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ESPEN Guideline

ESPEN guideline on clinical nutrition in surgery – Update 2025

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Abbreviations: ADL, activities of daily living; BIA, bioelectrical impedance analysis; BM, biomedical endpoint; BMI, body mass index; CCI, Comprehensive Complication Index; CFS, Clinical Frailty Scale; CrI, credible interval; CRP, C-reactive protein; CT, computed tomography; CVC, central venous catheter; DHA, docosahexaenoic acid; DT, Distress Thermometer; DXA, dual X-ray absorptiometry; E-SPN, early parenteral supplementation; ECOG-PS, Eastern Collaborative Oncology Group-Performance Status; EN, enteral nutrition; EPA, eicosapentaenoic acid; ERABS, Enhanced Recovery After Bariatric Surgery; ERAS, Enhanced Recovery After Surgery; fTRST, Flemish-triage risk screening tool; G-8, geriatric 8; GAI, Geriatric Anxiety Inventory; GDRS, Groningen Distress Rating Scale; GDS, Geriatric Depression Scale; GLIM, Global Leadership Initiative on Malnutrition; HE, health care economy endpoint; HEN, home enteral nutrition; HMB, hydroxymethylbutyrate; HOMA, homeostatic model assessment; IADL, Instrumental Activities of Daily Living; ICU, intensive care unit; IE, integration of classical and patient-reported endpoints, multidimensional endpoints; IL-6, interleukin 6; JBI, Joanna Briggs Institute; L-SPN, late parenteral supplementation; LCT, long-chain triglyceride; LOS, length of stay; MCT, medium-chain triglycerides; MFI, modified frailty Index; MMSE, mini-mental state examination; MNT, medical nutrition therapy; MPI, multidimensional prognostic index; MRI, magnetic resonance imaging; NCJ, (fine) needle catheter jejunostomy; NRS, Nutritional Risk Screening; ONS, oral nutritional supplements; PEG, percutaneous endoscopic gastrostomy; PEJ, percutaneous endoscopic jejunostomy; PG-SGA, Patient-generated Subjective Global Assessment; PG-SGA-SF, Patient-generated Subjective Global Assessment short form; PN, parenteral nutrition; POD, postoperative day; PROM, patient-reported outcome measure; POPF, postoperative pancreatic fistulas; PUFAs, polyunsaturated fatty acids; QL, quality of life; QUICKI, quantitative insulin sensitivity check index; RAI, Risk-analysis Index; RCT, randomized clinical trial; SARC-F/SARC-CalF, Questionnaire to identify individuals at risk of sarcopenia using the components Strength, Assistance in walking, Rise from a chair, Climb stairs, Falls, eventually enhanced by Calf circumference; SGA, Subjective Global Assessment; SMI, skeletal muscle index; SOP, standard operating procedure; TNFα, tumor necrosis factor alpha.

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SUMMARY

Early oral feeding is the preferred mode of nutrition for surgical patients. Avoidance of any nutritional therapy bears the risk of underfeeding during the postoperative course after major surgery. Considering that malnutrition and underfeeding are risk factors for postoperative complications, nutritional therapy is mandatory for any surgical patient at nutritional risk, especially for those undergoing upper gastrointestinal surgery. The focus of this guideline is to cover nutritional aspects of the Enhanced Recovery After Surgery (ERAS) concept and the special nutritional needs of patients undergoing major surgery, e.g. for cancer, and of those developing severe complications despite best perioperative care. From a metabolic and nutritional point of view, the key aspects of perioperative care include: a) Integration of nutrition into the overall management of the patient, b) avoidance of long periods of preoperative fasting c) re-establishment of oral feeding as early as possible after surgery d) start of nutritional therapy early, as soon as a nutritional risk becomes apparent e) metabolic control e.g. of blood glucose, f) reduction of factors which exacerbate stress-related catabolism or impair gastrointestinal function, g) minimized time on paralytic agents in the postoperative period, and h) early mobilization to facilitate protein synthesis and muscle function.

The guideline presents 44 recommendations for clinical practice in patients undergoing elective and non-elective surgery, including new recommendations for frailty assessment, sarcopenia diagnosis, and prehabilitation. As in the former ESPEN practical guideline, the recommendations were additonally presented in decision-making flowcharts.

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1. Preliminary remarks – principles of metabolic and nutritional care

The key aspects of perioperative care from a metabolic and nutritional point of view, include the overall management of the patient by:

- Integration of nutritional care into the overall management of the patient
- Tackling nutritional therapy early, as soon as nutritional risk or malnutrition is identified in the preoperative period and continuing in the postoperative period, also considering immunonutrition;
- Avoiding long periods of preoperative fasting by providing a carbohydrate load up to two hours before the operation;
- Re-establishing oral feeding as soon as possible after the operation;
- Starting nutritional therapy early;
- Controlling blood glucose;
- Reducing factors that exacerbate stress-related catabolism or impair gastrointestinal function (e.g., pain);
- Minimizing the time on paralytic agents in the postoperative period;
- Stimulating early mobilization to facilitate protein synthesis and muscle function.

This guideline focuses particularly on the nutritional aspects of the Enhanced Recovery After Surgery (ERAS) concept (Plan A). This relates preoperatively to strategies for preoperative optimization. ERAS guidelines advise the use of oral nutritional supplements (ONS) during the perioperative period [1,2]. Despite the best possible preoperative care, severe postoperative complications related to the surgical procedure may occur, with the possible need for intensive care therapy and even reoperation, requiring special nutritional therapy, including medical nutrition (Plan B).

The authors of this guideline update were committed to striving for rigor and quality according to a well-established and transparent methodology [3–5]. In the hope of implementation, which has to be improved [6], we emphasize physiological knowledge to personalize nutrition in clinical practice.

2. Definitions and classifications

2.1. Nutritional therapy

Synonym: Nutritional support is defined according to the European Society for Clinical Nutrition and Metabolism (ESPEN) consensus [7,8]:

Nutritional therapy is the provision of nutrition or nutrients either orally (regular diet, therapeutic diet, e.g., fortified food, ONS) or via enteral nutrition (EN) or parenteral nutrition (PN) to prevent or treat malnutrition. “Medical nutritional therapy” (MNT) is a term that encompasses ONS, enteral tube feeding (enteral nutrition), and parenteral nutrition” [7]. EN and PN have traditionally been called artificial nutritional support, which is covered now by the term MNT. Nutritional therapies are individualized and targeted nutritional care measures using diet or medical nutritional therapy. Dietary advice or nutritional counseling can be part of nutritional therapy.

2.2. Nutritional “metabolic” risk and disease-related malnutrition

Nutritional assessment before surgical procedures aims to minimize the risks associated with changes in the pathophysiology of the stress response [9]. Malnutrition is generally considered to be associated with starvation and lack of food. Its presence in the Western world, with an increasing percentage of obese people, is frequently neither realized nor well understood. For patients undergoing cancer surgery, malnutrition is an independent risk factor for the development of complications, is associated with increased mortality, and influences the hospital

length of stay (LOS) and costs [10–14]. Disease-related malnutrition is more subtle than suggested by the World Health Organization (WHO) definition of undernutrition with a body mass index (BMI) < 18.5 kg/m^2 [8,15]. Disease-related weight loss in patients who are overweight is not necessarily associated with a low BMI. However, this weight loss results in changes in body composition with a loss of fat-free mass contributing to sarcopenia or sarcopenic obesity [16] and inducing a "metabolic risk," which has to be kept in mind for patients undergoing major surgery with special regard to cancer. Chronic low-grade inflammation may also be a component of or contributor to malnutrition [17].

In 2019, the Global Leadership Initiative on Malnutrition (GLIM) developed a new tool to diagnose malnutrition, which is supported by major professional societies worldwide [18]. After screening for malnutrition, phenotypic and etiologic criteria are collected, which consider unintentional weight loss, low BMI, reduced muscle mass, decreased food intake or absorption, and inflammation.

Here, phenotypic and etiologic criteria are distinguished:

Phenotypic criteria are:

- Non-volitional weight loss
- Low BMI
- Reduced muscle mass

Etiologic criteria are:

- Reduced food intake or assimilation
- Inflammation or disease burden

Ideally, all the criteria should be assessed, but if not possible, at least one phenotypic and one etiologic criterion must be met for the diagnosis of malnutrition. The severity is defined by the phenotypic criteria, of which muscle mass assessment, when available, is relevant.

The GLIM recommendations for assessment of muscle mass include [19]:

- Bioelectrical impedance analysis (BIA)
- Computed tomography of the abdomen (CT)
- Dual X-ray absorptiometry (DXA)
- Ultrasound
- Anthropometric measures (e.g., calf circumference, mid-arm circumference)

CT is a routine procedure in patients with cancer. Muscle mass, and its radiodensity can be determined from the axial image at the level of the third lumbar vertebra (L3), which is representative of the entire muscle mass of the patient [20]. Subcutaneous fat and visceral fat can also be determined. There is a significant association between CT-defined sarcopenia and clinical outcomes in surgical patients with gastrointestinal tumors [21–23]. As this method of body composition analysis is not yet routine in clinical practice, this information will not be available for most patients. Instead, the definition of high metabolic risk of the ESPEN Surgery Working Group might be helpful.

While low BMI alone may be less common to define high metabolic risk [24], the guideline group recommends the presence of at least one of the following criteria:

- Weight loss >10–15 % within six months
- BMI <18.5 kg/m^2
- Nutritional Risk Screening (NRS) ≥5 or Subjective Global Assessment (SGA) Grade C
- Preoperative serum albumin <30 g/L (without evidence of hepatic or renal dysfunction).

Focusing on the surgical patient, preoperative serum albumin concentration is a prognostic factor for complications after surgery [14,25–31] and may also be associated with impaired nutritional status. However, serum albumin concentration is not modifiable by short-term nutritional therapy and should not be used as a nutritional marker anymore [32]. Nevertheless, serum albumin concentration might still serve to define surgical patients at high metabolic risk. This concept aligns with the current Joint Consensus Statement on Nutritional Screening and Therapy within a Surgical Enhanced Recovery Pathway of the American Society for Enhanced Recovery and Perioperative Quality Initiative [33]. Furthermore, albumin and C-reactive protein (CRP) are well-established parameters in the (modified) Glasgow Prognostic Score for postoperative complications and survival in patients with cancer [34–36]. C-reactive protein measurement has been also recommended for the etiologic GLIM criteria [37]. Procalcitonin has been proven to predict complications, e.g., anastomotic leak and EN tolerance in the critically ill [38–41].

3. Methodology

3.1. General methodology

The present guideline was developed according to the standard operating procedure (SOP) for ESPEN guidelines [5]. GRADE methodology was used for the evidence assessment [42]. The guideline is an updated version of the "ESPEN guideline: Clinical nutrition in surgery" developed in 2017 [2], and updated in German in 2023 [43]. The aforementioned underlying guidelines were developed using the SIGN methodology, which is why this guideline still contains remnants of the SIGN methodology. The present guideline update was developed by an international expert group representing different professions: surgery: M.B., M.B., M.I.T.D.C., L.G., M.H., J.F.B.I., M.S.J., S.K., T.K., O.L., D.N.L., C.L.S., I.M., B.R.R., N.M.S., H.-P.S., H.T., D.L.W., A.W., D.Y., anesthesia: P.E.W., gastroenterology: S.C.B., A.L., P.F-D., dietetics: C.G., O.W., nutrition scientist: A.S. All members of the working group had declared their individual conflicts of interest according to the rules of the International Committee of Medical Journal Editors (ICMJE).

Following the SOP for ESPEN guidelines and consensus papers, the first development step of this guideline was to check the 2017 PICO questions for further applicability and extension. PICO questions are designed to address specific **p**atient groups (or **p**roblems), **i**nterventions, **c**ompare different therapies, and be **o**utcome-related [5]. In total, the 2025 guideline update consists of 18 PICO questions divided into six main chapters entitled "Basic questions", "Indication for nutritional therapy", "Preoperative nutrition", "Postoperative nutrition", "Bariatric surgery", and "Organ transplantation". To answer these questions, a literature search that covered the period since the last guideline was performed to identify suitable meta-analyses, systematic reviews, and primary studies (for details see below, "search strategy"). Each PICO question was allocated to subgroups, including at least three experts for the different topics, and, initially, 48 recommendations and two statements answering the PICO questions were formulated.

In 2022, ESPEN switched from the Scottish Intercollegiate Guidelines Network (SIGN) methodology to the GRADE methodology. As the present guideline is based on previous guidelines developed with the SIGN methodology, the present guideline contains elements from both methodologies.

For grading and assessment of new literature, the GRADE method was applied. For systematic reviews and meta-analyses, the grading of the quality of evidence was performed for the five domains "Risk of Bias", "Inconsistency", "Indirectness", "Imprecision", and "Publication Bias" for all relevant outcomes according to the GRADE handbook [42]. Additionally, summary of finding tables were filled in. When no meta-analysis was possible, a narrative approach was used [44]. Supportive of this, data from every relevant publication were extracted to evidence tables. To evaluate the literature, the AMSTAR II checklist [45] was used for Systematic Reviews, the Cochrane risk of bias tool 2 [46] for randomized clinical trials (RCTs), the Newcastle-Ottawa scale [47] for cohort studies and cross-sectional studies, and the JBI (Joanna Briggs Institute) Critical Appraisal Checklist for Analytical Cross Sectional Studies [48] for the studies concerned. The results of the evaluation are presented in the evidence tables in Appendix A.

For literature originating from previous guidelines, the SIGN grading system was maintained (Table 1). Characteristics of these older publications are also presented in evidence tables. For reasons of continuity, the grade of recommendations of SIGN [49] was maintained. The grades of recommendation were decided according to the levels of evidence assigned (Table 1). These tables are available online as supplementary material to this guideline (**see** Appendix A **supplementary data**).

The wording of the recommendations reflects the grades of recommendations since level A is indicated by the use of the word "shall", level B by the word "should", and level 0 by the word "can" or "may" (Table 2). This also reflects the strength of recommendation with "shall" meaning a strong and "can/may" meaning a weak recommendation, and "should" lying in between. The good practice points (GPP), taken from the SIGN methodology, are based on expert opinions due to the lack of studies, for which the choice of wording was not restricted. Having the option of an expert opinion is essential in the field of clinical nutrition, where certain topics cannot be addressed by RCTs due to ethical considerations. Supporting the recommendations, the working group added commentaries to explain their basis.

As in the 2017 guideline, outcome parameters for the recommendations were weighed according to the type of evidence-based endpoints: biomedical (BM), multidimensional (IE), health economy (HE), and quality of life (QL) [50]. The QL endpoint was supplemented by patient-reported outcomes (PROMs), e. g. vomiting and nausea. Specifically for the recommendations concerning preoperative fasting or carbohydrate loading, insulin requirements were introduced as an additional endpoint.

