Review

Optimizing Perioperative Nutrition in Elective Gastrointestinal Surgery: An ERAS-Focused Narrative Review

Maria Alexandra Brăgaru , Alin Kraft * , Cosmin Moldovan , Adina-Diana Moldovan , Adam Răzvan , Daniel Cochior , Andrei Luca , Delia Nica-Badea , Ștefan Eugen Chirsanov Capanu , Elena Rusu

Posted Date: 26 February 2026

doi: 10.20944/preprints202602.1790.v1

Keywords: elective gastrointestinal surgery; perioperative nutrition; ERAS; malnutrition; sarcopenia; nutritional prehabilitation; carbohydrate loading; early postoperative feeding

Review

Optimizing Perioperative Nutrition in Elective Gastrointestinal Surgery: An ERAS-Focused Narrative Review

Maria Brăgaru [1,2], Alin Kraft [3,4,*], Cosmin-Alec Moldovan [3,4], Adina-Diana Moldovan [1,2,5], Adam Răzvan [6,7], Daniel Cochior [3,8], Andrei Luca [1], Delia Nica-Badea [9], Ștefan Eugen Chirsanov Capanu [10] and Elena Rusu [1]

[1]Department of Preclinical Sciences, Faculty of Medicine, "Titu Maiorescu" University of Bucharest, 031593 Bucharest, Romania
[2]Doctoral School in Medicine, "Titu Maiorescu" University of Bucharest, 031593 Bucharest, Romania
[3]Department of Medical-Surgical and Prophylactic Disciplines, Faculty of Medicine, Titu Maiorescu University of Bucharest, 031593 Bucharest, Romania
[4]Department of General Surgery, "General Doctor Aviator Victor Anastasiu" National Aeronautical and Space Medicine Institute, 010242 Bucharest, Romania
[4]Department of General Surgery, Witting Clinical Hospital, 010243 Bucharest, Romania
[5]MedLife SA, 010719 Bucharest, Romania
[6]Department of Orthopedics and Traumatology, Elias Emergency University Hospital, 011461 Bucharest, Romania
[7]Department of First Aid and Disaster Medicine, Faculty of Medicine, Titu Maiorescu University of Bucharest, 031593 Bucharest, Romania
[8]Department of General Surgery, Monza Hospital, 021967 Bucharest, Romania
[9]Health and Mobility Department, Medicinal and Behavioral Sciences Faculty, Constantin Brâncuși University, 210135, Târgu-Jiu, Romania
[10]Department of Specialties in Dental Medicine, Faculty of Dental Medicine, Titu Maiorescu University of Bucharest, 031593 Bucharest, Romania
*Correspondence: alin.kraft@gmail.com

Abstract

Background/Objectives: Perioperative malnutrition, sarcopenia, and reduced functional reserve are frequent in adults undergoing elective gastrointestinal (GI) surgery and are associated with higher postoperative morbidity and delayed recovery. Enhanced Recovery After Surgery (ERAS) pathways incorporate nutrition-focused elements, but reported effects vary across procedures, protocols, and baseline risk. This review aims to summarise and critically appraise current evidence on perioperative nutritional strategies within ERAS-focused elective GI care, including risk identification, nutritional prehabilitation (oral nutritional supplements and immunonutrition), preoperative carbohydrate loading, early postoperative feeding, and selected microbiome-directed adjuncts. **Methods:** This narrative literature review was informed by a focused search of PubMed/MEDLINE and Scopus (2010–2025), supplemented by targeted screening of relevant clinical practice guidelines and consensus statements (e.g., ESPEN). Evidence was interpreted by hierarchy (guidelines/meta-analyses, randomised trials, observational studies) and discussed with attention to heterogeneity in surgical populations, intervention definitions (composition, timing, duration), and endpoint reporting. **Results:** Early nutritional risk screening is consistently supported to identify malnutrition and sarcopenia and to trigger tailored optimisation plans. Perioperative oral nutritional supplementation, particularly when started preoperatively and continued postoperatively, is frequently associated with improved intake and reduced infectious morbidity in malnourished or at-risk patients, though effect sizes vary. Immunonutrition shows potential benefit in selected high-risk settings but remains formulation- and timing-dependent. Carbohydrate loading is generally

 doi:10.20944/preprints202602.1790.v1

endorsed within ERAS and may reduce insulin resistance and improve patient comfort, while impacts on major clinical outcomes are context-dependent. Early oral/enteral feeding is feasible in many elective GI procedures and may accelerate gastrointestinal recovery without increasing major complications when implemented with structured advancement and appropriate patient selection. Probiotics/synbiotics show the most consistent signals in colorectal surgery, with strain-specific effects and important safety boundaries in immunocompromised or critically ill patients. **Conclusions:** Perioperative nutritional optimisation is a core component of elective GI surgical care within ERAS pathways. Benefits are most reproducible in higher-risk patients and when interventions are integrated into high-compliance multidisciplinary programmes. Future research should prioritise procedure-specific, risk-stratified trials with standardised interventions and clinically meaningful endpoints.

Keywords: elective gastrointestinal surgery; perioperative nutrition; ERAS; malnutrition; sarcopenia; nutritional prehabilitation; carbohydrate loading; early postoperative feeding

---

1. Introduction

Elective gastrointestinal (GI) surgery encompasses planned, non-emergency procedures performed to diagnose or treat disorders of the digestive system, including conditions affecting the oesophagus, stomach, liver, pancreas, and intestines. It is commonly undertaken for obesity, gastrointestinal malignancy, severe gastroesophageal reflux disease (GERD), and structural abnormalities, and includes operations such as gastrectomy, Roux-en-Y gastric bypass, colorectal resections, hernia repair, and bariatric procedures (1). Across this spectrum, elective GI surgery elicits a pronounced surgical stress response characterised by hypermetabolism, insulin resistance, systemic inflammation, and accelerated skeletal muscle catabolism (2). These metabolic and inflammatory perturbations contribute to clinically relevant postoperative complications, including surgical site infection, anastomotic leak, prolonged ileus, impaired wound healing, and delayed functional recovery (3). In parallel, a substantial proportion of patients present preoperatively with malnutrition, cancer cachexia, or sarcopenia, all of which are independently associated with increased morbidity, longer length of stay, higher readmission rates, and greater healthcare expenditure, thereby positioning perioperative nutrition as a modifiable determinant of surgical resilience rather than a purely adjunctive therapy (4). In contemporary perioperative practice, nutritional optimisation is increasingly integrated into Enhanced Recovery After Surgery (ERAS) pathways and is supported by guidance from the European Society for Clinical Nutrition and Metabolism (ESPEN) (5). Core components include systematic preoperative nutritional evaluation and risk stratification using validated screening tools, recognition of sarcopenia, and implementation of nutritional prehabilitation strategies such as high-protein oral nutritional supplementation, selected immunonutrition protocols, and targeted micronutrient replacement. Additional ERAS-aligned measures include preoperative carbohydrate loading as metabolic preparation aimed at attenuating insulin resistance and improving patient comfort while avoiding prolonged fasting, as well as early postoperative oral intake and/or enteral nutrition (EN) to limit underfeeding, preserve lean body mass, and support gastrointestinal function. Notably, the magnitude of benefit reported for individual interventions may vary across surgical procedures and baseline risk profiles, underscoring the need to interpret the literature within a pathway-based framework. Current evidence informing perioperative nutrition within ERAS pathways is derived from clinical practice guidelines and a heterogeneous body of comparative studies, with variability in intervention definitions (composition, timing, duration), surgical case-mix, and outcome reporting. As a result, several aspects remain debated, including the consistency of benefit from immunonutrition across procedures, the impact of carbohydrate loading on major clinical endpoints beyond metabolic outcomes, and the optimal timing and advancement of early postoperative feeding in higher-risk resections. Overall, the literature most consistently supports risk-stratified nutritional optimisation

 doi:10.20944/preprints202602.1790.v1

within high-compliance ERAS programmes, while emphasising that effects are procedure- and protocol-dependent

The aim of this narrative review is to analyse the evidence underpinning these perioperative nutritional strategies in elective upper and lower GI surgery, focusing on outcomes that matter to patients and clinicians, including infectious complications, anastomotic integrity, ileus, functional recovery, feeding tolerance, and patient-centred measures.

2. Materials and Methods

This article is a narrative literature review addressing perioperative nutritional strategies in adult patients undergoing elective gastrointestinal surgery, with emphasis on nutritional screening and diagnosis (malnutrition and sarcopenia), nutritional prehabilitation (including oral nutritional supplements and immunonutrition), preoperative carbohydrate loading, and early postoperative oral/enteral feeding within enhanced recovery pathways. A focused literature search was conducted in PubMed/MEDLINE and Scopus (last search: 15 Dec 2025), supplemented by targeted screening of relevant clinical practice guidelines and consensus statements from major societies (including ESPEN and ERAS Society guidance). Search strings combined controlled vocabulary and free-text terms, including (“perioperative nutrition” OR “nutritional support” OR “nutritional screening” OR “malnutrition” OR “sarcopenia” OR “nutritional prehabilitation” OR “oral nutritional supplements” OR “immunonutrition” OR “carbohydrate loading” OR “early oral feeding” OR “early enteral nutrition”) AND (“gastrointestinal surgery” OR “colorectal surgery” OR “gastrectomy” OR “hepato-pancreato-biliary surgery”) AND (“elective” OR “enhanced recovery” OR “ERAS”). The search covered publications from 2010 to 2025 and was restricted to adult human studies published in English. Eligible sources included randomized controlled trials, observational studies, systematic reviews/meta-analyses, and guideline documents reporting clinically relevant perioperative outcomes (e.g., postoperative complications, infectious complications, length of stay, gastrointestinal recovery, readmissions). Exclusion criteria were pediatric populations, emergency surgery, non-gastrointestinal procedures, animal studies, and publications lacking perioperative outcome data. Titles/abstracts were screened and full texts assessed for relevance by two authors, and data were extracted using a structured approach capturing study design, surgical setting and population, nutritional intervention (type, timing, duration), comparators, and key outcomes. Given the narrative scope and heterogeneity of interventions and endpoints, findings were synthesized qualitatively, prioritizing higher-level evidence and highlighting areas of consistency as well as uncertainties across surgical contexts.

To strengthen interpretability, evidence is summarized by hierarchy (clinical practice guidelines and systematic reviews/meta-analyses, followed by randomized controlled trials and observational studies). When reporting effects, we indicate the direction of benefit and clinically relevant outcomes while acknowledging heterogeneity in surgical populations, intervention protocols (composition, timing, duration), and endpoint definitions across studies. Therefore, statements are phrased according to the certainty of evidence (e.g., “suggests”, “is associated with”, “may reduce”), and conclusions specify the contexts in which benefits are most consistently reported. Findings are interpreted through an ERAS framework, emphasizing pathway compliance, discharge criteria, and procedure-specific implementation differences.

