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Hot Topic Review

Diet and Nutrition in Inflammatory Bowel Disease: A Review of the Literature

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Diet is thought to contribute to the development of inflammatory bowel disease (IBD) and may act as a mediator of inflammation in patients with IBD. Patients commonly associate their diet with symptoms and inquire about dietary modifications to manage their IBD. Without clinical guidelines and well-established nutritional data, healthcare providers managing patients with IBD may find it difficult to provide recommendations. Strong evidence for enteral nutrition, particularly in the pediatric population, has been established in Crohn's disease (CD) as a therapeutic option. Enteral nutrition may also serve as an adjunct to an exclusion diet. Recent studies such as the randomized trial comparing the Specific Carbohydrate Diet to a Mediterranean Diet in CD patients provide additional insights in forming dietary plans. A low-fermentable oligosaccharides, disaccharides, monosaccharides, and polyols (FODMAP) diet in quiescent IBD and an anti-inflammatory diet have also been explored as adjunctive therapies. In this review, we discuss the latest evidence for the role of diet in IBD both as a therapeutic modality and as an opportunity to provide patient-centered care.

Lay Summary

This study intends to provide readers an up-to-date and comprehensive review of the complex relationship between diet and inflammatory bowel disease as well as evidence for diet as a therapeutic measure via multidisciplinary care with a registered dietitian.

Key Words: inflammatory bowel disease, diet, IBD treatment, nutrition

Introduction

Inflammatory bowel disease (IBD), including Crohn's disease (CD) and ulcerative colitis (UC), is a chronic immune-mediated disease affecting the gastrointestinal (GI) tract. Though the etiology of IBD is unclear, intestinal immune dysregulation is felt to arise from environmental triggers in individuals with a genetic predisposition toward developing IBD. Environmental risk factors include diet, tobacco use, obesity, and physical activity.[1] In this review, we aim to discuss the existing literature on diet and nutrition and its role in IBD.

Epidemiology

As of 2017, there were an estimated 6.8 million cases of IBD throughout the world.[2] Increased incidence rates of IBD have been described in regions where IBD used to be rare, such as eastern Europe and Asia. Evidence has also shown that children of immigrants from low-prevalence regions to western countries have a risk of IBD on par with children of nonimmigrants.[3] Though the cause for this is also unknown, the spread of a western-type diet high in fats, processed meat, and low in fruits and vegetables has been theorized as a potential explanation.[1]

The Role of Diet in the Development of IBD

The relationship between diet and IBD may start as early as infancy. A 2017 meta-analysis provided evidence for the protective effect of breastfeeding in the development of IBD with the strongest protection in those breastfed for at least 12 months.[4] Early development and introduction of nutrition represent an important time point for the intestinal microbiome, which may affect intestinal mucosal integrity and immune-mediated responses to intraluminal contents. In addition, immunoglobulins provided in breastmilk may also protect against enteric infections and subsequently maintain a healthy microbiome.[4] Introduction of solid foods represents another important moment in gut microbiome health and bacterial diversity, suggesting an ongoing dietary effect on growth and development.[5]

In addition to food choices, food preparation methods may affect the risk of IBD development. Processed foods, frequently seen in Western diets, include the use of preservatives and emulsifiers. A 2021 study, which included 3 cohorts within the United States, demonstrated an association between a high consumption of processed foods and CD development, though not in UC.[6] Use of emulsifiers is thought to disrupt the protective mucus layers within the intestinal lumen and affect bacterial translocation. This effect has been demonstrated in mouse models that developed colitis with the introduction of low concentrations of emulsifying agents.[7] An ex vivo study of human microbiota samples similarly were found to be altered by emulsifiers.[8]

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A western diet high in fats places individuals at higher risk of obesity. Mouse models have shown that diets high in fats with associated obesity increase the severity of colitis. A high-fat diet was associated with inflammation in mesenteric fat and elevated concentrations of leptin, an adipocytokine. This suggests both local and systemic proinflammatory effects in these models. A diet high in fat may also lead to increased intestinal permeability and changes in the microbiota leading to inflammation.[9] However, incorporation of omega-3 polyunsaturated fatty acids may have a role in the prevention or treatment of colitis.[10]

