nuts, fried foods, red meats, sodas, dairy/milk, alcohol, high-fiber foods, beans, seeds, and coffee.[33] Foods that appear to be better tolerated include yogurt, rice, and banana. Often, dietary patterns differ by IBD subtype (ie, CD or UC), disease activity, and history of surgery.[33] With respect to gluten, cohort studies have reported that 5% to 27% of patients with IBD have self-reported nonceliac gluten sensitivity, and 8% to 15% actively follow a gluten-free diet.[34,35] This is despite most patients with IBD not having concomitant celiac disease.[35] However, 66% of patients with IBD attempting a gluten-free diet reported improvement in gastrointestinal symptoms, raising questions as to whether these patients may have nonceliac gluten sensitivity.[34]

Deficiencies of Macronutrients and Micronutrients in Inflammatory Bowel Disease

Self-imposed dietary restrictions among patients with IBD are often associated with insufficient nutrient intake, which can contribute to both macronutrient and micronutrient deficiencies. A study of 78 patients with inactive or mild CD, compared with 80 non-IBD controls, identified inadequate nutrient intake due to exclusion of various food groups, particularly grains, milk, and vegetables.[36] More than one-third of patients with CD had a body mass index greater than 25, indicating a coexistence of malnutrition with obesity, likely due to corticosteroid use and physical inactivity.[36] Food avoidance is also common in children with IBD and may result in lower energy intake and higher rates of growth failure compared with the general population.[37] Micronutrient deficiencies commonly identified in patients with IBD include iron, vitamin B12, vitamin D, and zinc.[38] Calcium, vitamin A, folic acid, potassium, magnesium, copper, and selenium are less common, but may occur with extensive small bowel disease or small bowel resection. Consequences of deficiencies include fatigue, neurologic effects, muscle cramps, delayed growth, anemia, and calcium or bone homeostasis. As such, identification and repletion of micronutrients are critical and may contribute to patients' overall well-being.

Fiber Intake

There is substantial interest in fiber, as it serves as a prebiotic and is believed to have multiple potential benefits related to reductions in inflammation, colon cancer risk, blood sugar, and cholesterol. Perhaps one of the main benefits of dietary fiber occurs when it is fermented by certain colonic bacteria (ie, *Bifidobacteria*), resulting in the formation of short-chain fatty acids, which are

a main energy source for mucosal cells throughout the large intestine.[39] In a randomized study comparing a low-residue diet with a regular diet in patients with non-stenosing CD in remission, no difference in risk of relapse or obstruction was observed.[40] A cohort study including 1130 patients with CD and 489 patients with UC, all in remission and followed for 6 months, found a 40% reduction in the risk of flare among patients with fiber intake greater than 23 g/day compared with patients with fiber intake less than 10 g/day.[41] In addition, 30% of patients with CD who avoided high-fiber foods were more likely to flare.[41] Although data are limited, research does not support avoidance of fiber in the absence of a symptomatic intestinal stricture.

One recommendation is to focus on soluble fiber intake rather than intake of insoluble fibers, particularly when fiber is being incorporated into the diet. Soluble fiber dissolves or swells when it is combined with water, slowing intestinal transit, adding bulk, and softening stool, as well as helping to lower cholesterol levels. Examples of soluble fiber include oat and rice bran, beans, lentils, psyllium, barley, flax and chia seeds, and some fruits and vegetables, such as banana, avocado, applesauce, and carrot. When soluble fiber is initially incorporated into the diet, it is recommended to gradually increase fiber intake (by 2-3 grams no more than every 3-4 days) to reduce the risk for potential obstruction. Insoluble fibers do not dissolve or absorb water, and, therefore, act as bulking agents aiding in peristalsis and accelerating gastrointestinal transit. Examples of insoluble fiber include wheat bran, whole grain breads and cereals, and some fruits with skins and raw, dark green, leafy or root vegetables.

Dietary Interventions for Patients With Active Inflammatory Bowel Disease

Patients with CD and UC are increasingly turning to popular defined diets in the hopes of minimizing symptoms and, ideally, underlying inflammation. Many proposed diets involve single food exclusions or more complex dietary elimination protocols, and may exacerbate or inadequately replete micronutrient deficiencies. The rationale behind these diets is to avoid unique foods or food groups and additives that may, through their antigenic, proinflammatory, or osmotic effects, result in impaired epithelial barrier integrity, dysbiosis, intestinal inflammation, and/or symptomatic food intolerance.[13,42,43] These diets generally emphasize a nutrient-dense diet, consisting of fresh rather than processed foods, but are characterized by unique features in their approach.

Several variations of diets for the management of active IBD have been studied to date: the Specific Carbohydrate Diet (SCD),[44-49] the autoimmune protocol (AIP) diet,[50] the Crohn's disease exclusion diet with or without partial enteral nutrition (CDED ± PEN),[51,52] the low–fermentable oligosaccharide, disaccharide, monosaccharide, and polyol (FODMAP) diet,[53-55] the IBD–anti-inflammatory diet,[56] and the CD treatment-with-eating diet[57] (Table 1). There are no published data on the efficacy of dietary recommendations for IBD from the Crohn's & Colitis Foundation, or on the Gut and Psychology Syndrome (GAPS) diet. Table 1 broadly outlines foods and food groups that are eliminated and allowed on each protocol, the usual duration of elimination and maintenance phases, and a summary of available published data. A complete outline of foods that are allowed or not for each diet, as well as available data regarding each protocol, is available through the original studies.[45,50,56-59]

Fourteen studies were identified that examined the effects of dietary intervention for patients with active IBD[44-57] (Table 1). The majority of studies were observational, whether retrospective or prospective; only 1 study (on the low-FODMAP diet) was conducted as a randomized, controlled trial.[55] Study sizes ranged from 5 to 78 patients with IBD. Elimination phases ranged from 2 to 12 weeks, with maintenance phases lasting at least 5 weeks or remaining undefined. Clinical response or remission rates ranged from approximately 40% to 80% across all diets, and only a limited number of studies examined the effects of dietary change on biomarkers and mucosal healing.

