A correction notice has been published, see:
https://doi.org/10.1093/ecco-jcc/jjac104

*Journal of Crohn's and Colitis*, 2020, 431–444
doi:10.1093/ecco-jcc/jjz160
Advance Access publication September 24, 2019
ECCO Topical Review

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# Perioperative Dietary Therapy in Inflammatory Bowel Disease

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## Abstract

**Background and Aims:** The incidence of inflammatory bowel disease [IBD] is rising worldwide and no cure is available. Many patients require surgery and they often present with nutritional deficiencies. Although randomised controlled trials of dietary therapy are lacking, expert IBD centres have long-established interdisciplinary care, including tailored nutritional therapy, to optimise clinical outcomes and resource utilisation. This topical review aims to share expertise and offers current practice recommendations to optimise outcomes of IBD patients who undergo surgery.

**Methods:** A consensus expert panel consisting of dietitians, surgeons, and gastroenterologists, convened by the European Crohn's and Colitis Organisation, performed a systematic literature review. Nutritional evaluation and dietary needs, perioperative optimis ation, surgical complications, long-term needs, and special situations were critically appraised. Statements were developed using a Delphi methodology incorporating three successive rounds. Current practice positions were set when ≥80% of participants agreed on a recommendation.

**Results:** A total of 26 current practice positions were formulated which address the needs of IBD patients perioperatively and in the long term following surgery. Routine screening, perioperative optimisation by oral, enteral, or parenteral nutrition, dietary fibre, and supplements were reviewed. IBD-specific situations, including management of patients with a restorative proctocolectomy, an ostomy, strictures, or short-bowel syndrome, were addressed.
**Conclusions:** Perioperative dietary therapy improves the outcomes of IBD patients who undergo a surgical procedure. This topical review shares interdisciplinary expertise and provides guidance to optimise the outcomes of patients with Crohn's disease and ulcerative colitis. taking advantage of contemporary nutrition science.

**Key Words:** Nutrition; surgery; inflammatory bowel disease; IBD

## 1. Introduction

Inflammatory bowel disease [IBD] affects a growing number of children and adults. Until recently, IBD was generally considered a disease of the Western world. However, IBD is becoming more common in developing countries [such as countries in Africa, Asia, and South America], with yearly increases in incidence from 4% to 15% over the past three decades.[1,2] Today, IBD has become a global disease with a worldwide prevalence of >0.3%. No cure is available except for radical surgery for a minority of patients with ulcerative colitis [UC]. IBD as a chronic disease consumes a large share of resources and often causes long-term disability.

Although the mainstay of IBD treatment is medical, surgery remains an important treatment option. Up to 47% of Crohn's disease [CD] and 16% of UC patients undergo one or more surgical procedures during their lifetime.[3] Patients are frequently referred to surgery malnourished and acutely unwell owing to a prolonged course of disease. Indeed, enteric fistula or strictures [or both] and a state of persistent or recurrent mucosal inflammation impede the intake of nutrients. Chronic diarrhoea, reduced appetite, and medication side effects further worsen nutritional status. In malnourished patients, septic complications such as anastomotic leak, sepsis, and poor wound healing more frequently occur. Indeed, nutritional status is a fundamental driver of clinical and surgical outcomes,[4,5] is amenable to interventions, and is linked to an improved quality of life when properly addressed.[6] In this context, perioperative dietary therapy is increasingly recognised as a key element in the care of surgical IBD patients. However, attempts at developing nutritional guidelines have been hampered by a lack of high-quality evidence, particularly from randomised controlled trials [RCTs].[7] Nonetheless, expert centres have interdisciplinary teams with nutritional expertise who can optimise care and surgical outcomes of IBD patients.

The purpose of the present topical review is to share expertise and offer practice recommendations despite the paucity of strong evidence in the dietary therapy of IBD patients. Using a pragmatic approach with practical guidance for the clinician, the whole spectrum of perioperative nutritional interventions in adult IBD patients is addressed. It is hoped that the provision of contemporary practice positions, by an interdisciplinary group of experts under the umbrella of the European Crohn's and Colitis Organisation [ECCO], will be useful to the busy clinician.

## 2. Methods

ECCO identified a pressing need for guidance in the field of perioperative dietary therapy in IBD. As strong evidence in this area is scarce, gathering consensus agreement from an international and interdisciplinary group of experts was optimal to address this highly relevant clinical need in daily practice. A call for participants for a topical review on perioperative dietary therapy in IBD was announced to all ECCO members, under the leadership of the Dietitians and Surgeons of ECCO Committees and the oversight of the Guideline Committee. A total of 16 experts out of 37 qualified applicants was selected based on professional background, accomplishments, and commitment. The expert panel included dietitians, surgeons, and gastroenterologists, and had a balanced geographical and gender membership and methodological expertise. Four working groups were formed, and focused on nutritional evaluation and dietary needs, perioperative optimisation, surgical complications, long-term needs, and special situations. The working groups performed a systematic literature search of their topic using Medline/Pubmed, Embase, and the Cochrane database, in addition to their own files. Each working group discussed the literature and formulated draft statements.

The consensus statements were further developed using a Delphi methodology[8] incorporating three successive rounds. The first two consecutive rounds were web-based with anonymous voting, and explicitly asked for feedback and suggestions to be included into the iterative development of the statements. The third and final round was a dedicated expert meeting during the ECCO Congress in Copenhagen on 8 March 2019, with face-to-face discussion and completion of the consensus document. Current Practice Positions were accepted when ≥80% of participants agreed to the text of the statements. The group leaders and their respective members then finalised the supporting text. The final manuscript was edited for consistency by the two coordinators and by the Guideline Committee representative, before a final review and approval by all involved experts.

## 3. Current Practice Positions

### 3.1. Aetiology, presentation, and assessment of malnutrition

**ECCO Current Practice Position 1.1**

IBD patients should be routinely screened for malnutrition and nutritional assessment should be performed if needed. As a minimum, body mass index [BMI] and unintentional weight change should be assessed

The aetiology, presentation, and assessment of malnutrition in the surgical patient is distinct from the rest of the IBD population.

Lack of treatment response and fistulising and stenotic disease are typical characteristics of the preoperative patient at high risk of undernutrition.[5] Protracted diarrhoea and high-output fistula increase nutrient and fluid loss. Adequate intake is further compromised by the effect of inflammation on appetite regulation, food avoidance to control symptoms, and dietary restrictions often imposed in stricturing disease.[9]

Identification of nutritional risk and prevention and correction of malnutrition are of utmost importance. Nutritional risk screening[10,11] at hospital admission, and periodically during hospital stay, offer the opportunity to identify a proportion of patients who require comprehensive nutritional assessment. Nutritional assessment is the global outcome of a multifaceted approach encompassing measurements of anthropometry, assessment of dietary intake, biomarkers of nutritional status, clinical examination, and considerations of environmental and socioeconomic factors. Body mass index [BMI] and unintentional weight loss are the strongest indicators of nutritional risk and malnutrition as endorsed by the European Society of Clinical Nutrition and Metabolism,[12] and are based on the findings of a survey of health care professionals.[13]

Whether basal metabolic needs are increased in preoperative patients has not been studied extensively. In preoperative children with CD, resting energy expenditure and protein oxidation were higher than in healthy controls, but this effect was reduced in the postoperative phase.[14] In the early postoperative phase, the inflammatory response will increase release of nutrients into the circulation and increase metabolic demands for wound healing.[15] However, it is possible that any increments in metabolic needs are offset by a decrease in the physical activity of postoperative patients, although currently implementation of enhanced recovery pathways usually translate into limited postoperative impairment.

**ECCO Current Practice Position 1.2**

Micronutrient deficiency may be seen in IBD and is often associated with complicated disease. Reliable assessment of body micronutrient status requires patients to be in biochemical remission. Plasma proteins, such as albumin, should not be used as markers of nutrition in active disease. Correction of micronutrient deficiency is best achieved by a multidisciplinary team

A concise diet history should be obtained to ascertain dietary intake adequacy throughout the course of disease. Comprehensive dietary assessment methods, such as weighed food diaries, should be reserved for the very few patients whose nutrient intake needs to be estimated with a higher level of precision. There are currently no biomarkers of protein-energy status. Plasma measurements of micronutrients are used routinely to assess body status. However, since vitamins and trace elements are transferred bound to acute-phase reactant proteins [e.g. albumin], their plasma concentrations will be influenced in the presence of active disease, preoperatively or postoperatively.[16,17] Moreover, liver production of so-called negative acute-phase proteins [e.g. albumin, transferrin] physiologically decrease in the presence of infection, inflammation, or trauma, making any measurement thereof unreliable.[18]

The effect of the surgical course on the nutritional status of the patient varies and depends on the type of surgical procedure, the location and length of the remnant functional gut, and postoperative complications. Resection of terminal ileum may increase the risk of vitamin B12 deficiency, and patients with high-output stoma need monitoring for electrolytes and fluids.[19]

### 3.2. Nutritional status in surgical patients with IBD

**ECCO Current Practice Position 1.3**

Correction of undernutrition or overnutrition is advised in IBD patients before surgery, despite the limitations of current evidence

The nutritional status of surgical IBD patients has been poorly investigated, despite the fact that an intestinal operation is often performed in an active state of disease and always has an effect on gastrointestinal homeostasis. Much of the literature comes from retrospective analyses of medical charts. The indicators used to assess nutritional status include BMI and occasionally recent weight loss. Assessment of dietary intake or biomarkers is rarely reported.[20]

Before surgery, between 2% to 15% of patients with CD are reported to have a low BMI.[21–25] Research from the USA[10,12,25] suggests that in CD patients, obesity [BMI >30 kg/m$^2$] is more common than being underweight [BMI <18.5 kg/m$^2$]. In contrast, studies from Europe and Asia suggest that the prevalence of obesity is less common,[22,25–28] and BMI before surgery tends to be lower than in the USA.[22,25–38] These discrepancies may be due to variations in health practices or reflect differences in the prevalence of obesity in the general population throughout the world. The overall picture is further complicated by known ethnic discrepancies in BMI-body fat associations.

Three retrospective studies and one prospective study reported weight loss >10% in the 6 months preceding surgery in 23% to 54% of patients.[21,25,29,30] Taken together with the small proportion of patients who have a low BMI, this suggests that more patients at nutrition risk would be identified based on serial changes in BMI rather than on a sole weight measurement near the time of surgery.