Between 26th June and 22nd July 2024, an online voting (Delphi round) on the recommendations was performed using the guideline-services.com platform. All ESPEN members were invited to agree or disagree with the recommendations and to provide comments. A first draft of the guideline was also made available to the participants on that occasion. Thirty-three recommendations reached an agreement >90 %, 15 recommendations reached an agreement of 75–90 %, one of the statements reached an agreement >90 %, and the other one reached an agreement of 75–90 %. Those recommendations with an agreement >90 % (indicating a strong consensus, see Table 3) were directly passed [51], and all others were revised according to the comments and voted on again during a consensus conference that took place online in two parts on 27th August and 2nd September 2024. Eleven recommendations that originally had received >90 % agreement were also voted on during the consensus conference due to major changes in wording. During the consensus conference, three recommendations were deleted, two recommendations were also merged. Therefore, the final guideline comprises 44 recommendations and three statements. At the consensus conference, all recommendations but two received an agreement >90 %, and one statement that was also voted on received an agreement of 75–90 %.

Three recommendations (20, 27, and 31) underwent major changes after the consensus conference. To be consistent with the other recommendations, the patient group in recommendation 20 was specified as "and/or high metabolic risk". The duration in recommendation 27 was changed from 7–14 days to 10–14 days to align with recommendation 20, although seven days were retained as the minimum. Recommendation 31 was updated to include the need for stable electrolytes to make it more user-friendly. The percentages of agreement given below the recommendations are from the Delphi round and the consensus conference. The majority of the guideline working group agreed with the above recommendations in an e-mail-based voting.

3.2. Search strategy

The literature search was performed by the working group members at the end of January 2024 using the PubMed NCBI and the Cochrane Databases. The search was limited to publications for a three-year period (including publications since 2021) taking into account an overlap with the search for the previous DGEM guideline update in 2021 [43]. A longer period was chosen for the two new topics, prehabilitation and frailty. For all the PICO questions, the literature search was performed between December 2023 and March 2024 by subgroups of the guideline working group, including at least three members. Title and abstract screening, followed by full-text screening, was performed in duplicate, in case of disagreement mediated by the third member.

For the search strategy please refer to Appendix A.

Studies were included if they were systematic reviews, meta-analyses, or RCTs comparing a defined nutritional intervention (as reflected in the search strings) with either no intervention or a standard treatment. If none of the above-mentioned studies were available, prospective and retrospective observational studies, and occasionally case series, were also included. Both elective and emergency surgical procedures were considered. Outcomes had to

Table 1
Definition of levels of evidence.

1++	High-quality meta-analyses, systematic reviews of RCTs, or RCTs with a very low risk of bias
1+	Well-conducted meta-analyses, systematic reviews, or RCTs with a low risk of bias
1-	Meta-analyses, systematic reviews, or RCTs with a high risk of bias
2++	High-quality systematic reviews of case–control or cohort studies. High-quality case–control or cohort studies with a very low risk of confounding or bias and a high probability that the relationship is causal
2+	Well-conducted case–control or cohort studies with a low risk of confounding or bias and a moderate probability that the relationship is causal
2-	Case-control or cohort studies with a high risk of confounding or bias and a significant risk that the relationship is not causal
3	Non-analytic studies, e.g. case reports, case series
4	Expert opinion

According to the Scottish Intercollegiate Guidelines Network (SIGN) grading system [48]. RCT, randomized clinical trial.

Table 2
Definition of grades of recommendation [5].

A	At least one meta-analysis, systematic review, or RCT rated as 1++, and directly applicable to the target population; or A body of evidence consisting principally of studies rated as 1+, directly applicable to the target population, and demonstrating overall consistency of results
B	A body of evidence including studies rated as 2++, directly applicable to the target population; or A body of evidence including studies rated as 2+, directly applicable to the target population and demonstrating overall consistency of results; or and demonstrating overall consistency of results; or Extrapolated evidence from studies rated as 1++ or 1+
0	Evidence level 3 or 4; or Extrapolated evidence from studies rated as 2++ or 2+
GPP	Good practice points/expert consensus: Recommended best practice based on the clinical experience of the guideline development group

GPP, good practice point.

Table 3
Classification of the strength of consensus.

Strong consensus	Agreement of >90 % of the participants
Consensus	Agreement of >75–90 % of the participants
Majority agreement	Agreement of >50–75 % of the participants
No consensus	Agreement of <50 % of the participants

According to the Arbeitsgemeinschaft der Wissenschaftlichen Medizinischen Fachgesellschaften (AWMF) (Association of the Scientific Medical Societies) in Germany methodology [50].

align with the pre-defined, prioritized outcome parameters. Only articles published in English or German were included. An update search was performed in January 2025.

After this point, newly published articles that came to the authors' attention were described in the commentary texts, but they had no influence on the recommendations that had already been agreed upon.

Outcome parameters were graded as critical, important, and not important:

- Mortality (critical)
- Complications in general (Clavien-Dindo) (critical)
- Infectious complications (critical)
- Hospital length of stay (important)
- Readmission rate (important)
- Nutritional status and body composition (important)
- Quality of life (important)

3.3. Visualization of the guideline content

To promote the application of the guideline in practice, decision-making flowcharts were created to illustrate the process from the preoperative period to discharge. These flowcharts are intended to facilitate rapid bedside decision-making. First, there is an overview (Fig. 1), followed by the preoperative period (Fig. 2). The postoperative period is divided into general management (Fig. 3) and nutritional therapy (Fig. 4). The final flowchart covers special cases, such as organ transplantation and bariatric surgery (Fig. 5).

4. Basic questions

4.1. Is there a need for standard operating procedures?

Recommendation 1

Standard operating procedures should be used for quality management in the performance of clinical nutrition.

Grade of recommendation GPP – strong consensus 96 % agreement

Comment

The use of nutrition protocols and SOPs has been shown to be beneficial in ensuring the implementation of medical nutritional therapy and the achievement of nutritional goals [52,53]. The positive impact of a preoperative structured nutritional protocol on clinical parameters was observed in an RCT in 80 patients undergoing major gastrointestinal surgery: serum albumin concentration, earlier onset of bowel function, and initiation of EN [54]. However, the study was not powered for real outcome parameters. A very recent RCT (n = 84) showed, in patients undergoing pancreatoduodenectomy, that a pathway-directed whole-course nutritional management was associated with fewer complications, total and abdominal infections, and was even cost-effective [55].

4.2. Is preoperative fasting necessary?

Recommendation 2

Patients without a particular risk of tracheo-bronchial aspiration shall be allowed to ingest clear liquids up to two hours and solid foods up to six hours before the start of anesthesia (BM, IE, QL).

Grade of recommendation A – strong consensus 100 % agreement

Comment

In recent decades, there has been a growing departure from the dogma of preoperative fasting because there are no benefits from preoperative fasting. The risk of aspiration or regurgitation is not increased with two hours of fasting for liquids compared with twelve hours of fasting. This correlates with the physiologic time of gastric emptying for liquids, which is 60–90 min [56–59]. Accordingly, many national anesthesia societies have revised their guidelines on fasting [60–63] and allow patients to have clear liquids up to two hours before the start of anesthesia for elective procedures. Patients with a “special risk”, such as emergency surgery and patients with delayed gastric emptying [64] or gastroesophageal reflux [58], are exempt from this recommendation. Since the implementation of the guidelines, there have been no reports of an increase in the rate of aspiration, regurgitation, or perioperative pulmonary complications. Minimizing fasting episodes is a key component of the ERAS concept. The ability to consume clear liquids, as well as coffee or tea, reduces thirst symptoms and, consequently, headaches. Solid foods should be permitted six hours before the start of anesthesia and should be easily digestible.

4.3. Is preoperative metabolic preparation by carbohydrate administration useful in elective surgery?

Recommendation 3

Carbohydrate stores should be selectively replenished to trigger insulin release shortly before major elective abdominal surgery to counteract insulin resistance and increase patients' comfort (B) (QL, BM). Specific carbohydrate drinks can be given the evening before and up until two hours before the start of anesthesia to trigger insulin release (0) (BM).

Grade of recommendation B/0 – strong consensus 96 % agreement

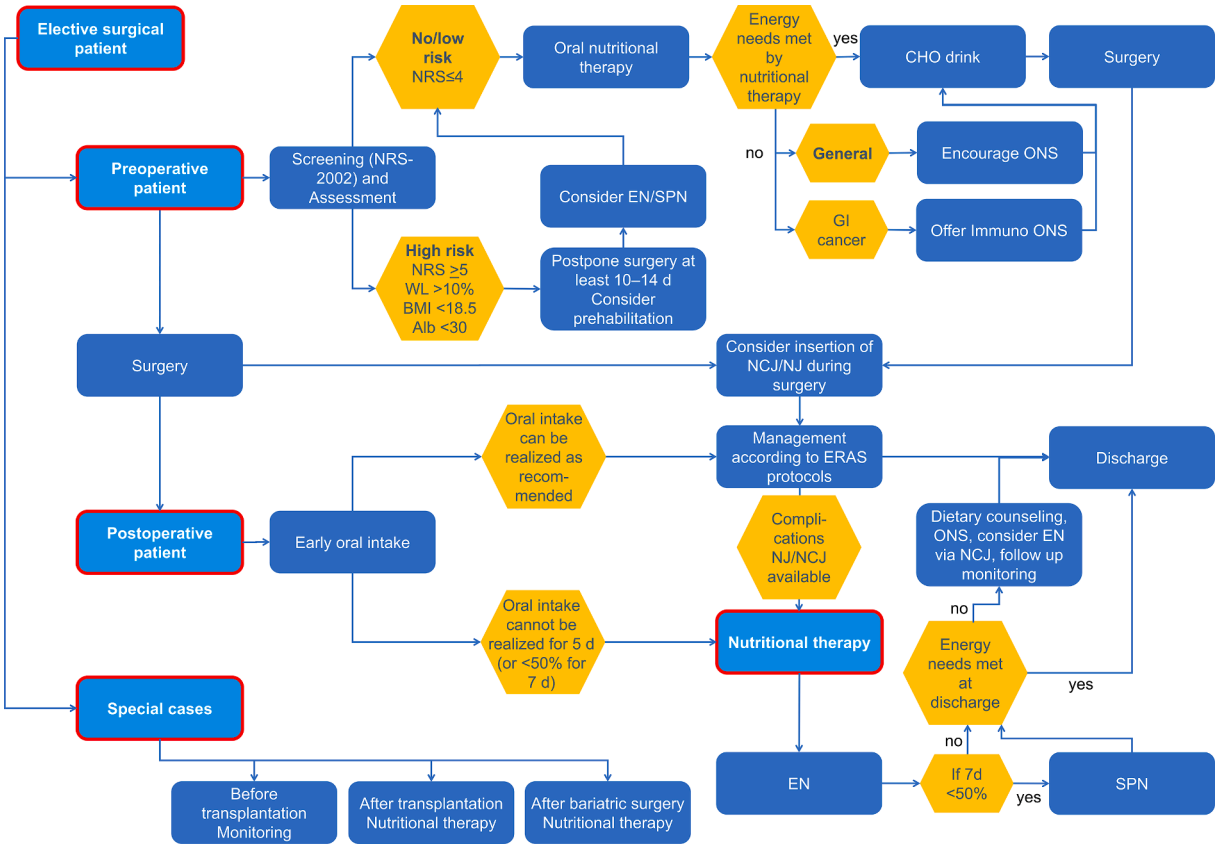

Fig. 1. Nutritional management of elective surgical patients (overview). Abbreviations: Alb, albumin; BMI, body mass index; CHO, carbohydrate; EN, enteral nutrition; MNT NCJ, (fine) needle catheter jejunostomy; NJ, (fine) needle jejunostomy; NRS, Nutritional Risk Screening; ONS, oral nutritional supplements; SPN, supplemental parenteral nutrition; WL, weight loss.

Comment

The preoperative intake of carbohydrate-containing beverages (so-called "carbohydrate loading") is part of the ERAS protocol [62]. Preoperative carbohydrate loading changes metabolism before the onset of surgery from an overnight fasted state to a fed state, and this reduces postoperative insulin resistance and impacts postoperative metabolism and recovery [65]. Most studies on the concept have used 800 mL of a 12 % maltodextrin-rich carbohydrate drink given the evening before surgery and a 400 mL dose approximately two hours before the induction of anesthesia. Extensive studies have shown that the risk of tracheobronchial aspiration using these doses was not increased [56,66–69] and that gastric emptying was well within the two hours prescribed for clear liquids in most fasting guidelines [58–60,62].

Some physiological aspects should be considered. Intake of carbohydrates causes the release of insulin that initiates anabolic reactions lasting only a few hours. The composition of the drink impacts these reactions. Gastric emptying is faster with lower osmolality drinks, and insulin release is related mainly to the concentration of the carbohydrates and not the overall amount. A 6 % sports drink causes almost no insulin release (purposely so), while the same load of carbohydrates as a 12 % drink causes a 5-6-fold increase, as seen after a normal meal. The morning dose is a key to the change in metabolism [70]. Not all commercially available drinks have been studied for safety or efficacy. Determinations of the treatment's metabolic and endocrine efficacy should also be measured accurately. In many studies, authors try to determine insulin resistance using methods when insulin is inactive [71–74]. These methods (homeostasis model assessment (HOMA) and quantitative insulin sensitivity check index (QUICKI)) cannot capture the development of insulin resistance [75]. Insulin sensitivity and resistance are best measured using the hyperinsulinemic-euglycemic clamp at physiological insulin concentrations [65]. If the clamp method is unavailable, it is better to study glucose concentrations associated with the development of complications [76,77]. Studies in major abdominal surgery using the clamp method at physiological levels have shown reduced insulin resistance and support recovery [65,78] while studies using HOMA or QUICKI show variable results.

The above factors impact much of the information gained from available meta-analyses. When mixing different surgical procedures, bundling minor and major surgeries, and adding surgical techniques, the variation in relevant outcomes is further enlarged [66,79–81]. Meta-analysis of such different underlying studies is at least problematic or even inadequate.