3. Preoperative Nutritional Assessment and Risk Stratification

Nutritional assessment in preoperative elective gastrointestinal (GI) surgery is crucial, as malnutrition and muscle depletion are common and directly affect postoperative outcomes (6). Malnutrition during preoperative phases of surgical patients is a known predisposing factor to peri-operative morbidity and mortality, postoperative morbidity, infection and longer hospitalisation (7). Cancer-related cachexia, decreased oral intake, early satiety, bowel obstruction, or malabsorption is common in patients undergoing colorectal, gastric, pancreatic, or oesophageal resections (8). The

Preprints.org (www.preprints.org) | NOT PEER-REVIEWED | Posted: 26 February 2026 doi:10.20944/preprints202602.1790.v1

prevalence of preoperative malnutrition is 17% to 20% (8). It predisposes to infectious complications following gastrointestinal surgery, primarily in malignant diseases of the oesophagus, stomach, colorectal, pancreatic and liver cancer, including inflammatory bowel diseases. It is also related to increased postoperative mortality and healthcare expenditure (7). Therefore, systematic nutritional assessment should form part of standard preoperative evaluation rather than being reserved for visibly underweight patients.

Malnutrition, in all its forms, includes undernutrition (wasting, stunting, underweight), inadequate vitamins or minerals, overweight, obesity, and resulting diet-related noncommunicable diseases. Laboratory predictors of malnutrition include urinary creatinine and urinary 3-methylhistidine, which reflect skeletal muscle mass and fat-free mass and reflect muscle protein breakdown, but require 24-hour urine collection and have poor sensitivity (9). Other markers include serum cholesterol, delayed hypersensitivity, blood lymphocyte count, serum IGF-1, leptin, nesfatin-1 and serum zinc, which are linked to protein-energy malnutrition, immune functioning, energy homeostasis, and micronutrient deficiency, yet are commonly affected by inflammation, renal dysfunction, liver disease, and acute-phase response (9). Contemporary diagnostic approaches rely on structured concepts such as those proposed by the Global Leadership Initiative on Malnutrition (GLIM), but in elective gastrointestinal surgery these can be operationalised pragmatically by combining phenotypic findings (Table 1) with etiologic drivers of risk (Table 2) to guide early optimization and perioperative planning.

Table 1. Phenotypic domains relevant to perioperative malnutrition risk in elective gastrointestinal surgery (GLIM-informed): practical assessment and action.

Phenotypic domain (what you observe)	How to assess in routine practice (examples)	Red flags / interpretation (pragmatic)	Why it matters perioperatively (clinical relevance)	Suggested perioperative response (actionable)
Unintentional weight loss / adverse weight trajectory	Serial weights (EHR trend), patient report (time course), clothing fit, corroboration from caregivers	Clear downward trend, rapid loss over weeks–months, or persistent loss despite intake	Signals depleted reserves and catabolic state; associated with higher infectious complications, impaired wound healing, and prolonged recovery	Early dietitian referral; start high-protein ONS; address drivers (pain, nausea, obstruction, dysphagia); consider prehabilitation if time allows
Low body reserves / reduced energy stores (contextual body size)	BMI as context (not a stand-alone diagnosis), body habitus history, clinical exam (loss of subcutaneous fat), frailty features	"Low reserve" phenotype (thin/frail), or sarcopenic obesity suspected (normal/high BMI but poor strength/function)	Low reserve → poor tolerance to surgical stress; sarcopenic obesity can mask risk and is linked to worse outcomes	Individualised protein/energy targets; avoid prolonged fasting; integrate nutrition plan into ERAS; monitor intake vs targets
Reduced muscle quantity or quality (sarcopenia phenotype)	Opportunistic CT-derived muscle estimates when available; BIA/ultrasound (where available); mid-upper arm circumference (proxy); clinical exam	Low muscle proxy, visible wasting, poor endurance; discordance between BMI and strength/function	Predicts complications, longer length of stay, delayed mobilisation and functional recovery	Protein-forward strategy; resistance exercise component (prehab); early mobilisation; plan early postoperative nutrition delivery
Reduced muscle strength and/or	Handgrip dynamometry, chair-	Low strength/function relative to age/sex	Captures functional reserve; correlates with postoperative	Multimodal prehabilitation

Preprints.org (www.preprints.org) | NOT PEER-REVIEWED | Posted: 26 February 2026 doi:10.20944/preprints202602.1790.v1

functional performance	stand test, SARC-F, gait speed, 6-minute walk test (if feasible)	norms; inability to complete basic functional tests; fatigue limiting ADLs	disability, prolonged recovery, and discharge challenges	(nutrition + exercise + optimisation); set discharge goals; consider post-acute support planning
Frailty-linked low physiologic resilience (phenotypic expression)	Brief frailty screen (e.g., Clinical Frailty Scale), history of falls, exhaustion, low activity; interpreted alongside domains above	Frailty features plus any phenotype above amplifies risk	Frailty interacts with malnutrition/sarcopenia → higher morbidity, slower recovery, higher readmission risk	Multidisciplinary planning (surgery–anaesthesia–nutrition–physio); prioritise preoperative optimisation; consider geriatric input when available

This table provides an original, practical perioperative framework summarising phenotypic domains commonly used to identify patients at risk of malnutrition and poor functional reserve in elective gastrointestinal surgery. It is GLIM-informed but presented as an operational tool rather than a reproduction of consensus criteria or cut-off values.

Table 2 summarizes practical etiologic domains that commonly drive perioperative nutritional risk in elective gastrointestinal surgery, including reduced intake, impaired assimilation, and disease- or inflammation-related catabolism. In clinical workflows, these drivers should be assessed alongside phenotypic findings (Table 1) to identify patients who require targeted preoperative optimization and a predefined postoperative nutrition delivery plan.

Table 2. Etiologic domains relevant to perioperative malnutrition risk in elective gastrointestinal surgery (GLIM-informed): clinical triggers and practical responses.

Etiologic domain (driver)	How it presents clinically (examples)	Common elective GI surgery contexts	What it implies for nutrition delivery	Suggested perioperative response (actionable)
Reduced oral intake (quantity/quality)	Early satiety, anorexia, pain, nausea/vomiting, dysphagia, poor dentition, fatigue; low appetite scores	Upper GI malignancy, benign strictures, severe GERD/achalasia, frail elderly	Likely failure to meet protein/energy targets orally without structured support	Early dietitian plan; high-protein ONS; symptom control; meal fortification; consider short prehab window if time allows
Impaired assimilation / malabsorption	Chronic diarrhoea/steatorrhoea, bloating; nutrient deficiencies; weight loss despite intake	Chronic pancreatitis, small bowel disease, IBD, cholestasis, post-gastrectomy/bypass physiology	Oral intake may be 'adequate' yet ineffective; higher risk of micronutrient deficits	Treat underlying cause; targeted micronutrients; enzyme replacement when indicated; lower threshold for EN if targets unmet
Inflammatory burden / disease stress–related catabolism	Elevated CRP, active malignancy, systemic inflammation; cachexia phenotype	GI oncology, advanced inflammatory disease, chronic infection/inflammation states; pancreatic inflammatory disease (including severe	Higher protein needs and accelerated lean-mass loss; risk persists even with acceptable BMI	Protein-forward targets; minimize unnecessary fasting; early postoperative feeding where feasible; integrate within ERAS

 doi:10.20944/preprints202602.1790.v1

		pancreatitis phenotypes) (10)		
Treatment-related nutrition compromise	Chemo-related anorexia/dysgeusia, mucositis, steroids, fatigue; reduced activity	Neoadjuvant pathways for GI cancer, prolonged preoperative treatment windows	Intake and function decline during 'waiting period' → missed optimization opportunity	Proactive prehabilitation (nutrition + exercise); timed supplementation; multidisciplinary coordination
Procedure-related constraints and anticipated postoperative intake limitation	Expected delayed gastric emptying, intolerance risk, planned anastomosis protection strategies; prolonged NPO risk	Esophagectomy, gastrectomy, major HPB resections	Higher likelihood of postoperative underfeeding unless route is planned	Predefine postoperative pathway (oral vs EN); consider feeding access when appropriate; set intake milestones and escalation triggers
Socio-functional barriers influencing intake and adherence	Low health literacy, poor support at home, financial barriers, depression, substance misuse	Any elective GI population (especially frail/older adults)	Plans fail without adherence/support despite appropriate prescribing	Simplify regimen; involve caregivers; written plan; early follow-up; connect with social support services

Legend: This table is an original perioperative synthesis of common etiologic drivers of malnutrition risk in elective gastrointestinal surgery. It is GLIM-informed at the conceptual level but intentionally avoids reproducing consensus grading tables or cut-off thresholds.

Inflammatory burden is particularly relevant in pancreatic inflammatory disease, where severity stratification reflects the systemic catabolic impact that can compromise perioperative reserve (10).

A single-centre prospective observational study conducted in 2020 and 2023 evaluated malnutrition risk among 467 elective surgery patients attending a pre-anaesthetic clinic (11). The results revealed that 19.9% of participants met the Global Leadership Initiative on Malnutrition (GLIM) malnutrition risk criteria, and 7.9% required structured preoperative nutrition (11). It is important to note that a significant percentage of patients at risk had a body mass index (BMI) greater than 25 kg/m^2, indicating that excess body weight does not preclude the presence of underlying nutritional deficiency. These results support the use of systematic screening instead of relying on BMI.

Sarcopenia represents a closely related but distinct risk factor characterised by loss of skeletal muscle mass and strength (12). It can be found in patients with either normal BMI or high BMI, which is referred to as sarcopenic obesity. Sarcopenia is closely linked with postoperative morbidity, intensive care unitisation, chemotherapy toxicity, and poor survival in GI oncology populations. Objective quantification of skeletal muscle mass can be achieved with computed tomography at the third lumbar vertebra (L3), which is commonly used to stage cancer (13). The timely diagnosis of sarcopenia enables the detection of at-risk patients with necessary targeted nutritional and functional optimization in the preoperative period.

Effective perioperative care requires structured nutritional risk stratification. Routine screening should occur at the time of surgical referral to ensure early identification of at-risk patients. Besides the Global Leadership Initiative on Malnutrition (GLIM) criteria, there are other well-established nutritional risk screening tools commonly used in clinical settings to identify patients who are already malnourished or at risk. The Nutritional Risk Screening 2002 (NRS-2002) (14) is widely used in hospitals and assesses disease severity and the inability to maintain nutritional intake. Mini Nutritional Assessment Short Form (MNA 2 -sf) and Long Form (MNA -LF) (15) are commonly

 doi:10.20944/preprints202602.1790.v1

utilised in the elderly in order to identify the early signs of nutritional decline in older adults. The Patient-Generated Subjective Global Assessment (PG-SGA) (16) is especially useful in oncology populations, which measures the history of weight, symptoms, intake, and functional capacity. The Malnutrition Screening Tool (MST) and the Malnutrition Universal Screening Tool (MUST) are straightforward, convenient tools that are based on weight loss and BMI and can thus be used in routine clinical practice (17). In older populations, SNAQ 65+ focuses on appetite and weight loss, whereas SARC-F directly assesses sarcopenia using functional measures (strength and mobility) (18). In gastrointestinal oncological surgery, sarcopenia has been consistently associated with higher postoperative complication rates, increased mortality, and prolonged length of stay, supporting its inclusion in perioperative risk stratification (19).

Overall, the strongest support for routine perioperative nutritional screening comes from clinical practice guidelines and consensus recommendations, complemented by observational data linking malnutrition and sarcopenia to higher postoperative morbidity and prolonged recovery. However, estimates vary across studies due to differences in diagnostic tools (e.g., GLIM components, screening instruments) and heterogeneous surgical case-mix. The clinical utility is most consistent in high-risk elective gastrointestinal surgery patients (older age, weight loss, frailty, oncologic burden), where early identification can trigger targeted nutritional optimization and perioperative planning.