Dietary nutrients may also affect inflammation. Amino acids are thought to regulate gut homeostasis. Supplementation of tryptophan, glutamine, or arginine into experimental models has been shown to improve colitis. Levels of histidine and threonine have been shown to be altered in IBD patients. Supplementation of histidine has the potential to down-regulate inflammatory cascades in experimental models.[11] Plant polysaccharides and poorly digestible fibers can decrease the severity of colitis through increased production of anti-inflammatory short-chain fatty acids.[11] In addition, vitamin D has been shown to assist in maintaining intestinal mucosal integrity and down-regulate inflammatory responses.[12] In mouse models, vitamin D has been shown to directly affect T cells and decrease secretion of proinflammatory cytokines in macrophages and dendritic cells.[13] In contrast, iron may increase inflammation through the production of free radicals and cellular damage. Iron may also affect the intestinal microbiome and be metabolized by bacterial species into proinflammatory metabolites.[14]

Diet as Therapy for IBD

Enteral Nutrition

Enteral nutrition (EN) is a well-established, low-risk, minimally invasive therapy that has successfully been used in IBD management. Exclusive enteral nutrition (EEN) is the intake of only liquid formulas without the intake of foods, usually for 6–8 weeks, and can provide 100% of daily nutritional requirements. Exclusive enteral nutrition should be considered and is preferred to total parental nutrition (TPN) in those with a functional gastrointestinal tract.[15] Enteral nutrition can also be recommended as partial enteral nutrition (PEN), which is the replacement of 35%–50% of habitual food intake with EN.

The composition of EN is classified by the nitrogen source derived from the amino acid or protein component of the formula and is classified into 3 types: elemental (amino acid-based), semielemental (oligopeptides), and polymeric (whole protein-based formulas).[16] Based on a Cochrane review, all 3 types demonstrate a similar efficacy in the management of CD.[15] In addition to its therapeutic potential, EN also provides nutritional benefits. Patients with active IBD are at risk for malnutrition, including micronutrient deficiencies and sarcopenia. This may occur due to proteolysis secondary to systemic inflammation, nutrient loss due to diarrhea, decreased nutrient absorption in areas of inflammation, and decreased oral intake. Patients with malnutrition may experience increased rates of hospitalization and adverse events during their admission such as infection and thromboembolism. Administration of EN serves as a source of nutritional support and a modality to reduce the risk of malnutrition.[15]

Enteral Nutrition as a Therapeutic Modality in Crohn's Disease

In children and adolescents with active CD, EEN is recommended as first-line therapy to induce remission.[17] A 2012 study demonstrated 6-week remission rates with EEN of 79% (polymeric formula) and 93% (elemental formula) (Table 1).[21] A 2018 Cochrane review suggested that EEN is superior to corticosteroids in pediatric CD.[26] A 2014 study noted in a post hoc analysis that both EEN and steroids were associated with week 12 normalization of CRP levels.[27] EEN induction has also shown complete mucosal healing rates of 33%.[28]

In comparing induction therapeutic modalities, Lee et al. found pediatric CD remission rates of 84% on anti-TNF therapy, 64% on PEN, and 88% on EEN. Fecal calprotectin levels were lower (<250 mcg/g) in those treated with EEN (45%) compared to those treated with PEN (14%).[29]

While the 2018 Cochrane review noted favorable results with EEN in the pediatric population, in a per-protocol analysis, steroids were superior to EEN in adults. Wall et al. noted that up to 41% of adult CD patients dropped out of EEN treatment due to poor adherence. Differing results in adult CD patients may be multifactorial and due to poor compliance, palatability, less multidisciplinary team support, and lack of guidance.[26,30] However, data also suggest that EEN may be efficacious in the setting of complicated CD. In adult CD patients with inflammatory strictures who completed EEN therapy for 12 weeks, intention-to-treat analysis demonstrated improvements in inflammatory and radiographic parameters.[31] A number of retrospective studies have also noted the potential benefits of EEN in decreasing rates of postoperative abdominal surgery complications.[32] ESPEN guidelines recommend that surgery should be postponed for at least 7–14 days to allow for nutritional supplementation via EN.[15]

During maintenance therapy, PEN is employed with a portion of the diet provided by enteral nutrition. A 2018 Cochrane review noted difficulty in determining recommendations and noted a very low certainty of evidence for superiority of PEN compared to a free diet. This was based on assessment of relapse rates of predominantly adult CD patients in remission at baseline.[33] In 2 studies that assessed postoperative recurrence rates in both adult and pediatric patients, the enteral nutrition groups experienced decreases in 1- and 5-year recurrence rates compared to a nonenteral nutrition group (Table 1).[23,25] When used in combination with biologic therapy, data suggest improved outcomes with incorporation of EN. A meta-analysis of adult CD studies demonstrated the benefit from PEN alongside maintenance infliximab for long-term clinical remission with sustained 1-year remission rates of 75% in the infliximab/PEN group versus 49% in the infliximab monotherapy group.[34]