There are several RCTs on the outcomes of using carbohydrate treatment. There has been no study reporting major harm from its treatment. In a small prospective RCT with a total of 36 patients undergoing elective colorectal surgery (fasting vs. water vs. maltodextrin solution), the LOS was reduced (study solution vs. water, $P = 0.019$) [82]. Another study reported that bowel function returned earlier in patients with carbohydrate loading and a one-day shorter LOS [71]. Two early meta-analyses of 21 prospective RCTs with a total of 1685 patients [79] and 27 prospective RCTs with 1976 patients [80] both showed a reduction in LOS after preoperative carbohydrate loading for major abdominal procedures, but not for short stay surgeries (≤2 d). A large network meta-

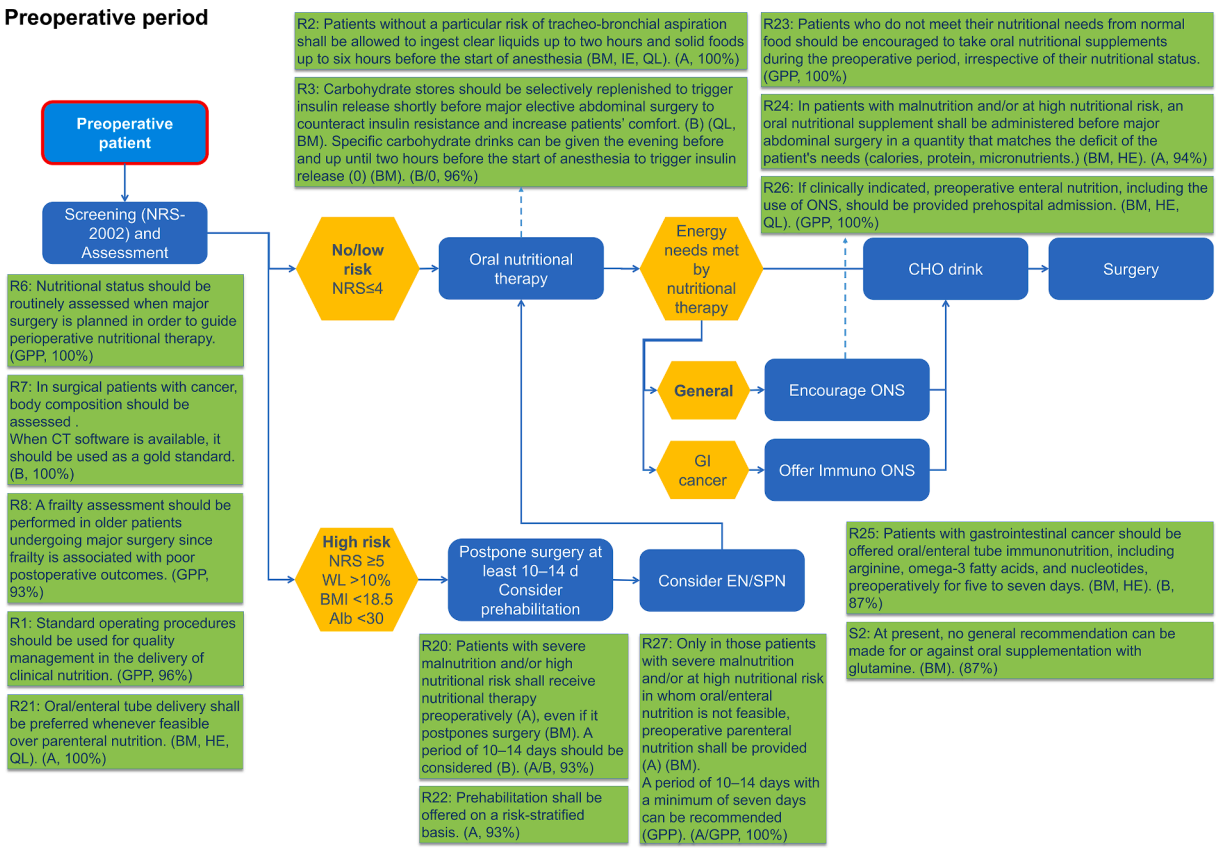

Fig. 2. Nutritional management in the preoperative period. Abbreviations: Alb, albumin; BM, biomedical endpoint; BMI, body mass index; CHO, carbohydrate; CT, computed tomography; HE, health economy endpoint; EN, enteral nutrition; NRS, Nutritional Risk Screening; ONS, oral nutritional supplements; QL, quality of life endpoint; SPN, supplemental parenteral nutrition; WL, weight loss.

analysis bundling 43 small, medium, and major surgeries and 3110 patients reported a slight reduction in LOS compared with the fasting group. However, it showed no advantage compared with water or placebo [66]. Avoiding the limitations of the basic studies and the weakness of bundling short and long-term surgeries, a meta-analysis with a more limited focus, such as only major abdominal surgery RCTs [83] or a sub-analysis in another meta-analysis [66], shows reduced LOS.

In elective colorectal surgery, carbohydrate loading positively affected postoperative weight and muscle mass preservation [84], and another study reported a reduction in interleukin-6 (IL-6) concentrations [71]. The two largest RCTs on carbohydrate loading performed by Gianotti et al. [85] and Savluk et al. [86] demonstrated a significant reduction in insulin requirements and an improvement in patient well-being with carbohydrates. In contrast, in cardiac surgery, two studies failed to confirm a similar impact of preoperative carbohydrates [87,88]. Despite reports showing associations between insulin resistance, hyperglycemia, and complications [66] and the effectiveness of preoperative carbohydrates to minimize insulin resistance and control glucose concentrations, there are no convincing data to show a reduction in major complications [66]. However, in one study in cardiac surgery, the need for inotropic support was significantly reduced in the carbohydrate-treated group [87].

Oral carbohydrate administration is reported to yield an improvement in recovery and postoperative well-being in several studies of different open and laparoscopic surgeries, including colorectal [89–94]. In elective cholecystectomy, a reduction in postoperative nausea and vomiting by carbohydrate drinks was reported compared with fasting patients, while another study found no difference when compared with placebo [95,96]. Other studies reported no benefit for postoperative pain or quality of recovery [97,98]. An extensive study in thyroid surgery reported an improvement in postoperative symptoms in the carbohydrate group in a range of parameters [99], while a smaller study demonstrated an improvement in well-being and patient satisfaction [64]. In thoracic and bariatric surgery, carbohydrates improved nausea and reduced analgesic requirements [100,101]. In neurosurgical patients, glucose homeostasis, hand grip strength, and lung function improved. In elderly patients undergoing hepatectomy, an RCT showed lower overall concentrations of inflammatory response mediators (CRP, IL-6) postoperatively, and lower patient self-reported symptoms of thirst, hunger, anxiety, and nausea, shortened times to first flatus and first defecation by approximately two to three days, respectively [102]. Furthermore, an RCT of patients with a planned Cesarean section showed an improvement in well-being [103].

Preoperative carbohydrates were initially investigated using an intravenous infusion of glucose at a rate of 5 mg/kg/min of a 10 % glucose solution. This treatment, given overnight, causes a rise in insulin concentrations seen after a meal and causes a reduction in postoperative insulin resistance [104] and fewer protein losses [105]. However, because of the discomfort of an overnight infusion of a high osmolar solution and the ease of a drink, this treatment is not used regularly in practice but could serve as an alternative if the patient is unable to drink.

There are also studies where carbohydrates have been mixed with other ingredients. In one RCT, patients with gynecologic

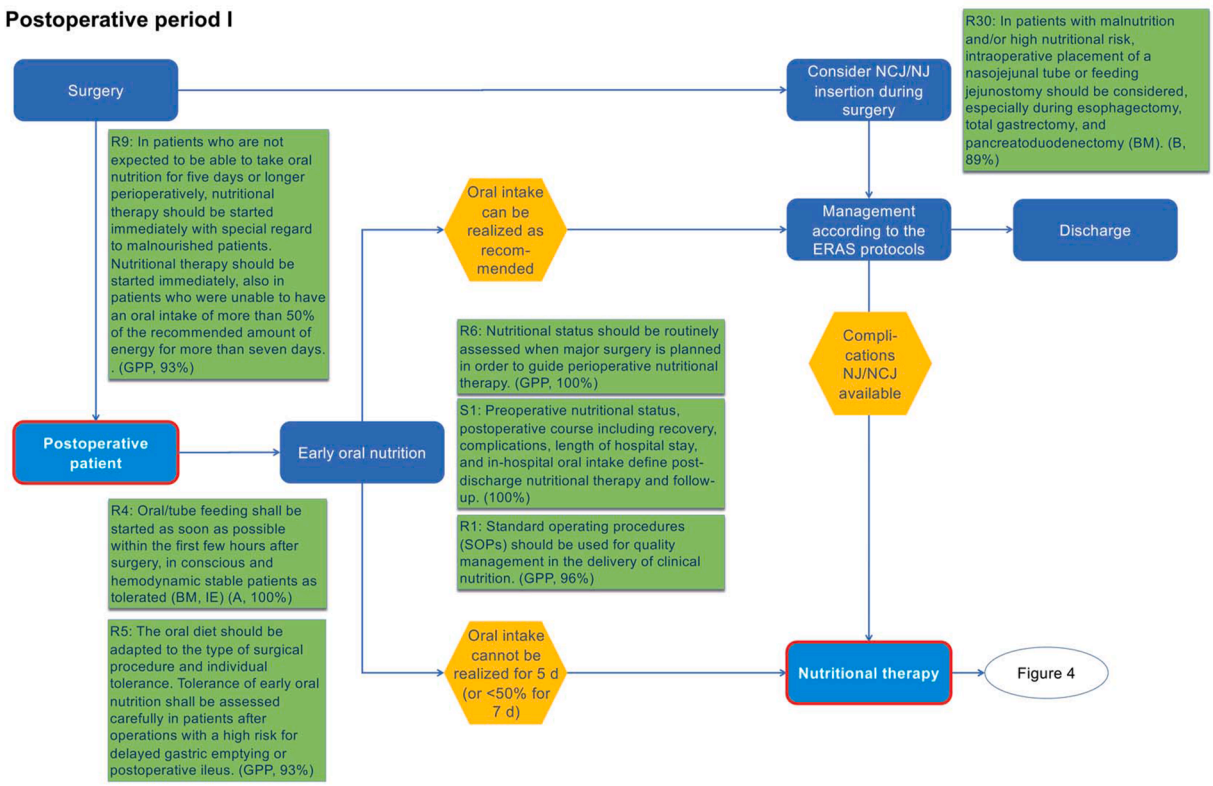

Fig. 3. Nutritional management in the postoperative period part I. Abbreviations: BM, biomedical endpoint; ERAS, Enhanced Recovery After Surgery; IE, multidimensional endpoint; NCJ, (fine) needle catheter jejunostomy; NJ, (fine) needle jejunostomy.

tumors were treated with carbohydrates and whey protein before surgery, and early feeding after surgery had better hand strength, a higher percentage of preserved muscle mass, a lower CRP/albumin ratio, and significantly better postoperative bowel function [106]. In pancreatic resections, preconditioning with glutamine, antioxidants, and green tea extract yielded a significant increase in plasma vitamin C concentration and an uplift in endogenous antioxidant capacity compared with the placebo group, without, however, improving oxidative stress and the inflammatory response [107].

In patients undergoing laparoscopic cholecystectomy, carbohydrate + glutamine supplementation showed a benefit in antioxidant status (serum glutathione concentration) and inflammatory response (serum IL-6 concentration) [71,72].

The use of homemade products such as sweetened tea has not yet been investigated in controlled studies. However, a small study of healthy volunteers showed that commercially available fruit-based soft drinks can empty the stomach almost entirely within two hours of intake. However, it did not result in the same level of insulin release compared with the drink most commonly studied for preoperative use [108].

There is limited evidence from RCTs for the use of preoperative carbohydrates in patients with diabetes [87,109–111]. According to a systematic review including 14 studies (seven RCTs), carbohydrate loading is safe for patients with well-controlled type 2 diabetes [112]. To prevent potential harm from carbohydrate administration, this concept should hence not be used in patients with severe diabetes, and especially not in suspected gastroparesis.

In summary, in major surgical procedures, oral carbohydrate loading minimizes postoperative insulin resistance, improves glucose control postoperatively and well-being, and potentially shortens LOS [83]. The treatment can generally be recommended to improve patient well-being based on low-quality data, for major surgery to control glucose, and for reducing insulin resistance and its potential effect on recovery.

4.4. Is a break in oral/enteral nutrition intake necessary in principle after a surgical procedure?

Recommendation 4

Oral/tube feeding shall be started as soon as possible within the first few hours after surgery, in conscious and hemodynamic stable patients as tolerated (BM, IE).

Grade of recommendation A – strong consensus 100 % agreement

Comment

Oral nutrition (balanced hospital diet and/or ONS) can, in most cases, be resumed immediately after surgery in neurologically and hemodynamically stable, fully conscious patients with no signs of bleeding. To be hemodynamically stable, patients should show adequate fluid resuscitation, normal or decreasing lactate, normal mixed venous oxygen (MVO_2) saturation, and stable or decreasing vasopressors. For both cholecystectomies and colorectal resections, neither esophagogastric decompression nor delayed oral feeding has been shown to have a beneficial effect [113–115]. Early oral or enteral feeding, including clear liquids on the first or second postoperative day (POD), did not cause any limitation of anastomotic healing in the colon or rectum [115–120] and rather led to a significantly shorter LOS [121–124]. This has been confirmed by a Cochrane review, with 17 prospective RCTs and 1437 included patients undergoing lower gastrointestinal tract surgery [125].