4. Nutritional Prehabilitation: Priming the Patient

This section may be divided by subheadings. It should provide a concise and precise description of the experimental results, their interpretation, as well as the experimental conclusions that can be drawn.

4.1. Timing and High-Protein Nutritional Optimisation

Prehabilitation targets metabolic risk conditioning in ERAS, implying a trimodal intervention with elements of nutrition, physical exercise, and psychological stress reduction (20). A significant decrease in complications was observed in elderly high-risk patients with American Society of Anesthesiologists (ASA) Grade III and IV (21). The meta-analyses revealed that prehabilitation could reduce postoperative complication rates and hospital length of stay (LOS) in patients undergoing major abdominal surgery. These findings are broadly consistent across systematic reviews and meta-analyses in major abdominal surgery populations (22), (23), (24). Wobith et al. (25) reported that malnutrition is an important risk factor for adverse outcomes in patients undergoing major abdominal and gastrointestinal surgery, and that nutritional prehabilitation should be targeted. The authors discovered that interventions are divided into short (7-14 days) conditioning and multimodal prehabilitation programs. However, they noted significant heterogeneity in medical nutrition therapy, which restricts the possibility of an evidence-based dietary recommendation (25).

Nutritional and exercise prehabilitation alone have been found to reduce length of hospital stay. Still, multimodal prehabilitation is reported to provide an additional effect on functional capacity, such as 6-minute walking distance, even though overall effect sizes are low to very low (26). Recent trimodal preoperative therapy (over 4 weeks) in patients undergoing colorectal resection, including targeted nutrition therapy (protein intake 1.5g/kg/day, whey protein supplementation 30g, and multivitamins) and exercise. The prehabilitation group showed a lower complication rate (17.1% vs 29.7%), with an odds ratio (OR) of 0.47 (95% CI 0.26–0.87), which is a consistent benefit of multimodal prehabilitation (27).

ESPEN recommends Oral Nutritional Supplements as protein- and energy-dense formulations to aid patients whose regular oral nutrition fails to fulfil nutritional needs, and they are regulated by the EU as Food for Special Purposes under Regulation 609/2013 (26). ONSs contain high amounts of energy and protein, can offer a full nutritional profile, and are usually administered in 150-300 mL portions per unit, two to five times a day via a sip-feeding method to minimize gastrointestinal upset (25). Whereas certain formulations are nutritionally balanced and can be used as a sole source of nutrition provided adequate volumes are consumed to meet individual energy and protein

 doi:10.20944/preprints202602.1790.v1

requirements, others can be supplemented with vitamins, trace elements or specialised fatty acids, and should be chosen based on patient needs, tolerance, and preferences (25).

Evidence from guidelines and multiple interventional studies suggests that perioperative oral nutritional supplementation—particularly when initiated preoperatively and continued postoperatively—may improve nutritional intake and is often associated with fewer complications and shorter length of stay. Reported effects are not uniform, reflecting variability in baseline nutritional risk, supplement composition and dosing, adherence, and the type and magnitude of surgery. Benefits appear most consistent in malnourished or at-risk patients undergoing major elective gastrointestinal procedures, especially within structured perioperative pathways.

4.2. Correcting Nutritional Deficiencies

Preoperative vitamin D deficiency may be present in up to 76%, iron deficiency in 6% to 50.5%, folic acid deficiency in 0% to 56%, low MCV in 19% to 47.9%, and anemia in 15.8% to 19.6% (28).

This malnourished condition not only impacts the quality of life of patients, but may also increase the risk of postoperative complications, such as anemia, neurological disorders, and metabolic bone disease Vitamin D has a widely acknowledged role in regulating the metabolism of calcium and phosphate, both essential to bone remodeling (29), (30).

To address these deficiencies before surgery, specific interventions are recommended based on the type and severity of the deficiency. For patients with vitamin D deficiency, oral vitamin D supplements are typically prescribed, with the daily dose adjusted according to serum 25(OH)D levels. The goal is to maintain serum 25(OH)D levels above 30 ng/mL. For iron deficiency, oral iron supplements are usually the first-line treatment, although intravenous iron may be considered in cases of severe deficiency or poor gastrointestinal absorption. Regular monitoring of serum ferritin and hemoglobin levels is essential to assess the effectiveness of the supplementation. In cases of severe anemia, additional interventions such as intravenous iron or even transfusions may be necessary (Table 3).

Table 3. Common Micronutrient Deficiencies and Recommended Supplementation Strategies in Metabolic and Bariatric Surgery.

Micronutrient	Preoperative Deficiency Prevalence	Recommended Supplementation
Vitamin D	Up to 76%	Oral vitamin D supplements to maintain serum 25(OH)D levels above 30 ng/mL
Iron	6% to 50.5%	Oral or intravenous iron, depending on severity and absorption
Folic Acid	0% to 56%	Oral folic acid supplements
Vitamin B12	Significant	Oral or injectable vitamin B12
Zinc	Significant	Oral zinc supplements
Vitamin A	Significant	Oral vitamin A supplements
Vitamin E	Significant	Oral vitamin E supplements

At the same time, micronutrient levels in blood, such as vitamin B1, vitamin B12, vitamin A, vitamin D, zinc, and copper, as well as mineral contents such as calcium, phosphorus, iron, potassium, sodium, and chloride, are measured to identify potential nutritional deficiencies (31), (32).

Common preoperative dietary patterns include energy restricted diets, low-carbohydrate ketogenic diets (LCKD), and dietary regimens incorporating ready-to-eat low-carbohydrate ketogenic products (RLCKPs) (33), (34).

In addition, energy restricted diets may increase the likelihood of eating disorders, food consumption anxiety, and internalization of weight stigma, adversely affecting pre- and

 doi:10.20944/preprints202602.1790.v1

postoperative outcomes (33). Therefore, preoperative micronutrient supplementation appears particularly necessary (35), (36).

When developing preoperative micronutrient supplementation strategies, patients first need to undergo a comprehensive nutritional assessment, including a detailed history, physical examination, and relevant laboratory tests, such as blood routine, serum ferritin, vitamin D, folic acid, and vitamin B12 measurements, to accurately understand the specific nutritional deficiency of patients. On this basis, a personalized supplementation program is developed according to the type and degree of micronutrients deficient in the patient. For patients with vitamin D deficiency, oral vitamin D supplements can be used, and the daily dose of supplementation depends on serum 25 (OH) vitamin D levels, and it is generally recommended to maintain serum 25 (OH) vitamin D levels above 30 ng/mL (37). For patients with iron deficiency, oral iron or intravenous iron supplementation can be given, and changes in serum ferritin, hemoglobin and other indicators should be monitored to assess the effect of supplementation; patients with folic acid and vitamin B12 deficiency can be corrected by oral or injection of the corresponding supplement (38).

4.3. Immunonutrition and Integration with ERAS

Immunonutrition is an advanced ONS supplemented with arginine, omega-3 fatty acids, and ribonucleotides that targets the perioperative immune response and mitigates the effects of surgical stress on immune suppression, especially in patients with a history of major gastrointestinal (GI) cancer surgery (25). Umbrella reviews show that exclusive preoperative administration within 5-7 days, with low heterogeneity, results in a significant reduction in postoperative infectious complications (OR about 0.52-0.58), as well as a modest decrease in hospital length of stay, but found no significant reduction in non-infectious complications or mortality (39). They are most effective in upper GI, colorectal, and oesophageal resections, independent of baseline nutritional status, and have also been validated within ERAS protocols, for example, in the SONVI trial, where infectious complication reduction was significant despite a constant overall hospital stay (40). When immunonutrition was compared with a control group using hypercaloric, hypernitrogenous supplements during the seven days of preoperative intervention and up to five days of postoperative intervention, the length of stay did not differ. Nevertheless, patients undergoing immunonutrition showed a reduction in the number of complications, with the greatest reduction in infectious complications (23.8 vs 10.7, $p = 0.0007$) (40).

The evidence base for immunonutrition includes meta-analyses and randomized trials showing potential reductions in infectious complications and, in some settings, shorter length of stay, although effect sizes differ across surgical domains and protocols. Heterogeneity is driven by differences in formulations, timing (preoperative-only vs perioperative), duration, and patient selection. The most reproducible signals of benefit are reported in major gastrointestinal oncologic surgery and in patients with higher baseline risk, whereas routine use in low-risk elective cases remains less certain..

5. Preoperative Carbohydrate Loading and Fasting Concepts

The traditional discipline of the midnight fast has gradually been subjected to less traditional observation, and the modern world has seen some evidence of its need and harmful effects. Table 4 summarises the main links between surgical stress, insulin resistance, and perioperative hyperglycaemia, together with practical modifiable perioperative levers. Pro-inflammatory cytokines (IL- 6, TNF-α) and sympathoadrenal (catecholamines, cortisol) mediators are released in response to surgical stress and suppress the GLUT4 transporter in skeletal muscle and activate hepatic gluconeogenesis. In parallel, fasting increases glucagon release and systemic insulin resistance (41). The resultant effect is a hyperglycaemic environment that is severe and affects wound healing and recovery. Possible mechanisms to counteract this insulin resistance include modern perioperative interventions, such as preoperative carbohydrate loading, which improve the stability of metabolic processes and postoperative outcomes. Such interventions consequently decrease morbidity, hospital stays and expenses. In more standardised elective settings such as laparoscopic cholecystectomy,

 doi:10.20944/preprints202602.1790.v1

meta-analytic evidence suggests that preoperative oral carbohydrate loading may improve early recovery outcomes, although the clinical effect size varies across protocols and endpoints (42). Laparoscopic cholecystectomy also illustrates how common elective GI procedures can carry clinically meaningful complication pathways (e.g., iatrogenic bile duct injuries), underscoring the importance of standardised perioperative algorithms and multidisciplinary care (43).

Table 4. Surgical stress, insulin resistance, and perioperative hyperglycaemia: pathway and modifiable levers.

Pathway component	Key mediators / contributors (examples)	Physiological effect	Clinical correlate in elective GI surgery	Modifiable perioperative levers (practical)
Neuroendocrine stress response to surgery	Catecholamines, cortisol, glucagon; sympathetic activation	Hepatic glucose output ↑; peripheral glucose uptake ↓	Early postoperative hyperglycaemia; glucose variability	Minimize unnecessary fasting; consider preoperative carbohydrate drink when appropriate; avoid excessive dextrose infusions; standardised ERAS workflow
Inflammation-driven insulin resistance	Pro-inflammatory cytokines; acute-phase response	Insulin signalling impairment; skeletal muscle glucose uptake ↓	Hyperglycaemia despite “normal” preop status	Early mobilisation; multimodal analgesia to reduce stress burden; prompt nutrition delivery when tolerated
Catabolic metabolism and lean mass loss	Proteolysis, lipolysis; reduced physical activity	Muscle protein breakdown ↑; functional reserve ↓	Delayed functional recovery; prolonged LOS	Protein-forward nutrition strategy; early oral/enteral intake; structured physiotherapy; consider prehabilitation in high-risk patients
Iatrogenic contributors	High-dose steroids (when used), parenteral glucose load, perioperative hypothermia, overly liberal fluids	Hyperglycaemia risk ↑; insulin requirement ↑	Higher glucose excursions; increased monitoring needs	Review glucose-containing fluids; protocolised insulin therapy per local policy; maintain normothermia; rational fluid strategy
Downstream clinical associations	Immune dysfunction (neutrophil function), impaired collagen synthesis, endothelial dysfunction	Susceptibility to infection and impaired wound repair (associative evidence)	Higher risk profile for SSI and other infectious complications; delayed healing	Perioperative glycaemic targets per institutional protocol; integrate nutrition + glycaemic monitoring into ERAS pathway; prioritise high-risk groups (diabetes, frailty, malnutrition)

Legend: This table is an original synthesis summarising commonly described mechanisms linking surgical stress to perioperative hyperglycaemia and highlighting practical, modifiable perioperative levers. It is intended for conceptual and clinical workflow guidance rather than as a quantitative model.