Common themes related to the elimination of gluten or grains, dairy, processed foods, artificial ingredients, and additives are seen across the diets, with a focus on nutrient density and variations in specific food groups and texture. Overall, the data suggest that diet can be used as an adjunct or as a substitute to therapy, and can modify symptoms to help achieve and maintain remission. Longitudinal follow-up data, along with larger randomized studies, are needed to fully understand whether such modification is altering symptoms, inflammation, or both in any individual patient.

Nutritional Adequacy of Popular Defined Diets for Active Inflammatory Bowel Disease

At present, data on dietary modification for active IBD are limited. General themes of elimination suggest that dietary change can impact symptoms and inflammation, although larger studies are needed. Further, a population with IBD is already likely to have nutrient deficiencies at baseline that require repletion; therefore, it is important to evaluate how these diets compare with respect to nutritional adequacy to avoid potentially exacerbating nutrient deficiency. The Dietary Reference Intake[60] is a

Table 1. Dietary Interventions for Patients With Active IBD

Foods/Food Groups Eliminated/Allowed	Study Design[a] and Aim	Patient Population	Study Results
SCD			
Eliminated: all grains, most dairy, refined sugars, canned or processed meats, packaged foods, soy, certain legumes, starches (potatoes, yams), starchy or canned fruits or vegetables, canola oil ***Allowed:*** select fruits and vegetables (not canned), unprocessed meats, eggs, monosaccharides (eg, honey), yogurt, aged cheeses, fruits and fruit juices without additives, nuts, specific legumes, animal meats	Retrospective study; assess endoscopic and histologic findings in pediatric CD patients pre- and post-SCD[49]	7 asymptomatic patients (<18 years old) with CD; FC >50 μg/g	Median duration of SCD, 26 months; complete endoscopic mucosal healing not observed in any patient
	Retrospective survey; examine utilization and perception of efficacy of SCD[48]	417 patients; 47% CD, 43% UC, 10% indeterminate colitis; age range, 1.5-70 years	42% reported CR at 6 and 12 months
	Prospective uncontrolled study; determine efficacy of SCD up to 12 weeks in pediatric IBD patients[47]	12 patients (<18 years old) with mild to moderate IBD (PCDAI, 10-45 or PUCAI, 10-65)	CR in 80% at 12 weeks. Decrease in mean PCDAI (28.1 ± 8.8 to 4.6 ± 10.3), mean PUCAI (28.3 ± 23.1 to 6.7 ± 11.0), and CRP at 12 weeks
	Retrospective study; evaluate effects of SCD on clinical outcomes in pediatric IBD patients[46]	26 patients (<18 years old); 20 with CD, 6 with UC	CD: decrease in PCDAI from 32.8 ± 13.2 to 8.8 ± 8.5 by 6 months UC: decrease in PUCAI from 28.3 ± 10.3 to 18.3 ± 31.7 by 6 months
	Retrospective study; evaluate SCD for maintenance of remission in pediatric CD patients[44]	11 patients (<18 years old) with CD	Mean time for liberalization of diet from strict SCD, 7.7 ± 4.0 months. Weight, height, hematocrit, albumin, and ESR improved on strict SCD; laboratory values remained stable but small loss in weight percentile after liberalization
	Prospective uncontrolled study; evaluate clinical and mucosal responses to SCD in pediatric CD patients[45]	9 patients (<18 years old) with active CD (PCDAI ≥15)	At 12 weeks: decrease in HBI (3.3 ± 2.0 to 0.6 ± 1.3), PCDAI (21.1 ± 5.9 to 7.8 ± 7.1), and Lewis score (2153 ± 732 to 960 ± 433). At 52 weeks, 7 patients remained on SCD, and HBI, PCDAI, and Lewis score remained improved; 2 patients had sustained mucosal healing.
AIP diet			
Eliminated: grains, legumes, dairy, refined and processed sugars and oils, eggs, nuts, seeds, nightshades, alcohol, NSAIDs, nonnutritive sweeteners, emulsifiers, thickeners, other food additives ***Allowed:*** foods that are nutrient-dense with incorporation of bone broth and fermented foods	Prospective uncontrolled study; evaluate clinical and endoscopic response to AIP diet in patients with active IBD[50]	15 adult patients with active IBD (HBI ≥5; partial Mayo clinic score ≥3) and active disease by endoscopy/imaging or FC >50 μg/g	73% of patients achieved CR by week 6 and sustained through week 11. At weeks 6 and 11, partial Mayo score improved from 5.8 to 1.2 and 1.0, respectively; HBI improved from 7 to 3.6 and 3.4, respectively. Mean FC improved (471 μg/g to 112 μg/g) at week 11. Endoscopy: 6/7 patients who underwent pre- and post-AIP endoscopy at week 11 had endoscopic improvement.