Enteral Nutrition as a Therapeutic Modality in Ulcerative Colitis

There is a lack of evidence to support EEN as a therapeutic modality for pediatric and adult UC.[35] A randomized trial compared the efficacy of EEN and TPN as an adjunct therapy in patients with acute severe UC on intensive corticosteroid therapy.[36] Ulcerative colitis patients were randomized to receive polymeric EEN (n = 22) or TPN (n = 20) after 48 hours

Table 1. Enteral nutrition in the induction and maintenance of remission in patients with Crohn's disease.

Treatment goal	Study author	Patients	Diets	Results
Induction of remission	Royall (1994)[18]	40 Adult	Amino acid-based EEN vs peptide-based EEN	3-week clinical remission rate: no significant difference (84% amino acid group; 75% peptide group)
	Gassull (2002)[19]	62 Adult	EEN vs oral prednisone	4-week clinical remission rate per protocol analysis: 27% and 63% in different EEN formulation groups vs 79% in steroid group
	Borrelli (2006)[20]	37 Pediatric	EEN vs oral methylprednisolone	10-week mucosal healing rate ITT analysis: 74% in EEN group vs 33% in steroid group
	Grogan (2012)[21]	34 Pediatric	Elemental EEN vs Polymeric EEN	6-week clinical remission rate: no significant difference (93% elemental group vs 79% polymeric group)
Maintenance of remission	Verma (2000)[22]	39 Adult	PEN vs normal diet	1-year clinical remission rate ITT analysis: 48% in PEN group vs 22% in normal diet group
	Esaki (2006)[23]	145 Adult and pediatric	>1200 kcal/day EN vs <1200 kcal/day EN	5-year postoperative recurrence rate: 48% in >1200 kcal group vs 64% in <1200 kcal group
	Takagi (2006)[24]	51 Adult	PEN vs normal diet	2-year relapse rate: 34.6% in PEN group vs 64% in normal diet group
	Yamamoto (2007)[25]	40 Adult and pediatric	PEN vs normal diet	1-year postoperative recurrence rate: 30% in PEN group vs 70% in normal diet group

Abbreviations: *CD*, Crohn's disease; *EEN*, exclusive enteral nutrition; *EN*, enteral nutrition; *ITT*, intention to treat; *PEN*, partial enteral nutrition.

of steroid therapy. Remission rates and the need for colectomy were similar in the 2 groups, but there was a 16.7% median increase in serum albumin in the EN group versus 4.6% in the TPN group.[36] A 2021 randomized trial investigated EEN as adjunctive therapy to intravenous corticosteroids in patients with acute severe ulcerative colitis. Thirty-two patients randomized to EEN for 7 days were found to have a shorter hospital stay and higher day 7 albumin level compared to 40 patients receiving standing of care. The EEN group also had a greater reduction in serum C-reactive protein and fecal calprotectin as well as a lower composite outcome of colectomy and hospitalization at 6 months compared to standard of care.[37]

Crohn's Disease Exclusion Diet and Crohn's Disease Treatment with Eating Diet

Previous studies have shown that although EEN is beneficial in promoting remission in children with active CD, PEN with 50% of calories from formula and a free diet is ineffective, suggesting that the benefit from EEN at least partially is due to the exclusion of a free diet.[38] The Crohn's disease Exclusion Diet (CDED) was designed to add whole foods in conjunction with PEN, while limiting or eliminating foods that have been shown to induce inflammation, such as gluten, dairy, animal fat, processed meats, products containing emulsifiers, canned goods, and packaged products (Table 2).[38] Adherence to the CDED with and without PEN was shown to promote remission in mild-to-moderate luminal CD in both pediatric and adult populations and decrease inflammatory markers.[38] In a small study of 21 patients, the CDED with PEN diet was also shown to promote remission in over 60% of patients who had loss of response to biologics despite dose escalation or combination therapy.[39] In pediatric patients, CDED + PEN is not only better tolerated than EEN but can also be more effective in inducing sustained remission at 12 weeks.[40] Both EEN and CDED have been similarly effective in the pediatric CD population at inducing remission as early as 3 weeks.[41] A more recent study showed that CDED is also effective at achieving clinical remission in biologic-naive adults with CD with or without PEN (Table 3).[42]

In a similar approach mimicking the benefits of EEN, but adding ordinary foods to the diet, CD-TREAT was a study designed to match the composition of EEN as closely as possible using ordinary whole foods (Table 2).[43] This food-based approach was not only easier to adhere to when compared to EEN, but also produced similar biochemical effects on the gut microbiome and was effective at inducing clinical remission in 3 of the 5 children with active CD.[43]

Although there are only a few uncontrolled studies, adding whole foods either with CDED ± PEN or through whole foods in the CD-TREAT may have the potential to achieve remission in patients with active Crohn's disease.