5.1. Metabolic Rationale

Loading with carbohydrate (CHO), as is most often 400 ml of a 12.5% maltodextrin solution two hours before surgery, is an effective way to shift patients to the fed metabolic state, which otherwise would be hyperglycaemic and insulin-resistant following surgery (44). This metabolic transition lowers the catabolic impulse that burns glycogen stores and triggers muscle protein degradation, thereby creating functional reserve.

 doi:10.20944/preprints202602.1790.v1

5.2. Functional Advantage

CHO loading has been shown to reduce thirst, hunger, and anxiety, preoperative factors that may increase and contribute to preoperative discomfort and affect intra-operative haemodynamics, as well as biochemical parameters (45). Further, a series of randomized controlled trials has shown that preoperative CHO consumption is associated with a significant difference in the interval to bowel motility restoration, an outcome of special importance in abdominal surgery, where postoperative ileus increases length of stay and morbidity (42), (46).

5.3. Safety Profile

The concern that clear fluids may elevate the risk of pulmonary aspiration is not well grounded in clinically stable patients undergoing elective, non-obstructed procedures, rather than emergency or obstructed contexts (47). The systematic reviews and meta-analyses support the idea that clear, non-alcoholic liquids administered to patients up to two hours before induction do not increase the rate of aspiration in contrast to more rigorous fasting protocols (48). This security lies in the low volume, prompt emptying of clear fluids from the stomach, and the absence of solids, which would slow down gastrointestinal emptying or augment the residual volume.

The metabolic and functional data are strong, but due to a variety of study designs, differences in CHO concentration, volume, timing, and patient demographics, extrapolation should be done with caution. In addition, the possibility of individual differences in gastric emptying, especially in diabetic or motility-disordered subjects, demands individualised fasting plans. Another issue is that preoperative clear fluid intake increases logistical challenges for operating room workflow and patient education, which need to be considered in the development of institutional policy (49). The evidence supports a paradigm shift toward a more differentiated form of midnight fasting, including the use of CHO loading (50). This is an approach that ensures congruence between metabolic physiology and clinical outcomes, minimises patient suffering, and safeguards the safety of elective and non-obstructed operations. The next generation of research in this area should standardise CHO loading protocols, expand indications to include high-risk surgical patients, and incorporate these practices into improved recovery pathways to optimise peri-operative treatment.

Guidelines and controlled studies generally support preoperative carbohydrate loading as part of ERAS, with evidence suggesting improved patient comfort and reduced perioperative insulin resistance, and in some studies earlier gastrointestinal recovery. Nevertheless, impacts on “hard” outcomes (overall complications, length of stay) are less consistent, partly due to differences in CHO regimens, fasting policies, and concurrent ERAS elements. Benefits are most applicable to non-diabetic or well-controlled diabetic patients undergoing elective procedures, while careful selection is required in patients with delayed gastric emptying or high aspiration risk.

To summarise the main perioperative nutritional strategies discussed so far—together with the typical hierarchy of evidence, the most reproducible clinical signals, and the populations most likely to benefit—Table 5 provides an at-a-glance synthesis intended for clinical interpretation. Importantly, these effects remain context- and protocol-dependent across procedures and baseline risk profiles (Table 5).

 doi:10.20944/preprints202602.1790.v1

Table 5. Perioperative nutritional interventions in elective GI surgery: evidence hierarchy, expected benefits, and best-fit populations.

Intervention	Evidence hierarchy (typical)	Most reproducible clinical signal	Where benefit is most likely	Key limitations / heterogeneity	Practical implementation note
Nutritional screening (malnutrition/sarcopenia)	Guidelines + observational cohorts	Risk stratification; identifies high-risk	Elderly, oncologic, weight loss, frailty	Tool variability; sarcopenic obesity	Screen early (first surgical consult); trigger dietitian plan
ONS (high-protein)	Guidelines + mixed RCTs/meta-analyses	Lower infectious morbidity/LOS (often)	Malnourished/at-risk; major resections	Dose/adherence varies; baseline risk matters	Start preop, continue postop; monitor intake vs targets
Immunonutrition	Meta-analyses + RCTs	Infectious complications ↓ in some settings	GI oncology; higher-risk major surgery	Formulation/timing vary; not universal	Use protocolised window + defined formula; avoid blanket use
CHO loading	Guidelines + controlled studies	Comfort, insulin resistance ↓; GI recovery earlier in some	Non-diabetic or controlled diabetic; low aspiration risk	Hard endpoints inconsistent; protocol differences	Standardised CHO drink; follow fasting guidelines
Early oral/EN feeding	Guidelines + RCTs/meta-analyses	GI recovery earlier; no ↑ major complications in many cohorts	Colorectal, lower-risk GI resections	Procedure-dependent; intolerance possible	Define advancement milestones + escalation triggers

Legend: Table 5 provides an ERAS-focused, at-a-glance synthesis of perioperative nutritional strategies in elective gastrointestinal surgery. Interventions are summarized by typical evidence hierarchy (guidelines/meta-analyses, randomized trials, observational studies), the most reproducible clinical signals, and the patient populations in whom benefit is most consistently reported. Interpretation is framed within pathway implementation factors—including protocol compliance, discharge criteria, and procedure-specific context—which contribute to heterogeneity in reported outcomes.

6. Early Postoperative Feeding: Rationale and Protocols

6.1. Rationale for Early Feeding

The shift away from the traditional 'rest-and-gut' doctrine toward early feeding is supported by evidence that enteral nutrient exposure and specific dietary components can preserve mucosal integrity and gut barrier function, thereby limiting translocation of luminal microbial products. Table 6 outlines proposed mechanisms through which early postoperative feeding may influence gastrointestinal recovery and downstream clinical correlates, highlighting heterogeneity in the certainty of evidence across contexts. These elements also influence mucosal immunity through microbiome modulation, suppressed LPS-TLR4/ERK signalling, decreased ROS, and excessive immune cell activation. SCFAs from fermentable fibres also enhance additional barrier function and anti-inflammatory mechanisms (51). Together, these nutrients play a concerted role in maintaining epithelial integrity and immune response balance, thus demonstrating their therapeutic benefit in gastrointestinal diseases. These nutrients are observed to improve barrier integrity and reduce inflammation in bowel disease.

Building on these gut-barrier and microbiome-mediated mechanisms, perioperative microbiome-directed strategies—particularly lactic acid bacteria (LAB)-based probiotics and synbiotics—have been investigated as adjuncts to nutritional care to reduce dysbiosis, support mucosal integrity, and potentially mitigate postoperative infectious morbidity.

Table 6. Early postoperative feeding: proposed mechanisms, clinical correlates, and certainty of evidence.

Mechanistic domain	Representative mediators / processes (examples)	Expected direction of effect	Clinical correlate in elective GI surgery	Certainty / evidence profile (pragmatic)	Key limitations / notes
Mucosal integrity and barrier function	Tight junction regulation; epithelial turnover; enterocyte energy supply; short-chain fatty acid signalling	Permeability ↓; barrier resilience ↑	Reduced "feed intolerance cascade" in some settings; potentially lower infectious signal (procedure-dependent)	Mixed: strong mechanistic rationale; clinical outcomes heterogeneous	Effects depend on procedure, timing, and tolerance; bundle effects within ERAS
Motility and gastrointestinal recovery	Enteral stimulation of gut–brain axis; neurohormonal responses; reduced ileus drivers	Earlier transit; earlier return of bowel function	Earlier flatus/stool; earlier progression of diet; earlier discharge readiness	Moderate: supported by many clinical protocols but variable results	Intolerance not negligible; upper-GI/complex resections often require slower advancement
Inflammation and immune modulation	Reduced stress signalling with feeding; mucosal immune homeostasis; microbiome–immune interactions	Inflammatory tone ↓ (hypothesis); immune function supported	Potential reduction in infectious complications in some cohorts	Low–moderate: indirect clinical signal, often confounded	Difficult to isolate feeding effect from ERAS compliance and case-mix
Microbiome and metabolite profile	Maintenance of luminal substrate; microbial diversity support; SCFA production	More favourable microbial metabolites; colonisation resistance ↑	Improved stool patterns and tolerance in some contexts	Low–moderate: mechanistic and associative clinical data	Highly variable between patients; antibiotics and bowel prep confound
Protein delivery and muscle preservation	Earlier achievement of protein targets; reduced fasting-related catabolism	Lean mass loss ↓; functional recovery ↑	Improved mobilisation and rehabilitation participation	Moderate: depends on actual intake achieved	Requires monitoring of intake vs targets; nausea/pain can limit delivery
Anastomotic healing context	Adequate substrate delivery; avoidance of prolonged NPO; local perfusion context	Neutral-to-beneficial overall when tolerance is respected	Early feeding is feasible after many colorectal procedures; more caution in high-risk anastomoses	Procedure-dependent	High-risk anastomoses (complex upper GI/HPB) may need individualised advancement

Legend: This table is an original synthesis outlining commonly proposed mechanisms through which early postoperative feeding may influence recovery. "Certainty/evidence profile" is a pragmatic descriptor (conceptual to moderate) reflecting heterogeneity across procedures, protocols, and endpoints; it does not represent a formal GRADE assessment.

Traditional prolonged postoperative fasting has been linked to mucosal atrophy, poor motility, and an increased risk of postoperative complications such as infection and ileus. Biomarkers of gut permeability, such as plasma lipopolysaccharide-binding protein, can be used to show that perioperative feeding within the initial 24 h of abdominal surgery suppresses endotoxin leakage (52). Together, these mechanisms may support epithelial integrity and a more balanced mucosal immune response, although clinical impact remains context-dependent across procedures and feeding protocols.

6.2. Microbiome-directed adjuncts: probiotics/synbiotics (lactic acid bacteria)

Improving surgical outcomes requires optimal nutritional management. Increasing attention is being given to the gut microbiome as a modifiable factor in postoperative outcomes, alongside macronutrient adequacy and immunonutrition. Surgical stress, anesthesia, antibiotic prophylaxis, bowel preparation and perioperative fasting disrupt intestinal microbial balance, contributing to increased gut permeability, systemic inflammation and infectious complications (53).

Lactic acid bacteria (LAB), including strains within the genera *Lactobacillus*, *Pediococcus* and *Bifidobacterium*, represent a nutritional approach that is targeted to reduce perioperative dysbiosis. Their integration into surgical nutrition care may support intestinal barrier function, modulate immune responses and reduce postoperative morbidity (54), (55).