(Table continued on next page)

Table 1. *(Continued)* Dietary Interventions for Patients With Active IBD

Foods/Food Groups Eliminated/Allowed	Study Design[a] and Aim	Patient Population	Study Results
CDED ± PEN			
Eliminated: gluten, dairy, soy, animal fats, processed meats, emulsifiers, canned goods, packaged products, coffee, chocolate, alcohol ***Allowed:*** foods may be grilled, fried, baked, boiled, or broiled; select fruits and vegetables, eggs, chicken, fish, beef, spices	Prospective uncontrolled study; assess outcomes of 12-week treatment with CDED + PEN in CD patients[51]	21 patients (11 adults, 10 children) with CD, with loss of response to biologic therapy or combination therapy	At 6 weeks: 61.9% achieved CR. Mean HBI decreased from 9.4 ± 4.2 to 2.6 ± 3.8, with decreases in CRP and increases in albumin.
	Prospective uncontrolled study; assess outcomes of 6-week treatment with CDED ± PEN in active CD patients[52]	47 patients with active CD (PCDAI >7.5 or HBI ≥4); mean age, 16.1 ± 5.6 years	At 6 weeks: 70.2% achieved CR. Mean PCDAI decreased from 27.7 ± 9.4 to 5.4 ± 8; HBI decreased from 6.4 ± 2.7 to 1.8 ± 2.9. CRP normalized in 70%. CR achieved in 6/7 patients using CDED without PEN
Low-FODMAP diet			
Eliminated: fermentable oligosaccharides (fructose and galacto-oligosaccharides), disaccharides (lactose), monosaccharides (fructose), polyols (sorbitol, mannitol, maltitol) ***Allowed:*** lactose-free products; hard cheeses; gluten/wheat-free grains; meats; certain teas, coffees, and alcohol; limited nuts; some packaged or processed foods	Randomized, controlled, open-label trial; compare low-FODMAP diet to normal diet in IBD patients for 6 weeks[55]	89 patients randomized, 78 completed study; adults with IBD in remission or with mild to moderate disease and coexisting IBS-like symptoms	Response higher with low-FODMAP diet (81%) than normal diet (46%). Low-FODMAP diet group showed lower median IBS-SSS and a greater increase in SIBDQ compared to normal diet group.
	Retrospective study; examine efficacy of low-FODMAP diet in patients with IBD[54]	72 adult patients (52 CD, 20 UC) with predominantly functional gastrointestinal symptoms	70% dietary adherence. 50% of patients responded (improvement of ≥5/10 symptoms, including abdominal pain, bloating, gas, and diarrhea). Constipation did not improve.
	Combined retrospective/prospective study; examine efficacy of low-FODMAP diet in patients with IBD with ileal pouch or ileorectal anastomosis[53]	15 patients with IBD (13 ileal pouch, 2 ileorectal anastomosis) with increased stool frequency and/or nocturnal bowel movements	Retrospective data: 5/7 patients improved stool frequency (median 8/day to 4/day). Prospective data: 5/8 patients completed study; 1 improved stool frequency, 1 decreased gas. No improvement in 8 patients with pouchitis. Median stool frequency decreased from 8/day to 4/day in 7 patients without pouchitis.
IBD-AID			
Eliminated: trans fats, refined sugars, most grains, fast foods, processed foods, most dairy ***Allowed:*** flax, chia, oats, yogurt, kefir, certain cheeses, lean meats, poultry, fish, omega-3 eggs, select fruits and vegetables, nut and legume flours, miso and other cultured products (rich with certain probiotics), soluble fibers	Retrospective study; examine efficacy of IBD-AID in IBD patients[56]	40 adults with IBD with failure of drug treatment, persistent symptoms, or reluctance to proceed with other options	60% of patients with response (unclear timeline, but on diet for ≥4 weeks). Average decrease in HBI was 9.5, and in MTLWSI was 7.

(Table continued on next page)

Table 1. *(Continued)* Dietary Interventions for Patients With Active IBD

Foods/Food Groups Eliminated/Allowed	Study Design[a] and Aim	Patient Population	Study Results
Gut and Psychology Syndrome diet			
Eliminated: processed foods, grains, dairy, starchy vegetables ***Allowed:*** fresh meats, animal fats, fish, eggs, fermented foods, vegetables	No data found	No data found	No data found
CD-TREAT diet			
Eliminated: gluten, lactose, alcohol ***Allowed:*** macronutrients, vitamins, minerals, and fibers matching EEN as close as possible; maltodextrin (high-starch, low-fiber foods); micronutrients (multivitamin tablets)	Open-label trial in pediatric patients with active CD; examine exclusive use of CD-TREAT diet[57]	5 pediatric patients with mild to moderate active luminal disease (PCDAI range, 22.5-42.5)	Week 4: 60% of patients had clinical response (PCDAI change, >17.5) and 40% achieved CR (PCDAI <12.5). Week 8: 80% of patients had clinical response and 60% achieved CR.

AIP, autoimmune protocol; CD, Crohn's disease; CDED ± PEN, Crohn's disease exclusion diet with or without partial enteral nutrition; CD-TREAT, Crohn's disease treatment-with-eating; CR, clinical remission; CRP, C-reactive protein; EEN, exclusive enteral nutrition; ESR, erythrocyte sedimentation rate; FC, fecal calprotectin; FODMAP, fermentable oligosaccharide, disaccharide, monosaccharide, and polyol; HBI, Harvey-Bradshaw Index; IBD, inflammatory bowel disease; IBD-AID, IBD–anti-inflammatory diet; IBS, irritable bowel syndrome; IBS-SSS, IBS severity scoring system; MTLWSI, Modified Truelove and Witts Severity Index; NSAID, nonsteroidal anti-inflammatory drug; PCDAI, pediatric Crohn's disease activity index; PUCAI, pediatric ulcerative colitis activity index; SCD, Specific Carbohydrate Diet; SIBDQ, short IBD questionnaire; UC; ulcerative colitis.