Specific Carbohydrate Diet

The specific carbohydrate diet (SCD) was created in the 1920s by Dr. Sidney Haas and was initially intended for children with celiac disease. With his son, Dr. Merrill Haas, they published a book entitled, "Management of Celiac Disease," in 1951. In 1987, Elaine Gottschall published "Breaking the Cycle" after her daughter with UC was referred to Dr. Sidney Hass and was treated with the SCD, leading to clinical improvement in her symptoms.[54] The core principle of the diet is to eliminate all grains, limit complex carbohydrates, but allow fruits and vegetables. All sugars are eliminated with the exception of honey. It also eliminates all milk products except for aged cheeses and yogurt fermented greater than 24 hours (Table 2).

Since the first introduction of the SCD, there has been growing interest in the utility of its use for treating IBD. In 2015, the first large case series of 50 patients with IBD adhering to the SCD was published. After a mean of 9.9 months of dietary adherence, 66% of the cohort noted complete symptom resolution.[55] Suskind and Cohen have published on the theoretical ability of the SCD to shift the balance of the gut microbiome to a low-inflammatory state.[56–61] This is based on the idea that complex carbohydrates are poorly absorbed

Table 2. Description of specific diets used in patients with inflammatory bowel disease.

Diet	Descriptor
Crohn's disease exclusion diet	Whole foods diet in conjunction with partial enteral nutrition. Eliminates dairy products, processed foods, preservatives, products containing emulsifiers, artificial sweeteners, coffee, alcohol, certain animal fats, and minimizes gluten
Crohn's disease treatment with eating diet	Personalized diet designed to mimic exclusive enteral nutrition as closely as possible by excluding certain dietary components (gluten, alcohol, and lactose) and matching macronutrients, fiber, vitamins, minerals using ordinary foods
Specific carbohydrate diet	Eliminates: all grains, all sugars except honey, all milk products except hard cheese and yogurt fermented >24 h, and most processed foods. Complex carbohydrates are limited
Mediterranean diet	High consumption: Olive oil, legumes, grains, vegetables, fruits, nuts, and seeds. Moderate consumption: fish, poultry, dairy foods Low consumption: processed foods, red, and processed meats
Low FODMAP diet	Limits low-fermentable oligosaccharides, disaccharides, monosaccharides, and polyols (FODMAPs) to reduce bowel water and gas that can lead to distension and symptoms
Anti-inflammatory diet	5 basic components: [1] restrict specific carbohydrates (processed complex carbohydrates, gluten-based grains, refined sugars), [2] ingest pre- and probiotic foods, [3] reduce intake of total fat and saturated fatty acids and increase omega-3 rich foods, [4] review patient's overall diet and identify intolerances or nutrient deficiency, and [5] texture modification

in the intestine, causing potential bacterial overgrowth and subsequent inflammation.[62] In 2020, Suskind published the first double-blinded trial that randomized pediatric patients into 1 of 3 diets: SCD, modified SCD (MSCD) that included oats and rice, or a whole food diet that eliminated wheat, corn, sugar, milk, and food additives.[44] This study found that all diets similarly lead to clinical remission, but only SCD and MSCD lead to improvements in ESR and CRP (Table 3).[44] In 2019, 21 newly diagnosed mild-moderate IBD pediatric patients were randomized to SCD or MSCD. Multiple crossovers were performed between the diets after 8-week periods. Most patients experienced no significant difference between the diets, including no difference in IBD symptoms or fecal calprotectin levels.[45] More randomized control trials are needed to further assess the benefit of this diet in IBD and, in particular, among adult populations.