6.2.1. Mechanisms of Action of Lactic Acid Bacteria in Surgical Nutrition

The potential benefits of lactic acid bacteria in surgical nutrition care are supported by multiple interconnected core mechanisms linked to molecular, immunological and metabolic pathways. These mechanisms are particularly relevant in the context of surgical stress, barrier disruption or antibiotic exposure and are directly targeting the pathophysiological drivers of postoperative infectious complications (56), (57).

6.2.2. Preservation of Intestinal Barrier Function

Surgical stress and systemic inflammation can disrupt epithelial tight junctions increasing intestinal permeability and facilitating bacterial translocation. This process contributes to systemic inflammatory response and surgical site infections. LAB support barrier integrity by: upregulating tight junction proteins, enhancing mucin production or by reducing lipopolysaccharide translocation. By increasing epithelial cohesiveness and preserving the mucus layer, LAB may prevent microbial translocation during the perioperative period. This barrier-protective effect is one of the most clinically relevant mechanisms underlying reduced infectious complications in abdominal surgery (58), (59).

6.2.3. Modulation of Immune Responses

Surgery induces complex immune responses characterized by concomitant hyperinflammation and transient immunosuppression. An increased vulnerability to infection and organ dysfunction is the result of dysregulated cytokine signaling. LAB interact with intestinal epithelial cells and immune cells via pattern recognition receptors influencing downstream signaling pathways. This interaction can: reduce pro-inflammatory cytokines (TNF-α, IL-6, IL-1β), increase anti-inflammatory mediators (IL-10), enhance secretory IgA production in the gut. Through balanced immunomodulation rather than broad immune stimulation, LAB may attenuate excessive inflammatory responses while preserving antimicrobial defense (60), (61).

6.2.4. Limitation of Pathogen Overgrowth

After the administration of antibiotics during surgery, opportunistic pathogens, such as *Enterobacteriaceae* species, may be able to occupy ecological niches in the gut. Studies have shown that pathogen overgrowth is strongly associated with postoperative infectious morbidity. In order to combat this, LAB produce antimicrobial metabolites, such as lactic acid, bacteriocins - strain-specific peptides with targeted antimicrobial activity and hydrogen peroxide, which have the capacity to

Preprints.org (www.preprints.org) | NOT PEER-REVIEWED | Posted: 26 February 2026 doi:10.20944/preprints202602.1790.v1

inhibit growth of pathogenic organisms, including Gram-negative bacteria implicated in surgical site infections. Other mechanisms include adhesion to epithelial surfaces - LAB compete with pathogens for epithelial binding sites, reducing colonization potential and quorum sensing interference - emerging data suggest that some LAB strains may disrupt pathogen quorum sensing systems, thereby attenuating virulence factor expression (62), (63).

6.2.5. Short-Chain Fatty Acid (SCFA) and Metabolic Signaling

Although LAB are primarily lactate producers, they contribute also to SCFA production. When fermented by gut microbes, fibers produce short-chain fatty acids (SCFAs) like butyrate, propionate, and acetate, which have anti-inflammatory effects and help maintain gut barrier integrity (64), (65). Butyrate serves as a primary energy substrate for colonocytes and enhances epithelial regeneration. It also promotes tight junction assembly and mucosal repair. Moreover, SCFAs act as inhibitors for histone deacetylases (HDACs), altering gene transcription toward anti-inflammatory pathways. In the postoperative state—characterized by insulin resistance and catabolism—these metabolic interactions may contribute to improved glycemic stability and mucosal healing.

6.2.6. Gut–Organ Axes in Surgical Recovery

The gut microbiome interacts with distant organs via systemic metabolites and immune signaling (e.g. gut–brain axis - affecting stress responses and recovery trajectories) LAB-mediated modulation of these axes may partially explain reductions in infectious and inflammatory complications observed in clinical trials (64).

6.2.7. Clinical Evidence in Surgical Populations

The clinical evidence for perioperative LAB-based probiotics and synbiotics derives primarily from randomized controlled trials and meta-analyses, with outcomes that are influenced by substantial heterogeneity in strain composition, dosing, timing (preoperative-only vs perioperative), duration, antibiotic exposure, baseline nutritional risk, and the extent to which supplementation is embedded within bundled ERAS care. Consequently, reported effects should be interpreted as context- and protocol-dependent rather than uniform across procedures and patient risk profiles.

Within elective gastrointestinal surgery, the strongest and most consistent signal has been reported in colorectal surgery. Multiple randomized controlled studies and meta-analyses indicate that perioperative LAB-containing probiotics or synbiotics may reduce surgical site infections, decrease overall infectious morbidity, and in some studies shorten length of hospital stay; several reports also describe reductions in inflammatory markers and improved tolerance to early enteral feeding, although effect sizes vary across trials and formulations (66), (43). By contrast, evidence in oesophageal and gastric surgery is comparatively limited and emerging; available studies suggest potential improvements in postoperative nutritional tolerance, selected pulmonary outcomes, and inflammatory response profiles in specific cohorts, but generalisability remains constrained by smaller sample sizes and protocol variability (67). Overall, these data support a risk- and procedure-stratified interpretation: benefits appear most plausible in major abdominal surgery with higher infectious risk and/or greater anticipated dysbiosis burden, while the incremental value in low-risk elective cases remains more uncertain and likely strain-specific.

6.2.8. Safety Considerations

In elective surgery cohorts, LAB-based probiotics and synbiotics are generally well tolerated, but safety remains contingent on appropriate patient selection, product quality, and clinical context. The practical goal is not routine use in all patients, but cautious consideration in settings where potential benefit is biologically plausible and patient risk is acceptable.

Heightened caution is warranted in severely immunocompromised patients (e.g., post-transplant recipients and those receiving intensive chemotherapy), in sepsis or multi-organ failure

Preprints.org (www.preprints.org) | NOT PEER-REVIEWED | Posted: 26 February 2026 doi:10.20944/preprints202602.1790.v1

(where use—if considered at all—should occur only under close monitoring), and in patients with significant intestinal compromise (e.g., severe mucosal injury or conditions that may increase microbial translocation risk) (68). Although probiotic-associated bacteraemia has been reported, the overall incidence appears low when clinically validated preparations are used appropriately. When integrated as an adjunct to—rather than a substitute for—structured nutritional optimization and ERAS principles, LAB supplementation may contribute to reduced infectious morbidity and support recovery in selected major abdominal surgery populations, while acknowledging that observed benefits are not universal and remain dependent on strain and protocol characteristics (69), (70). Rigorous patient selection, adherence to clinically validated strains, and monitoring in high-risk contexts are key safeguards (68).

Remaining uncertainties include optimal strain selection, dosing, timing, and the patient subgroups most likely to benefit, which should be clarified by future procedure- and risk-stratified trials.

For practical interpretation, Table 7 summarises the proposed roles of perioperative LAB-based probiotics/synbiotics, identifies settings where benefit is most plausible, and delineates key safety boundaries for patient selection (Table 7)

Table 7. Perioperative probiotics/synbiotics (LAB): potential roles, target populations, and safety boundaries.

Topic	Key message	Best-fit populations	Where evidence is weaker	Safety boundary ("avoid/caution")
Clinical signal	Infectious complications may decrease in some cohorts; effects strain/protocol-dependent	Colorectal surgery; higher infectious risk	Low-risk elective cases; non-colorectal procedures	N/A
Mechanistic rationale	Barrier support + immune modulation + dysbiosis mitigation (conceptual)	Major abdominal surgery with dysbiosis burden	Hard outcomes not uniform	N/A
Implementation	Adjunct, not substitute for ONS/ERAS; needs protocol	Centres with defined product/strain and timing	Unstandardised "over-the-counter" use	N/A
Safety	Generally well tolerated in elective cohorts	Stable elective patients	Critically ill cohorts	**Avoid/caution:** severe immunosuppression, sepsis/MOF, significant mucosal compromise

6.3. Clinical Evidence for Early Postoperative Oral Intake

The early oral intake (with less than 24 hours) has become the norm in colorectal procedures. The randomized controlled trials and systematic reviews all indicate that early feeding decreases the occurrence rates of postoperative ileus, shortens the LOS in hospitals, and enhances patient satisfaction without escalating adverse events. As an illustration, colorectal resection multicentre RCT reported a 30% decrease in ileus and a 1.5-day decrease in LOS in patients who commenced oral intake within 24 hours as compared to those who followed a later schedule (71). Similarly, meta-analyses involving the diverse types of gastrointestinal surgeries have also demonstrated that early oral intake has been linked to a reduced incidence of surgical site infections and reduced readmissions further emphasizing its safety profile. Notably, such benefits are preserved among subgroups of patients, such as those with comorbid conditions, such as diabetes or obesity, as long as perioperative glucose control is satisfactory.

 doi:10.20944/preprints202602.1790.v1

6.4. Real-Life Procedures and Dietetic Interventions

Universally, EN is more desirable than parenteral nutrition because it is associated with reduced infections, cost-effectiveness, and functionality of the gut. PN is used on patients with a non-functional gastrointestinal tract or patients who are unable to obtain at least 60 per cent of their caloric requirements through EN or oral intake seven days after surgery (72). The feeding protocols in the practical stages usually go through clear liquids, all liquids, soft solids, and to regular diet as tolerated. Early EN is often administered using jejunostomy or nasojejunal feeding tubes in upper gastrointestinal surgeries including esophagectomy to circumvent the proximal anastomosis to decrease anastomotic stress. Jejunal feeding can help ensure postoperative nutritional delivery and is often associated with earlier return of bowel function in upper gastrointestinal procedures. Reported effects on anastomotic leak are variable across studies and depend on procedure type, feeding protocols, and baseline anastomotic risk; therefore, jejunal feeding is best framed as a supportive strategy within a broader perioperative pathway rather than a stand-alone determinant of leak prevention (73). Tolerance is assessed regularly as protocols include abdominal distension, nausea and residual volume monitoring and individualised escalation is allowed. If feeding intolerance has developed, step-down measures such as re-introduction of clear liquids or trophic feeds are observed and escalation is reinitiated when the intolerance has ended.

Across guidelines and interventional evidence, early oral intake and/or EN is generally feasible and may accelerate gastrointestinal recovery, with many studies reporting no increase in major complications compared with traditional delayed feeding. However, outcomes vary by procedure type (upper GI vs colorectal vs HPB), anastomotic risk profile, and definitions of “early feeding,” and intolerance rates are not negligible in selected cohorts. The clearest applicability is within ERAS pathways for elective colorectal and other lower-risk GI resections, whereas individualized advancement is prudent after complex upper GI or high-risk anastomoses.

7. Clinical Outcomes and Functional Recovery

7.1. Postoperative Complications

Nutritional optimization is a key component of perioperative care, particularly in older adults undergoing major elective abdominal surgery. Evidence from systematic review and meta-analytic data suggests that preoperative oral nutritional supplementation may reduce postoperative infectious complications, with the most consistent signal reported for surgical site infections (SSIs) (74). The background process is the restoration of the micronutrients and amino acids which promote the growth of immune cells, generation of cytokines and integrity of the barrier affecting the dampening of the systemic inflammatory response leading to infection predisposition. In addition to infection, the recent data highlight the great impact of preoperative provision of targeted nutritional support on the reduction of postoperative delirium, which is a frequent and expensive complication of aging. In this way, nutritional optimization acts in two forms of protection, namely, strengthening of host protection against pathogens and stabilisation of neurocognitive homeostasis, which are the most important factors in safe surgical recovery.