[a]The durations of elimination and maintenance phases were based on study designs. SCD, elimination: 12 weeks, maintenance: varied; AIP diet, elimination: 6 weeks, maintenance: 5 weeks; CDED ± PEN, elimination: 6 weeks, maintenance: 6 weeks; low-FODMAP diet, elimination: 2-8 weeks, maintenance: 8 weeks; IBD-AID, elimination: not defined, maintenance: not defined; Gut and Psychology Syndrome diet, elimination: not defined, maintenance: not defined; CD-TREAT diet, elimination: 8 weeks, maintenance: not defined.

collection of reference values from the Institute of Medicine that assesses nutrient intake. A comparison of the Dietary Reference Intake was made among the following dietary protocols for patients with IBD: SCD, AIP diet, CDED ± PEN, low-FODMAP diet, IBD–anti-inflammatory diet, and GAPS diet. Of note, the GAPS diet was included based on patient usage. In addition to these diets, the nutritional adequacy of the USDA General Recommendations[19] (modified according to recommendations from the Crohn's & Colitis Foundation[61] for IBD and the USDA–Crohn's & Colitis Foundation) was examined. Typical macronutrient and micronutrient intake with such diets was calculated and compared using published sample menus[52,61-66] for hypothetical 35-year-old men and women with IBD (Table 2).[67] For an average 35-year-old man or woman, most of the published and/or popular dietary protocols previously discussed adequately met macronutrient requirements, except fiber. Daily caloric range was 1543 to 2577 kcal. All diets were sufficient in vitamin B12. Iron intake was generally adequate for men (6/8 diets) but inadequate for women (1/8 diets). Most diets (7/8) failed to meet the Dietary Reference Intake for vitamin D and calcium, while at least 3/8 were deficient in omega-3 fatty acids and zinc. A recent study by Hartman and colleagues[68] found similar results for children and adolescents with IBD; based on the Recommended Daily Allowance, intake of calories, carbohydrates, magnesium, fiber, calcium, and other vitamins was inadequate compared with healthy children.

From a practical standpoint, evaluating and managing nutrition in patients with IBD can start with the assessment of nutritional status and micronutrient deficiencies, and the recommendation of supplementation based on medication (Table 3). In the setting of active IBD or flare, the acute-phase response due to inflammation can increase positive acute-phase proteins, such as C-reactive protein, ferritin, and fibrinogen, and decrease

negative acute-phase proteins, such as albumin, prealbumin, transthyretin, and retinol-binding protein.[69] Changes in the concentration of intravascular binding proteins due to inflammation, clearance, or losses can also affect measured micronutrient levels. Therefore, it is best to assess for micronutrient deficiency when patients are in remission rather than during active disease or flare. Iron deficiency may be assessed during active IBD. A recent Crohn's & Colitis Foundation care pathway for anemia in patients with IBD supported the use of a higher threshold for ferritin (<100 ng/mL, or ≥100 ng/mL and transferrin saturation <20%) for defining iron deficiency anemia in the setting of inflammation.[70]

Recommendations for Patients Wishing to Try Dietary Modification

Elimination diets can be effective in abating the signs and symptoms of active inflammation in patients with IBD. Although the concept of a complete dietary upheaval can be daunting, the immediate positive response from establishing a (somewhat) clean slate can allow patients to stick with a specific dietary regimen. The key aspect of an elimination diet resides on the fact that the initial strict elimination phase is meant to be brief, typically 2 to 12 weeks in duration, in an effort to reduce any evidence of toxifying elements and mucosal inflammation. Prolonged strict elimination has the potential to put the patient at risk for numerous nutritional deficiencies, namely calcium, vitamin D, iron, zinc, vitamin B12, folate, and protein. Additionally, risk for orthorexia, obsessive behavior in the pursuit of a healthy diet, may be prominent in this population with such steadfast adherence to these restrictive diets in an effort to improve quality of life.

It is important to partner with a registered dietitian to allow for close monitoring throughout the different phases of an elimination diet or during any significant dietary modification to establish individualized nutrition therapy based on comorbidities, ensure adequate nutrient intake, and adjust for anatomic changes due to surgical intervention and other disease complications, such as strictures or fistulas.

Sifting through the specifics of individualized diet regimens can be cumbersome and time-consuming. When advising patients on a specific diet, it may be helpful to keep in mind the severity of the patient's current clinical condition and degree of malnutrition prior to diet initiation, the patient's readiness or willingness to adhere to a specific diet and his or her level of commitment, the feasibility of the diet itself (eg, access to specialty foods, lifestyle considerations, and food preparation constraints or limitations), and the use of a registered dietitian to provide individualized meal planning and address the patient's questions and concerns as they may arise throughout the different stages of diet therapy.

All patients with IBD should be assessed for nutritional status. Ideally, micronutrient assessment should be performed during times of inactive disease, as the inflammatory response during active disease can alter micronutrient levels, making interpretation of such results challenging. Continued follow-up is recommended with assessment of nutritional status and regular laboratory monitoring for micronutrient deficiencies.

Dietary Interventions Based on Inflammatory Bowel Disease Activity

For patients in remission, dietary modification may not be necessary, but management may include assessment of any dietary modifications patients may already be doing and education on the importance of a Mediterranean-style, healthy, nutrient-dense diet. For patients with mild IBD, dietary change may potentially be appropriate with or without medications.[71] Regular follow-up is advised to monitor for ongoing or progressive disease activity that may necessitate a change in therapy. Follow-up should include assessing the extent and severity of bowel inflammation. For patients with moderate to severe IBD, dietary change may be appropriate, typically as an adjunct to IBD-specific therapy, to reduce the risk of ongoing disease and/or complications. Regular follow-up is advised to monitor for ongoing or progressive disease activity that may necessitate a change in therapy.

Outpatient Dietary Suggestions During Inflammatory Bowel Disease Flares

During IBD flares, the following dietary suggestions can help to improve the nutrient density of dietary intake and minimize exacerbating the risk for micronutrient deficiency. In the setting of decreased oral intake and/or increased fluid losses through diarrhea and bleeding, patients should be advised to ensure adequate hydration (consider electrolyte-based fluids, which would improve volume repletion). Systemic inflammation increases protein requirements to 1.2 to 1.5 g/kg/day.[72] Therefore, patients should also consider supplementing with protein shakes and/or bone broth unless oral nutritional therapy using a dietary protocol is pursued for primary management (in which case, protein requirements can be met through diet and/or supplements, depending on the protocol). Dairy may not be well tolerated in the setting of a flare, potentially due to gas and/or diarrhea. Protein supplements based on other sources such as peas, soy, eggs, and nuts, for example, may be better tolerated.