Mediterranean Diet

The Mediterranean Diet (MedDiet) was initially defined by Ancel Keys in the 1960s and has grown in popularity.[63] Despite slight variations since its initial introduction, the MedDiet is still largely based on the principle of eating an abundance of olive oil, legumes, leafy greens, nuts, and seeds while limiting red meat, poultry, and sweets (Table 2).[63] Similar to other diets of interest as a therapeutic option for patients with IBD, the MedDiet also has some support for its anti-inflammatory and microbiome-balancing benefits.[64,65] It is also well known for its cardiovascular benefits, with a major randomized control trial PREDIMED concluding that following a MedDiet can decrease incidence of major cardiovascular events in patients at high risk for these events.[66,67] Its benefit to IBD patients has been more recently explored.

Three recent studies have examined the influence of the MedDiet on IBD populations. Papada et al. found that increased adherence to the MedDiet was associated with clinical remission, improved quality of life, and decreased disease activity in 86 patients with CD.[46] Godny et al. observed in 153 patients who had undergone pouch surgery for UC an association between adherence and inactive disease, decreased risk of pouchitis at 8 years, and significantly lower fecal calprotectin levels.[47] Further, Chicco et al. found similar benefits in 142 patients with both CD and UC.[48] After following a MedDiet for 6 months, there were significant improvements in the following: body mass index (BMI) and waist circumference, liver steatosis, active disease, CRP levels, fecal calprotectin, and overall quality of life.[48] A fourth study, and the first randomized control trial to evaluate the utility of the MedDiet in Crohn's was The Diet to Induce Remission in Crohn's Disease (DINE-CD) (Table 3).[49]

The DINE-CD study's goal was to better understand if there are significant differences in outcomes with the use of the MedDiet versus SCD in mild-to-moderate CD. The study was conducted across 33 sites in the United States with 194 patients randomized to either MedDiet or SCD for 12 weeks. The primary outcome of interest was symptomatic remission at 6 weeks. Secondary outcomes of interest included decreased fecal calprotectin and serum CRP values. During the first 12 weeks patients were given prepared meals, followed by 6 weeks of self-prepared meals under the guidance of resources (including a dietitian). Both groups at 6 weeks had significant improvement in scores on the sCDAI, CDAI, sIBDQ, as well as less fatigue, pain, and social isolation. However, there was no significant difference in fecal calprotectin or CRP levels within or between groups. Few patients had both symptomatic and objective inflammatory improvement with low rates of CRP response. Despite lack of objective evidence, this study concluded that the MedDiet may be a more attractive option to allow for symptomatic remission in patients with CD as it is easier to follow and potentially more readily incorporated into existing food choices than the SCD (Table 3). Findings are limited by the consideration that it can be difficult to ensure absolute adherence to a diet that patients are randomized into.

Low FODMAP

The low-FODMAP diet is based on the concept that certain short-chained carbohydrates that are poorly digested and highly fermentable in the bowel lead to accumulation of water and gas that cause distension and visceral hypersensitivity, thereby exacerbating gastrointestinal symptoms (Table 2). In

Table 3. Summary of diets with associated studies in patients with inflammatory bowel disease.