Several meta-analyses demonstrate significant benefits in terms of complication rates in general [124,126,127], but also

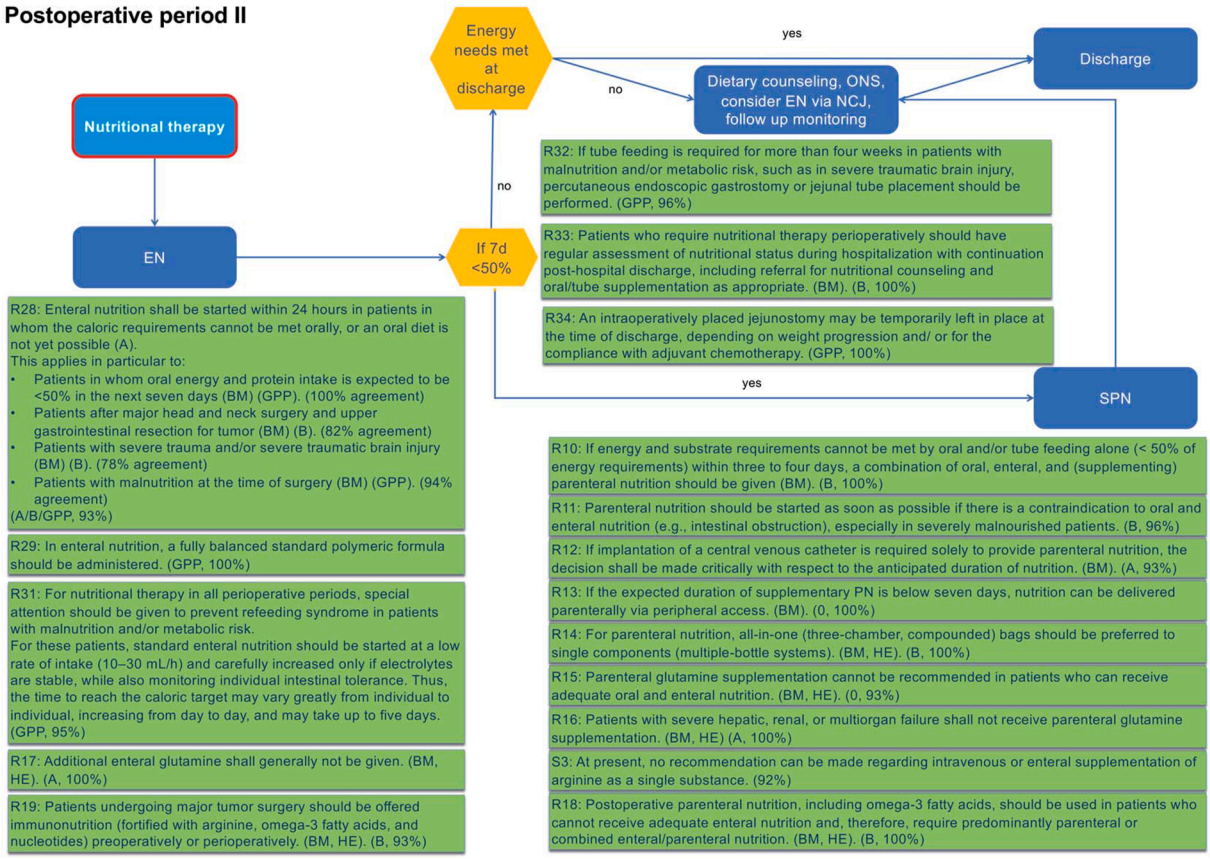

Fig. 4. Nutritional management in the postoperative period part II. Abbreviations: BM, biomedical endpoint; HE, health economy endpoint; EN, enteral nutrition; NCJ, (fine) needle catheter jejunostomy; ONS, oral nutritional supplements; PEG, percutaneous endoscopic gastrostomy; PEJ, percutaneous endoscopic jejunostomy; SPN, supplemental parenteral nutrition.

specifically in terms of wound infections, intra-abdominal abscesses, as well as anastomotic insufficiency [124,127]. One showed that early oral feeding increased vomiting [128].

Early oral feeding is also a central component of ERAS, with significantly fewer complications and a reduction in LOS in several meta-analyses [129–139]. Even without participation in an ERAS program, early oral feeding shortens LOS [140].

Compared with a traditional diet, a free diet on POD2 after surgical procedures shortened the time to oral food tolerance without a higher rate of gastric tube reinsertion. No differences were found regarding the duration of postoperative ileus [129,141].

Recent studies suggest that early oral nutrition reduces the postoperative stress response as measured by the concentrations of circulating proinflammatory cytokines [142].

Even after gastrectomy, not using a feeding tube resulted in a reduction in LOS [143]. A meta-analysis of 15 studies (including eight RCTs) involving 2112 patients with upper gastrointestinal tract surgery also yielded a shortening of LOS in the early oral feeding group, and the complication rate, particularly the rate of anastomotic insufficiency, was not different [144].

Although early oral feeding after esophageal resection is controversial [145], current data suggest that even in this context, an early oral diet is at least equivalent to oral food restriction with EN. Recent studies [146–148] show that early oral feeding after minimally invasive thoracic esophagectomy is safe and does not impact complication rates. In addition, early oral feeding has been shown to result in a faster initiation of bowel activity and a shortened LOS [149], as well as improving short-term quality of life [150].

In open esophageal surgery, as well as in cervical anastomosis, the situation remains unclear. Two retrospective studies [151,152] suggest that early oral feeding increased leak rates. An investigation based on high-quality studies is needed before the safe use of early oral feeding can be made for these patients [153,154].

In pancreatic surgery, the implementation of ERAS has been shown to reduce the complication rate and shorten LOS [138]. In a multicenter RCT, it was demonstrated that oral nutrition did not lead to an increased incidence of postoperative pancreatic fistulas (POPF), nor was it equal to EN with regard to the healing of POPF [122]. Oral feeding is also possible in patients with POPF without risk of clinical deterioration, with prolongation of the need for drainage and prolonged LOS [155].

A meta-analysis in patients undergoing urological surgery could show that early EN leads to a significant reduction in the rate of infectious complications as well as in costs compared with PN [127].

Comparing open surgery with laparoscopic surgery, oral food intake is better tolerated in the latter due to an earlier return bowel function [156–158]. In combination with ERAS, no differences were found between laparoscopic and open colon surgery with full implementation of the program [159]. In a multicenter RCT, LOS was significantly shorter with laparoscopic surgery [160]. A recent meta-analysis confirmed the benefits of combining ERAS and laparoscopic surgery in terms of morbidity and LOS [161].

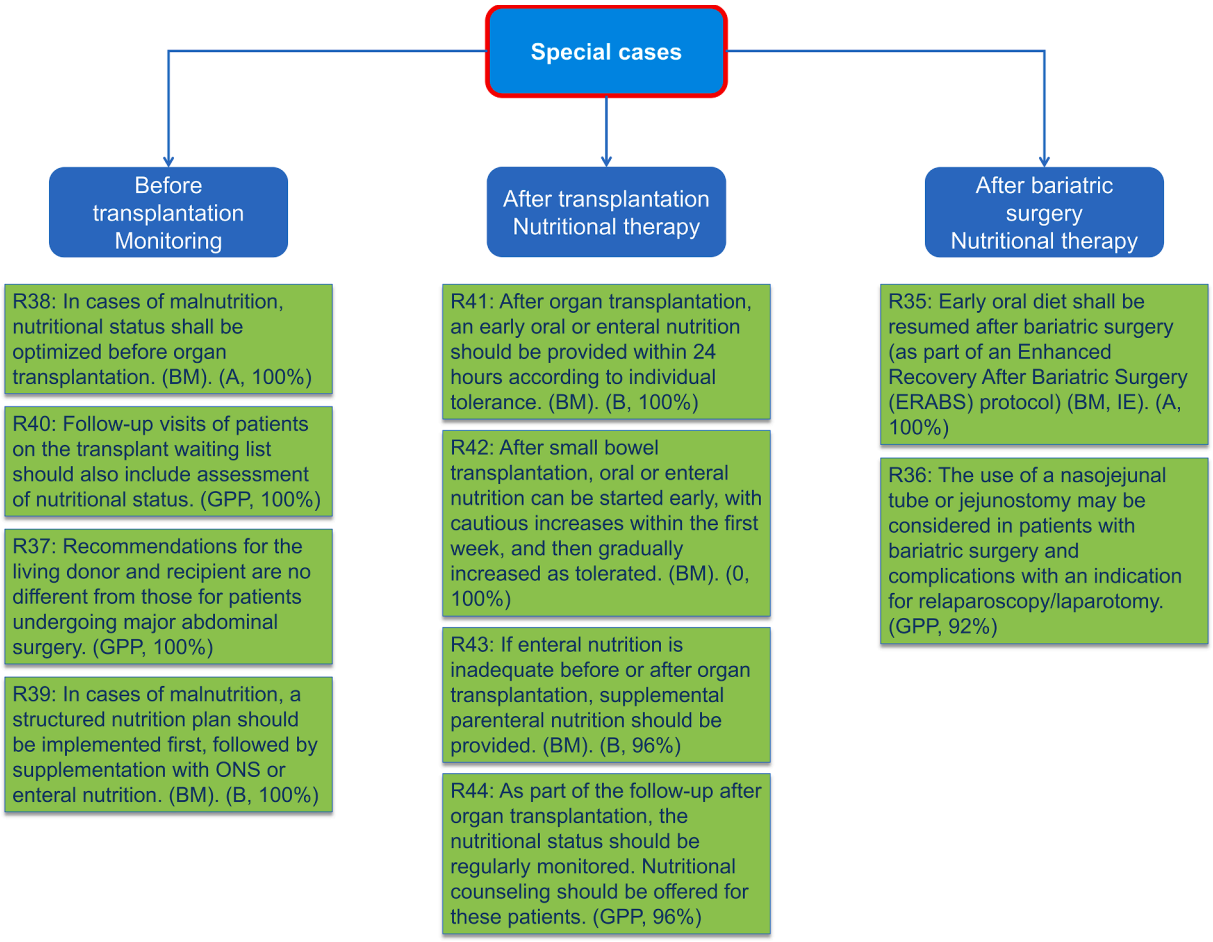

Fig. 5. Particularities in nutritional management of organ transplantation and bariatric surgery patients. Abbreviations: BM, biomedical endpoint; ERABS, Enhanced Recovery After Bariatric Surgery.

Recommendation 5

The oral diet should be adapted to the type of surgical procedure and individual tolerance. Tolerance of early oral nutrition shall be assessed carefully in patients after operations with a high risk for delayed gastric emptying or postoperative ileus (BM, QL).

Grade of recommendation GPP – strong consensus 93 % agreement

Comment

The amount of oral food intake should be adjusted according to the patient's gastrointestinal function and individual tolerance [116–118,126,162–164]. This is shown by a study of older Chinese patients who had more nausea, vomiting, gastric retention, intestinal obstruction, and a higher readmission rate in the ERAS group compared with the conventional group when oral tolerance of food was impaired [165]. Thus, a more cautious approach should be adopted, especially in older patients (>75 years old). In these patients, caution should also be advised regarding early postoperative EN therapy after resections in the upper gastrointestinal tract and pancreas [151,152,165,166]. According to the ERAS guidelines the postoperative recovery of gastrointestinal motility should not be inhibited by paralytic agents [1].

While in colorectal surgery, there is sufficient evidence to recommend early postoperative oral nutrition, data in other surgical fields also point in this direction but are less clear. Even in esophageal and pancreatic surgery, early oral nutrition does not bear more risk than EN or even PN [147,166]. Here, however, a more individualized therapeutic approach should be maintained.

5. Indication for nutritional therapy

5.1. Which nutritional diagnostics are needed to determine the indication for nutritional therapy in the surgical patient?

Recommendation 6

Nutritional status should be routinely assessed when major surgery is planned in order to guide perioperative nutritional therapy.

Grade of recommendation GPP – strong consensus 100 % agreement

Statement 1

Preoperative nutritional status, postoperative course including recovery, complications, length of hospital stay, and in-hospital oral intake define post-discharge nutritional therapy and follow-up.

Strong consensus 100 % agreement

Comment

The impact of nutritional status on postoperative morbidity and mortality has been clearly demonstrated for different diseases in both retrospective [167–170] and prospective studies [12–14,171–189], and recent meta-analyses [190,191]. Inadequate oral nutritional intake for more than 14 days is associated with increased mortality [192]. Therefore, even for patients undergoing minor surgical procedures, the nutritional status should be carefully assessed, especially in case of complicated course, and weekly follow-up is recommended [193].

Major procedures, internationally referred to as "major surgery", involve abdominal organ resections due to tumors or (chronic) inflammatory diseases, in which procedure-specific severe (surgical-site, infectious) complications beyond simple wound healing disorders can lead to a prolongation of LOS and increased mortality.

According to GLIM criteria [18], malnutrition was associated with postoperative complications in patients with abdominal resections in the Norwegian registry study [194]. In several studies, the prevalence of malnutrition was higher when using GLIM [195,196].

Recommendation 7

In surgical patients with cancer, body composition should be assessed (BM).

When CT software is available, it should be used as a gold standard.

Grade of recommendation B – strong consensus 100 % agreement

Comment

Malnutrition is characterized by decreased body cell mass and often co-occurs with sarcopenia (reduced muscle mass and function), particularly in patients with cancer [197]. In older adults, sarcopenia can develop independently of malnutrition [198]. The SARC-F or SARC-CalF questionnaire (Questionnaire to identify individuals at risk of sarcopenia using the components Strength, Assistance in walking, Rise from a chair, Climb stairs, Falls, eventually enhanced by Calf circumference) is recommended for sarcopenia screening, and assessment involves hand grip or chair stand tests combined with measures of muscle quantity/quality via CT, DXA, magnetic resonance imaging (MRI), or BIA [19,199]. Low scores on hand grip strength or chair rise tests may be sufficient to initiate intervention [199].

Sarcopenic obesity, where increased fat can mask muscle loss, poses an additional risk [16,200–202]. It is a strong predictor of poor outcomes after major pancreatic surgery [203] and reduced long-term survival in patients with cancer [204]. Diagnosing sarcopenic obesity requires evidence of altered muscle function and body composition with increased fat and reduced muscle mass [201]. Preoperative sarcopenia is associated with increased morbidity, major complications, and longer LOS in patients with esophageal cancer [21,205–207] and with poorer overall survival in patients with gastric cancer [208]. Specific CT scan findings can predict postoperative pancreatic fistula [209]. For patients with rectal cancer, sarcopenia is linked to higher overall morbidity and infection rates, while visceral obesity is more associated with anastomotic failure [210].

Preoperative functional decline alongside poor nutritional status impairs postoperative recovery. Sarcopenia may be a modifiable factor for preoperative intervention [211,212]. Muscle mass measurement is integrated into the GLIM criteria [18]. Utilizing existing CT scans for body composition analysis is encouraged [196,202,213], particularly analyzing the L3 level axial scan for muscle area and density [20,214]. While implementation faces workload barriers, future machine learning may help. Alternatives include BIA and anthropometric measurements [196,215–218]. Standardized phase angle measurement and hand grip strength have prognostic value for postoperative complications [204,219].

Recommendation 8

A frailty assessment should be performed in older patients undergoing major surgery since frailty is associated with poor postoperative outcomes.

Grade of recommendation GPP – strong consensus 93 % agreement

Comment

Frailty, rather than chronological age, should be the primary factor in preoperative risk stratification [220,221]. Chronological age has been a long-standing variable in research evaluating how patients tolerate treatments and their outcomes across various medical settings, including surgery. The age of 65 years is often used to define older patients due to Medicare eligibility, but with increasing life expectancy, ages of 70 and 75 years are becoming more frequent cutoffs. Studies examining the link between age and outcomes have yielded inconsistent results under these varying age definitions.

A key limitation of using age as a study variable is its non-modifiable nature, which inherently restricts the development of actionable interventions. Consequently, many clinicians advocate that age should not be the sole determinant when making critical treatment decisions. While there is a broad consensus that frail patients are more susceptible to adverse events due to a diminished multisystem reserve capacity, the routine assessment of frailty has not been consistently implemented in various clinical studies. Nevertheless, the findings that link frailty to adverse outcomes following surgery demonstrate remarkable consistency across different tools used to measure frailty.

A Cochrane review and meta-analysis encompassing five RCTs with a total of 1316 patients aged 65 and older who were undergoing surgery indicated that preoperative and/or postoperative geriatric assessment when compared with standard surgical care, might lead to a reduction in mortality rates (RR 0.85, 95 % CI 0.68 to 1.05). A more focused subgroup analysis involving 941 patients who underwent surgery for hip fracture revealed that the application of geriatric assessment was associated with a decreased discharge rate to an institutional setting (RR 0.71, 95 % CI 0.55 to 0.92) [222].