With respect to preoperative body composition, four retrospective studies[22,31,39,40] have reported sarcopenia in a quarter of CD patients[31,40] without clear relation to BMI, whereas excess visceral fat [visceral fat area >130 cm$^2$] was observed in 30% of patients.[39] Barroso observed an excess in fat deposition and a deficit in skeletal muscle, with an inverse correlation between subcutaneous fat and abdominal musculature in IBD patients when compared with healthy controls.[22]

When considering dietary assessment in surgical IBD patients, a prospective study commented that 27% of patients had complete intolerance to food prior to surgery.[30] Another prospective study assessed preoperative dietary intake of micronutrients, using a food frequency questionnaire and plasma micronutrient concentrations. This study revealed that both pre- and postoperative calcium and vitamin D3 levels were below their respective reference ranges. However, for similar intake there were no statistically significant differences in the concentrations of plasma copper, iron, calcium, and vitamin D3 between the two groups.[34] Hence, with up to every second IBD patient suffering from malnutrition, routine assessment and correction of nutritional status is advised before elective surgery.

### 3.3. Preoperative nutritional status and clinical outcome in IBD patients

**ECCO Current Practice Position 1.4**

Undernutrition, overnutrition, and altered body composition are predictors for poor postoperative outcome in surgical IBD patients

Undernutrition and obesity can have a negative impact on the clinical course of a patient, leading to postoperative complications such as infections and up to anastomotic breakdown. Indeed, a low preoperative BMI was associated with a higher risk of postoperative infectious complications, including anastomotic breakdown, reoperations, prolonged hospitalisations, and increased mortality. Two studies have shown that weight loss >10% within the 6 months preceding first ileocaecal resection for CD was associated with adverse surgical outcomes, such as septic abdominal complications.[25,29] Likewise, IBD-associated sarcopenia was associated with poor postoperative outcomes.[31,40] Pedersen showed that sarcopenia was associated with need for blood transfusion, postoperative sepsis, deep vein thrombosis, intensive care unit [ICU] admission, and major complications.[40] In UC patients receiving restorative proctocolectomy, sarcopenia was associated with a higher rate of surgical-site infections, including pelvic sepsis.[31]

Few studies have explored the associations between presumptive biomarkers of nutritional status and perioperative outcomes. Three retrospective studies conducted in Asia, which used albumin/prealbumin concentrations and total lymphocyte count [calculating a prognostic nutritional index from serum albumin and total lymphocytes], showed inverse correlations with infectious complications in the postoperative phase.[26,36,41] In the study by Zhou, a prognostic nutritional index <40 [indicating higher nutritional risk] was an independent predictor for complications, particularly infectious complications.[41] Similar findings were reported by Maeda, who found that the prognostic nutritional index was the only factor associated with incisional site surgical infections.[26] Finally, a retrospective study conducted by Zhang suggested that a BMI <16.2 kg/m$^2$ was a stronger risk factor of postoperative abdominal septic complications, such as anastomotic and intestinal fistulae and intra-abdominal abscesses, than serum albumin.[36]

On the other hand, three retrospective studies that investigated obese BMI and postoperative outcomes yielded inconsistent evidence, except for a longer operative time.[24,42,43] Using CT-based analysis, visceral adiposity was associated with a longer surgery duration, greater blood loss, longer bowel resection, postoperative ileus, and a higher number of overall postoperative complications within 30 days of surgery, in a further study of 164 CD patients.[39] However, a smaller study in Scotland did not confirm these results.[22]

Based on the available literature, both undernutrition and obesity are independent risk factors for postoperative complications in IBD. However, it is likely that these associations are confounded by disease severity and high steroid use. Associations between biomarkers of nutritional status and clinical outcomes should be interpreted with caution, as these are influenced by the inflammatory process in active disease.

### 3.4. Preoperative nutritional optimisation in CD

**ECCO Current Practice Position 2.1**

Malnutrition is common among CD patients awaiting surgery and is a risk factor for adverse postoperative outcomes and complications

Patients with IBD are often at high risk for surgical complications for several reasons. These include malnutrition, chronic inflammation, medications that compromise wound healing, and septic complications related to the disease. The concept of perioperative optimisation assumes that mitigating these risk factors will lower postoperative complication rates. Perioperative nutritional support, by either the enteral or the parenteral route, may theoretically mitigate most of these risk factors. Malnutrition in patients with IBD can be caused by low dietary intake, malabsorption, and increased energy expenditure due to active inflammation. Therefore, it seems logical that nutritional support can improve nutritional status and attenuate the inflammatory process in the gut, particularly in small bowel CD. Attenuation of the inflammatory process may positively impact on postoperative complications and, more importantly, may allow discontinuation of medications such as steroids, which are associated with increased risk of postoperative complications.

In patients with CD, enteral nutrition [EN] was initially used preoperatively to improve nutritional status.[44] EN was subsequently also found to reduce inflammation and became common practice, mainly in children.[45] The most recent guidelines from the European Society of Clinical Nutrition and Metabolism recommend preoperative EN for 7 to 10 days for mildly malnourished patients [longer duration for those severely malnourished] who are undergoing major gastrointestinal surgery.[46]

The gastrointestinal tract should be used if it is accessible and not contraindicated. First, consider dietary advice to increase nutritional intake, which may or may not include oral nutritional supplements [ONS]. There are no randomised controlled trials [RCTs] of ONS in preoperative IBD patients. Second, EN, particularly exclusive EN [EEN] may be used. Third, where the gastrointestinal tract is not accessible, is contraindicated, or nutrient absorption is impaired, consider parenteral nutrition [PN].

Two systematic reviews and a Cochrane review summarise the use of perioperative nutritional support.[47–49] The largest systematic review of 29 studies, including 14 original papers,[47] concluded that perioperative nutritional care should be a mandatory strategy to improve patients' postoperative outcomes. Although most studies were retrospective or associated with some methodological flaws, the efficacy of preoperative EN was strongly suggested. The Cochrane review concluded that even though a low-to-moderate heterogeneity exists, a significant benefit was shown in reduction of total postoperative complications (relative risk [RR] 0.67; 95% confidence interval [CI] 0.53–0.84).[48]

### 3.5 Exclusive enteral nutrition in CD

**ECCO Current Practice Position 2.2**

Exclusive enteral nutrition [EEN] has shown promise as a preoperative optimisation strategy for reducing complications and improving nutritional status in CD patients. The optimal duration and route of administration is best defined by the multidisciplinary team

EEN for 4 to 6 weeks has been used in several retrospective studies in preoperative CD and compared with patients not taking EN. A major limitation was that these studies were retrospective case reviews, poorly controlled for surgery type, and prone to selection bias as participants were not randomised.[28,50–52] Heerasing demonstrated, in a retrospective case-control study, that 6 weeks of EEN led to reduction in C-reactive protein [CRP], shorter surgery duration, and lower incidence of postoperative abscesses or anastomotic leaks. A total of 25% of patients were able to avoid surgery.[28] Additionally, Wang showed a significantly lower incidence of both infectious and non-infectious complications compared with controls.[53]

A retrospective study including 114 patients showed a reduction in CRP, fewer anastomotic leakages [2.3% versus 17.9%; $p$ = 0.023], and less temporary diverting stomas [22.8% versus 40.9%; $p$ = 0.036] among those who received nutritional optimisation.[50] Additionally, EEN for penetrating CD allowed ileocolic resections with lower rates of postoperative morbidity and faecal diversion, in a retrospective study by Zerbib.[27]

In a prospective randomised study among 108 patients, Zhu found that EEN before surgery led to a reduction in inflammation followed by an improvement in nutrition [$p$ <0.0023].[54] Preoperative improvement in these parameters may potentially translate to lower postoperative complication rates.[30] Last, Li published a retrospective study including 497 patients who were divided into four groups. Patients who received EEN before surgery had better outcomes, including fewer postoperative complications [$p$ <0.05], lower rates of stoma creation [$p$ <0.05], fewer urgent operations [$p$ <0.05], and a longer postoperative immunosuppressant-free interval.[52]

In a prospective French study, 35 CD patients at high risk of surgical complications were treated with preoperative EEN for a mean of 3 weeks before surgery.[30] Postoperative outcomes were compared with 21 patients with CD at low surgical risk. Preoperative treatment with EEN resulted in similar postoperative complication rates in the high-risk [23.8%] and the low-risk [22.9%] patients. These results suggest that preoperative EEN is protective for high surgical risk patients who require resection.

A recent prospective investigation that treated 48 CD patients with enterocutaneous fistulae with short-peptide based EEN for 3 month,s revealed that 30 [62.5%] patients demonstrated successful closure of fistulae after 3 months of treatment.[55] However, these positive results were tempered by the GROWTH CD prospective study of EEN in 285 paediatric patients. Although higher remission rates and a trend towards improved growth were observed, there were no differences in the rate of complications.[56]

As most data originate from relatively small retrospective studies, there is a pressing need for further large prospective studies to help inform clinical practice. In addition, the mechanisms for how EEN affects inflammation are still unclear. Accordingly, further investigation is also required to better understand the biological processes by which nutritional optimisation may help reduce surgical complications.

To date, EEN may serve as a bridge to optimise high-risk patients before surgery in CD, by acting both at the pathophysiological and the nutritional level.

Of note, there are no studies that assessed the use of EEN in patients with UC.

### 3.6. Parenteral nutrition for preoperative optimisation in CD

**ECCO Current Practice Position 2.3**

Parenteral nutrition [PN] in patients with CD can optimise nutritional status before surgery as a supplement to EN, or as an alternative if the use of EN is not possible or is contraindicated

The use of PN in the perioperative period is reserved for patients who are unable to tolerate EN or do not meet their nutritional requirements via the enteral route.[7] PN should be considered if the patient is malnourished at the time of surgery or if oral intake is not possible within a week after surgery. Other indications for PN include bowel obstruction or subileus, high-output fistulae, bowel ischaemia, severe haemorrhage, anastomotic leak, or when the gut is dysfunctional due to active disease.[46]

**ECCO Current Practice Position 2.4**

Administration of PN preoperatively may reduce overall postoperative complications and septic complications in malnourished CD patients

A recent systematic review and meta-analysis of observational studies compared preoperative EN and PN, to assess whether they reduce postoperative complications in CD patients.[49] Five studies were included, three of which focused on the use of PN; a total of 280 patients were pooled. PN was used for a minimum of 11.5 ± 1.2 days, and 30-day morbidity and mortality were recorded. CD patients who received preoperative PN had a trend towards reduced rates of postoperative complications [15%] compared with the group that had standard care without any nutritional support [24.4%]. However, this trend did not reach statistical significance, and therefore definitive conclusions on the benefits of perioperative PN could not be drawn.