7.2. Ileus, Anastomotic Leaks, and Healing

Prolonged postoperative ileus (PPOI) remains a clinically relevant driver of delayed recovery after major colorectal surgery, supporting the need for structured prevention and early recognition strategies (46). Nutritional status also has an effect on intestinal motility and anastomotic integrity but this is less direct. Sufficient protein consumption and a set of micronutrients including zinc, and vitamin C provide an environment in which collagen synthesis and angiogenesis take place and are required to repair tissues (75). Nevertheless, the key factors that cause anastomotic leak are the surgical technique, tension of the anastomosis, and local perfusion; the secondary, but non-negligible role is played by nutrition. The increased leakage associated with prolonged malnutrition is due to the inhibition of fibroblast proliferation and undermining of the mucosal barrier functions, weakening the anastomosis (76). On the other hand, in case of corrected malnutrition, the number of leaks is not reduced similarly but the level of leaks and the morbidity decreases. In addition, the best nutrition accelerates the recovery of postoperative ileus through maintenance of enteric neural activity and motilin secretion, which shortens the bowel rest period and related complications. Thus, although nutrition is not a panacea of surgical leakage, a proper nutritional condition is an essential supplement that aids healing and minimises the risk of adverse sequelae development.

7.3. Length of stay, readmissions, and functional recovery

Structured nutritional programmes embedded within ERAS pathways are consistently associated with shorter postoperative length of stay across elective gastrointestinal procedures, although the magnitude of benefit varies by surgical population, institutional baseline practice, and protocol adherence. Across elective colorectal and anorectal surgery, postoperative complication profiles are also shaped by baseline comorbidity burden, reinforcing the rationale for risk-stratified pathway implementation and patient-centred discharge criteria (77).

Given the variability in protocol compliance, discharge criteria, case-mix, and endpoint definitions across studies and centres, Table 8 summarises key sources of heterogeneity that influence observed effects on length of stay and readmissions (Table 8).

Table 8. Why ERAS effects vary: drivers of heterogeneity in LOS and readmission outcomes.

Domain	What varies across studies/centres	How it biases LOS/readmissions	Practical mitigation in interpretation
Protocol compliance	Adherence to key ERAS elements (feeding, mobilization, analgesia, fluids)	High compliance → clearer LOS reduction; low compliance → diluted effect	Report/consider compliance; interpret bundled effects cautiously
Discharge criteria	Formal discharge rules vs clinician judgement	Shorter LOS may increase early readmission if discharge is premature	Interpret LOS alongside readmission and functional readiness
Case-mix	Procedure type (upper GI vs colorectal vs HPB), oncologic burden, frailty	Higher complexity → smaller/variable LOS effects	Stratify conclusions by procedure/risk
Outcome definitions	Different definitions for ileus, complications, "tolerance"	Apparent inconsistency across trials	Prefer standardized endpoints; state definition used
Baseline care	"Control care" may already be ERAS-like	Smaller incremental gains	Compare context; avoid deterministic language

Overall, ERAS pathways are supported by substantial guideline endorsement and a broad body of comparative studies, which consistently show an association with shorter postoperative length of stay and faster functional recovery in elective gastrointestinal surgery. Nevertheless, the magnitude of benefit varies across institutions and procedures, reflecting differences in baseline care, adherence to ERAS elements, discharge criteria, and patient complexity. Readmission effects are more heterogeneous across studies, and improvements are most consistently observed when high protocol compliance is achieved and perioperative nutrition is integrated within a multidisciplinary pathway. Evidence regarding 30-day readmissions is more heterogeneous, with several reports suggesting reductions, while others show neutral effects, particularly when early discharge is paired with robust

 doi:10.20944/preprints202602.1790.v1

outpatient follow-up and clear discharge criteria (78). Such cuts can be explained by several synergistic effects of reduced rates of infection, reduced rates of delirium, earlier bowel functions, and enhanced wound healing. Notably, patient-centered outcomes have become a core concept behind modern ERAS initiatives because functional capacity and quality of life (QoL) are seen as being as vital as conventional morbidity indicators. The six-minute walk test (6MWT) is an aerobic endurance and lower-limb strength test that is a validated measure of functional recovery and is commonly used in research to measure functional recovery. Some studies report that preoperative nutritional counselling and supplementation are associated with modestly better postoperative functional performance, including an approximately 15–20 m greater distance on the 6-minute walk test compared with control groups; however, effect sizes vary with baseline nutritional risk, surgical magnitude, and concurrent prehabilitation components (79). Significant improvements in physical functioning, role limitation, and overall well-being are also found in nutritionally optimised cohorts in QoL assessments, which are usually quantified through disease-specific instruments i.e. EORTC QLQ-C30, or generic ones, like the SF-36 (80). These patient-reported outcomes provide evidence of the holistic effect of nutrition: in addition to complications prevention, patients are empowered to become independent again and keep psychosocial health.

8. Conclusion: Practical Takeaways and Future Directions

In elective gastrointestinal surgery, perioperative nutritional optimization has become a central component of ERAS-aligned care pathways. Across the available literature, routine screening for nutritional risk and reduced functional reserve supports early identification of high-risk patients and facilitates targeted optimization strategies, including oral nutritional supplementation, selected immunonutrition protocols, carbohydrate loading when appropriate, and early postoperative feeding within structured pathways. Importantly, the magnitude and consistency of clinical benefit varies by procedure type and baseline patient risk, and effects are most reproducible when nutritional strategies are embedded within high-compliance, multidisciplinary perioperative programmes.

This review has limitations. The evidence base is heterogeneous with respect to intervention definitions (timing, composition, dosing, and duration), surgical case-mix (upper GI, colorectal, HPB), and outcome reporting, and many studies evaluate nutrition as part of bundled ERAS care, making it difficult to isolate the independent effect of single components. Additional limitations include variable baseline nutritional risk across cohorts, inconsistent adherence reporting, and differences in discharge criteria that influence length-of-stay outcomes.

Future research should prioritise procedure-specific, risk-stratified trials using standardised nutrition targets and transparent adherence reporting. Key PICO-oriented research questions include: (1) in malnourished or sarcopenic patients scheduled for major elective GI resection (P), does a structured multimodal prehabilitation programme combining high-protein supplementation and resistance training (I), compared with standard ERAS care alone (C), reduce infectious complications and improve functional recovery at 30 days (O)? (2) in patients undergoing elective colorectal resection (P), does protocolised early oral intake with defined escalation triggers (I), compared with traditional diet advancement (C), reduce prolonged postoperative ileus and shorten length of stay without increasing readmissions (O)? (3) in high-risk GI oncology patients receiving neoadjuvant therapy (P), does perioperative immunonutrition administered for a standardised perioperative window (I), compared with isocaloric/isoproteic standard supplementation (C), reduce infectious complications and support timely adjuvant therapy delivery (O)?

Author Contributions: Conceptualization, M.B., A.K. and E.R.; methodology, M.B., A.K. and A.L.; investigation (literature search and study selection), M.B., A.K., C.-A.M. and A.-D.M.; data curation (evidence extraction and organization), M.B., C.-A.M., A.-D.M. and D.N.-B.; writing—original draft preparation, M.B. and A.K.; writing—review and editing, A.K., E.R., C.-A.M., A.-D.M., A.R., D.C., A.L., D.N.-B. and Ș.E.C.C.; visualization (tables and summary frameworks), M.B. and A.K.; supervision, E.R. and A.K.; project administration, M.B. and E.R. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable. This narrative review did not involve human participants or animal experiments and did not require ethical approval.

Informed Consent Statement: Not applicable. This study did not involve human participants or identifiable patient data.

Data Availability Statement: Not applicable. This narrative review did not generate or analyze any new datasets; all information is derived from publicly available published literature.

Acknowledgments: The authors would like to thank Associate Professor Luiza-Anca Kraft of "Carol I" National Defence University—Bucharest, Romania, for the language editing work.

Conflicts of Interest: The authors declare no conflicts of interest.

Abbreviations

The following abbreviations are used in this manuscript:

ADLs	Activities of Daily Living
BIA	Bioelectrical Impedance Analysis
CHO	Carbohydrate (carbohydrate loading)
EHR	Electronic Health Record
GLUT4	Glucose Transporter Type 4
LAB	Lactic Acid Bacteria
MNA	Mini Nutritional Assessment
MST	Malnutrition Screening Tool
MUST	Malnutrition Universal Screening Tool
NPO	Nil Per Os (nothing by mouth)
NRS-2002	Nutritional Risk Screening 2002
ONS	Oral Nutritional Supplements
PG-SGA	Patient-Generated Subjective Global Assessment
PICO	Population, Intervention, Comparator, Outcome
QLQ-C30	EORTC Quality of Life Questionnaire - Core 30
SARC-F	Strength–Assistance with walking–Rise from a chair–Climb stairs–Falls questionnaire
SCFA	Short-Chain Fatty Acid
SF-36	36-Item Short Form Health Survey
SNAQ 65+	Short Nutritional Assessment Questionnaire 65+

References

1. 1. **Schlottmann F, Herbella FA, Patti MG.** Bariatric surgery and gastroesophageal reflux. *J Laparoendosc Adv Surg Tech A.* 2018, Vols. 28(8):953-955.
2. 2. **Calvani R, Picca A, Coelho-Júnior HJ, Tosato M, Marzetti E.** Postoperative stress, metabolism, and catabolism; p. 287-308. [book auth.] Luigi Marano Virginia Boccardi. *The Frail Surgical Patient: A Geriatric Approach Beyond Age.* Cham : Springer Nature Switzerland, 2025.
3. 3. **Scott MJ, Baldini G, Fearon KC, Feldheiser A, Feldman LS, Gan TJ, Ljungqvist O, Lobo DN, Rockall TA, Schricker T, Carli F.** Enhanced Recovery After Surgery (ERAS) for gastrointestinal surgery, part 1: pathophysiological considerations. *Acta Anaesthesiol Scand.* 2015, Vols. 59(10):1212-1231.