A systematic review published in 2015 aimed to determine the predictive capability of frailty assessment regarding postoperative outcomes. The authors analyzed six prospective studies that included 1019 patients undergoing various elective oncologic surgical procedures and evaluated the utility of geriatric assessment in predicting surgical outcomes. Their findings indicated that dependency in Instrumental Activities of Daily Living (IADLs), fatigue, and frailty were significantly associated with the occurrence of overall complications. Furthermore, dependency in IADLs was also found to be predictive of discharge to an institutional setting. Major complications were observed more frequently in patients exhibiting cognitive impairment and dependency in both IADLs and Activities of Daily Living (ADLs). Notably, the study found that age was not associated with a higher rate of complications [223].

In another study conducted from 2016 to 2019, patients aged 65 years and older with gastrointestinal cancer who were scheduled for surgical resection were randomly assigned to receive a Perioperative Enhanced Recovery for Seniors undergoing Surgery (PERI-OP) intervention (n = 82) or usual care (n = 78). Patients in the PERI-OP group had consultations with a geriatrician preoperatively in the outpatient setting and postoperatively as an inpatient consultant. In per protocol analyses, patients in the intervention group experienced shorter postoperative LOS (5.90 d vs. 8.21 d, $P = 0.024$), and the complication rate was notably, albeit not significantly lower (6.7 % vs. 20.6 %, $P = 0.137$) [224].

The assessment of frailty appears to be effective not only in predicting postoperative complications but also in anticipating toxicity in frail older adults undergoing treatments for cancer. The GAP70+ trial investigated the effects of a geriatric assessment intervention on the toxic effects of cancer treatment in older patients with advanced cancer. This trial enrolled 718 patients aged 70 years and older with incurable solid tumors or lymphoma who were commencing a new treatment regimen. The geriatric assessment intervention significantly reduced the risk of severe toxicity from cancer treatment, with 50.7 % of patients in the intervention arm experiencing grade 3–5 toxicity compared with

71.3 % in the usual care arm (RR 0.74, 95 % CI 0.64 to 0.86, $P < 0.001$). The intervention also demonstrated positive effects on falls and polypharmacy, with fewer falls and a greater number of medications discontinued in the intervention arm. The results suggest that geriatric assessment and geriatric assessment-guided management should be considered as the standard of care for older patients with advanced cancer and aging-related conditions [225].

While significant emphasis has been placed on the consequences of malnutrition, it is crucial to recognize that this is just one of several facets that characterize high-risk patients, such as older, frail individuals. A comprehensive assessment of frailty should include various domains, such as mobility and functional ability, cognition, the ability to succeed in daily activities, and psychosocial condition, alongside an evaluation of nutritional status.

Numerous tools have been validated for assessing frailty, with different tools focusing on specific domains of concern. Some examples of these tools, which are not exclusively limited to this list, include [221,226]:

- Global frailty evaluation tests: Flemish-triage risk screening tool (fTRST), geriatric 8 (G-8), Risk-analysis Index (RAI); Modified frailty index (MFI), Multidimensional prognostic index (MPI), Clinical Frailty Scale (CFS), Age-adjusted Charlson Comorbidity Index.
- Mobility and functional ability: Timed up and go test, 6-min walking test, sit-to-stand test, and a question about falls over the last six months
- Cognition: Mini-Cog; Mini-Mental State Examination (MMSE)
- Ability to succeed in daily activities: Katz Activity of Daily Living (ADL), instrumental-ADL (iADL), Eastern Collaborative Oncology Group-Performance Status (ECOG-PS)
- Psycho-social condition: Distress Thermometer (DT), Geriatric Depression Scale (GDS), Geriatric Anxiety Inventory (GAI), Groningen Distress Rating Scale (GDRS); question about living situation and support

Many prospective studies have investigated the relationship between a single frailty screening tool and postoperative outcomes. While numerous tools have been identified as significant predictors of risk, it is generally recommended that tools encompassing a broader range of possible domains should be favored. These domains should be assessed for every patient and offer an ideal framework for the development of personalized rehabilitation programs based on the individual patient's specific frailty profile.

According to a survey conducted within the guideline working group, the most frequently utilized tools were:

- Global frailty evaluation: CFS (53 %),
- Mobility and functional ability: Six-Minute Walking Test (71 %),
- Cognition: MMSE (59 %),
- Ability to perform daily activities: Katz Activity of Daily Living (ADL) (65 %),
- Psychosocial condition: Tailored questions about living situation and support (44 %).

5.2. *When is nutritional therapy indicated in the surgical patient?*

Recommendation 9

In patients who are not expected to be able to take oral nutrition for five days or longer perioperatively, nutritional therapy should be started immediately with special regard to malnourished patients.

Nutritional therapy should be started immediately, also in patients who were unable to have an oral intake of more than 50 % of the recommended amount of energy for more than seven days.

Grade of recommendation GPP – strong consensus 93 % agreement

Comment

The general indication for nutritional therapy in surgery is the prevention and treatment of disease-specific malnutrition, such as compensating for a nutritional deficit before surgery and maintaining nutritional status after surgery, especially when prolonged periods of fasting and severe catabolism are anticipated. Morbidity, LOS, and mortality are the main endpoints for evaluating the benefit of nutritional therapy in the hospital.

After hospital discharge or in the setting of palliation, the primary goals of medical nutrition are to improve nutritional status and quality of life [227–238].

Enteral delivery should generally be preferred. Exceptions include:

- intestinal obstruction or ileus
- peritonitis
- suspected mesenteric ischemia
- severe shock
- high output intestinal fistulas
- severe gastrointestinal bleeding

The effect of EN on postoperative outcome has been investigated in many studies, but not homogeneously [239]. The working group reviewed 35 controlled trials with outcome endpoints [240–274]. Patients were included primarily after gastrointestinal surgery, but also after trauma or femoral neck fracture. EN was defined as the use of an oral balanced diet with supplements (ONS) and/or tube feed. Early EN was compared with a normal diet, parenteral delivery of crystalloids, and total PN. Twenty-four of the 35 studies showed significant benefits of EN in terms of a reduction in the rate of infectious complications, hospital LOS, and costs.

No benefits were observed in eight of the 35 studies [240,249,253,257–259,264,268,270], and possible disadvantages were observed in three. The disadvantages were related to prolonged LOS [268], decreased pulmonary function after esophagectomy and pancreatic resection due to abdominal distension [272], or delayed gastric emptying after pancreatic resection resulting in prolonged LOS [273]. These problems could be a consequence of a too high EN feeding rate in the early postoperative period. In patients with severe trauma, special attention should be paid to the tolerance of the amount of EN [274]. Careful monitoring of the surgical patient in the intensive care unit (ICU) is mandatory at the beginning of EN [275]. Compared with PN, early EN decreased the postoperative infection rate in a multicentric trial including malnourished patients with gastrointestinal cancer [245].

In seven of eleven RCTs [276–286], only surrogate parameters of outcome were measured, such as the positive effects of EN on nitrogen balance and substrate tolerance. Four of the eleven studies showed no significant differences between early enteral and standard hospital nutrition [276–278,285]. The benefits of early enteral feeding within 24 h have been shown in two meta-analyses [125,128]. Focusing on patients after gastrointestinal surgery, another meta-analysis [124] of 29 studies involving 2552 patients confirmed these beneficial effects. However, no reduction in mortality could be shown.

For elective surgery, a large RCT (n = 411) showed that in postoperative patients at nutritional risk, immediate goal-directed EN was non-inferior to gradual goal-dose EN with regard to

infectious complications. However, immediate goal-directed EN was associated with more gastrointestinal intolerance events [287].

In patients after femoral neck fracture stratified by nutritional status before randomization, nocturnal nasogastric feeding showed a significant reduction in rehabilitation time and postoperative LOS in the malnourished patients [241]. In another study with tube feeding, there was no effect on in-hospital outcomes; however, six-month mortality was reduced [269]. Use of a sip feed once daily significantly improved outcomes at six months with lower complication rates and mortality [248]. Meta-analyses of RCTs have shown lower rates of postoperative complications and shorter LOS [288,289].

Recommendation 10

If energy and substrate requirements cannot be met by oral and/or tube feeding alone (<50 % of energy requirements) within three to four days, a combination of oral, enteral, and (supplementing) parenteral nutrition should be given (BM).

Grade of recommendation B – strong consensus 100 % agreement

Comment

There are still limited controlled data on combined enteral and parenteral feeding in case of insufficient oral/enteral uptake after elective surgery. One RCT after esophagectomy showed significantly improved insulin sensitivity and decreased glucose concentrations with combined feeding [290].

A meta-analysis [291] has shown no advantage for combined nutrition in terms of mortality, infection rate, LOS, and length of ventilation. Two prospective multicenter RCTs, including critically ill patients, have addressed the question of whether parenteral supplementation should be started "early" (within four days) or "late" (after seven days) in patients with enteral intolerance. The results support starting early parenteral supplementation at day four at the latest in malnourished patients and those with an expected prolonged ICU stay [292–294] (see ESPEN guideline "Clinical Nutrition in Intensive Care Medicine" [295]).

A multicenter RCT that was rated low risk of bias by the working group [296], enrolled 230 patients undergoing abdominal surgery, with the aim of an increase of nutrient intake in cases of inadequate oral/enteral nutrition. This was defined as ≤30 % of energy targets from EN on POD2. The effect of early parenteral (E-SPN day 3) versus late supplementation (L-SPN was compared, and the E-SPN group received a higher mean (SD) energy intake between days three and seven compared with the L-SPN group (26.5 ± 7.4 vs. 15.1 ± 4.8 kcal/kg/d; $P < 0.001$). The E-SPN group had significantly fewer nosocomial infections compared with the L-SPN group (10/115 [8.7 %] vs. 21/114 [18.4 %]; risk difference 9.7 %; 95 % CI 0.9 to 18.5 %; $P = 0.04$). No significant differences were observed between the E-SPN group and the L-SPN group in the number of noninfectious complications, adverse events, and other secondary endpoints. A significant difference was still found in the mean number of antibiotic therapy days between the E-SPN group and the L-SPN group (6.0 ± 0.8 vs. 7.0 ± 1.1 d, MD 1.0 d, 95 % CI 0.2 to 1.9 d, $P = 0.01$) [296].

An RTC enrolled 80 patients after esophageal resection, with the aim of meeting caloric needs by early parenteral supplementation of EN [297]. Individual caloric requirements were determined by indirect calorimetry. Only patients in the combined-fed group were able to maintain stable body weight (0.18 ± 3.38 kg vs. −2.15 ± 3.19 kg, $P < 0.05$) and fat-free mass (1.46 ± 2.97 kg vs. −2.08 ± 4.16 kg). Morbidity, LOS, and laboratory chemistry parameters were no different. However, at three months, the early parenteral supplementation group showed significantly better quality of life scores for physical function (71.5 ± 24.3 vs. 60.4 ± 27.4, $P < 0.05$) and energy/fatigue (62.9 ± 19.5 vs. 54.2 ± 23.5, $P < 0.05$) [297].

Several authors have pointed out possible advantages of PN when there is limited tolerance to EN due to intestinal dysfunction, especially in the early postoperative period [270], which is then also associated with lower nutrient intake. Thus, adequate nutrient intake in the presence of limited gastrointestinal tolerance may be better achieved by PN [298].

In a randomized RCT including 254 patients undergoing open pancreatoduodenectomy in the context of an ERAS program, no benefit of supplementing parenteral nutrition to early oral feeding starting on POD1 could be observed with regard to the Comprehensive Complication Index (CCI) and the 90-day morbidity [299].

The tolerance to EN may be influenced by the rate of infusion, as shown in a large RCT (n = 411) in postoperative patients at nutritional risk, where immediate goal-directed EN was noninferior to gradual goal-dose EN with regard to infectious complications. However, immediate goal-directed EN was associated with more gastrointestinal intolerance events [287]. A multicenter RCT in patients undergoing pancreatoduodenectomy (n = 204) showed a significantly higher overall complication rate in patients with nasojejunal enteral feeding versus those with total PN. However, there was no comparison for nasojejunal versus jejunostomy feeding [300].

Recommendation 11

Parenteral nutrition should be started as soon as possible if there is a contraindication to oral and enteral nutrition (e.g., intestinal obstruction), especially in severely malnourished patients (BM).

Grade of recommendation B – strong consensus 96 % agreement

Comment

There was controversy in the past about the effects of PN compared with standard oral/enteral nutrition with regard to the prognosis of surgical patients [239,240,244,245,250,252,256,257,259,262,264,271,298,301–308]. The secondary analysis from two RCTs (n = 635) revealed that early achievement of energy target was associated with fewer nosocomial infections (46/521 [8.8 %] vs. 21/114 [18.4 %]; risk difference, 9.6 %; 95 % CI, 2.1 to 17.1 %; $P = 0.004$] and improved clinical outcomes (number of infectious complications and nutritional status), regardless of the nutritional strategy (early EN alone or combined with early supplemental PN) [309]. Another secondary analysis from two RCTs from the same group including 314 patients showed that early EN compared with isoenergetic SPN may not be associated with a reduced rate of nosocomial infection in patients undergoing major abdominal surgery, but may be associated with improved concentrations of serum albumin, prealbumin, and retinol-binding protein [310].

The 2009 ESPEN guidelines on parenteral nutrition in surgical patients recommend PN in the following cases [311]: malnourished patients in whom oral nutrition or EN is not feasible or not tolerated, and in patients who are incapable of ingesting and absorbing adequate amounts of nutrients for a period of at least 5–7 days due to preoperative obstruction or postoperative complications caused by limitation of gastrointestinal function [311]. This is especially true for patients with intestinal failure (e.g., short bowel <60 cm or peritoneal carcinomatosis).

The ASPEN guidelines recommend postoperative PN for patients who cannot meet their energy needs orally for 7–10 days [312].

A meta-analysis of 29 RCTs with 2552 patients after gastrointestinal surgery showed favorable effects of EN with lower rates of infectious complications, fewer anastomotic insufficiencies, and shorter LOS [124]. A meta-analysis including 18 RCTs with 2540 patients found, for the comparison EN versus PN, earlier onset of flatus, shorter LOS, and a higher increase in serum albumin concentration in the EN group [313]. There was no impact on mortality. Similarly, a large multicenter RCT that compared EN and PN in 2388

patients in the ICU found no difference in mortality, rate of infectious complications, and LOS between the two groups [314].

Recommendation 12

If implantation of a central venous catheter is required solely to provide parenteral nutrition, this indication shall be made critically with respect to the anticipated duration of nutrition (BM).