Cohort studies have shown a reduction in postoperative morbidity in CD patients receiving PN for 5 days or more.[57,58]

Lashner investigated whether preoperative PN versus no preoperative PN reduced the length of bowel resection in 103 patients requiring segmental small bowel resection, ileocaecal resection, or segmental or total colectomy. Patients in the PN group required on average 20 cm less resection.[59]

A recent cohort study by Ayoub assessed 55 patients with CD who received preoperative PN for 60 days, compared with 89 controls. Multivariate analysis controlling for disease severity and malnutrition at baseline showed that patients receiving preoperative PN had significantly lower rates of non-infectious complications. Furthermore, weight loss >10% within the 6 months preceding surgery was a significant predictor of postoperative complications.[21] Overall, convincing evidence supports the use of preoperative PN in malnourished CD patients for at least 5 days, to reduce morbidity.

### 3.7. Preoperative nutritional optimisation in UC

**ECCO Current Practice Position 2.5**

There is no evidence to support routine perioperative administration of EN or PN to improve surgical outcomes in patients with UC

Although malnutrition has been associated with poorer postoperative paediatric outcomes in UC,[60] data supporting nutritional optimisation are currently lacking. Salinas compared 56 UC patients who received at least 7 days' preoperative PN with 179 UC patients who did not receive PN.[61] The groups were not balanced in baseline parameters and the PN group had greater disease activity. More patients in the PN group had total abdominal colectomy and end ileostomy. It is not clear how many, if any, of those patients received a non-diverted ileoanal pouch; 12% of the PN group patients had central line-related complications; and overall this group was more likely to develop complications. The

imbalance in baseline parameters and surgical procedures yielded a significant bias and therefore does not permit comparisons or conclusions. Nevertheless, it is common practice to stage surgery for UC in high-risk patients, whereas well-nourished patients mostly benefit from a one- or two-stage operation rather than a three-stage procedure as typically seen in the emergency setting. Despite the lack of firm evidence, it is advisable to correct nutritional deficiency before surgery for UC, as in CD

### 3.8. Nutritional optimisation in emergency IBD surgery

**ECCO Current Practice Position 2.6**

Emergency surgery should not be delayed for preoperative nutritional optimisation. Whenever surgical delay is reasonable, nutritional status should be optimised

Improvements in preoperative management can have a major positive impact on surgical outcomes in IBD patients, including reduced rates of stoma formation, lower rates of anastomosis leakage, and reduced length of hospital stay. This ultimately leads to reduced health care costs and improves inpatient experience and patient long-term quality of life. Preoperative nutritional optimisation may be required to achieve optimal postoperative outcomes, including reduction in surgical complications, and should be individualised taking into consideration disease phenotype and patient characteristics.[62]

There are situations where surgery cannot be delayed for nutritional optimisation. For example, in cases of acute severe colitis that do not respond to two lines of medical therapy or in more complicated and severe phenotypes of CD.[63] Current knowledge suggests that in such cases surgery should not be delayed for optimisation, as delay in surgery is associated with increased mortality.[64] The decision to proceed to immediate surgery or delayed intervention is ideally made by an interdisciplinary team and in a timely fashion if possible.

### 3.9. Postoperative nutritional care in IBD

**ECCO Current Practice Position 3.1**

Postoperative nutritional status in IBD patients should be assessed and appropriate nutritional support provided in a timely manner

Major surgery is associated with catabolic response, weight loss, decreased appetite, and reduction in measurable nutritional parameters. Enhanced recovery pathways encourage early oral intake after surgery, including oral nutritional supplementation. However, the catabolic response usually resolves only a few weeks after surgery. Postoperative nutritional status should be assessed and appropriate nutritional support provided in a timely manner if intake is inadequate.[46]

Generally, patients in surgical remission have no dietary restrictions. Several small studies suggested that combining formula EN with a regular or restricted diet postoperatively may prevent disease recurrence.[65–67] However, this approach has not been investigated in large studies and is currently not common practice.

### 3.10. Use of postoperative nutritional optimisation for decreasing complications

**ECCO Current Practice Position 3.2**

In elective IBD bowel surgery, patients should be offered oral nutrition starting on the day of surgery, according to the principles of enhanced recovery pathways

Malnutrition and nutrient deficiencies are common in people with IBD[68,69] and are independent risk factors for poor postoperative outcomes, including increased abdominal septic complications and higher mortality rates.[70] The optimal nutritional intervention to reduce malnutrition and improve surgical outcomes in IBD is not known. However, enhanced recovery pathways, including an earlier start of normal diet and postoperative nutritional support, have led to significant improvements in the care of patients undergoing elective gastrointestinal surgery.[71] This has led to reduced length of hospital stay, reduced morbidity, and improved quality of life.[72,73]

### 3.11. Long-term nutritional needs

**ECCO Current Practice Position 4.1**

There is no evidence to support withholding dietary fibre in patients with IBD, with the exception of patients with stricturing CD

IBD patients who are in remission but have chronic stricturing disease should adhere to a low-fibre diet to avoid obstruction.[74,75] Otherwise, there are no dietary restrictions. Chewing thoroughly and eating slowly are general advice and have the potential to improve intestinal transit, particularly in the context of stricturing disease.

**ECCO Current Practice Position 4.2**

There is no consistent evidence for the routine supplementation of dietary fibre, prebiotics, omega-3 fatty acids, probiotics, supplemental enteral nutrition, and antioxidants in the maintenance of remission of IBD patients

Dietary fibre has a beneficial effect on commensal gut bacteria and may have a role in maintaining remission in IBD.[76] Formation of short-chain fatty acids following fibre absorption stimulates water and sodium absorption in the colon and promotes mucosal healing. In a study of 1130 CD patients in remission, patients with the highest quartile intake of fibre were less likely to suffer a flare compared with those in the lowest quartile (odds ratio [OR] 0.59, 95% CI 0.43–0.81). However, the same study failed to demonstrate any benefits in patients with UC or indeterminate colitis.[74] A systematic review of 23 RCTs, including 1296 patients, reported that fibre supplementation was beneficial in 3/10 UC trials, in 1/1 pouchitis study, and in 0/12 CD studies.[75]

Prebiotics are specific carbohydrates that are regarded as a type of dietary fibre. In vitro and animal studies provide some support for the use of prebiotics to alter intestine-derived inflammation, a key contributor to IBD pathogenesis. Currently available data are hampered by inconsistency in both outcomes and their assessment,

variations in disease activity and study duration, the low number of CD and UC patients treated, and the lack of control groups.[77]

Furthermore, a variety of prebiotics have been assessed [fructans, four studies;[78–81] germinated barley, one study;[82] Plantago ovate, two studies[83,84]], ande some studies combined prebiotics and probiotics and thus prevent any direct interpretation.[85,86]

A Cochrane review of six studies, including 1039 CD patients, assessed fish oil [omega-3 fatty acids, or *n*-3 FA] for the maintenance of remission.[87] Relapse in the *n*-3 FA group was 39% at 12 months compared with 47% of placebo patients (relative risk [RR] 0.77; 95% CI 0.61–0.98). The same effect was also found in two other systematic reviews.[88,89] However, a GRADE analysis rated the overall quality of the evidence for relapse as very low. Analysis of the EPIC1 and EPIC2 studies,[90] which were at low risk of bias, did not show statistically significant effects any more [RR 0.88; 95% CI 0.74–1.05; $I^2$ = 0%]. No serious adverse events were recorded in any of the studies. However, a pooled analysis revealed a significantly higher rate of diarrhoea [RR 1.36; 95% CI 1.01–1.84] and upper gastrointestinal tract symptoms [RR 1.65; 95% CI 1.25–2.18] in the *n*-3 FA treatment group. A systematic review of RCTs of *n*-3 FA supplementation in UC patients found no difference in relapse rate [RR 1.02; 95% CI 0.51–2.03].[88] These findings were also confirmed in another systematic review.[91]

Last, a recent meta-analysis compiled the evidence for use of probiotics in IBD patients.[92] For the maintenance of remission in UC patients, 3/6 RCTs compared probiotics with 5-aminoslaicylate [5-ASA][93–95] and 3/6 compared probiotics with placebo[96–98]; no apparent benefit was observed with probiotics [Table 1]. Similarly, there was no benefit of probiotics in preventing relapse of quiescent CD [RR of disease relapse 1.03; 95% CI 0.70–1.51][98,99] or in preventing relapse of CD after surgically induced remission.

A systematic review analysed partial EN for the maintenance of remission in CD, but failed to provide a statistical analysis, due to differences in the control interventions and outcome assessments.[100]

The data regarding the use of antioxidants for patients with IBD are not substantial enough to make any recommendations. One trial of 57 patients who were administered a combination of vitamin C and E supplements for 4 weeks did not demonstrate any effect on disease activity.[101]

**ECCO Current Practice Position 4.3**

Probiotics may help to prevent acute pouchitis and maintain remission of chronic pouchitis. Probiotics are not indicated in the treatment of moderate pouchitis

The interaction between the gut microbiota and the patient's immune response plays a central role in the aetiology of IBD. Therefore, therapies that modulate the microbiota, including probiotics, have gained popularity over the past two decades. In the context of long-term postoperative nutritional needs, probiotics may potentially benefit patients with CD [to prevent postoperative recurrence] and UC [to avoid or treat pouchitis].

Four randomised trials, with a total of 131 patients, and one comparative cohort study of 117 patients demonstrated the efficacy of probiotics in preventing pouchitis, when used as a prophylactic treatment after pouch surgery.[102–106] Additionally, two randomised trials with a total of 76 patients and one observational study including 31 patients showed that VSL#3, a cocktail of eight strains of probiotics, was effective in treating chronic pouchitis and in preventing relapse in patients with a history of intermittent pouchitis.[107–109] Treating moderate active pouchitis with probiotics was not successful.[110,111] Finally, another small randomised trial did not reveal any benefit of a cocktail of probiotics [*Lactobacillus plantarum* 299 and *Bifidobacterium infantis* Cure 21] on pouch function.[112] These findings were confirmed in a total of four meta-analyses, including a Cochrane meta-analysis.[113–116] These meta-analyses highlighted the low quality of all reported trials, referring specifically to their low sample size and significant heterogeneity.

**ECCO Current Practice Position 4.4**

Probiotics are not indicated as prophylactic treatment of postoperative recurrence after surgery for CD

About 80% of CD patients undergoing surgery will show endoscopic recurrence within a year after surgery. The potential role of probiotics as prophylaxis after surgery has been assessed in five placebo-controlled randomised trials.[117–121] None of these trials demonstrated any significant benefit of probiotics on postoperative endoscopic recurrence. The most recent trial randomised 119 patients between placebo or VSL#3, and assessed endoscopic recurrence at postoperative Day 90.[121] Similar to previous trials, endoscopic findings did not reach statistical significance. Despite some heterogeneity, most trials had an acceptable sample size and were placebo controlled and double blind. Therefore, it is reasonable to assume that sufficient evidence supports the lack of efficacy of the probiotics [*Lactobacilllus* GG, *Lactobacillus johnsonii*, Synbiotic 2000, and VSL#3] for the prevention of postoperative endoscopic recurrence in patients with CD who have undergone an ileocolic resection. This was further confirmed in a meta-analysis that pooled data from 4/5 randomized studies.[122] Probiotics should therefore not be used as prophylaxis in postoperative patients with CD.