In the setting of an IBD flare, it would also be reasonable to consider one of the elimination diets described,

Table 2. Dietary Reference Intake Among Dietary Protocols for IBD

Case 1: 35-year-old man; 5'10"; 170 lbs; BMI, 24.3; lightly active											
Diet	**Calories**	**Protein (%)**	**Carbs (%)**	**Fat (%)**	**Fiber (%)**	**Iron (%)**	**Vitamin D (%)**	**Vitamin B12 (%)**	**Calcium (%)**	**Omega-3 Fatty Acids (%)**	**Zinc (%)**
Estimated needs[a]	2350 kcal	56 g	130 g	65 g	38 g	8 mg	600 IU	2.4 µg	1000 mg	1.6 g	11 mg
USDA–Crohn's & Colitis Foundation[b]	1967	232	164	112	74	229	22	337	142	47	95
AIP diet	1543	214	101	100	83	186	6	170	68	27	96
SCD	1743	183	149	101	37	88	18	276	61	31	110
CDED without PEN	1836	182	131	134	57	123	97	238	27	294	58
CDED with PEN	2577	230	193	189	57	213	144	288	36	294	123
IBD-AID	1902	193	162	125	117	137	6	134	82	41	65
Low-FODMAP diet	1814	155	158	105	42	85	39	128	65	73	62
GAPS diet	2186	214	104	209	66	150	64	207	48	194	89
Case 2: 35-year-old woman; 5'6"; 140 lbs; BMI, 22.5; lightly active											
Diet	**Calories**	**Protein (%)**	**Carbs (%)**	**Fat (%)**	**Fiber (%)**	**Iron (%)**	**Vitamin D (%)**	**Vitamin B12 (%)**	**Calcium (%)**	**Omega-3 Fatty Acids (%)**	**Zinc (%)**
Estimated needs[a]	1862 kcal	46 g	130 g	65 g	25 g	18 mg	600 IU	2.4 µg	1000 mg	1.1 g	8 mg
USDA–Crohn's & Colitis Foundation[b]	1967	283	164	112	112	102	22	337	142	69	131
AIP diet	1543	260	101	100	127	83	6	170	68	40	131
SCD	1743	222	149	101	57	39	18	276	61	45	151
CDED without PEN	1836	222	131	134	86	55	97	238	27	428	80
CDED with PEN	2577	279	193	189	86	95	144	288	36	428	170
IBD-AID	1902	235	162	125	178	61	6	134	82	59	90
Low-FODMAP diet	1814	189	158	105	64	38	39	128	65	106	85
GAPS diet	2186	261	104	209	101	66	64	207	48	282	123

AIP, autoimmune protocol; BMI, body mass index; carbs, carbohydrates; CDED, Crohn's disease exclusion diet; FODMAP, fermentable oligosaccharide, disaccharide, monosaccharide, and polyol; GAPS, Gut and Psychology Syndrome; IBD, inflammatory bowel disease; IBD-AID, IBD–anti-inflammatory diet; PEN, partial enteral nutrition; SCD, Specific Carbohydrate Diet; USDA, US Department of Agriculture.

[a]Estimated needs for calories are determined by the Mifflin-St Jeor energy equation[67] assuming light activity level. Estimated needs for macronutrients and micronutrients are based on the Dietary Reference Intake.[60]

[b]USDA General Recommendations modified according to Crohn's & Colitis Foundation recommendations for IBD.

Table 3. Clinical Practice Pointers to Assess Nutrition Among Patients With Inflammatory Bowel Disease

Assess nutritional status, dietary intake, and nutritional adequacy based on disease activity.
• Partner with a registered dietitian, if possible. • The Malnutrition Universal Screening Tool is a simple method to assess risk of malnutrition. • The Subjective Global Assessment can evaluate nutritional status.
Assess for micronutrient deficiencies, and reassess as needed.
• Deficits can occur even in apparently well-nourished patients or in patients without laboratory abnormalities. • Inflammation can alter plasma micronutrient levels. It is ideal to assess micronutrient levels during remission rather than during active disease or flare. • Vitamin D, iron, vitamin B12, and zinc should be assessed at least once, and then periodically. • Consider assessment of calcium, selenium, magnesium, copper, vitamin A, and folate, particularly among patients on elimination diets, who present with symptoms of deficiency, or who meet <75% of estimated energy requirements for >1 month. • Most micronutrient deficiencies resolve with supplementation and disease control.
For patients taking sulfasalazine or methotrexate, recommend folic acid supplementation.

understanding that data are limited; otherwise, general dietary recommendations for foods to include during flares would be lean proteins, healthy fats (eg, avocado, olive oil, smooth nut butters), soluble fibers (eg, well-cooked vegetables, low-fiber fruits), dairy alternatives (eg, soy, almond, rice), and easy-to-digest grains (eg, quinoa, white rice, well-cooked pasta). Foods to minimize or avoid during flares include fatty/tough meats, raw vegetables, peels/seeds/skins (insoluble fibers), high-fiber fruits, lactose-containing foods among patients with lactase deficiency, added/refined sugars, and fried foods. Once patients are clinically improving, it is important to begin to liberalize the diet by reintroducing foods slowly, in small amounts, as tolerated.