Diet	Study author	Patients	Study endpoints	Results
Crohn's exclusion diet	Sigall-Boneh (2014)[38]	-47 -Adult and pediatric -Active Crohn's disease	-Clinical remission at 6 weeks -Normalization of CRP at 6 weeks	-Remission rate 70.2% -CRP normalization rate 70%
	Sigall Boneh (2017)[39]	-21 -Adult and pediatric -LOR to anti-TNF therapy	-Clinical remission at 6 weeks	-Remission rate 61.9%
	Levine (2019)[40]	-74 -Pediatric -Mild-moderate CD	-Dietary tolerance at 6 weeks -Clinical remission at 6 weeks and 12 weeks	-CDED + PEN was tolerated in 97.5%, EEN was tolerated by 73.6% (P = .002) -Steroid free remission in 75% of CDED + PEN group vs 59% of EEN group (P = .38) -Steroid free remission in 75.6% of CDED + PEN group vs 45.1% of EEN group (P = .01)
	Sigall Boneh (2021)[41]	-73 -Pediatric -Mild-moderate CD	-Clinical remission at 3 weeks -Clinical remission at 6 weeks among diet responsive patients at week 3	-Remission at week 3 in 63% CDED group and 67% EEN group (no significant difference) -75.4% diet responsive patients at week 3 achieved remission at week 6
	Yanai (2022)[42]	-44 -Adult -Biologic naive mild-moderate CD	-Clinical remission at 6 weeks	-Remission at week 6 in 68% CDED + PEN group and 57% in CDED (P = .46) -Among patients in week 6 admission, 80% remained in clinical remission and 35% were in endoscopic remission at week 24
Crohn's disease treatment with eating diet	Svolos (2019)[43]	-5 -Pediatric -Mild-moderate CD	-Clinical response at 4 and 8 weeks -Clinical remission at 4 and 8 weeks	Week 4 -3/5 with clinical response -2/5 with clinical remission Week 8 -4/5 with clinical response -3/5 with clinical remission
SCD, MSCD, WF	Suskind (2020)[44]	-10 -Pediatric -Mild-moderate CD	-Clinical remission at 12 weeks -Improvement in CRP and ESR by week 12 -Microbiome composition over study period	-Clinical remission: 100% at week 12 -Improvement in CRP by week 12: 100% (normalization in SCD and MSCD groups) Improvement in ESR by week 12: 8/10 (normalization in SCD and MSCD groups) -Microbiomes shifted in all patients: MSCD increase in Bacteroidetes and decrease in Firmicutes
	Kaplan (2022)[45]	-21 -Pediatric -Mild-moderate IBD	-Patient reported outcomes, weekly IBD symptoms, and fecal calprotectin	-After randomization to SCD or MSCD, multiple crossovers were performed. No significant difference in clinical parameters between diets were found
Mediterranean diet	Papada (2020)[46]	-86 -Adult -Active and inactive CD	-Dietary adherence over the prior 6 months -Quality of life scores -Disease activity scores	-Higher dietary adherence in inactive CD compared to active CD (P = .005) -Positive correlation with dietary adherence and quality of life (P = .008) -Negative correlation with dietary adherence and disease activity (P < .001) and CRP levels (P = .027)
	Godny (2020)[47]	-153 -Adult -Patients after pouch surgery due to UC	-Dietary adherence -Pouch behavior -Inflammatory markers: CRP and fecal calprotectin	Higher dietary adherence trend in inactive disease (though not significant) -Higher dietary adherence associated with calprotectin <200 mcg/g (P < .05) -Over 8 years, trend of a decreased risk of pouchitis in those with dietary adherence (though not significant)

Table 3. Continued

Diet	Study author	Patients	Study endpoints	Results
	Chicco (2021)[48]	-142 -Adult -UC and CD	-Impact of 6 month dietary intervention on anthropometric parameters, bloodwork, hepatic steatosis, and IBD disease activity	-Significant improvements in BMI and waist circumference in UC and CD -Significant decrease in hepatic steatosis in UC and CD -Significant decrease in patients with active disease and improvement in quality-of-life scores in UC and CD
Mediterranean diet vs SCD	Lewis (2021)[49]	-194 -Adult -Mild-moderate CD	-Symptomatic remission at 6 and 12 weeks -Fecal calprotectin and CRP response	-At weeks 6 and 12, no difference in symptomatic remission between SCD and MD (but both significantly improved from baseline) -Calprotectin response by week 6 achieved by >30% of patients with both diets -CRP response at week 6 or 12 achieved by <11% of patients with both diets
Low FODMAP	Cox (2017)[50]	-29 -Adult patients -Quiescent CD and UC	-GI symptoms score during challenge of FODMAPs or placebo -Bristol Stool Form Scale during challenge of FODMAPs or placebo	-Fewer patients reported relief of GI symptoms at the end of a FODMAP challenge compared to placebo (P = .033) -Greater severity of pain, bloating, flatulence and fecal urgency in FODMAP group compared to placebo -Greater Bristol Stool Scale score in FODMAP group compared to placebo
	Cox (2020)[51]	-52 -Adult -Quiescent CD and UC	-GI symptom scores at 4 weeks -Quality-of-life scores -Disease activity and inflammatory marker levels -Microbiome composition	-Trend toward greater reduction in IBS-SSS scores in low-FODMAP group compared to sham diet (though not significant) -More adequate relief of gut symptoms (P = .007) and higher quality of life (P = .042) in low-FODMAP group -No difference in microbiome diversity, IBD disease activity scores, or inflammatory markers between the 2 groups
Anti-inflammatory diet	Olendzki (2014)[52]	-40 (11 had complete data collection and underwent further review) -Adult patients -UC and CD	-Clinical response and remission at 4 weeks	-All 11 patients discontinued at least one of prior IBD medications -All 11 patients experienced symptom reduction with a mean decrease in IBD disease activity scores
	Olendzki (2021)[53]	-553 dietary records and 340 stool samples from 22 subjects -UC and CD	-Effect of IBD-AID on the microbiome	-IBD-AID favored the growth of SCFA-producing bacteria that are depleted during IBD dysbiosis