 doi:10.20944/preprints202602.1790.v1

4. 4. **Suriyaraj SP, Ganapathy D, Shanmugamprema D.** Prehabilitation strategies: enhancing surgical resilience with a focus on nutritional optimization and multimodal interventions. *Adv Nutr.* 2025, Vol. 16(4):100392. doi:10.1016/j.advnut.2025.100392. PMID: 40086400.
5. 5. **Thiele R, Friedman J.** Enhanced recovery after surgery (ERAS) and immunonutrition: an evidence-based approach. *Pract Gastroenterol.* 2020, Vols. 25:24-37.
6. 6. **Strobel RM, Beyer K, Lauscher JC, Martignoni M, Reißfelder C, Vilz T, Weimann A, Wobith M.** Perioperative nutrition practices in gastrointestinal cancer surgery: a nationwide survey among German surgical departments. *Langenbecks Arch Surg.* 2025, Vols. 411(1):7. doi:10.1007/s00423-025-03906-2.
7. 7. **Magro DO, Lima AP, Coy CSR, Kotze PG.** Perioperative nutritional support in gastrointestinal surgery - why is it essential? *Arq Gastroenterol.* 2025, Vols. 62:e24094. doi:10.1590/S0004-2803.24612024-94. PMID: 40531682.
8. 8. Mulita F, Verras GI, Kotis K, Tchabashvili L, Perdikaris I, Argentou MI, Michailidou M, Sarantis N, Liolis E, Kaplanis C, Maroulis I. The importance of preoperative assessment of the elderly patient. *Cureus.* 2023, Vol. 15(9).
9. 9. **Keller, U.** Nutritional Laboratory Markers in Malnutrition. *J Clin Med.* 2019, Vol. May 31;8(6):775. doi: 10.3390/jcm8060775. PMID: 31159248; PMCID: PMC6616535.
10. 10. **Cochior D, Constantinoiu S, Copaescu C, Serbanoiu D, Bîrla R, Boeriu M.** Clinical Importance of the Determinant-Based Classification of Acute Pancreatitis Severity. *Chirurgia.* 2013, Vols. 108(5):631-42.
11. 11. **Kutnik P, Wichowska O, Sysiak-Sławecka J, Szczukocka M, Rypulak E, Piwowarczyk P, Borys M, Czuczwar M.** Malnutrition risk in elective surgery patients and effectiveness of preoperative nutritional interventions at a pre-anaesthetic clinic: a 4-year apart, single-centre, observational study. *Anaesthesiol Intensive Ther.* 2023, Vols. 55(3):179-185. doi:10.5114/ait.2023.130632. PMID: 37728445.
12. 12. **Cawood AL, Elia M, Stratton RJ.** Systematic review and meta-analysis of the effects of high protein oral nutritional supplements. *Ageing Res Rev.* 2012, Vols. 11(2):278-296.
13. 13. **Krenitsky, J.** Nutrition for the bariatric patient. *Practical Gastroenterology.* 2010, Vol. Jun 1;34(6).
14. 14. **Schneider SM, Veyres P, Pivot X, Soummer AM, Jambou P, Filippi J, et al.** Malnutrition is an independent factor associated with nosocomial infections. *Br J Nutr.* 2004, Vols. 92(1):105-111.
15. 15. **Vellas B, Guigoz Y, Garry PJ, Nourhashemi F, Bennahum D, Lauque S, Albarede JL.** The Mini Nutritional Assessment (MNA) and its use in grading the nutritional state of elderly patients. *Nutrition.* 1999, Vols. 15(2):116-122. doi:10.1016/S0899-9007(98)00171-3.
16. 16. **Ottery, FD.** Patient-Generated Subjective Global Assessment. [book auth.] Polisena CG, McCallum PD. *The Clinical Guide to Oncology Nutrition.* Chicago (IL) : American Dietetic Association, 2000. p. 11-23.
17. 17. **Isenring EA, Bauer JD, Banks M, Gaskill D.** The Malnutrition Screening Tool is a useful tool for identifying malnutrition risk in residential aged care. *J Hum Nutr Diet.* 2009, Vols. 22(6):545-550. doi:10.1111/j.1365-277X.2009.01008.x.
18. 18. **Jensen GL, Compher C.** The Global Leadership Initiative on Malnutrition (GLIM). *Am J Clin Nutr.* 2025, Vols. Sep;122(3):712-714. doi: 10.1016/j.ajcnut.2025.06.028. Epub 2025 Jul 1. PMID: 40609750.
19. 19. **Bossi P, Delrio P, Mascheroni A, Zanetti M.** The spectrum of malnutrition/sarcopenia. *Nutrients.* 2021, Vols. 13(11):1-17.
20. 20. Weimann A, Braga M, Carli F, Higashiguchi T, Hübner M, Klek S, Laviano A, Ljungqvist O, Lobo DN, Martindale RG, Waitzberg D, Bischoff SC, Singer P. ESPEN practical guideline: Clinical nutrition in surgery. *Clin Nutr. .* 2021, Vols. 40(7):4745-4761.
21. 21. **Barberan-Garcia A, Ubré M, Roca J, Lacy AM, Burgos F, Risco R, Momblán D, Balust J, Blanco I, Martínez-Pallí G.** Personalised prehabilitation in high-risk patients undergoing elective major abdominal surgery: a randomised blinded controlled trial. *Ann Surg.* 2018, Vols. 267(1):50-56. doi:10.1097/SLA.0000000000002293. PMID: 28328628.
22. 22. **Singh F, Newton RU, Galvão DA, Spry N, Baker MK.** A systematic review of pre-surgical exercise intervention studies with cancer patients. *Surg Oncol.* 2013, Vols. 22(2):92-104.
23. 23. **Bolshinsky V, Li MHG, Ismail H, Burbury K, Riedel B, Heriot A.** Multimodal prehabilitation programs as a bundle of care in gastrointestinal cancer surgery: a systematic review. *Dis Colon Rectum.* 2018, Vols. 61(1):124-138.

 doi:10.20944/preprints202602.1790.v1

24. 24. **Lambert JE, Hayes LD, Keegan TJ, Subar DA, Gaffney CJ.** The impact of prehabilitation on patient outcomes in hepatobiliary, colorectal, and upper gastrointestinal cancer surgery: a PRISMA-accordant meta-analysis. *Annals of surgery.* 2021, Vols. 274(1):70-7.
25. 25. **Wobith M, Hill A, Fischer M, Weimann A.** Nutritional prehabilitation in patients undergoing abdominal surgery—a narrative review. *Nutrients.* 2024, Vol. 16(14):2235.
26. 26. **Commission Delegated Regulation.** (EU) 2016/128 of 25 September 2015 supplementing Regulation (EU) No 609/2013 of the European Parliament and of the Council as regards the specific compositional and information requirements for food for special medical purposes (Text with EEA relevance). *Official Journal of the European Union.* 2016, Vols. L 25:30–43. Available at: https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=celex%3A32016R0128. Accessed 2026 Feb 17.
27. 27. Molenaar CJ, Minnella EM, Coca-Martinez M, Ten Cate DW, Regis M, Awasthi R, Martínez-Palli G, López-Baamonde M, Sebio-Garcia R, Feo CV, Van Rooijen SJ. Effect of multimodal prehabilitation on reducing postoperative complications and enhancing functional capacity following colorectal cancer surgery: the PREHAB randomised clinical trial. *JAMA surgery.* 2023, Vols. 158(6):572-81.
28. 28. **Grace C, Vincent R, Aylwin SJ.** High prevalence of vitamin D insufficiency in a United Kingdom urban morbidly obese population: implications for testing and treatment. *Surg Obes Relat Dis.* 2014, Vols. 10(2):355–360. PMID: 24411192. doi:10.1016/j.soard.2013.07.
29. 29. **Ba F, Siddiqi ZA.** Neurologic complications of bariatric surgery. *Rev Neurol Dis.* 2010, Vols. 7(4):119–124. PMID: 21206427. .
30. 30. **Nica-Badea D, Udriștioiu A.** The Relevance of Supplemental Vitamin D in Malignancies. *Anti-Cancer Agents in Medicinal Chemistry.* 2021, Vols. 21(1), Doi.org/10.2174/18715206216662115846.
31. 31. **Parrott J, Frank L, Rabena R, Craggs-Dino L, Isom KA, Greiman L.** American society for metabolic and bariatric surgery integrated health nutritional guidelines for the surgical weight loss patient 2016 update: micronutrients. *Surg Obes Relat Dis.* 2017, Vols. 13(5):727–741. PMID: 28392254. doi:10.1016/j.soard.2016.12.01829.
32. 32. **O'Kane M, Parretti HM, Pinkney J, et al.** British obesity and metabolic surgery society guidelines on perioperative and postoperative biochemical monitoring and micronutrient replacement for patients undergoing bariatric surgery-2020 update. *Obes Rev.* 2020, Vol. 21(11):e13087. PMID: 32743907; PMCID: PMC7583474. doi:10.1111/obr.13087. .
33. 33. **Nordmo M, Danielsen YS, Nordmo M.** The challenge of keeping it off, a descriptive systematic review of high-quality, follow-up studies of obesity treatments. *Obes Rev.* 2020, Vol. 21(1):e12949. PMID: 31675146. doi:10.1111/obr.1294935. .
34. 34. **Khalooeifard R, Rahmani J, Ghoreishy SM, Tavakoli A, Najjari K, Talebpour M.** Evaluate the effects of different types of preoperative restricted calorie diets on weight, body mass index, operation time and hospital stay in patients undergoing bariatric surgery: a systematic review and meta analysis study. *Obes Surg.* . 2024, Vols. 34(1):236–249. PMID: 38052747. doi:10.1007/s11695-023-06973-w36.
35. 35. **Reytor-González C, Frias-Toral E, Nuñez-Vásquez C, et al.** Preventing and managing pre- and postoperative micronutrient deficiencies: a vital component of long-term success in bariatric surgery. *Nutrients.* 2025, Vol. 17(5):741. PMID: 40077612; PMCID: PMC11902.
36. 36. **Stegenga H, Haines A, Jones K, Wilding J.** Guideline Development Group. Identification, assessment, and management of overweight and obesity: summary of updated NICE guidance. *BMJ.* 2014, Vol. 349:g6608. PMID: 25430558. doi:10.1136/bmj.g6608 .
37. 37. **Pludowski P, Grant WB, Karras SN, Zittermann A, Pilz S.** Vitamin D supplementation: a review of the evidence arguing for a daily dose of 2000 international units (50 µg) of vitamin D for adults in the general population. *Nutrients.* 2024, Vol. 16(3):391. PMID: 38337676; PMCID: PMC10857599. doi:10.3390/nu16030391.
38. 38. **Lo JO, Benson AE, Martens KL, et al.** The role of oral iron in the treatment of adults with iron deficiency. *Eur J Haematol.* 2023, Vols. 110(2):123–130. PMID: 36336470; PMCID: PMC9949769. doi:10.1111/ejh.13892 .
39. 39. **Li H, Lim SL, Chan DKH.** The role of oral nutritional supplementation in hospitalised elderly patients. *Clinical Nutrition.* 2021, Vols. 40(3):1-7.