**ECCO Current Practice Position 4.5**

There are no specific nutritional measures for patients with an ileal pouch-anal anastomosis. However, advice on fluid and fibre intake is beneficial and monitoring for anaemia, vitamin B12 deficiency, and osteopenia is indicated in the long term

**Table 1.** Meta-analysis of RCT assessing the efficacy of probiotics in IBD.[92]

| No. of RCTs | Included patients | RR relapse [95% CI] | Heterogeneity between studies | Adverse events |
|---|---|---|---|---|
| 3 Probiotics vs 5-ASA | 555 | 1.02 [0.85–1.23] | [$I^2$ = 0%, $p$ = 0.62]. | RR 1.09; 95% CI 0.71–1.67 |
| 3 Probiotics vs placebo | 122 | 0.62 [0.33–1.16] | [$I^2$ = 76%, $p$ = 0.02] | None reported[x] |

RCTs, randomised controlled trials; RR, relative risk; CI, confidence interval; ASA, aminosalicylate.

The nutritional state of patients after ileal pouch-anal anastomosis [IPAA] for UC is generally better than before surgery.[123] Moreover, the patients' nutritional state is similar after segmental colectomy, total colectomy, or proctocolectomy for CD, indicating the redundancy of any nutritional support after proctocolectomy.[124]

Patients with an IPAA develop adequate intake of trace elements [including zinc, copper, manganese, and selenium] when compared with a healthy control group.[125] However, anaemia is observed in 5% to 56% of all pouch patients.[126] This may be caused by iron and vitamin B12 deficiencies, which are present in about 25% of all IPAA patients.[127,128]

Additionally, pouch patients can present with osteopenia to a greater degree than UC patients.[128–130] Indeed, the presence of a pelvic pouch is an independent risk factor for osteopenia.[130] Accordingly, monitoring for anaemia, vitamin B12 deficiency,

## 3.12. Management of short bowel syndrome and intestinal failure

**ECCO Current Practice Position 4.6**

Short bowel syndrome [SBS] and intestinal failure [IF] can complicate the course of CD as a consequence of high enterocutaneous or entero-enteric fistulae, strictures, or extended surgical resections

The cumulative incidence of short bowel syndrome [SBS] or intestinal failure [IF] in a large retrospective multicentre study in CD patients[131] reached 8.5% [including IF-related death] over 20 years after initial surgery. SBS and IF are thus not rare in the long term. A total of 1703 patients from 12 different hospitals were included in the analysis. SBS may cause either intestinal insufficiency or IF, in which IF is defined as decreased intestinal absorption that results in dependency on intravenous fluids, micronutrients, or PN[132] to maintain health status, growth, or both. IF is classified as type 1 [acute], type 2 [prolonged acute], and type 3 [chronic]; chronic IF often requires long-term PN.[133] Chronic IF typically arises as the irreversible result of [complications of] multiple surgical resections many years after initial CD diagnosis.[134] It may also arise as a potentially reversible consequence of high enterocutaneous or entero-enteric fistula or bypass, respectively, intestinal strictures.[135] Risk factors for SBS or IF include congenital short bowel length,[136] family history of IBD, delay in diagnosis, stricturing disease, early disease onset, young age at first surgery, and surgical complications.[137] The importance of appropriately timed and executed surgery in this context cannot be overemphasized.

**ECCO Current Practice Position 4.7**

Teduglutide and intestinal transplantation can be considered in individual CD patients with SBS or IF when PN therapy fails

PN with intravenous fluid and micronutrients is the mainstay treatment of IF.[132] Teduglutide, a recombinant human GLP-2 analogue, improved many clinical, laboratory, and histological abnormalities in SBS patients in several phase II and III trials.[138,139] One retrospective cohort study with teduglutide [median duration of 365 days] was performed in 13 CD patients with SBS or IF. This study showed that most patients could be weaned off parenteral support.[140] Intestinal transplantation is a well-established further treatment for the few CD patients who fail PN or have life-threatening PN-related complications.[141] A retrospective study in 1115 intestinal transplant patients [of whom 142 were CD patients] revealed that the risk of graft rejection or death is similar for patients with or without CD.[142] The intestinal transplant was rejected in 37% of CD patients and in 33% of non-CD patients 1 year after the procedure. Both use of teduglutide and intestinal transplantation can be considered in individual CD patients with SBS or IF when PN therapy fails.

**ECCO Current Practice Position 4.8**

EEN can induce clinical remission in selected CD patients presenting with functional SBS or IF as a consequence of inflammatory strictures

A functional SBS or [temporary] IF can occur as a consequence of inflammatory strictures. A 12-week course of EEN can be considered in CD patients with inflammatory strictures. Hu prospectively studied 65 CD patients, of whom 81.4% achieved symptomatic and 64.4% clinical remission on EEN therapy.[143] Yang showed in a non-controlled study in 41 adult CD patients with intestinal fistulae/abdominal abscesses or inflammatory intestinal strictures, that EEN was effective in inducing clinical remission and mucosal healing, promoting fistula closure, and reducing abscess size.[144]

## 3.13. Management of enterostomies

The care of enterostomies is of central importance for IBD patients. Some patients quickly learn to master their enterostomy, including the pitfalls of high output/dehydration, food bolus obstruction, and appliance management, but others may struggle. Stoma therapists or IBD specialist nurses are a crucial resource and should be involved as early as possible whenever a patient receives an enterostomy. When an enterostomy becomes a cause of concern, its management is best addressed by an interdisciplinary team, particularly when nutritional concerns arise.

**ECCO Current Practice Position 4.9**

There is scarce evidence on the best nutritional management in CD patients with high-output ileostomy or proximal jejunostomy

Approximately 50% of CD patients undergo surgery within the first 10 years after CD diagnosis, and another 30% at some point in their lifetime.[145] The age of first stoma is earlier in CD than UC, and stoma-related complications [such as fistula, retraction, and stenosis] are more frequent in CD [36.8%] than UC [17.4%] [$p$ <0.05]. Among CD patients, colostomies need earlier revisional surgery than ileostomies [$p$ <0.05].[146]

There is limited evidence on nutritional management of IBD patients with a [high-output] ileostomy, proximal jejunostomy, or colostomy. A retrospective study conducted by Jang, on 394 CD patients after small-bowel resection, showed that active disease, having an ileostomy, and a remnant small bowel length ≤230 cm are risk factors for reduced nutritional status [BMI <17.5 kg/m$^2$ or modified nutritional risk index <83.5].[147] The small prospective studies of Ecker showed that oral budesonide significantly improved water absorption and decreased stoma output in CD patients with an ileostomy.[148,149] Despite limited evidence, interdisciplinary and

interprofessional management of enterostomy patients is frequently key to optimal care and quality of life.

**ECCO Current Practice Position 4.10**

Nutritional and clinical assessments must be performed on patients with high-output stoma [HOS]

Dehydration necessitating hospital admission occurs in up to 17% of patients after colorectal resection with a diverting loop ileostomy.[150] High-output stomas [HOS] are common within 3 weeks of surgery, and spontaneous resolution occurs in half of the patients. HOS are most commonly seen in jejunostomy patients and are unlikely to occur in those with a colostomy with retained small bowel.[19] A HOS has been defined as an effluent of 1000 to 2000 mL/24 h. When output is >2000 mL/24 h, dehydration, depletion of sodium and magnesium, and malnutrition can occur.[151] Electrolyte deficiencies due to a combination of reduced absorption and increased renal excretion should be replaced orally, or by intravenous supplementation if insufficient.[152] Laboratory investigations include serum urea and creatinine, sodium, potassium, magnesium, and urinary sodium. A random urinary sodium <20 mmol/L suggests sodium depletion. Patients should also be assessed for vitamin B12 and iron deficiency and provided with replacement therapy if required. Assessment for selenium, zinc, and vitamin A, D, E, and K deficiencies should be considered.[153]

**ECCO Current Practice Position 4.11**

HOS patients should restrict hypotonic/hypertonic fluids to <1000 mL daily. The remaining fluid requirements should be met by oral intake of an isotonic glucose-saline solution

There is no [prospective] research on the optimal nutritional strategy for HOS management specific to IBD patients. In general, HOS treatment is a combination of drug therapies [to reduce intestinal motility or secretions] and nutritional therapy, including hypotonic fluid restriction, oral rehydration solution, salt-rich diets, EN, and/or short-term parenteral electrolytes.[19,154] In the initial phase of treatment, if there is marked dehydration, rehydration with intravenous fluids [such as 0.9% saline] while limiting oral intake is advised, followed by gradual withdrawal of intravenous fluids and further restriction of hypotonic oral fluids. Intravenous saline may be required as a long-term therapy in patients unable to maintain hydration with the above measures. A random urinary sodium >20 mmol/L should be the target of treatment. Patients may be allowed to drink daily <1000 ml of fluids of their choice irrespective of osmolarity; further fluid requirements are best met by an isotonic glucose-saline solution. Isotonic solutions can be purchased without prescription or handmade according to Box 1.