Grade of recommendation A – strong consensus 93 % agreement

Comment

The placement of a central venous line may be associated with severe complications. According to a systematic review and meta-analysis of 130 studies, placement failure occurred at 20.4 (95 % credible interval (CrI), 10.9 to 34.4) events per 1000 catheters placed. Other rates of central venous catheter (CVC) placement complications (per 1000 catheters) were arterial cannulation (2.8, 95 % CrI 0.1 to 10), arterial puncture (16.2, 95 % CrI 11.5 to 22), and pneumothorax (4.4, 95 % CrI 2.7 to 6.5). Rates of CVC use complications (per 1000 catheter-days) were malfunction (5.5, 95 % CrI 0.6 to 38), infection (4.8, 95 % CrI 3.4 to 6.6), and deep vein thrombosis (2.7, 95 % CrI 1.0 to 6.2). It was estimated that 30.2 (95 % CrI 21.8 to 43.0) in 1000 patients with a CVC for three days would develop one or more serious complications (arterial cannulation, pneumothorax, infection, or deep vein thrombosis. Thus, due to these risks, the indication for central PN solely should be very critical and limited to the anticipated duration of at least 15 or more days [315].

Recommendation 13

If the expected duration of supplementary PN is below seven days, nutrition can be delivered parenterally via peripheral access (BM).

Grade of recommendation 0 – strong consensus 100 % agreement

Comment

In an RCT (n = 158) of peripheral PN after colorectal resection in an ERAS program, supplementation (one day before and three days after surgery) was shown to be protective in preventing complications in those patients with decreased compliance i.e. delay in oral diet build-up and mobilization (moderate risk of bias) [316]. In the *post-hoc* subgroup analysis, patients with low skeletal muscle index (SMI) or BMI ≥35 kg/m^2 particularly benefited, with a significant reduction in postoperative complications [317].

An European expert group has recommended the implementation of peripheral PN, which has been little used to date, in ERAS protocols for major gastrointestinal surgery [318]. In an European survey, the use of peripheral PN was endorsed by 71 % of the surgeons surveyed as a less invasive and underutilized route for PN [319]. It is the opinion of the working group that if there is an available central venous line, it should also be used for PN if indicated. The aim of PN is to help meet nutritional requirements.

A very recent randomized RCT including 254 patients undergoing open pancreatoduodenectomy in the context of an ERAS program did not show any benefit of supplementing peripheral parenteral nutrition to early oral feeding starting on POD1 with regard to the CCI and the 90-day morbidity [299].

Recommendation 14

For parenteral nutrition, all-in-one (three-chamber, compounded) bags should be preferred to single components (multiple-bottle systems) (BM, HE).

Grade of recommendation B – strong consensus 100 % agreement

Comment

In three RCTs, the safety and cost-benefit advantages of a three-chamber bag (all-in-one) over a multiple-bottle system/compounded mono-bag have been demonstrated [320–322]. In the retrospective analysis of a large US database [323], significantly fewer sepsis episodes have been demonstrated with the use of a three-chamber bag.

5.3. Is there an indication for supplementation with glutamine?

Recommendation 15

Parenteral glutamine supplementation cannot be recommended in patients who can receive adequate oral and enteral nutrition (BM, HE).

Grade of recommendation 0 – strong consensus 93 % agreement

Recommendation 16

Patients with severe hepatic, renal, or multiorgan failure shall not receive parenteral glutamine supplementation (BM, HE).

Grade of recommendation A – strong consensus 100 % agreement

Recommendation 17

Additional enteral glutamine shall generally not be given (BM, HE).

Grade of recommendation A – strong consensus 100 % agreement

Comment on recommendations 15–17

The benefit of glutamine supplementation has been widely discussed in recent years after no benefit of supplementation or high-dose pharmacotherapy was demonstrated in general ICU patients [324–329]. A distinction must be made between a complementary strategy, as recommended and necessary in all guidelines to complete a pure PN solution, and supplementation, which involves administration of high doses beyond the essential requirement, as was done, for example, in the REDOX study enterally and parenterally [324]. In this multicenter RCT, high-dose enteral or parenteral glutamine administration showed a significant increase in mortality in critically ill patients with organ dysfunction [324], raising equal concerns about its use in surgical patients.

While smaller studies in patients with severe trauma or burns [330–333] had demonstrated clinical benefits of glutamine-enriched EN, no difference in time to discharge alive from the hospital and mortality was observed in a large-scale multicenter study (n = 1209) [334].

A number of older studies and subsequent meta-analyses have demonstrated significant benefits, such as shortened postoperative LOS and reduced number of postoperative complications after glutamine supplementation [335]. Similarly, two older meta-analyses (including 14 RCTs involving 587 surgical patients) demonstrated significant benefits after glutamine supplementation in terms of infectious complications and hospital LOS [336,337]. In addition, a 2015 meta-analysis showed an improvement in immune response in the postoperative course in 13 RCTs that included 1034 surgical patients with gastrointestinal tumors [338]. Another meta-analysis included 19 RCTs with 1243 patients and found a significant reduction in LOS, with no differences in complication rates [339]. A recent meta-analysis included 31 studies with 2201 patients undergoing colorectal cancer surgery. Glutamine was administered parenterally in 23 studies and enterally in eight. A significant improvement was found in the glutamine group for immune function, the rates of wound complications (Z = 3.18, P = 0.001, RR 0.48, 95 % CI 0.30 to 0.75, I^2 = 0 %), the rate of anastomotic leakage (Z = 2.98, P = 0.003, RR 0.23, 95 % CI 0.09 to 0.61, I^2 = 0 %), and LOS (Z = 4.03, P = 0.000, SMD = −1.13, 95 % CI −1.68 to −0.58, I^2 = 85.6 %) [340].

However, from a methodological point, all these meta-analyses and included studies reveal significant weaknesses, such as the

lack of clear criteria for defining infectious complications and heterogeneity in hospital LOS.

A 2014 RCT in 60 patients undergoing colon resection showed significant beneficial effects of preoperative and postoperative glutamine infusion with respect to perioperative glucose-insulin homeostasis and recovery of bowel function [341]. In contrast, a large multicenter RCT of normally nourished patients undergoing major gastrointestinal surgery failed to demonstrate any significant benefit of preoperative and postoperative parenteral administration of 0.4 g dipeptide/kg/d with regard to the development of postoperative complications or LOS [342].

In a multicenter, double-blind study of 150 surgical intensive care patients, the safety and effect of parenteral glutamine administration at the standard dose of 0.5 g/kg/d was investigated. This showed no safety risks, but also no significant differences regarding the primary endpoints of in-hospital mortality and infection rate. The 6-month cumulative mortality was 31.4 % in the parenteral glutamine group and 29.7 % in the standard parenteral group ($P = 0.88$). Despite all the positive results for glutamine supplementation, this study, rated as having low risk of bias by the working group, did not show any difference in outcomes [343]. This was a reason to downgrade the recommendation.

In conclusion, based on available data, glutamine administration at a standard dose is safe in patients without organ dysfunction. However, it has to be emphasized that most of the studies were performed with exclusive PN for 5–7 days, which cannot be recommended anymore according to ERAS, especially after elective colorectal surgery with an uncomplicated course [129,131,344]. Only expert recommendations can be made for additional administration in (sub)total PN. Based on current data, enteral pharmacotherapy by means of supplemental glutamine should not be performed, and similarly, no general recommendation can be made for supplementation of parenteral glutamine in surgical patients. For those severely malnourished patients who cannot be adequately fed by the oral and enteral route, parenteral glutamine supplementation may be considered.

Statement 2

At present, no general recommendation can be made for or against oral supplementation with glutamine. (BM)

Consensus 87 % agreement

Comment

Currently, limited evidence exists for the potential effects of oral supplementation with glutamine as a single substance. In patients undergoing pancreatic surgery, oral conditioning with glutamine, antioxidants, and green tea extract significantly increased plasma vitamin C concentrations compared with placebo, thus improving overall endogenous antioxidant capacity, but without significantly reducing oxidative stress and inflammatory response [345].

While in burn patients, a Cochrane analysis of 16 trials with 678 patients for primarily glutamine oral/enteral immunonutrition had shown a reduction in LOS (−5.65, 95 % CI –8.09 to −3.22, $I^2 = 29.5$ %) and even mortality (RR 0.25, 95 % CI 0.08 to 0.78, I^2 not applicable) [346], a more recent multicenter RCT with a low risk of bias including 1200 patients did not confirm these results: The median time to discharge alive from the hospital was 40 days (IQR 24–87) in the glutamine group and 38 days (IQR 22–75) in the placebo group (subdistribution hazard ratio for discharge alive 0.91, 95 % CI 0.80 to 1.04, $P = 0.17$). Mortality at six months was 17.2 % in the glutamine group and 16.2 % in the placebo group (hazard ratio for death 1.06, 95 % CI 0.80 to 1.41) [334]. Overall, evidence for clinical benefit is lacking to date.

Statement 3

At present, no recommendation can be made regarding intravenous or enteral supplementation of arginine as a single substance.

Strong consensus 92 % agreement

Comment

The data on arginine supplementation as a single substance are severely limited and, in the opinion of the working group, do not permit a recommendation.

In a small RCT (n = 19) in patients after curative total gastrectomy, arginine-enriched EN (10.1 g/d) in comparison with PN did not show improved body-weight loss but only a positive nitrogen balance on POD7 [347].

A meta-analysis of six studies and 397 patients who underwent surgery for head and neck cancer and received peri- or only postoperative enteral supplementation with arginine in various doses (sometimes in combination with other substances) showed a reduction in fistula formation and shortening of LOS. No significant differences were demonstrated regarding the development of wound infections, and no reduction in infectious complications was observed [348].

Data from a long-term follow-up over ten years in 32 patients with head and neck cancer who received an arginine-enriched diet perioperatively showed significantly longer survival and fewer tumor recurrences. Critically, this study was not statistically powered for survival benefit [349].

A recent secondary analysis [350] of a previous RCT [351] in patients undergoing major surgery for esophageal and pancreatic cancer failed to confirm the effects of arginine-enriched nutrition on long-term survival.

5.4. Is there an indication for parenteral supplementation with omega-3 fatty acids?

Recommendation 18

Postoperative parenteral nutrition, including omega-3 fatty acids, should be used in patients who cannot receive adequate enteral nutrition and, therefore, require predominantly parenteral or combined enteral/parenteral nutrition (BM, HE).

Grade of recommendation B – strong consensus 100 % agreement

Comment

Patients after surgical interventions regularly show a perioperative inflammatory reaction, so the use of anti-inflammatory and immunomodulatory substances such as fish oil solutions appears promising to counteract the development of organ dysfunction and complications. A systematic review and meta-analysis of ten studies regarding anti-inflammatory and immunomodulatory effects of omega-3-fatty acids supplemented lipid emulsions showed significantly decreased IL-6, CRP, and anti-tumor necrosis factor alpha (TNFα) concentrations in surgical patients with gastrointestinal carcinoma. This meta-analysis also showed a reduced LOS ($P = 0.007$), although no differences in postoperative infections were identified [352].

There is expert consensus that the use of omega-3 polyunsaturated fatty acids (PUFAs), eicosapentaenoic acid (EPA), and docosahexaenoic acid (DHA) found in fish oil exhibits potent anti-inflammatory properties. Fish oil seems to play a role in resolving inflammation, preserving muscle mass, and protecting liver function because of the lower phytosterol content compared with soybean oil-based formulations. This is especially true in patients with an excessive inflammatory response and postoperative indication for PN or combined EN/PN [353].

Most RCTs on different lipid emulsions for PN were conducted before 2020 and several meta-analyses have summarized these findings [316,352,354–362].

For surgical patients a meta-analysis of 19 studies omega-3 fatty acids supplemented PN found reduced infectious morbidity (OR 0.44, 95 % CI 0.30 to 0.65, $P < 0.0001$, $I^2 = 0$ %) and a significant

reduction in LOS (weighted mean difference, −2.70 d, 95 % CI –3.60 to −1.79 d, $P < 0.00001$, I^2 0 %) [354].

For hospitalized patients, another meta-analysis (AMSTAR II 12/16) of 24 RCTs included 2154 hospitalized patients. In comparison with standard solutions without fish oil, fish oil enriched lipid emulsions reduced the risk of infections (RR 0.60, 95 % CI 0.49 to 0.72, $P < 0.00001$, $I^2 = 0$ %), and consecutively the LOS in intensive care (−1.95 d, 95 % CI –3.49 to −0.42, $P = 0.01$, $I^2 = 83$ %) and in hospital (−2.14 d, 95 % CI –2.93 to −1.36, $P < 0.00001$, $I^2 = 51$ %). The risk of sepsis (nine RCTs) was reduced by 56 % (RR 0.44, 95 % CI 0.28 to 0.70, $P = 0.0004$). The reduction in 30-day mortality was not significant (RR 0.84, 95 % CI 0.65 to 1.07, $P = 0.15$, $I^2 = 0$ %) [361].

A meta-analysis of six RCTs evaluated potential differences between different lipid emulsions containing soybean oil, medium-chain triglycerides (MCT), olive oil, and fish oil compared with olive oil- and MCT- and long-chain triglyceride (LCT)-based emulsions [357]. No significant differences with special regard to adverse events were observed.

Another systematic review and network meta-analysis included 47 studies investigating parenteral nutrition with fish oil-containing lipid emulsions published from 2001 to 2021. Third-generation lipid emulsions containing fish oil showed a lower risk of infection compared with soybean lipid emulsions (OR 0.43, 90 % CrI 0.29 to 0.63), MCT/soybean oil emulsions (OR 0.59, 90 % CrI 0.43 to. 0.82), and olive lipid emulsions (OR 0.56, 90 % CrI 0.33 to 0.91), lower risk of sepsis when compared with soybean oil lipid emulsion, and reduced ICU LOS when compared with soybean (and MCT/soybean lipid emulsion [362].

It has to be emphasized that most of the studies were performed with exclusive PN for 5–7 days which cannot be recommended anymore according to ERAS protocols especially after elective colorectal surgery with an uncomplicated course [131,134,344], Although there is evidence supporting the benefits of fish oil lipid emulsions in surgical patients, data on their integration into ERAS protocols remain limited.

In an RCT with moderate risk of bias, olive oil-containing peripheral PN was compared with standard intravenous fluid therapy in patients one day before and three days after colorectal resections as part of an ERAS program [316]. Multivariable analysis of this study showed a protective effect against the incidence of postoperative complications.

So far, there are limited data comparing olive and fish oil use in surgical patients. The secondary analysis of a small RCT in critically ill patients after abdominal surgery supplemented with olive oil-based (n = 29) or a mixed-lipid emulsion (soybean oil, medium chain triglycerides, olive oil, and fish oil, SMOF, n = 25) showed no difference in clinical parameters and outcomes (serum concentrations of prealbumin, transferrin, triglycerides, cholesterol, apolipoprotein A1, and apolipoprotein B, SOFA score), oxidative stress (15-F2t-isoprostane), and inflammatory markers (IL-1β and IL-6) [363].