Abbreviations: *CD,* Crohn's disease; *CDAI,* Crohn's disease activity index; *CDED,* Crohn's disease exclusion diet; *CD-TREAT,* Crohn's disease treatment with eating diet; *CRP,* C-reactive protein; *ESR,* erythrocyte sedimentation rate; *FCP,* fecal calprotectin; *FODMAP,* fermentable oligosaccharides, disaccharides, monosaccharides, and polyols; *IBD-AID,* anti-inflammatory diet; *IBS-SSS,* irritable bowel syndrome severity scoring system; *LOR,* loss or response; *MD,* Mediterranean diet; *MSCD,* modified specific carb diet; *PEN,* partial enteral nutrition; *SCD,* specific carb diet; SCFA, short-chain fatty acids; *TNF,* tumor necrosis factor; *UC,* ulcerative colitis; *WF,* whole food.

2004, the acronym "FODMAPS," standing for Fermentable Oligosaccharides, Disaccharides, Monosaccharides, and Polyols, was coined.[68]

Two recent studies have questioned whether a low FODMAP diet has utility in decreasing symptoms among those with quiescent IBD. They were conducted under the theory that a low FODMAP diet may control symptoms from possible concomitant irritable bowel syndrome. Cox et al. in 2020 performed a study randomizing patients with CD or UC into either a low-FODMAP diet or control diet.[51] At 4 weeks, patients within the low FODMAP group had significantly higher relief of gut symptoms and improved quality of life.[51] No difference between the groups was seen when comparing microbiome diversity or markers of inflammation.[51] In 2017, Cox et al. performed a double-blind rechallenge trial among IBD patients with improvements in symptoms following a low FODMAP diet and 3 days of reintroducing either fructans, galacto-oligosaccharides (GOS), sorbitol, or glucose (placebo).[50] They found a significant difference in negative symptoms among those randomized to high-dose fructans including pain, flatulence, and fecal urgency compared to placebo.[50] These studies provide evidence in the utility of restricting certain short-chained carbohydrates in patients with quiescent IBD but lingering GI symptoms (Table 3).

Anti-inflammatory Diet

Research has shown that gut dysbiosis, an imbalance of intestinal bacteria, can contribute to the development of inflammatory bowel disease.[69] Initially building off of the SCD, the anti-inflammatory diet (IBD-AID) was designed to decrease inflammation and restore the balance between helpful and harmful bacteria, with the goal of decreasing flares and obtaining clinical remission.[52] The diet was developed based on the knowledge that specific carbohydrates can act as substrates for harmful intestinal bacteria. Accordingly, the IBD-AID limits certain carbohydrates such as lactose, wheat, refined sugar, and corn that can encourage inflammatory bacterial growth.[52,70] The diet has 5 basic principles: [1] restrict specific carbohydrates (processed complex carbohydrates, gluten-based grains, refined sugars), [2] ingest pre- and probiotic foods to restore the balance of the gut microbiome, [3] reduce intake of total fat and saturated fatty acids and increase consumption of omega-3 rich foods, [4] review patient's overall diet and identify intolerances or nutrient deficiency, and [5] texture modification (Table 2).[52,70,71] The texture of the foods is modified to match with severity of symptoms, with the idea being that patients with an active flare may require foods to be softened or pureed to enhance absorption and reduce intact fiber.[52] Olendzki et al. showed that the IBD-AID can be a beneficial diet in a small number of patients who are refractory to pharmacotherapy or with otherwise inadequately controlled symptoms. In that study, 11 adult patients with IBD who used the IBD-AID for at least 4 weeks had symptom reduction, decrease in clinical activity scores, and discontinued at least one of their prior IBD medications.[52] A more recent study by Olendzki et al. in 2021 showed that the anti-inflammatory diet promoted growth of short-chain fatty acid-producing bacteria that are typically depleted in IBD (Table 3).[53] Although these studies suggest that an anti-inflammatory diet could be a beneficial adjunctive therapy for inflammatory bowel disease, further research in the form of randomized control trials are warranted.