**Box 1. Modified World Health Organization cholera solution [also known as St Mark's solution].**

**Solution ingredients**

- Sodium chloride 60 mmol [3.5 g]
- Sodium bicarbonate 30 mmol [2.5 g]
- Glucose 110 mmol [20 g]
- Water 1 L

**ECCO Current Practice Position 4.12**

Drug therapy [proton-pump inhibitors, loperamide, opium, psyllium fibres, cholestyramine] can help reduce intestinal motility or secretions and thereby support absorption

The large volume of gastric secretion may minimise time for absorption and thus contribute to increased faecal losses. The associated hyperacidity may also denature pancreatic enzymes and compromise bile salt function, which may further impede absorption. In this context, mitigation of gastric hypersecretion is achieved with proton-pump inhibitors.[132]

The use of anti-diarrhoeal medication, loperamide, and opiate drugs [such as codeine phosphate or opium] reduces water and electrolyte losses and minimises diarrhoea. Loperamide is preferred to opiate drugs as it is non-sedating, non-addictive, and does not cause fat malabsorption.[132]

Fat maldigestion due to bile-salt malabsorption occurs when >100 cm of terminal ileum have been resected. The bile acid sequestering agent cholestyramine can be useful in decreasing bile salt-related diarrhoea. However, due to its ability to bind to dietary lipids, cholestyramine may worsen steatorrhea in patients who have undergone a more significant resection.[155]

A trial of bulk-forming agents may slow gastric emptying and improve stool consistency and overall transit time in the small bowel. Psyllium or bulking agents are inexpensive and devoid of significant adverse effects. However, they may also lead to decreased food intake due to increased satiety and may also reduce the absorption of nutrients.[156]

**ECCO Current Practice Position 4.13**

HOS patients require a large oral energy intake, in which osmolality is kept low by using large molecules that are high in fat or carbohydrate content

Patients with HOS require a large oral dietary energy intake, in which osmolality is kept low by using large molecules that are high in fat or carbohydrate content. Patients should follow a low-fibre diet,[152] avoiding nuts, wholemeal products, and fruits and vegetables with skins in particular.[155] Oral sodium intake should not exceed 90 mmol/L and a diet osmolality close to 300 mOsm/kg should be maintained. Hyperosmolar elemental diets should be avoided as they exacerbate a HOS. PN is required when patients cannot absorb more than one-third of their energy requirements enterally, typically when <75 cm of small bowel remains or has been sited as a high jejunostomy.[152]

**ECCO Current Practice Position 4.14**

The risk of renal calculae in patients with a jejuno-colic anastomosis and SBS can be minimised by preventing chronic dehydration and advising patients on a diet low in oxalate, moderate in fat, and high in calcium

Patients who have a jejuno-colic anastomosis and SBS are at increased risk of developing renal calculae due to increased colonic oxalate absorption.[157] Fat malabsorption results in an increase in free fatty acids that preferentially bind to calcium, which leads to an increased concentration

of unbound oxalate. Due to the presence of unabsorbed bile salts, colonic permeability to oxalate is increased resulting in hyperoxaluria. In addition, this process is aggravated by chronic dehydration.[158]

Specific components of the diet should consist of moderate fat intake [providing 20–30% of total energy as fat], a reduction in foods high in oxalate [e.g. beetroot, chocolate, most nuts, parsley, rhubarb, spinach, tea], and an increase in calcium-rich foods [or if not possible, a calcium supplement].[159] Chronic dehydration should be avoided.

## 4. Discussion

Although the evidence to support perioperative dietary therapy in IBD and to optimise perioperative outcomes lacks high-quality RCTs, dietary therapy is common practice in expert centres. Indeed, nutritional screening and dietary optimisation in medical and surgical patients is a standard of care that translates into improved clinical and economic outcomes. In this context, randomisation of high-risk patients undergoing surgery with and without dietary therapy is unethical and unlikely to happen. On the other hand, many IBD patients may benefit from increased awareness and correction of their nutritional deficiencies. The integration of perioperative nutritional screening and *ad hoc* dietary therapy has the potential to improve quality of care and patient-reported outcomes. Simple interventions such as iron deficiency screening and supplementation are useful in reducing the need for transfusion and improving recovery rates and quality of life.[160–163] In addition, preoperative carbohydrate loading and early feeding have become an integral part of enhanced recovery pathways in gastrointestinal surgery.[72] Last, the interplay between the immune system, the gut microbiome, and nutrition may explain the initiation and persistence of IBD at large and is currently the subject of intensive investigation[164,165]; for example, EEN has shown promising clinical results.[28,166]

The present topical review has covered key elements in perioperative dietary therapy in IBD, including routine nutritional assessment, perioperative nutritional supplementation, EEN, and the management of enterostomy. Current practice positions have been recommended based on an extensive literature review and an interdisciplinary consensus of European experts on behalf of ECCO. The expert appraisal of the evidence at hand, and the high rate of recommendation [80% agreement] across specialties, have allowed for balanced recommendations with clinical relevance in daily practice.

## Funding

This work was supported by the European Crohn's and Colitis Organisation.

## Conflict of Interest

ECCO has diligently maintained a disclosure policy of potential conflicts of interests [CoI]. The conflict of interest declaration is based on a form used by the International Committee of Medical Journal Editors [ICMJE]. The CoI statement is not only stored at the ECCO Office and the editorial office of *JCC*, but is also open to public scrutiny on the ECCO website [https://www.ecco-ibd.eu/about-ecco/ecco-disclosures.html], providing a comprehensive overview of potential conflicts of interest of authors. The ECCO Topical Review Projects are based on an international consensus process. Any treatment decisions are a matter for the individual clinician and should not be based exclusively on the content of the ECCO Topical Reviews. ECCO and/or any of its staff members and/or any consensus contributor may not be held liable for any information published in good faith in the ECCO Topical Reviews.

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## Acknowledgments

The authors thank the ECCO Office, in particular Julia Gabriel and Dauren Ramankulov, for their constant support in the development of this topical review. The authors also thank Torsten Karge from the user group–clinical guidelines services for his valued assistance.

## Author Contributions

This manuscript is a joint expert consensus activity. Hence all authors participated sufficiently, intellectually or practically, in the work to take public responsibility for the content of the article, including the concept, design, data interpretation, and writing of the manuscript. The final version of the manuscript was approved by all authors.

## References

1. Ng SC, Shi HY, Hamidi N, *et al*. Worldwide incidence and prevalence of inflammatory bowel disease in the 21st century: a systematic review of population-based studies. *Lancet* 2018;**390**:2769–78.
2. Sykora J, Pomahacova R, Kreslova M, *et al*. Current global trends in the incidence of pediatric-onset inflammatory bowel disease. *World J Gastroenterol* 2018;**24**:2741–63.
3. Frolkis AD, Dykeman J, Negron ME, *et al*. Risk of surgery for inflammatory bowel diseases has decreased over time: A systematic review and meta-analysis of population-based studies. *Gastroenterology* 2013;**145**:996–1006.
4. Peyrin-Biroulet L, Germain A, Patel AS, Lindsay JO. Systematic review: Outcomes and post-operative complications following colectomy for ulcerative colitis. *Aliment Pharmacol Ther* 2016;**44**:807–16.
5. Patel KV, Darakhshan AA, Griffin N, *et al*. Patient optimisation for surgery relating to Crohn's disease. *Nat Rev Gastroenterol Hepatol* 2016;**13**:707–19.
6. Dreznik Y, Horesh N, Gutman M, *et al*. Preoperative nutritional optimisation for Crohn's disease patients can improve surgical outcome. *Dig Surg* 2018;**35**:442–7.
7. Forbes A, Escher J, Hebuterne X, *et al*. Espen guideline: Clinical nutrition in inflammatory bowel disease. *Clin Nutr* 2017;**36**:321–47.
8. Fletcher AJ, Marchildon GP. Using the delphi method for qualitative, participatory action research in health leadership. *Int J Qual Methods* 2014;**13**:1–18.
9. Gerasimidis K, McGrogan P, Edwards CA. The aetiology and impact of malnutrition in paediatric inflammatory bowel disease. *J Hum Nutr Diet* 2011;**24**:313–26.
10. Gerasimidis K, Keane O, Macleod I, Flynn DM, Wright CM. A four-stage evaluation of the paediatric Yorkhill malnutrition score in a tertiary paediatric hospital and a district general hospital. *Br J Nutr* 2010;**104**:751–6.
11. Gerasimidis K, Drongitis P, Murray L, Young D, McKee RF. A local nutritional screening tool compared with malnutrition universal screening tool. *Eur J Clin Nutr* 2007;**61**:916–21.
12. Cederholm T, Bosaeus I, Barazzoni R, *et al*. Diagnostic criteria for malnutrition - an ESPEN consensus statement. *Clin Nutr* 2015;**34**:335–40.