In conclusion, repeatedly demonstrated positive effects for omega-3 fatty acids supplemented lipid emulsions, such as reduction of infectious complications, shorter LOS in ICU and hospital, support their use, especially in surgical ICU patients with the indication for (sub-) total PN [316,352,354–362]. The potential benefits of short-term perioperative omega-3 fatty acid infusion and its potential conditioning effect before elective surgery need further clarification [364].

Individualized use may be facilitated in the future by using artificial intelligence, including biomarkers of omega-3 derivatives, inflammatory-resolving processes, and/or muscle protein breakdown [365].

5.5. Is there an indication for a specific oral/enteral formula fortified with different immunologically active nutrient combinations (immunonutrition)?

Recommendation 19

Patients undergoing major tumor surgery should be offered immunonutrition (fortified with arginine, omega-3 fatty acids, and nucleotides) preoperatively or perioperatively (BM, HE).

Grade of recommendation B – strong consensus 93 % agreement

Comment

The rationale for perioperative oral and enteral immunonutrition is conditioning, downregulation of inflammation, and enhancement of the immune functions in order to reduce the risk of complications. It has also been called pharmaconutrition for the intended pharmacological effects [366,367].

A large number of studies in general surgical patients have investigated the effect of immunomodulating substrates such as arginine, omega-3 fatty acids, and ribonucleotides with or without glutamine as part of nutritional supplements [368–379].

The results of the RCTs and meta-analyses (in March 2025 PubMed listed 55 meta-analyses) suggest that perioperative administration of immunomodulating substances contributes to a reduction in postoperative complications and consequently to a reduced LOS [368–428]. In terms of immunomodulating substrates, most RCTs have been conducted with arginine, omega-3 fatty acids, and nucleotides.

An umbrella review included 20 meta-analyses on different types of abdominal surgery. Overall, taking into account considerable heterogeneity, immunonutrition was associated with significantly lower rates of infectious complications (OR 0.60, 95 % CI 0.54 to 0.65, $I^2 = 64$ %) and lower postoperative morbidity (OR 0.78, 95 % CI 0.74 to 0.81, $I^2 = 30.3$ %). The exclusion of three studies with substantial heterogeneity did not change the results. Surprisingly, there was no significant difference in the timing of the intervention (pre-, peri-, or postoperative only) [429].

Regarding the timing of immunonutrition, it has been demonstrated that preoperative administration of oral immunonutrition for 5-7 days (arginine, omega-3 fatty acids, and ribonucleotides) can reduce postoperative morbidity and hospital LOS after major abdominal tumor surgery [395–398,401–404]. Three RCTs showed that exclusive postoperative administration of immunomodulating tube feedings was effective in both malnourished [400] and normally nourished patients with gastrointestinal tumors [396,398] and contributed to a reduction in postoperative complications in malnourished patients [401]. For a combined peri- and only postoperative use of immunomodulating diets, significant benefits in terms of the development of infectious complications and hospital LOS were demonstrated in three meta-analyses [388,393,394]. Only for postoperative use, a meta-analysis of 19 RCTs involving 2016 patients undergoing esophagectomy, gastrectomy, and pancreatectomy demonstrated a significant clinical benefit regarding a reduction in wound infections and hospital LOS [395].

A Cochrane meta-analysis on the preoperative administration of immunomodulating diets for patients undergoing gastrointestinal surgery had demonstrated significant advantages with regard to postoperative complications [410]. The recent update, including seven studies (925 patients), revealed low-certainty evidence for a decrease in infectious complications (RR 0.74, 95 % CI 0.53 to 1.04) [430]. The selection of studies may be a matter of debate.

In many studies, immunomodulating diets were compared with a usual hospital diet. In a meta-analysis of eight studies with immunomodulating ONS (561 patients) and standard ONS (895 patients) significant positive effects were shown in the

intervention group with a decrease in infectious complications and reduction of LOS only in comparison with a normal hospital diet, but not in comparison with standard ONS [409]. Another AMSTAR II (13/16) well-rated meta-analysis focused on the preoperative use in gastrointestinal cancer patients, including data from 16 RCTs involving 1387 surgical patients with gastrointestinal carcinoma (immunonutrition n = 715, control n = 672). Preoperative immunonutrition alone for 5–7 days significantly reduced the incidence of infectious complications (OR 0.52, 95 % CI 0.38 to 0.71, $P < 0.0001$, $I^2 = 16$ %) compared with both a normal diet and a standard isonitrogenous diet. For hospital LOS, there was a significant reduction compared with normal diet and a tendency compared with standard ONS (−1.57 d, 95 % CI –2.48 to −0.66, $P = 0.0007$, $I^2 = 34$ %). No impact was observed on noninfectious complications and mortality [412].

Another meta-analysis (AMSTAR II 11/16) included 35 studies with 3692 patients with surgery for gastrointestinal carcinoma. The intervention with immunonutrition was shown to significantly reduce the incidence of complications overall (RR 0.79, 95 % CI 0.70 to 0.88, $P < 0.001$, $I^2 = 2$ %), infectious complications (RR 0.66, 95 % CI 0.55 to 0.78, $P < 0.001$, $I^2 = 45$ %), and LOS [414].

Two more recent meta-analyses are available. One [431] included 37 studies with 3793 patients (22 preoperative, eleven perioperative, and nine postoperative, four trials with multiple protocols) (AMSTAR II rated 11/16). The main outcome of postoperative infectious complications was reduced with immunonutrition (OR 0.58, 95 % CI 0.47 to 0.72). This association was significant in subgroup analysis only with preoperative and perioperative administration and in trials including upper gastrointestinal cancers, colorectal cancer, and 'mixed gastrointestinal' cancer populations. Significance was independent of nutritional status. In the pooled analysis, immunonutrition reduced surgical site infection (OR 0.65, 95 % CI 0.52 to 0.81), anastomotic leak (OR 0.67, 95 % CI 0.47 to 0.93), and LOS by −1.94 d (95 % CI –3 to −0.87) [431].

The other meta-analysis included 48 studies with 4825 patients: 19 studies had patients with upper gastrointestinal cancer, nine had lower, and eight had mixed cancer, whereas 12 had head and neck cancers (AMSTAR II 11/16). Immunonutrition reduced total postoperative complications (RR 0.78, 95 % CI, 0.66 to 0.93) and infectious complications (RR 0.71, 95 % CI, 0.61 to 0.82) compared with standard nutritional therapy [432].

Considering different types of tumors, for mixed abdominal cancer surgery, a meta-analysis of 61 RCTs showed a significant reduction in postoperative infectious complications, wound infections, respiratory tract infections, urinary tract infections, as well as fewer anastomotic leaks [411].

Three meta-analyses of six, seven, and ten good-quality RCTs involving 320, 604, and 1052 patients, respectively, have shown no clinical benefits of immunomodulation for patients undergoing esophageal resection [421,422,433].

A significant reduction in complication rate has been shown after gastrectomy in three meta-analyses [394,419,420]. Significant benefits were observed for preoperative administration in patients with gastrectomy regarding surgical site infections, infectious complications, LOS, and costs [380,418,434].

For patients undergoing liver resection, two meta-analyses (eight prospective RCTs with 805 patients and nine prospective RCTs with 966 patients, respectively) showed a significantly lower rate of overall complications, infectious complications, and significantly shorter hospital LOS when omega-3 fatty acid-containing diets were used [423,424]. Another meta-analysis with eleven studies and 1084 patients found a significant reduction in the rate of wound infections and hospital LOS for major liver resections [425].

In patients undergoing pancreatic resections, three meta-analyses (four RCTs with 299 patients, six RCTs with 366 patients, and ten RCTs with 574 patients) have also shown significantly lower rates of infectious complications and hospital LOS [426,427,435].

For patients undergoing colorectal resections, a large prospective cohort study with 3375 patients and propensity score matching as a control also observed a significant reduction in hospital LOS in the care setting when patients took an immunomodulating ONS three times daily for five days [436].

Minimally invasive surgery – ERAS

A recent meta-analysis of nine RCTs investigated immunonutrition in laparoscopic versus open colorectal surgery. The analysis included 1199 patients (592 immunonutrition group and 592 control group). Of these, 55.3 % (655/1184) had open colorectal surgery and 44.7 % (529/1184) underwent laparoscopic colorectal surgery. Immunonutrition reduced the risk of wound infection significantly in the studies with open surgery (RR 0.48, 95 % CI 0.32 to 0.72, $P = 0.0005$) and the studies including open and laparoscopic surgery (RR 0.33, 95 % CI 0.15 to 0.76, $P = 0.008$). Immunonutrition was also associated with a significantly shorter LOS in the open surgery group [437].

Only a few RCTs have evaluated the use of immunonutrition compared with a standard diet in patients with colorectal resections within an ERAS program. In the SONVI multicenter trial, 264 patients were randomized to receive the intervention or control seven days before and five days after surgery. A significant reduction in infectious complications was observed in the intervention group (23.8 % vs. 10.7 %, $P = 0.0007$). In terms of infectious complications, a significant difference was found in wound infections (16.4 % vs. 5.7 %, $P = 0.0008$) [438]. In another RCT including ERAS patients after colorectal surgery, no benefits were observed for the postoperative administration for five days in case of normal nutritional status [439].

Overall, a critical review of the trials in the numerous meta-analyses reveals some heterogeneity regarding the timing and duration of the intervention. This is the reason for the B recommendation for the pre- and perioperative use. More studies have to be performed in the future according to an ERAS protocol.

Modulation of the microbiota

The administration of probiotics or synbiotics (a combination of prebiotics and probiotics) to influence the microbiome with beneficial effects on the intestinal barrier and local immune defenses has been shown to reduce postoperative infection rates in several prospective randomized placebo-controlled clinical trials and meta-analyses, especially after major digestive surgery (pancreas, liver resection, liver transplantation, rectum), but also in trauma patients in intensive care [440].

A meta-analysis of 13 RCTs involving 962 patients found that probiotic and synbiotic use in elective surgical patients can lead to a significant reduction in septic complications [440]. A meta-analysis of five studies involving 281 trauma patients showed significant benefits in terms of a reduction in nosocomial infections ($P = 0.02$), rates of ventilator-associated pneumonia (three studies, $P = 0.01$), and LOS in the intensive care unit (two studies, $P = 0.001$). However, no difference was observed with respect to mortality, as there was high heterogeneity between studies [441]. A study of patients after neurosurgical trauma [442] showed significant benefits of tube feeding enriched with glutamine and probiotics in terms of the development of infectious complications and LOS in the ICU [442]. A meta-analysis of 34 prospective RCTs including 2723 patients and abdominal procedures (colorectal, upper gastrointestinal, hepatopancreaticobiliary, and liver transplant) confirmed good tolerance without adverse events. Perioperative administration of both probiotics and

synbiotics reduced postoperative infectious complications compared with controls (RR 0.56, 95 % CI 0.46 to 0.69, $P < 0.00001$, n = 2,723, $I^2 = 42$ %). In this regard, synbiotics showed a greater effect than probiotics alone. Only synbiotics significantly reduced hospital LOS. There was no difference in mortality and noninfectious complications [443].

After colorectal surgery, a significant reduction in pneumonia (2.4 vs. 11.3 %, $P = 0.029$), in wound infections (7.1 vs. 20.0 %, $P = 0.020$), and in anastomotic leaks (1.2 vs. 8.8 %, $P = 0.031$) were demonstrated [444]. Similarly, a reduction in infections after pancreatic and hepatobiliary resections and liver transplantation was demonstrated [445–450]. In recent well-designed prospective studies mainly with lactobacilli and bifidobacteria, patients who received synbiotics until transplantation after listing for liver transplantation had significantly lower infection rates and lower bilirubin and transaminase concentrations at 30 and 90 days than the control group (4.8 % vs. 34.8 %) [451]. After liver resection for colorectal metastases, perioperative administration of probiotics also significantly reduced the rate of infectious complications and plasma endotoxin concentrations compared with controls [452]. In addition to reducing infectious complications, a shortened duration of antibiotic therapy and a reduction in the LOS were demonstrated in patients undergoing hepatobiliary surgery for bile duct cancer [445]. On the other hand, a nonrandomized study of patients after liver resection found no difference in surgical infections with the administration of *Clostridium butyricum* and prebiotics compared with the conventional group [453]. Since the available studies are very heterogeneously designed with respect to the onset and duration of therapy, composition of the probiotics and synbiotics, and route of administration, it is difficult to make a general recommendation, especially since increased mortality was observed in a large multicenter study of patients with severe pancreatitis [454]. However, this was the only study with detrimental side effects. This study was criticized because a very highly concentrated synbiotic combination was used for the first time in severe critical illness.

Another limiting factor is the very restricted availability of effective synbiotic preparations tested in clinical trials. The most effective type of probiotics is still unclear, and further adequately designed clinical studies in this field are urgently needed.

6. Preoperative nutrition

6.1. Which patients benefit from preoperative nutritional therapy?

Recommendation 20

Patients with severe malnutrition and/or high metabolic risk shall receive nutritional therapy preoperatively (A), even if it postpones surgery (BM).

A period of 10–14 days should be considered (B).

Grade of recommendation A/B – strong consensus 93 % agreement

Comment

Severe malnutrition represents a high global burden in cancer surgery and is an independent risk factor for 30-day mortality and surgical-site infection following elective surgery for colorectal or gastric cancer worldwide [455]. Preoperative weight loss ≥10 % has been shown to be a significant predictor of 1-year mortality independent of tumor stage, adjuvant treatment, age, and gender [212].

In malnourished patients and those with high metabolic risk benefits of preoperative nutritional therapy, aiming at a reduction of postoperative infections and complications, have been demonstrated in several RTCs [265,271,301,307,456] and supported by four meta-analyses [430,457–459]. Here, patients were fed preoperatively for a duration of at least seven to ten days.

Using the GLIM criteria, it has been shown that severely malnourished patients are at risk of increased morbidity [196,432,460,461]. According to the validation of GLIM criteria in surgical cancer patients, it can predict complications after surgery (OR 2.31, 95 % CI 1.67 to 3.21), especially infection-related complications (OR 2.19, 95 % CI 1.38 to 3.49) and wound-healing-related complications (OR 2.54, 95 % CI 1.38 to 4.71) [462].

High metabolic risk has been defined by the ESPEN working group in 2017 in the presence of any of the following criteria:

- Weight loss >10–15 % within six months
- BMI <18.5 kg/m^2
- NRS ≥5 or subjective global assessment (SGA) grade C
- Serum albumin <30 g/L (exclusion of hepatic or renal insufficiency).