Summary

General recommendations for patients with IBD include focusing on nutrient-dense foods as well as on modifications of specific nutrients based on disease activity, complications, and anatomy. Minimizing processed foods, emulsifiers, and artificial ingredients that may promote mucosal inflammation should be encouraged. Recommendations for clinicians in the treatment of IBD begin with assessing nutritional status and micronutrient deficiencies, and reassessing the patient throughout the course of treatment. Assessing nutrition risk using the MUST, followed by an examination of overall nutritional status and severity of malnutrition using the SGA, can provide a platform from which to launch medical nutrition therapy. Once the patient's nutritional status has been determined, the next step is to provide an appropriate treatment plan inclusive of diet. At a minimum, food-based dietary modification can be an effective adjunct to the management of symptoms and inflammation, yet more research is needed to define the most effective dietary strategies. The use of a registered dietitian to assist with the aforementioned nutritional interventions is important and can help tailor dietary modification based on IBD history, anatomy, complications, comorbidities, and nutrient needs.

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References

1. Peyrin-Biroulet L, Sandborn W, Sands BE, et al. Selecting therapeutic targets in inflammatory bowel disease (STRIDE): determining therapeutic goals for treat-to-target. *Am J Gastroenterol*. 2015;110(9):1324-1338.
2. Lewis JD, Abreu MT. Diet as a trigger or therapy for inflammatory bowel diseases. *Gastroenterology*. 2017;152(2):398-414.e6.
3. Kaplan GG, Ng SC. Understanding and preventing the global increase of inflammatory bowel disease. *Gastroenterology*. 2017;152(2):313-321.e2.
4. Bach JF. The effect of infections on susceptibility to autoimmune and allergic diseases. *N Engl J Med*. 2002;347(12):911-920.
5. Zuo T, Kamm MA, Colombel JF, Ng SC. Urbanization and the gut microbiota in health and inflammatory bowel disease. *Nat Rev Gastroenterol Hepatol*. 2018;15(7):440-452.
6. Hou JK, Abraham B, El-Serag H. Dietary intake and risk of developing inflammatory bowel disease: a systematic review of the literature. *Am J Gastroenterol*. 2011;106(4):563-573.
7. Racine A, Carbonnel F, Chan SS, et al. Dietary patterns and risk of inflammatory bowel disease in Europe: results from the EPIC study. *Inflamm Bowel Dis*. 2016;22(2):345-354.
8. Ananthakrishnan AN, Khalili H, Konijeti GG, et al. A prospective study of long-term intake of dietary fiber and risk of Crohn's disease and ulcerative colitis. *Gastroenterology*. 2013;145(5):970-977.
9. Ananthakrishnan AN, Khalili H, Konijeti GG, et al. Long-term intake of dietary fat and risk of ulcerative colitis and Crohn's disease. *Gut*. 2014;63(5):776-784.
10. Ananthakrishnan AN, Khalili H, Song M, et al. High school diet and risk of Crohn's disease and ulcerative colitis. *Inflamm Bowel Dis*. 2015;21(10):2311-2319.
11. Tjonneland A, Overvad K, Bergmann MM, et al; IBD in EPIC Study Investigators. Linoleic acid, a dietary n-6 polyunsaturated fatty acid, and the aetiology of ulcerative colitis: a nested case-control study within a European prospective cohort study. *Gut*. 2009;58(12):1606-1611.
12. Roberts CL, Rushworth SL, Richman E, Rhodes JM. Hypothesis: increased consumption of emulsifiers as an explanation for the rising incidence of Crohn's disease. *J Crohns Colitis*. 2013;7(4):338-341.