13. Huysentruyt K, Hulst J, Bian F, *et al.* Opinions and practices of healthcare professionals on assessment of disease associated malnutrition in children: Results from an international survey. *Clin Nutr* 2019;**38**:708–14.
14. Varille V, Cezard JP, de Lagausie P, *et al.* Resting energy expenditure before and after surgical resection of gut lesions in pediatric Crohn's disease. *J Pediatr Gastroenterol Nutrn* 1996;**23**:13–9.
15. Lenz A, Franklin GA, Cheadle WG. Systemic inflammation after trauma. *Injury* 2007;**38**:1336–45.
16. McMillan DC, Maguire D, Talwar D. Relationship between nutritional status and the systemic inflammatory response: Micronutrients. *Proc Nutr Soc* 2019;**78**:56–67.
17. Sattar N, Scott HR, McMillan DC, *et al*. Acute-phase reactants and plasma trace element concentrations in non-small cell lung cancer patients and controls. *Nutr Cancer* 1997;**28**:308–12.
18. Jain S, Gautam V, Naseem S. Acute-phase proteins: As diagnostic tool. *J Pharm Bioallied Sci* 2011;**3**:118–27.
19. Baker ML, Williams RN, Nightingale JM. Causes and management of a high-output stoma. *Colorectal Dis* 2011;**13**:191–7.
20. Sandall AM, Wall CL, Lomer MCE. Nutrition assessment in Crohn's disease using anthropometric, biochemical, and dietary indexes: a narrative review. *J Acad Nutr Diet* 2019, Jun 24. doi: 10.1016/j.jand.2019.04.013. [Epub ahead of print.]
21. Ayoub FK, Ouni AY, Chaudhry A, *et al.* Pre-operative total parenteral nutrition improves post-operative outcomes in a subset of Crohn's disease patients undergoing major abdominal surgery. *Gastroenterol Rep [Oxf]s* 2019;**7**:107–14.
22. Barroso T, Conway F, Emel S, *et al*. Patients with inflammatory bowel disease have higher abdominal adiposity and less skeletal mass than healthy controls. *Ann Gastroenterol* 2018;**31**:566–71.
23. Canedo J, Pinto RA, Regadas S, *et al*. Laparoscopic surgery for inflammatory bowel disease: Does weight matter? *Surg Endosc* 2010;**24**:1274–9.
24. Krane MK, Allaix ME, Zoccali M, *et al.* Does morbid obesity change outcomes after laparoscopic surgery for inflammatory bowel disease? Review of 626 consecutive cases. *J Am Coll Surg* 2013;**216**:986–96.
25. Skowronska-Piekarska U, Matysiak K, Sowinska A. The impact of the nutritional state of patients on the results of the surgical treatment of ulcerative colitis. *Pol Przegl Chir* 2013;**85**:424–32.
26. Maeda K, Nagahara H, Shibutani M, *et al.* A preoperative low nutritional prognostic index correlates with the incidence of incisional surgical site infections after bowel resection in patients with Crohn's disease. *Surg Today* 2015;**45**:1366–72.
27. Zerbib P, Koriche D, Truant S, *et al.* Pre-operative management is associated with low rate of post-operative morbidity in penetrating Crohn's disease. *Aliment Pharmacol Ther* 2010;**32**:459–65.
28. Heerasing N, Thompson B, Hendy P, *et al.* Exclusive enteral nutrition provides an effective bridge to safer interval elective surgery for adults with Crohn's disease. *Aliment Pharmacol Ther* 2017;**45**:660–9.
29. Alves A, Panis Y, Bouhnik Y, *et al*. Risk factors for intra-abdominal septic complications after a first ileocecal resection for Crohn's disease: a multivariate analysis in 161 consecutive patients. *Dis Colon Rectum* 2007;**50**:331–6.
30. Beaupel N, Brouquet A, Abdalla S, *et al*. Preoperative oral polymeric diet enriched with transforming growth factor-beta 2 [module] could decrease postoperative morbidity after surgery for complicated ileocolonic Crohn's disease. *Scand J Gastroenterol* 2017;**52**:5–10.
31. Fujikawa H, Araki T, Okita Y, *et al.* Impact of sarcopenia on surgical site infection after restorative proctocolectomy for ulcerative colitis. *Surg Today* 2017;**47**:92–8.
32. Lee JS, Kim HJ, Cho HM, Lee KM, Kye BH. The importance of the Crohn's disease activity index in surgery for small bowel Crohn's disease. *J Visc Surg* 2016;**153**:339–45.
33. Liu S, Miao J, Wang G, *et al.* Risk factors for postoperative surgical site infections in patients with Crohn's disease receiving definitive bowel resection. *Sci Rep* 2017;**7**:9828.
34. Ma X, Zhao K, Wei L, *et al.* Altered plasma concentrations of trace elements in ulcerative colitis patients before and after surgery. *Biol Trace Elem Res* 2013;**153**:100–4.
35. Serradori T, Germain A, Scherrer ML, *et al.* The effect of immune therapy on surgical site infection following Crohn's disease resection. *Br J Surg* 2013;**100**:1089–93.
36. Zhang M, Gao X, Chen Y, *et al.* Body mass index is a marker of nutrition preparation sufficiency before surgery for Crohn's disease from the perspective of intra-abdominal septic complications: A retrospective cohort study. *Medicine (Baltimore)* 2015;**94**:e1455.
37. Zhu Y, Zhou W, Qi W, *et al.* Body mass index is a practical preoperative nutritional index for postoperative infectious complications after intestinal resection in patients with Crohn's disease. *Medicine (Baltimore)* 2017;**96**:e7113.
38. Liu S, Miao J, Wang G, *et al.* Risk factors for postoperative surgical site infections in patients with Crohn's disease receiving definitive bowel resection. *Int J Colorect Dis* 2017;**7**:9828.
39. Ding Z, Wu XR, Remer EM, *et al.* Association between high visceral fat area and postoperative complications in patients with Crohn's disease following primary surgery. *Colorectal Dis* 2016;**18**:163–72.
40. Pedersen M, Cromwell J, Nau P. Sarcopenia is a predictor of surgical morbidity in inflammatory bowel disease. *Inflamm Bowel Dis* 2017;**23**:1867–72.
41. Zhou W, Cao Q, Qi W, *et al.* Prognostic nutritional index predicts short-term postoperative outcomes after bowel resection for Crohn's disease. *Nutr Clin Pract* 2017;**32**:92–7.
42. Causey MW, Johnson EK, Miller S, *et al*. The impact of obesity on outcomes following major surgery for Crohn's disease: An American College of Surgeons national surgical quality improvement program assessment. *Dis Colon Rectum* 2011;**54**:1488–95.
43. Malik TA, Manne A, Oster RA, *et al*. Obesity is associated with poor surgical outcome in Crohn's disease. *Gastroenterology Res* 2013;**6**:85–90.
44. El-Hussuna A, Iesalnieks I, Horesh N, *et al*. The effect of pre-operative optimization on post-operative outcome in Crohn's disease resections. *Int J Colorectal Dis* 2017;**32**:49–56.
45. Ruemmele FM, Veres G, Kolho KL, *et al.*; European Crohn's and Colitis Organisation; European Society of Pediatric Gastroenterology, Hepatology and Nutrition. Consensus guidelines of ECCO/ESPGHAN on the medical management of pediatric Crohn's disease. *J Crohns Colitis* 2014;**8**:1179–207.
46. Weimann A, Braga M, Carli F, *et al.* ESPEN guideline: Clinical nutrition in surgery. *Clin Nutr* 2017;**36**:623–50.
47. Grass F, Pache B, Martin D, *et al.* Preoperative nutritional conditioning of crohn's patients-systematic review of current evidence and practice. *Nutrients* 2017;**9**:562. doi: 10.3390/nu9060562.
48. Burden S, Todd C, Hill J, Lal S. Pre-operative nutrition support in patients undergoing gastrointestinal surgery. *Cochrane Database Syst Rev* 2012;**11**:CD008879.
49. Brennan GT, Ha I, Hogan C, *et al.* Does preoperative enteral or parenteral nutrition reduce postoperative complications in Crohn's disease patients: A meta-analysis. *Eur J Gastroenterol Hepatol* 2018;**30**:997–1002.
50. Guo Z, Guo D, Gong J, *et al.* Preoperative nutritional therapy reduces the risk of anastomotic leakage in patients with Crohn's disease requiring resections. *Gastroenterol Res Pract* 2016;**2016**:5017856.
51. Li G, Ren J, Wang G, *et al.* Preoperative exclusive enteral nutrition reduces the postoperative septic complications of fistulizing Crohn's disease. *Eur J Clin Nutr* 2014;**68**:441–6.
52. Li Y, Zuo L, Zhu W, *et al.* Role of exclusive enteral nutrition in the preoperative optimization of patients with Crohn's disease following immunosuppressive therapy. *Medicine* 2015;**94**:e478.
53. Wang H, Zuo L, Zhao J, *et al.* Impact of preoperative exclusive enteral nutrition on postoperative complications and recurrence after bowel resection in patients with active Crohn's disease. *World J Surg* 2016;**40**:1993–2000.
54. Zhu W, Guo Z, Zuo L, *et al.* CONSORT: Different end-points of preoperative nutrition and outcome of bowel resection of Crohn disease: A randomized clinical trial. *Medicine (Baltimore)* 2015;**94**:e1175.
55. Yan D, Ren J, Wang G, Liu S, Li J. Predictors of response to enteral nutrition in abdominal enterocutaneous fistula patients with Crohn's disease. *Eur J Clin Nutr* 2014;**68**:959–63.