doi:10.20944/preprints202602.1790.v1

40. 40. **Wilson MM, Thomas DR, Rubenstein LZ, Chibnall JT, Anderson S, Baxi A, et al.** Appetite assessment: simple appetite questionnaire predicts weight loss in community-dwelling adults and nursing home residents. *Am J Clin Nutr.* 2005, Vols. 82(5):1074-1081.
41. 41. Cerantola Y, Valerio M, Persson B, Jichlinski P, Ljungqvist O, Hubner M, Kassouf W, Muller S, Baldini G, Carli F. Enhanced Recovery After Surgery (ERAS®) society recommendations. *Clin Nutr.* 2013, Vols. 32(6):879-887.
42. 42. **Wang XH, Wang ZY, Shan ZR, Wang R, Wang ZP.** Effects of preoperative oral carbohydrates on recovery after laparoscopic cholecystectomy: a meta-analysis of randomised controlled trials. *J Perianesth Nurs.* 2025, Vols. 40(1):169-180.
43. 43. **Moldovan, C., et al.** Clinical and surgical algorithm for managing iatrogenic bile duct injuries during laparoscopic cholecystectomy: A multicenter study. *Exp Ther Med.* 2021, Vols. 22, 1385, doi:10.3892/etm.2021.10.
44. 44. **Berg A, Roed H, Honoré B, Lindorff-Larsen K, Rasmussen HH.** Analysis of the effect of perioperative immunonutrition on complications after surgery for gastrointestinal cancer. *Clin Nutr.* 2021, Vols. 30(5):1-10.
45. 45. **Beattie AH, Prach AT, Baxter JP, Pennington CR.** A randomised controlled trial evaluating the use of enteral nutritional supplements postoperatively. *Gut.* 2000, Vols. 46(6):813-818.
46. 46. **Chapman SJ, Pericleous A, Downey C, Jayne DG.** Postoperative ileus following major colorectal surgery. *Br J Surg.* 2018, Vols. 105(7):797-810. doi:10.1002/bjs.10888. PMID: 29679662.
47. 47. Konstantinides SV, Torbicki A, Agnelli G, Danchin N, Fitzmaurice D, Galiè N, Gibbs J, Huisman MV, Humbert M, Kucher N, Lang I, Lankeit M, Lekakis J, Maack C, Mayer E, Meneveau N, Perrier A, Pruszczyk P, Rasmussen LH, Schindler TH, Svitil P, et al. Corrigendum to: 2014 ESC Guidelines on the diagnosis and management of acute pulmonary embolism. *Eur Heart J.* 2015, Vols. Oct 14;36(39):2642. doi: 10.1093/eurheartj/ehu479. Epub 2015 Jul 28. Erratum for: Eur Heart J. 2014 Nov 14;35(43):3033-69, 3069a-3069k. doi:10.1093/eurheartj/ehu283. PMID: 26224077.
48. 48. Anesthesiologists, Practice Guidelines for Preoperative Fasting and the Use of Pharmacologic Agents to Reduce the Risk of Pulmonary Aspiration: Application to Healthy Patients Undergoing Elective Procedures: An Updated Report by the American Society of. Task Force on Preoperative Fasting and the Use of Pharmacologic Agents to Reduce the Risk of Pulmonary Aspiration. *Anesthesiology.* 2017, Vols. 126(3):376-393. doi: 10.1097/ALN.0000000000001452. PMID: 28045707.
49. 49. **Kim, J.** Transforming pre-operative fasting practice: a nurse-led liberal fluid fasting regimen. *J Perioper Nurs.* 2025, Vols. 38(1):e12-e15. doi:10.26550/2209-1092.1264.
50. 50. **Swann J, Salimrouhi E.** Fasting and exercise: Effects on cellular adaptation, performance, and recovery. *Basic and Clinical Biochemistry and Nutrition.* 2025, Vols. 1(2):56-65.
51. 51. **Khoshbin K, Camilleri M.** Effects of dietary components on intestinal permeability in health and disease. *Am J Physiol Gastrointest Liver Physiol.* 2020, Vols. 319(5):G589–G608. doi:10.1152/ajpgi.00245.2020. PMID:32902315. PMCID:PMC8087346.
52. 52. **Camilleri, M.** Is intestinal permeability increased in obesity? A review including the effects of dietary, pharmacological and surgical interventions on permeability and the microbiome. *Diabetes, obesity & metabolism.* 2022, Vol. 25(2):325.
53. 53. **Nichols L, El-Kholy O, Elsayed AAR, Basson MD.** The bidirectional interplay between gut dysbiosis and surgical complications: A systematic review. *Am J Surg.* 2025, Vol. Jul;245:116369. doi: 10.1016/j.amjsurg.2025.116369. Epub 2025 May 2. PMID: 40344995.
54. 54. **Petrut, Ş. M., et al.** Screening of lactic acid bacteria from spontaneously fermented products of Romania. *Rom. Biotechnol. Lett.* 2019, Vols. 24 (2): 254-260. DOI:10.25083/rbl/24.2/254.260.
55. 55. **Petrut, S. M., et al.** Safety assessment of lactic acid bacteria strains isolated from traditional Romanian fermented foods. *Journal of Biotechnology.* Valencia, Spain, 11-13 April 2019, 305, S47-S48.
56. 56. Weimann A, Braga M, Carli F, Higashiguchi T, Hübner M, Klek S, Laviano A, Ljungqvist O, Lobo DN, Martindale R, Waitzberg DL, Bischoff SC, Singer P. ESPEN guideline: Clinical nutrition in surgery. *Clin Nutr.* 2017, Vols. Jun;36(3):623-650. doi: 10.1016/j.clnu.2017.02.013. Epub 2017 Mar 7. PMID: 28385477.

 doi:10.20944/preprints202602.1790.v1

57. 57. **Corbu, V., et al.** Environmental stress responses in yeasts and lactic acid bacteria strains isolated from dairy traditional Romanian fermented products. *Rom. Biotechnol. Lett.* 2021, Vols. 26 (2): 2548- 2559. DOI: 10.25083/rbl/26.2/2548.2559.
58. 58. **Kim MJ, Lee YJ, Hussain Z, Park HJ.** Effect of probiotics on improving intestinal mucosal permeability and inflammation after surgery. *Gut Liver.* 2025, Vols. 19(2):207–218.
59. 59. **Petrut, S., et al.** Influence of various carbon sources on growth and biomass accumulation of some lactic acid bacteria strains. *Rev. Chim.* 2019, Vols. 70 (7), 2434-2438. DOI: 10.37358/RC.19.7.7356.
60. 60. **Ebrahimpour-Koujan, S., Milajerdi, A., Larijani, B., & Esmaillzadeh, A.** Effects of probiotics on salivary cytokines and immunoglobulines: a systematic review and meta-analysis on clinical trials. . *Scientific Reports.* 2020, Vols. 10(1), 11800.
61. 61. **Budden KF, et al.** Gut–organ axes: Microbiome and systemic outcomes. *Nat Rev Microbiol.* 2017, Vols. 15(1): 55–63.
62. 62. **Oelschlaeger, TA.** Mechanisms of probiotic actions - A review. *Int J Med Microbiol.* 2010, Vols. Jan;300(1):57-62. doi: 10.1016/j.ijmm.2009.08.005. Epub 2009 Sep 23. PMID: 19783474.
63. 63. **Lebeer S, et al.** Probiotics and quorum sensing inhibition. *Gut Microbes.* 2018, Vols. 9(4):334–343.
64. 64. **Petrut, S.-M., et al.** Gut over Mind: Exploring the Powerful Gut–Brain Axis. *Nutrients.* 2025, Vols. 17, 842. https://doi.org/10.3390/ nu17050842.
65. 65. **Hamer HM, Jonkers D, Venema K, Vanhoutvin S, Troost FJ, Brummer RJ.** Review article: the role of butyrate on colonic function. *Aliment Pharmacol Ther.* 2008, Vols. Jan 15;27(2):104-19. doi: 10.1111/j.1365-2036.2007.03562.x. Epub 2007 Oct 25. PMID: 17973645.
66. 66. **An, S., Kim, K., Kim, M. H., Jung, J. H., & Kim, Y.** Perioperative probiotics application for preventing postoperative complications in patients with colorectal cancer: A systematic review and meta-analysis. *Medicina.* 2022, Vols. 58(11), 1644.
67. 67. **Yang, Z., Wu, Q., Liu, Y., & Fan, D.** Effect of perioperative probiotics and synbiotics on postoperative infections after gastrointestinal surgery: a systematic review with meta-analysis. *Journal of Parenteral and Enteral Nutrition.* 2017, Vols. 41(6), 1051.
68. 68. **Doron S, Snydman DR.** Risk and safety of probiotics. *Clin Infect Dis.* 2015, Vols. May 15;60 Suppl 2(Suppl 2):S129-34. doi: 10.1093/cid/civ085. PMID: 25922398; PMCID: PMC4490230.
69. 69. **Veziant, J., Bonnet, M., Occean, B. V., Dziri, C., Pereira, B., & Slim, K.** Probiotics/synbiotics to reduce infectious complications after colorectal surgery: a systematic review and meta-analysis of randomised controlled trials. *Nutrients.* 2022, Vols. 14(15), 3066.
70. 70. **Wu H, Guan Z, Zhang K, Zhou L, Cao L, Mou X, Cui W, Tian B, Zhang G.** The effect of perioperative probiotics and synbiotics on postoperative infections in patients undergoing major liver surgery: a meta-analysis of randomized controlled trials. *PeerJ.* 2025, Vol. Feb 17;13:e18874. doi: 10.7717/peerj.18874. PMID: 39981042; PMCID: PMC11841616.
71. 71. **Kumar V, Hong J.** Ileus and small bowel obstruction. [book auth.] Stephen M Cohn. *Acute Care Surgery and Trauma.* Boca Raton (FL) : CRC Press, 2023. p. 301-310.
72. 72. **Berlana, D.** Parenteral Nutrition Overview. *Nutrients.* 2022, Vol. Oct 25;14(21):4480. doi: 10.3390/nu14214480. PMID: 36364743; PMCID: PMC9659055.
73. 73. **Canzan F, Longhini J, Caliaro A, Cavada ML, Mezzalira E, Paiella S, Ambrosi E.** The effect of early oral postoperative feeding on the recovery of intestinal motility after gastrointestinal surgery: a systematic review and meta-analysis of randomised clinical trials. *Frontiers in Nutrition.* 2024, Vol. 11:1369141.
74. 74. **Cadili L, van Dijk PAD, Grudzinski AL, Cape J, Kuhnen AH.** The effect of preoperative oral nutritional supplementation on surgical site infections among adult patients undergoing elective surgery: a systematic review and meta-analysis. *Am J Surg.* 2023, Vols. 226(3):330-339. doi:10.1016/j.amjsurg.2023.06.011. PMID:37385857.
75. 75. **Stanescu C, Chiscop I, Mihalache D, Boev M, Tamas C, Stoleriu G.** The roles of micronutrition and nutraceuticals in enhancing wound healing and tissue regeneration: A systematic review. *Molecules.* 2025, Vol. 30(17):3568.

doi:10.20944/preprints202602.1790.v1

76. 76. **Liu Y, Li B, Wei Y.** New understanding of gut microbiota and colorectal anastomosis leak: a collaborative review of the current concepts. *Frontiers in Cellular and Infection Microbiology.* 2022, Vol. 12:1022603.
77. 77. **Moldovan C, Rusu E, Cochior D, Toba ME, Mocanu H, Adam R, et al.** Ten-year multicentric retrospective analysis regarding postoperative complications and impact of comorbidities in hemorrhoidal surgery with literature review. *World Journal of Clinical Cases.* 2023, Vols. 11(2):366–384.
78. 78. **Sauro KM, Smith C, Ibadin S, Thomas A, Ganshorn H, Bakunda L, Bajgain B, Bisch SP, Nelson G.** Enhanced recovery after surgery guidelines and hospital length of stay, readmission, complications, and mortality: a meta-analysis of randomised clinical trials. *JAMA Netw Open.* 2024, Vol. 7(6):e2417310.
79. 79. **Jain SR, Kandarpa VL, Yaow CYLY, Tan WJH, Ho LML, Sivarajah SS, et al.** The role and effect of multimodal prehabilitation before major abdominal surgery: a systematic review and meta-analysis. *World J Surg.* 2023, Vols. 47(1):86-102. doi:10.1007/s00268-022-06761-0. PMID:36184673.
80. 80. **Grande GE, Farquhar MC, Barclay SI, Todd CJ.** Quality of life measures (EORTC QLQ-C30 and SF-36) as predictors of survival in palliative colorectal and lung cancer patients. *Palliative & supportive care.* 2009, Vols. 7(3):289-97.