13. Chassaing B, Koren O, Goodrich JK, et al. Dietary emulsifiers impact the mouse gut microbiota promoting colitis and metabolic syndrome. *Nature*. 2015;519(7541):92-96.
14. Benard C, Cultrone A, Michel C, et al. Degraded carrageenan causing colitis in rats induces TNF secretion and ICAM-1 upregulation in monocytes through NF-kappaB activation. *PLoS One*. 2010;5(1):e8666.
15. Shang Q, Sun W, Shan X, et al. Carrageenan-induced colitis is associated with decreased population of anti-inflammatory bacterium, Akkermansia muciniphila, in the gut microbiota of C57BL/6J mice. *Toxicol Lett*. 2017;279:87-95.
16. Bhattacharyya S, Shumard T, Xie H, et al. A randomized trial of the effects of the no-carrageenan diet on ulcerative colitis disease activity. *Nutr Healthy Aging*. 2017;4(2):181-192.
17. Nickerson KP, Chanin R, McDonald C. Deregulation of intestinal anti-microbial defense by the dietary additive, maltodextrin. *Gut Microbes*. 2015;6(1):78-83.
18. Girardi B, Principi M, Pricci M, et al. Chemoprevention of inflammation-related colorectal cancer by silymarin-, acetyl-11-keto-beta-boswellic acid-, curcumin- and maltodextrin-enriched dietetic formulation in animal model. *Carcinogenesis*. 2018;39(10):1274-1282.
19. US Department of Health and Human Services; US Department of Agriculture. 2015-2020 dietary guidelines for Americans. 8th ed. http://health.gov/dietaryguidelines/2015/guidelines/. Published December 2015. Accessed February 11, 2019.
20. Panico S, Mattiello A, Panico C, Chiodini P. Mediterranean dietary pattern and chronic diseases. *Cancer Treat Res*. 2014;159:69-81.
21. Milajerdi A, Namazi N, Larijani B, Azadbakht L. The association of dietary quality indices and cancer mortality: a systematic review and meta-analysis of cohort studies. *Nutr Cancer*. 2018:1-15.
22. Chassaing B, Van de Wiele T, De Bodt J, Marzorati M, Gewirtz AT. Dietary emulsifiers directly alter human microbiota composition and gene expression ex vivo potentiating intestinal inflammation. *Gut*. 2017;66(8):1414-1427.
23. White JV, Guenter P, Jensen G, Malone A, Schofield M; Academy of Nutrition and Dietetics Malnutrition Work Group; A.S.P.E.N. Malnutrition Task Force; A.S.P.E.N. Board of Directors. Consensus statement of the Academy of Nutrition and Dietetics/American Society for Parenteral and Enteral Nutrition: characteristics recommended for the identification and documentation of adult malnutrition (undernutrition). *J Acad Nutr Diet*. 2012;112(5):730-738.
24. White JV, Guenter P, Jensen G, Malone A, Schofield M; Academy Malnutrition Work Group; A.S.P.E.N. Malnutrition Task Force; A.S.P.E.N. Board of Directors. Consensus statement: Academy of Nutrition and Dietetics and American Society for Parenteral and Enteral Nutrition: characteristics recommended for the identification and documentation of adult malnutrition (undernutrition). *JPEN J Parenter Enteral Nutr*. 2012;36(3):275-283.
25. Stratton RJ, Hackston A, Longmore D, et al. Malnutrition in hospital outpatients and inpatients: prevalence, concurrent validity and ease of use of the 'malnutrition universal screening tool' ('MUST') for adults. *Br J Nutr*. 2004;92(5):799-808.
26. Sandhu A, Mosli M, Yan B, et al. Self-screening for malnutrition risk in outpatient inflammatory bowel disease patients using the malnutrition universal screening tool (MUST). *JPEN J Parenter Enteral Nutr*. 2016;40(4):507-510.
27. Detsky AS, McLaughlin JR, Baker JP, et al. What is subjective global assessment of nutritional status? *JPEN J Parenter Enteral Nutr*. 1987;11(1):8-13.
28. Nguyen GC, Munsell M, Harris ML. Nationwide prevalence and prognostic significance of clinically diagnosable protein-calorie malnutrition in hospitalized inflammatory bowel disease patients. *Inflamm Bowel Dis*. 2008;14(8):1105-1111.
29. Gajendran M, Umapathy C, Loganathan P, Hashash JG, Koutroubakis IE, Binion DG. Analysis of hospital-based emergency department visits for inflammatory bowel disease in the USA. *Dig Dis Sci*. 2016;61(2):389-399.
30. Ananthakrishnan AN, McGinley EL. Infection-related hospitalizations are associated with increased mortality in patients with inflammatory bowel diseases. *J Crohns Colitis*. 2013;7(2):107-112.
31. Ananthakrishnan AN, McGinley EL, Binion DG, Saeian K. A novel risk score to stratify severity of Crohn's disease hospitalizations. *Am J Gastroenterol*. 2010;105(8):1799-1807.
32. Zallot C, Quilliot D, Chevaux JB, et al. Dietary beliefs and behavior among inflammatory bowel disease patients. *Inflamm Bowel Dis*. 2013;19(1):66-72.
33. Cohen AB, Lee D, Long MD, et al. Dietary patterns and self-reported associations of diet with symptoms of inflammatory bowel disease. *Dig Dis Sci*. 2013;58(5):1322-1328.
34. Aziz I, Branchi F, Pearson K, Priest J, Sanders DS. A study evaluating the bidirectional relationship between inflammatory bowel disease and self-reported non-celiac gluten sensitivity. *Inflamm Bowel Dis*. 2015;21(4):847-853.
35. Herfarth HH, Martin CF, Sandler RS, Kappelman MD, Long MD. Prevalence of a gluten-free diet and improvement of clinical symptoms in patients with inflammatory bowel diseases. *Inflamm Bowel Dis*. 2014;20(7):1194-1197.
36. Sousa Guerreiro C, Cravo M, Costa AR, et al. A comprehensive approach to evaluate nutritional status in Crohn's patients in the era of biologic therapy: a case-control study. *Am J Gastroenterol*. 2007;102(11):2551-2556.
37. Diederen K, Krom H, Koole JCD, Benninga MA, Kindermann A. Diet and anthropometrics of children with inflammatory bowel disease: a comparison with the general population. *Inflamm Bowel Dis*. 2018;24(8):1632-1640.
38. Massironi S, Rossi RE, Cavalcoli FA, Della Valle S, Fraquelli M, Conte D. Nutritional deficiencies in inflammatory bowel disease: therapeutic approaches. *Clin Nutr*. 2013;32(6):904-910.
39. Woting A, Blaut M. The intestinal microbiota in metabolic disease. *Nutrients*. 2016;8(4):202.
40. Levenstein S, Prantera C, Luzi C, D'Ubaldi A. Low residue or normal diet in Crohn's disease: a prospective controlled study in Italian patients. *Gut*. 1985;26(10):989-993.
41. Brotherton CS, Martin CA, Long MD, Kappelman MD, Sandler RS. Avoidance of fiber is associated with greater risk of Crohn's disease flare in a 6-month period. *Clin Gastroenterol Hepatol*. 2016;14(8):1130-1136.
42. Barrett JS, Gearry RB, Muir JG, et al. Dietary poorly absorbed, short-chain carbohydrates increase delivery of water and fermentable substrates to the proximal colon. *Aliment Pharmacol Ther*. 2010;31(8):874-882.
43. Ballantyne S. *The Paleo Approach: Reverse Autoimmune Disease and Heal Your Body*. 1st ed. Las Vegas, NV: Victory Belt Publishing; 2014.
44. Burgis JC, Nguyen K, Park KT, Cox K. Response to strict and liberalized specific carbohydrate diet in pediatric Crohn's disease. *World J Gastroenterol*. 2016;22(6):2111-2117.
45. Cohen SA, Gold BD, Oliva S, et al. Clinical and mucosal improvement with specific carbohydrate diet in pediatric Crohn disease. *J Pediatr Gastroenterol Nutr*. 2014;59(4):516-521.
46. Obih C, Wahbeh G, Lee D, et al. Specific carbohydrate diet for pediatric inflammatory bowel disease in clinical practice within an academic IBD center. *Nutrition*. 2016;32(4):418-425.
47. Suskind DL, Cohen SA, Brittnacher MJ, et al. Clinical and fecal microbial changes with diet therapy in active inflammatory bowel disease. *J Clin Gastroenterol*. 2018;52(2):155-163.
48. Suskind DL, Wahbeh G, Cohen SA, et al. Patients perceive clinical benefit with the specific carbohydrate diet for inflammatory bowel disease. *Dig Dis Sci*. 2016;61(11):3255-3260.
49. Wahbeh GT, Ward BT, Lee DY, Giefer MJ, Suskind DL. Lack of mucosal healing from modified specific carbohydrate diet in pediatric patients with Crohn disease. *J Pediatr Gastroenterol Nutr*. 2017;65(3):289-292.
50. Konijeti GG, Kim N, Lewis JD, et al. Efficacy of the autoimmune protocol diet for inflammatory bowel disease. *Inflamm Bowel Dis*. 2017;23(11):2054-2060.
51. Sigall Boneh R, Sarbagili Shabat C, Yanai H, et al. Dietary therapy with the Crohn's disease exclusion diet is a successful strategy for induction of remission in children and adults failing biological therapy. *J Crohns Colitis*. 2017;11(10):1205-1212.
52. Sigall-Boneh R, Pfeffer-Gik T, Segal I, Zangen T, Boaz M, Levine A. Partial enteral nutrition with a Crohn's disease exclusion diet is effective for induction of remission in children and young adults with Crohn's disease. *Inflamm Bowel Dis*. 2014;20(8):1353-1360.
53. Croagh C, Shepherd SJ, Berryman M, Muir JG, Gibson PR. Pilot study on the effect of reducing dietary FODMAP intake on bowel function in patients without a colon. *Inflamm Bowel Dis*. 2007;13(12):1522-1528.
54. Gearry RB, Irving PM, Barrett JS, Nathan DM, Shepherd SJ, Gibson PR. Reduction of dietary poorly absorbed short-chain carbohydrates (FODMAPs) improves abdominal symptoms in patients with inflammatory bowel disease—a pilot study. *J Crohns Colitis*. 2009;3(1):8-14.
55. Pedersen N, Ankersen DV, Felding M, et al. Low-FODMAP diet reduces irritable bowel symptoms in patients with inflammatory bowel disease. *World J Gastroenterol*. 2017;23(18):3356-3366.
56. Olendzki BC, Silverstein TD, Persuitte GM, Ma Y, Baldwin KR, Cave D. An anti-inflammatory diet as treatment for inflammatory bowel disease: a case series report. *Nutr J*. 2014;13:5.
57. Svolos V, Hansen R, Nichols B, et al. Treatment of active Crohn's disease with an ordinary food-based diet that replicates exclusive enteral nutrition [published online December 11, 2018]. *Gastroenterology*. doi:10.1053/j.gastro.2018.12.002.
58. SAD to AIP in 6: the gentle approach to the autoimmune protocol. http://www.sadtoaip.com. Accessed February 11, 2019.