56. Cohen-Dolev N, Sladek M, Hussey S, *et al.* Differences in outcomes over time with exclusive enteral nutrition compared with steroids in children with mild to moderate Crohn's disease: Results from the growth CD study. *J Crohns Colitis* 2018;**12**:306–12.
57. Rombeau JL, Barot LR, Williamson CE, Mullen JL. Preoperative total parenteral nutrition and surgical outcome in patients with inflammatory bowel disease. *Am J Surg* 1982;**143**:139–43.
58. Jacobson S. Early postoperative complications in patients with Crohn's disease given and not given preoperative total parenteral nutrition. *Scand J Gastroenterol* 2012;**47**:170–7.
59. Lashner BA, Evans AA, Hanauer SB. Preoperative total parenteral nutrition for bowel resection in Crohn's disease. *Dig Dis Sci* 1989;**34**:741–6.
60. McAteer JP, Larison C, Wahbeh GT, Kronman MP, Goldin AB. Total colectomy for ulcerative colitis in children: When are we operating? *Pediatr Surg Int* 2013;**29**:689–96.
61. Salinas H, Dursun A, Konstantinidis I, *et al.* Does preoperative total parenteral nutrition in patients with ulcerative colitis produce better outcomes? *Int J Colorectal Dis* 2012;**27**:1479–83.
62. Spinelli A, Allocca M, Jovani M, Danese S. Review article: Optimal preparation for surgery in Crohn's disease. *Aliment Pharmacol Ther* 2014;**40**:1009–22.
63. Toh JWT, Wang N, Young CJ, *et al.*; and the Sydney IBD Cohort Collaborators. Major abdominal and perianal surgery in Crohn's disease: Long-term follow-up of Australian patients with Crohn's disease. *Dis Colon Rectum* 2018;**61**:67–76.
64. Randall J, Singh B, Warren BF, *et al.* Delayed surgery for acute severe colitis is associated with increased risk of postoperative complications. *Br J Surg* 2010;**97**:404–9.
65. Yamamoto T, Nakahigashi M, Umegae S, Kitagawa T, Matsumoto K. Impact of long-term enteral nutrition on clinical and endoscopic recurrence after resection for Crohn's disease: A prospective, non-randomized, parallel, controlled study. *Aliment Pharmacol Ther* 2007;**25**:67–72.
66. Ohara N, Mizushima T, Iijima H, *et al.* Adherence to an elemental diet for preventing postoperative recurrence of Crohn's disease. *Surg Today* 2017;**47**:1519–25.
67. Esaki M, Matsumoto T, Hizawa K, *et al.* Preventive effect of nutritional therapy against postoperative recurrence of Crohn disease, with reference to findings determined by intra-operative enteroscopy. *Scand J Gastroenterol* 2005;**40**:1431–7.
68. Bryant RV, Trott MJ, Bartholomeusz FD, Andrews JM. Systematic review: Body composition in adults with inflammatory bowel disease. *Aliment Pharmacol Ther* 2013;**38**:213–25.
69. Weisshof R, Chermesh I. Micronutrient deficiencies in inflammatory bowel disease. *Curr Opin Clin Nutr Metab Care* 2015;**18**:576–81.
70. Sungurtekin H, Sungurtekin U, Balci C, Zencir M, Erdem E. The influence of nutritional status on complications after major intraabdominal surgery. *J Am Coll Nutr* 2004;**23**:227–32.
71. Kehlet H, Wilmore DW. Multimodal strategies to improve surgical outcome. *Am J Surg* 2002;**183**:630–41.
72. Adamina M, Kehlet H, Tomlinson GA, Senagore AJ, Delaney CP. Enhanced recovery pathways optimise health outcomes and resource utilization: A meta-analysis of randomized controlled trials in colorectal surgery. *Surgery* 2011;**149**:830–40.
73. Spanjersberg WR, Reurings J, Keus F, van Laarhoven CJ. Fast track surgery versus conventional recovery strategies for colorectal surgery. *Cochrane Database Syst Rev* 2011:CD007635.
74. 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**:1130–6.
75. Wedlake L, Slack N, Andreyev HJ, Whelan K. Fiber in the treatment and maintenance of inflammatory bowel disease: A systematic review of randomized controlled trials. *Inflamm Bowel Dis* 2014;**20**:576–86.
76. Chapman MA. The role of the colonic flora in maintaining a healthy large bowel mucosa. *Ann R Coll Surg Engl* 2001;**83**:75–80.
77. Rasmussen HE, Hamaker BR. Prebiotics and inflammatory bowel disease. *Gastroenterol Clin North Am* 2017;**46**:783–95.
78. Lindsay JO, Whelan K, Stagg AJ, *et al.* Clinical, microbiological, and immunological effects of fructo-oligosaccharide in patients with Crohn's disease. *Gut* 2006;**55**:348–55.
79. Benjamin JL, Hedin CR, Koutsoumpas A, *et al.* Randomised, double-blind, placebo-controlled trial of fructo-oligosaccharides in active Crohn's disease. *Gut* 2011;**60**:923–9.
80. Casellas F, Borruel N, Torrejón A, *et al.* Oral oligofructose-enriched inulin supplementation in acute ulcerative colitis is well tolerated and associated with lowered faecal calprotectin. *Aliment Pharmacol Ther* 2007;**25**:1061–7.
81. De Preter V, Joossens M, Ballet V, *et al.* Metabolic profiling of the impact of oligofructose-enriched inulin in Crohn's disease patients: A double-blinded randomized controlled trial. *Clin Transl Gastroenterol* 2013;**4**:e30.
82. Kanauchi O, Mitsuyama K, Homma T, *et al.* Treatment of ulcerative colitis patients by long-term administration of germinated barley foodstuff: Multi-center open trial. *Int J Mol Med* 2003;**12**:701–4.
83. Fernández-Bañares F, Hinojosa J, Sánchez-Lombraña JL, *et al.* Randomized clinical trial of Plantago ovata seeds [dietary fiber] as compared with mesalamine in maintaining remission in ulcerative colitis. Spanish group for the study of Crohn's disease and ulcerative colitis [GETECCU]. *Am J Gastroenterol* 1999;**94**:427–33.
84. Fujimori S, Gudis K, Mitsui K, *et al.* A randomized controlled trial on the efficacy of synbiotic versus probiotic or prebiotic treatment to improve the quality of life in patients with ulcerative colitis. *Nutrition* 2009;**25**:520–5.
85. Furrie E, Macfarlane S, Kennedy A, *et al.* Synbiotic therapy [bifidobacterium longum/synergy 1] initiates resolution of inflammation in patients with active ulcerative colitis: A randomised controlled pilot trial. *Gut* 2005;**54**:242–9.
86. Ishikawa H, Matsumoto S, Ohashi Y, *et al.* Beneficial effects of probiotic bifidobacterium and galacto-oligosaccharide in patients with ulcerative colitis: a randomized controlled study. *Digestion* 2011;**84**:128–33.
87. Lev-Tzion R, Griffiths AM, Leder O, Turner D. Omega 3 fatty acids [fish oil] for maintenance of remission in Crohn's disease. *Cochrane Database Syst Rev* 2014:CD006320.
88. Turner D, Shah PS, Steinhart AH, Zlotkin S, Griffiths AM. Maintenance of remission in inflammatory bowel disease using omega-3 fatty acids [fish oil]: A systematic review and meta-analyses. *Inflamm Bowel Dis* 2011;**17**:336–45.
89. Turner D, Zlotkin SH, Shah PS, Griffiths AM. Omega 3 fatty acids [fish oil] for maintenance of remission in Crohn's disease. *Cochrane Database Syst Rev* 2009:CD006320.
90. Feagan BG, Sandborn WJ, Mittmann U, *et al.* Omega-3 free fatty acids for the maintenance of remission in Crohn disease: The EPIC randomized controlled trials. *JAMA* 2008;**299**:1690–7.
91. Cabré E, Mañosa M, Gassull MA. Omega-3 fatty acids and inflammatory bowel diseases - a systematic review. *Br J Nutr* 2012;**107**[Suppl 2]:S240–52.
92. Derwa Y, Gracie DJ, Hamlin PJ, Ford AC. Systematic review with meta-analysis: the efficacy of probiotics in inflammatory bowel disease. *Aliment Pharmacol Ther* 2017;**46**:389–400.
93. Kruis W, Schütz E, Fric P, *et al.* Double-blind comparison of an oral *Escherichia coli* preparation and mesalazine in maintaining remission of ulcerative colitis. *Aliment Pharmacol Ther* 1997;**11**:853–8.
94. Kruis W, Fric P, Pokrotnieks J, *et al.* Maintaining remission of ulcerative colitis with the probiotic *Escherichia coli* Nissle 1917 is as effective as with standard mesalazine. *Gut* 2004;**53**:1617–23.
95. Zocco MA, dal Verme LZ, Cremonini F, *et al.* Efficacy of Lactobacillus GG in maintaining remission of ulcerative colitis. *Aliment Pharmacol Ther* 2006;**23**:1567–74.
96. Yoshimatsu Y, Yamada A, Furukawa R, *et al.* Effectiveness of probiotic therapy for the prevention of relapse in patients with inactive ulcerative colitis. *World J Gastroenterol* 2015;**21**:5985–94.
97. Cui HH, Chen CL, Wang JD, *et al.* Effects of probiotic on intestinal mucosa of patients with ulcerative colitis. *World J Gastroenterol* 2004;**10**:1521–5.

98. Willert RP, Peddi KK, Ombiga J. Randomised, double blinded, placebo controlled study of vsl#3 versus placebo in the maintenance of remission in Crohns disease. *Gastroenterology* 2010;**138**:S517–8.
99. Bourreille A, Cadiot G, Le Dreau G, *et al.*; FLORABEST Study Group. Saccharomyces boulardii does not prevent relapse of Crohn's disease. *Clin Gastroenterol Hepatol* 2013;**11**:982–7.
100. Akobeng AK, Thomas AG. Enteral nutrition for maintenance of remission in Crohn's disease. *Cochrane Database Syst Rev* 2007:CD005984.
101. Aghdassi E, Wendland BE, Steinhart AH, *et al.* Antioxidant vitamin supplementation in Crohn's disease decreases oxidative stress. A randomized controlled trial. *Am J Gastroenterol* 2003;**98**:348–53.
102. Pronio A, Montesani C, Butteroni C, *et al.* Probiotic administration in patients with ileal pouch-anal anastomosis for ulcerative colitis is associated with expansion of mucosal regulatory cells. *Inflamm Bowel Dis* 2008;**14**:662–8.
103. Tomasz B, Zoran S, Jarosław W, *et al.* Long-term use of probiotics Lactobacillus and Bifidobacterium has a prophylactic effect on the occurrence and severity of pouchitis: A randomized prospective study. *Biomed Res Int* 2014;**2014**:208064.
104. Gosselink MP, Schouten WR, van Lieshout LM, *et al.* Delay of the first onset of pouchitis by oral intake of the probiotic strain Lactobacillus rhamnosus GG. *Dis Colon Rectum* 2004;**47**:876–84.
105. Gionchetti P, Rizzello F, Helwig U, *et al.* Prophylaxis of pouchitis onset with probiotic therapy: A double-blind, placebo-controlled trial. *Gastroenterology* 2003;**124**:1202–9.
106. Yasueda A, Mizushima T, Nezu R, *et al.* The effect of *Clostridium butyricum* MIYAIRI on the prevention of pouchitis and alteration of the microbiota profile in patients with ulcerative colitis. *Surg Today* 2016;**46**:939–49.
107. Gionchetti P, Rizzello F, Venturi A, *et al.* Oral bacteriotherapy as maintenance treatment in patients with chronic pouchitis: A double-blind, placebo-controlled trial. *Gastroenterology* 2000;**119**:305–9.
108. Mimura T, Rizzello F, Helwig U, *et al.* Once daily high dose probiotic therapy [VSL#3] for maintaining remission in recurrent or refractory pouchitis. *Gut* 2004;**53**:108–14.
109. Shen B, Brzezinski A, Fazio VW, *et al.* Maintenance therapy with a probiotic in antibiotic-dependent pouchitis: Experience in clinical practice. *Aliment Pharmacol Ther* 2005;**22**:721–8.
110. Gionchetti P, Rizzello F, Morselli C, *et al.* High-dose probiotics for the treatment of active pouchitis. *Dis Colon Rectum* 2007;**50**:2075–82; discussion 2082–4.
111. Kuisma J, Mentula S, Jarvinen H, *et al.* Effect of Lactobacillus rhamnosus GG on ileal pouch inflammation and microbial flora. *Aliment Pharmacol Ther* 2003;**17**:509–15.
112. Bengtsson J, Adlerberth I, Ostblom A, *et al.* Effect of probiotics ] Lactobacillus plantarum 299 plus Bifidobacterium Cure21] in patients with poor ileal pouch function: A randomised controlled trial. *Scand J Gastroenterol* 2016;**51**:1087–92.
113. Elahi B, Nikfar S, Derakhshani S, Vafaie M, Abdollahi M. On the benefit of probiotics in the management of pouchitis in patients underwent ileal pouch anal anastomosis: A meta-analysis of controlled clinical trials. *Dig Dis Sci* 2008;**53**:1278–84.
114. Nikfar S, Darvish-Damavandi M, Abdollahi M. A review and meta-analysis of the efficacy of antibiotics and probiotics in the management of pouchitis. *Int J Pharmacol* 2010;**6**:826–35.
115. Shen J, Zuo ZX, Mao AP. Effect of probiotics on inducing remission and maintaining therapy in ulcerative colitis, Crohn's disease, and pouchitis: Meta-analysis of randomized controlled trials.[erratum appears in Inflamm Bowel Dis 2014;20:2526–8]. *Inflamm Bowel Dis* 2014;**20**:21–35.
116. Holubar SD, Cima RR, Sandborn WJ, Pardi DS. Treatment and prevention of pouchitis after ileal pouch-anal anastomosis for chronic ulcerative colitis. *Cochrane Database Syst Rev* 2010;**6**:Cd001176. doi: 10.1002/14651858.CD001176.pub2.
117. Prantera C, Scribano ML, Falasco G, Andreoli A, Luzi C. Ineffectiveness of probiotics in preventing recurrence after curative resection for Crohn's disease: A randomised controlled trial with Lactobacillus GG. *Gut* 2002;**51**:405–9.
118. Marteau P, Lémann M, Seksik P, *et al.* Ineffectiveness of Lactobacillus johnsonii LA1 for prophylaxis of postoperative recurrence in Crohn's disease: a randomised, double blind, placebo controlled GETAID trial. *Gut* 2006;**55**:842–7.
119. Chermesh I, Tamir A, Reshef R, *et al.* Failure of synbiotic 2000 to prevent postoperative recurrence of Crohn's disease. *Dig Dis Sci* 2007;**52**:385–9.
120. Van Gossum A, Dewit O, Louis E, *et al.* Multicenter randomized-controlled clinical trial of probiotics [Lactobacillus johnsonii, LA1] on early endoscopic recurrence of Crohn's disease after lleo-caecal resection. *Inflamm Bowel Dis* 2007;**13**:135–42.
121. Fedorak RN, Feagan BG, Hotte N, *et al.* The probiotic VSL#3 has anti-inflammatory effects and could reduce endoscopic recurrence after surgery for Crohn's disease. *Clin Gastroenterol Hepatol* 2015;**13**:928–35.e2.
122. Doherty G, Bennett G, Patil S, Cheifetz A, Moss AC. Interventions for prevention of post-operative recurrence of Crohn's disease. *Cochrane Database Syst Rev* 2009:CD006873. doi: 10.1002/14651858.CD006873.pub2.
123. Fahy AS, Potter DD, Ravi A, *et al.* Colectomy in refractory Crohn's colitis improves nutrition and reduces steroid use. *J Pediatr Surg* 2017;**52**:1769–75.
124. Lee JL, Yu CS, Lim SB, *et al.* Surgical treatment of Crohn colitis involving more than 2 colonic segments: Long-term outcomes from a single institution. *Medicine* 2016;**95**:e3793.
125. El Muhtaseb MS, Duncan A, Talwar DK, *et al.* Assessment of dietary intake and trace element status in patients with ileal pouch-anal anastomosis. *Dis Colon Rectum* 2007;**50**:1553–7.
126. M'Koma AE, Wise PE, Schwartz DA, Muldoon RL, Herline AJ. Prevalence and outcome of anemia after restorative proctocolectomy: A clinical literature review. *Dis Colon Rectum* 2009;**52**:726–39.
127. Buckman SA, Heise CP. Nutrition considerations surrounding restorative proctocolectomy. *Nutr Clin Pract* 2010;**25**:250–6.
128. Khanna R, Shen B. Adverse metabolic sequelae following restorative proctocolectomy with an ileal pouch. *Gastroenterol Hepatol* 2012;**8**:322–6.
129. McLaughlin SD, Perry-Woodford ZL, Clark SK, *et al.* Osteoporosis in patients over 50 years of age following restorative proctocolectomy for ulcerative colitis: is DXA screening warranted? *Inflamm Bowel Dis* 2010;**16**:250–5.
130. Shen B, Remzi FH, Oikonomou IK, *et al.* Risk factors for low bone mass in patients with ulcerative colitis following ileal pouch-anal anastomosis. *Am J Gastroenterol* 2009;**104**:639–46.
131. Watanabe K, Sasaki I, Fukushima K, *et al.* Long-term incidence and characteristics of intestinal failure in Crohn's disease: A multicenter study. *J Gastroenterol* 2014;**49**:231–8.
132. Pironi L, Arends J, Bozzetti F, *et al.*; Home Artificial Nutrition & Chronic Intestinal Failure Special Interest Group of ESPEN. ESPEN guidelines on chronic intestinal failure in adults. *Clin Nutr* 2016;**35**:247–307.
133. Elriz K, Palascak-Juif V, Joly F, *et al.* Crohn's disease patients with chronic intestinal failure receiving long-term parenteral nutrition: A cross-national adult study. *Aliment Pharmacol Ther* 2011;**34**:931–40.
134. Thompson JS, Iyer KR, DiBaise JK, *et al.* Short bowel syndrome and Crohn's disease. *J Gastrointest Surg* 2003;**7**:1069–72.
135. Agwunobi AO, Carlson GL, Anderson ID, Irving MH, Scott NA. Mechanisms of intestinal failure in Crohn's disease. *Dis Colon Rectum* 2001;**44**:1834–7.
136. Glehen O, Lifante JC, Vignal J, *et al.* Small bowel length in Crohn's disease. *Int J Colorectal Dis* 2003;**18**:423–7.
137. Gearry RB, Kamm MA, Hart AL, *et al.* Predictors for developing intestinal failure in patients with Crohn's disease. *J Gastroenterol Hepatol* 2013;**28**:801–7.
138. Mardini HE, de Villiers WJ. Teduglutide in intestinal adaptation and repair: Light at the end of the tunnel. *Expert Opin Investig Drugs* 2008;**17**:945–51.