Registered Dietitian's Role in Diet for IBD

A registered dietitian's personalized nutrition therapy plan focuses on preventing malnutrition by correcting nutrient deficiencies, improving disease activity and symptoms, and quality of life. The role of diet in IBD management is crucial in the inpatient and outpatient settings with a multidisciplinary IBD team (gastroenterologists, surgeons, pharmacists, IBD nurse specialists, and dietitians). An understanding of the implications of diet in the treatment for IBD is often limited by healthcare providers. In a 2016 survey, 41% of gastroenterologists and 16% of nurses reported their knowledge of nutrition in IBD as "very good," compared to 87% of dietitians.[72] Available time and resources during a clinic visit to provide dietary counseling is also limited. As a correlate, in a 2022 survey study of providers in the management of irritable bowel syndrome, 77% reported spending <10 minutes on nutritional counseling.[73] In the 2016 survey, only 46% of providers felt they had adequate access to nutritional care resources.[72] Dietitians provide a key aspect of multidisciplinary care and in bridging knowledge gaps through nutritional and dietary assessments, counseling, and interventions.

In performing nutritional assessments, dietitians contribute toward the identification of patients with or at risk of malnutrition. Early identification of such patients may prevent adverse medical and surgical outcomes. This is particularly beneficial in patients with active disease who may require preoperative nutritional optimization with enteral nutrition. In patients diagnosed with malnutrition, ESPEN guidelines recommend delaying surgery 7–14 days to provide intensive medical nutrition.[15] While BMI is commonly used as a nutrition screening tool, some IBD patients with a low lean body mass, but a normal or high BMI, may be missed.[15] Several screening tools are available such as the Malnutrition Universal Screening Tool (MUST) and Inflammatory Bowel Disease-Nutrition Screening tool (IBD-NST). MUST incorporates BMI with the presence/absence of unplanned weight loss and acute illness. Similarly, the IBD-NST is based on BMI, weight loss, active disease, and nutrition concerns.[74] A nutritional assessment may also include a food diary, diet history, or 24-hour recall to assess energy, protein, carbohydrates, vitamin, and mineral requirements. Dietitians will then provide the patient and their care team with appropriate diet and supplement recommendations.

Dietitians also contribute toward multidisciplinary care by performing an in-depth dietary analysis. In reviewing a food diary and diet history, a dietitian may identify food avoidance practices. This allows a dietitian to help patients recognize mal-adaptive behaviors and work with them in developing a personalized diet plan. The IBD patient population is particularly at risk for malnutrition. Forty-eight percent of patients perceive diet to be an inciting factor in their disease; 49%–90% of patients avoid or restrict foods due to beliefs that certain foods may exacerbate symptoms.[75,76] Due to perceived trigger foods as well as discomfort from active inflammation and possible sequelae such as luminal narrowing, patients with IBD often consciously and subconsciously alter and restrict their diet. A 2021 study found that 17% of IBD patients were at risk for avoidant/restrictive food intake disorder, particularly in patients with active disease.[75] Dietitians may also facilitate discussions with patients regarding the concept of food-based nutritional interventions including dietary exclusion diets and/or EN based on a patient's nutritional status, symptoms, disease activity, and food availability. Once a dietary intervention is agreed upon, dietitians are able to provide initial education and ongoing patient guidance, which can improve dietary adherence. In several studies noted in this review, dietitians provided dietary guidance to patients during initiation of a dietary intervention with as-needed follow-up. Olendzki et al. conducted a study where 37 patients met with an RD and received guidance on the IBD-AID diet. Of those who reported symptomatic improvements, >70% reported compliance to the diet.[52]

In quiescent IBD, ESPEN guidelines recommend dietary counseling as part of a multidisciplinary care team as well.[15] As noted in Cox et al., 35% of quiescent IBD patients meet criteria for irritable bowel syndrome. Implementation of a low-FODMAP diet in such cases led to improvement in GI symptoms.[50] In an IBD patient population at risk for malnutrition, continued multidisciplinary care involving a dietitian allows for ongoing close monitoring of symptoms and nutritional status during use of a restrictive diet. Thus, whether a patient is newly diagnosed or has controlled disease with persistent GI symptoms, ongoing multidisciplinary care involving a dietitian allows for an elevated combined clinical assessment and therapeutic approach.

Conclusions

Previous studies have provided insight into the complex relationship between diet and IBD. While studies assessing diet as a therapy for IBD have been limited by a small number of randomized controlled trials, continued interest in this area may offer additional avenues to manage IBD. As patients frequently express an interest in dietary modalities to manage IBD, individuals may proactively practice food avoidance and increase the risk for micronutrient deficiencies.[76] Patient education from a multidisciplinary IBD care team of clinicians and dietitians and development of personalized diet plans may ensure positive outcomes from both provider and patient perspectives.

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Conflicts of Interest

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Data Availability

No new data were created or analyzed for this review article.

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