59. International Nutrition. GAPS diet: natural digestive healing. http://www.gapsdiet.com/gaps-full-diet.html. Accessed February 11, 2019.
60. National Institutes of Health Office of Dietary Supplements. Nutrient recommendations: dietary reference intakes. https://ods.od.nih.gov/Health_Information/Dietary_Reference_Intakes.aspx. Accessed February 11, 2019.
61. Crohn's and Colitis Foundation of America. Diet, nutrition, and inflammatory bowel disease. http://www.crohnscolitisfoundation.org/assets/pdfs/diet-nutrition-2013-1.pdf. Accessed February 11, 2019.
62. Burnetter S. AIP meal plan: what to eat each day on the autoimmune diet. http://reversingautoimmunity.com/aip-meal-plan/. Published September 28, 2016. Accessed February 11, 2019.
63. University of Massachusetts Medical School; Center for Applied Nutrition. IBD-AID phases daily options. https://www.umassmed.edu/nutrition/ibd/sample-daily-menus-for-each-phase/. Accessed February 11, 2019.
64. Holden T. Why and how to start the GAPS diet. http://trinaholden.com/why-and-how-to-start-gaps/. Accessed February 11, 2019.
65. Kakodkar S, Farooqui AJ, Mikolaitis SL, Mutlu EA. The specific carbohydrate diet for inflammatory bowel disease: a case series. *J Acad Nutr Diet*. 2015;115(8):1226-1232.
66. Nutrition Care Manual. Low FODMAP nutrition therapy. https://www.nutritioncaremanual.org/. Accessed February 11, 2019.
67. Mifflin MD, St Jeor ST, Hill LA, Scott BJ, Daugherty SA, Koh YO. A new predictive equation for resting energy expenditure in healthy individuals. *Am J Clin Nutr*. 1990;51(2):241-247.
68. Hartman C, Marderfeld L, Davidson K, et al. Food intake adequacy in children and adolescents with inflammatory bowel disease. *J Pediatr Gastroenterol Nutr*. 2016;63(4):437-444.
69. Tomkins A. Assessing micronutrient status in the presence of inflammation. *J Nutr*. 2003;133(5)(suppl 2):1649S-1655S.
70. Hou JK, Gasche C, Drazin NZ, et al. Assessment of gaps in care and the development of a care pathway for anemia in patients with inflammatory bowel diseases. *Inflamm Bowel Dis*. 2017;23(1):35-43.
71. Lichtenstein GR, Loftus EV, Isaacs KL, Regueiro MD, Gerson LB, Sands BE. ACG Clinical Guideline: management of Crohn's disease in adults. *Am J Gastroenterol*. 2018;113(4):481-517.
72. Mueller CM, ed. *The A.S.P.E.N. Adult Nutrition Support Core Curriculum*. 2nd ed. Silver Spring, MD: The American Society for Parenteral and Enteral Nutrition; 2012.