139. Iyer KR, Kunecki M, Boullata JI, *et al.* Independence from parenteral nutrition and intravenous fluid support during treatment with teduglutide among patients with intestinal failure associated with short bowel syndrome. *JPEN J Parenter Enteral Nutr* 2017;**41**:946–51.
140. Kochar B, Long MD, Shelton E, *et al.* Safety and efficacy of teduglutide [gattex] in patients with Crohn's disease and need for parenteral support due to short bowel syndrome-associated intestinal failure. *J Clin Gastroenterol* 2017;**51**:508–11.
141. Drastich P, Oliverius M. Crohn's disease and intestinal transplantation. *Dig Dis* 2017;**35**:127–33.
142. Limketkai BN, Orandi BJ, Luo X, Segev DL, Colombel JF. Mortality and rates of graft rejection or failure following intestinal transplantation in patients with vs without Crohn's disease. *Clin Gastroenterol Hepatol* 2016;**14**:1574–81.
143. Hu D, Ren J, Wang G, *et al.* Exclusive enteral nutritional therapy can relieve inflammatory bowel stricture in Crohn's disease. *J Clin Gastroenterol* 2014;**48**:790–5.
144. Yang Q, Gao X, Chen H, *et al.* Efficacy of exclusive enteral nutrition in complicated Crohn's disease. *Scand J Gastroenterol* 2017;**52**:995–1001.
145. Fumery M, Dulai PS, Meirick P, *et al.* Systematic review with meta-analysis: Recurrence of Crohn's disease after total colectomy with permanent ileostomy. *Aliment Pharmacol Ther* 2017;**45**:381–90.
146. Takahashi K, Funayama Y, Fukushima K, *et al.* Stoma-related complications in inflammatory bowel disease. *Dig Surg* 2008;**25**:16–20.
147. Jang KU, Yu CS, Lim SB, *et al.* Factors affecting poor nutritional status after small bowel resection in patients with Crohn disease. *Medicine (Baltimore)* 2016;**95**:e4285.
148. Ecker KW, Stallmach A, Loffler J, Greinwald R, Achenbach U. Long-term treatment of high intestinal output syndrome with budesonide in patients with Crohn's disease and ileostomy. *Dis Colon Rectum* 2005;**48**:237–42.
149. Ecker KW, Stallmach A, Seitz G, *et al*. Oral budesonide significantly improves water absorption in patients with ileostomy for Crohn disease. *Scand J Gastroenterol* 2003;**38**:288–93.
150. Messaris E, Sehgal R, Deiling S, *et al.* Dehydration is the most common indication for readmission after diverting ileostomy creation. *Dis Colon Rectum* 2012;**55**:175–80.
151. Nightingale J, Woodward JM; Small Bowel and Nutrition Committee of the British Society of Gastroenterology. Guidelines for management of patients with a short bowel. *Gut* 2006;**55**[Suppl 4]:iv1–12.
152. Nightingale J. *Intestinal Failure*. London: Greenwich Medical Media; 2001.
153. Rodrigues CA, Lennard-Jones JE, Thompson DG, Farthing MJ. Energy absorption as a measure of intestinal failure in the short bowel syndrome. *Gut* 1989;**30**:176–83.
154. Pironi L, Guidetti C, Incasa E, *et al.* Oral rehydration solution containing rice maltodextrins in patients with total colectomy and high intestinal output. *Int J Clin Pharmacol Res* 2000;**20**:55–60.
155. Woolf GM, Miller C, Kurian R, Jeejeebhoy KN. Diet for patients with a short bowel: High fat or high carbohydrate? *Gastroenterology* 1983;**84**:823–8.
156. Higham SE, Read NW. The effect of ingestion of guar gum on ileostomy effluent. *Br J Nutr* 1992;**67**:115–22.
157. Nightingale JM, Lennard-Jones JE, Walker ER, Farthing MJ. Oral salt supplements to compensate for jejunostomy losses: Comparison of sodium chloride capsules, glucose electrolyte solution, and glucose polymer electrolyte solution. *Gut* 1992;**33**:759–61.
158. Johnson E, Vu L, Matarese LE. Bacteria, bones, and stones: Managing complications of short bowel syndrome. *Nutr Clin Pract* 2018;**33**:454–66.
159. Culkin A. Intestinal failure and nutrition. In: Lomer MCE, editor. *Advanced Nutrition and Dietetics in Gastroenterology*. Chichester, UK: Wiley Blackwell; 2014:210–7.
160. Keeler BD, Dickson EA, Simpson JA, *et al.*; IVICA Trial Group. The impact of pre-operative intravenous iron on quality of life after colorectal cancer surgery: Outcomes from the intravenous iron in colorectal cancer-associated anaemia (IVICA) trial. *Anaesthesia* 2019;**74**:714–25.
161. Madanchi M, Fagagnini S, Fournier N, *et al.*; Swiss IBD Cohort Study Group. The relevance of vitamin and iron deficiency in patients with inflammatory bowel diseases in patients of the Swiss IBD Cohort. *Inflamm Bowel Dis* 2018;**24**:1768–79.
162. Khalafallah AA, Yan C, Al-Badri R, *et al.* Intravenous ferric carboxymaltose versus standard care in the management of postoperative anaemia: A prospective, open-label, randomised controlled trial. *Lancet Haematol* 2016;**3**:e415–25.
163. Aksan A, Işık H, Radeke HH, Dignass A, Stein J. Systematic review with network meta-analysis: Comparative efficacy and tolerability of different intravenous iron formulations for the treatment of iron deficiency anaemia in patients with inflammatory bowel disease. *Aliment Pharmacol Ther* 2017;**45**:1303–18.
164. Levine A, Sigall Boneh R, Wine E. Evolving role of diet in the pathogenesis and treatment of inflammatory bowel diseases. *Gut* 2018;**67**:1726–38.
165. Sigall-Boneh R, Levine A, Lomer M, *et al.* Research gaps in diet and nutrition in inflammatory bowel disease. A topical review by D-ECCO working group [dietitians of ECCO]. *J Crohns Colitis* 2017;**11**:1407–19.
166. 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. *Gastroenterology* 2019;**156**:1354–1367.e6.