These parameters reflecting nutritional status and disease-related catabolism have been validated for surgical patients. Ten percent weight loss in the preceding six months was associated with increased risk of adverse perioperative outcomes among adults undergoing gastrointestinal cancer surgery in the American College of Surgeons National Surgical Quality Improvement Program database (2005–2017) [463].

In agreement with the literature, the working group considers hypoalbuminemia as an evidence-based prognostic factor in surgical patients [27,464]. Recent data confirm the prognostic impact of serum albumin concentration for the occurrence of postoperative complications [14,27–29,31,464,465]. However, this is primarily more a matter of disease severity and disease-associated catabolism than nutritional status [466]. There is consensus that visceral proteins should not be used as markers of the nutritional status [32]. The degree of preoperative weight loss and serum albumin concentration were without significant influence on the rate of postoperative complications in a study [258] with 145 patients undergoing gastrectomy or subtotal gastric resection. Although the study was not statistically powered to address this issue, the data reveal that the number of patients with gastric cancer and critical weight loss or decreased serum albumin concentration is likely to be less than 20 %.

In patients undergoing abdominal surgery, decreased food intake in the week before hospital admission was identified as the only independent risk factor for the development of postoperative complications [467].

The duration of preoperative nutritional therapy should be planned according to metabolic risk. In 800 patients with gastric cancer and high metabolic risk according to the ESPEN definition, the comparison between adequate energy intake for at least 10 days and inadequate or no nutritional therapy showed a significantly lower incidence of surgical site infections (17.0 % vs. 45.4 %, $P = 0.00069$). Severe complications after Clavien-Dindo > III were not observed until after a therapy duration of 10–13 days. Multivariate analysis showed nutritional therapy as an independent factor for reduced incidence of surgical site infections (OR 0.14, 95 % CI 0.05 to 0.37, $P = 0.0002$) [468].

Preoperative administration for three days, continued for seven days postoperatively, of an oral supplement fortified with hydroxymethylbutyrate (1.2 g HMB), 7 g L-arginine, and 7 g L-glutamine showed no differences in the rate of wound healing as well as other complications compared with a placebo in patients undergoing open surgery for abdominal malignancy. Body composition and handgrip strength were also without difference [468,469]. Based on these data, the expert recommendation of 10–14 days is made.

Only one RCT is available comparing PN and EN preoperatively. No clear advantage of preoperative PN could be shown [271]. A meta-analysis of RCTs [470] is in favor of PN in malnourished patients, as significantly lower mortality with a tendency toward lower infection rates was observed in the malnourished patients with PN (see also 5.1). Another meta-analysis [457] showed a beneficial effect of PN on reducing complication rates only in malnourished patients (see also 5.1). In a series of 1085 patients with nutritional risk by NRS-2002 before abdominal surgery [471], 512 had high nutritionalrisk. These received EN or PN for seven days preoperatively, based on the surgeon's experience, without knowledge of the nutrition screening. A difference in infection rate and hospital LOS was not found in patients with an NRS of three and four in the case of preoperative nutrition. Of 120 patients with an NRS of more than 5, those who received preoperative nutrition benefited significantly: with a lower complication rate (25.6 vs. 50.6 %, $P = 0.008$) and shorter LOS (13.7 ± 7.9 vs. 17.9 ± 11.3 d, $P = 0.018$).

In a meta-analysis of nine studies including 442 patients undergoing esophageal resection and 418 undergoing gastric resection, dietary counseling and EN in patients receiving neoadjuvant treatment showed positive effects in the patients with esophageal cancer for body weight maintenance and also a lower rate of surgical complications. However, the GRADE evidence rating for study quality was very low. Preoperative nutrition in patients with gastric cancer resulted in a reduction in surgical site infections, LOS, and costs. However, GRADE assessment was not possible here due to incomplete outcome data [418].

As part of a prehabilitation program, the duration of prehospital conditioning varies from two to six weeks (see recommendation 22).

Recommendation 21

Oral/enteral tube delivery shall be preferred whenever feasible over parenteral nutrition (BM, HE, QL).

Grade of recommendation A – strong consensus 100 % agreement

Comment

Based on the data presented in comments 10–14, the working group recommends that oral or tube supplementation shall be preferred whenever possible [313,472]. Even in the case of PN necessary to meet caloric needs, as in the case of stenosis in the upper gastrointestinal tract, oral caloric intake should be maintained, e.g., through ONS.

To avoid a refeeding syndrome in severe malnutrition, enteral tube feeding and PN should only be increased slowly under control of serum phosphate, potassium, and magnesium, taking into account possible need for thiamine replacement [125–129,140,142,473].

6.2. Is prehabilitation useful for elective surgical patients?

Recommendation 22

Prehabilitation shall be offered on a risk-stratified basis (BM, IE).

Grade of Recommendation A – strong consensus 93 % agreement

Comment

Surgical prehabilitation enhances functional capacity and physiological reserve to allow patients to withstand surgical stress [474]. Multimodal prehabilitation, comprising preoperative exercise, nutrition, psychological interventions, and/or respiratory therapy, has been found to improve both patient-centered and clinician-centered outcomes [475,476]. An umbrella of 55 systematic reviews identified there was moderate-certainty evidence that surgical prehabilitation improved functional recovery for patients with cancer [475]. Likewise, a network meta-analysis of over 100 RCTs of uni- or multimodal prehabilitation prior to major surgery, identified exercise and nutrition prehabilitation alone, or in combination, reduced the odds of postoperative complications by 36–38 % (n = 8343 patients) and LOS by approximately one day (n = 10,060). Importantly, these results were robust to the exclusion of high-risk of bias trials [477]. Finally, a meta-analysis of 16 studies (six RCTs) of older adults with and without frailty (n = 3339) suggested that prehabilitation reduced the odds of severe complications by up to 44 % in this vulnerable patient group [478].

The intensity of prehabilitation services should be risk-stratified, varying according to the severity of identified deficits. Assessment of functional, nutritional, and psychological aspects is required for appropriate risk stratification, guiding the level of support and resources required for optimal benefit [479,436]. Supervised prehabilitation delivered by a specialist team should be considered for patients with high risk of adverse surgical outcomes, which may include patients with severe malnutrition [480], older adults with an American Society of Anesthesiologists score III/IV [481], six-minute walk test <400 m [482] or preoperative anaerobic threshold ≤11.1 ml/kg/min [483] (as determined by cardiopulmonary exercise testing). Patients with low risk of adverse outcomes may benefit from “universal prehabilitation” or “surgery school” services, promoting better health-related quality of life, adherence to the ERAS pathway, and contributing to earlier discharge [484] or their readiness for discharge [485].

6.3. When is there an indication for preoperative use of ONS or enteral nutrition?

Recommendation 23

Patients who do not meet their nutritional needs from normal food should be encouraged to take oral nutritional supplements during the preoperative period, unrelated of their nutritional status.

Grade of recommendation GPP – strong consensus 100 % agreement

Comment

Regardless of nutritional status, ONS feeds have been studied preoperatively in digestive surgery patients in three major RCTs [253,267,486]. Although two trials did not show significant improvement in outcome, another found a significant reduction in minor complications. In addition, postoperative continuation of ONS was associated with less weight loss [267]. In a systematic review and meta-analysis of nine controlled trials (six nutritional intervention only, three multimodal) compiled from the perspective of preoperative prehabilitation in patients with colorectal resections, nutritional intervention with ONS and/or counselling for at least seven days was found to significantly reduce hospital LOS by two days. While nutritional prehabilitation alone did not improve recovery in terms of functionality at four and eight weeks, this was achieved by multimodal prehabilitation [289]. A special risk group is older adult patients with sarcopenia. Data are sparse with special regard to older patients. Daniels et al. included 33 studies with 3962 patients in their AMSTAR II well-rated systematic review targeting older patients with abdominal cancer surgery. Targeted preoperative nutritional therapy was shown to reduce postoperative complication rates in the meta-analysis. (Risk difference −0.18, 95 % CI −0.26 to −0.10, $P < 0.001$, $I^2 = 0$ %) [487].

It can be critically argued that most patients undergoing colorectal resection for cancer do not have a high nutritional risk with an overall low complication rate. This also explains the result of a systematic review of five RCTs involving 583 patients, in which

preoperative intake of an ONS did not significantly reduce the complication rate [488]. Of note, in patients undergoing surgery for colorectal carcinoma, a lower rate of surgical site infections was observed, using the Buzby definition, in those patients with preoperative weight loss [486].

Since many patients do not meet their nutritional requirements orally in the last week preoperatively, the consensus in the working group is to motivate these patients to take ONS regardless of their nutritional status. Since compliance may be limited, it is reasonable to inform the patient in detail about potential advantages and benefits [489]. When encouraging the intake of a vitamin D supplement in patients undergoing orthopedic surgery, benefits for healing and reduction of the risk of reoperation were the most convincing arguments for the patients [490].

Recommendation 24

In patients with malnutrition and/or at high metabolic risk, an oral nutritional supplement shall be administered before major abdominal surgery in a quantity that matches the deficit of the patient's needs (calories, protein, micronutrients) (BM, HE).

Grade of recommendation A – strong consensus 94 % agreement

Comment

For severely malnourished (SGA C) undergoing gastrectomy, randomized perioperative administration of ONS (500 mL/d) has been shown to significantly reduce overall complication rates, especially severe complications (Clavien-Dindo > IIIa) [491]. In a multicenter Australian observational study of 200 patients with upper gastrointestinal tract resections, patients with preoperative use of ONS for more than two weeks had significantly lower weight loss than those without (1.2 ± 1.8 % vs. 2.9 ± 3.4 %, $P = 0.001$). Among malnourished patients, taking the ONS for more than two weeks resulted in decreased LOS (regression coefficient −7.3, 95 % CI –14.3 to −0.3, $P = 0.04$). More than three dietary consultations resulted in a significantly reduced complication rate in malnourished patients (OR 0.2, 95 % CI 0.1 to 0.9, $P = 0.04$) [492].

It is the consensus of the working group that ONS must have a fully balanced nutrient composition that is not disease-specific, can serve as a sole source of nutrition, and must comply with the Regulations to a Food for Dietetic Purposes of the European Union (2016/128) (FSMP) [288,438].

The cost-effectiveness of ONS has been demonstrated for hospitalized surgical patients in a meta-analysis of RCTs [288]. Nevertheless, the overall data are somewhat inconsistent [288]. Regarding preoperative nutritional therapy in the recently updated Cochrane Review, including 16 RCTs, sensitivity analysis based on malnourished and weight-losing patients found that oral nutrition supplements may result in a slight reduction in infections (RR 0.58, 95 % CI 0.40 to 0.85; two RCTs, 184 participants) [430].

Recommendation 25

Patients with gastrointestinal cancer should be offered oral/enteral tube immunonutrition, including arginine, omega-3 fatty acids, and nucleotides, preoperatively for five to seven days. (BM, HE)

Grade of recommendation B – consensus 87 % agreement

Comment

For immunonutrition, an AMSTAR II (13/16) well-rated meta-analysis focused on preoperative administration only in patients with gastrointestinal cancer. Available data from 16 RCTs involving 1387 surgical patients with gastrointestinal carcinoma (immunonutrition n = 715, control n = 672) were included. Preoperative immunonutrition alone for 5-7 days significantly reduced the incidence of infectious complications (OR 0.52, 95 % CI 0.38 to 0.71, $P < 0.0001$, $I^2 = 16$ %) compared with both a normal diet and a standard isonitrogenous diet. For LOS, there was a significant reduction compared with normal diet and a tendency compared with standard ONS (−1.57 d, 95 % CI –2.48 to 0.66, $P = 0.0007$, $I^2 = 34$ %). No impact was observed on noninfectious complications and mortality [412] (see also comment for recommendation 19). In another meta-analysis, Khan et al. explored the impact of immunonutrition on postoperative outcomes in patients undergoing surgery for gastrointestinal cancer. They demonstrated that postoperative infections were reduced by immunonutrition (OR 0.58, 95 % CI 0.47 to 0.72). Moreover, other postoperative complications and LOS were reduced as well [431]. Apart from patients with gastrointestinal cancer, Matsui et al. additionally included patients with head and neck cancers to their meta-analysis. In line with the above-mentioned analyses postoperative complications (RR 0.78, 95 % CI 0.66 to 0.93), especially infectious complications (RR 0.71, 95 % CI 0.61 to 0.82), were reduced in patients receiving immunonutrition [432].

Recommendation 26

If clinically indicated, preoperative enteral nutrition, including the use of oral nutritional supplements, should be provided prehospital admission (BM, HE, QL).

Grade of recommendation GPP – strong consensus 100 %

Comment

Prehospital implementation of EN therapy, if necessary, with the support of a homecare service, should be aimed for both economic and infectious reasons. For the immunomodulating formula, see comment on recommendation 19.

6.4. When is there an indication for preoperative parenteral nutrition?

Recommendation 27

Only in those patients with severe malnutrition and/or at high metabolic risk in whom oral/enteral nutrition is not feasible, preoperative parenteral nutrition shall be provided (A) (BM).

A period of 10–14 days with a minimum of seven days can be recommended (GPP).

Grade of recommendation A/GPP – strong consensus 100 % agreement

Comment

Patients with severe malnutrition and/or at high metabolic risk in whom oral/enteral nutrition is not feasible are a highly selected group of surgical patients. In this group of patients, the benefits of preoperative PN with the aim of reducing postoperative complications are evidence-based [282,301,307,471]. Malnutrition with non-feasibility of oral/enteral nutrition is mostly observed in cases of upper gastrointestinal tumor stenosis or severe inflammatory bowel disease [493].

A large Cochrane analysis of preoperative PN showed a risk reduction for non-infectious complications from 45.2 % to 28.9 % in patients with gastrointestinal tract resections [410]. While the authors discussed a high bias in three of the included studies that were more than 20 years old, two more recent studies with positive results were not included in this meta-analysis [301,307].

If PN is administered for ten days preoperatively and continued for nine days postoperatively, a 1/3rd reduction in complication rate and even a reduction in mortality was observed [301].

Recovery of physical function and body protein can be achieved after only seven days of PN. Further significant improvement requires one more week [494,495]. Controlled studies comparing a duration of seven and 14 days are not available. Using the ESPEN definition of high metabolic risk for patients after gastrectomy, a retrospective study showed that severe complications according to

Clavien-Dindo IIIb were only reduced after 10–13 days of nutritional therapy, and continuation did not provide further benefits [468].

To date, only retrospective data are available for defining risk by CT-diagnosed sarcopenia. In a propensity score matching analysis of 166 sarcopenic gastrectomy patients each, Huang et al. observed a reduction in postoperative complications and hospital LOS with preoperative PN for 3-7 days only with concomitant hypalbuminemia (<35 g/l) [496]. In an RCT with moderate risk of bias, olive oil-containing peripheral PN was compared with normal fluid therapy in patients one day before and three days after colorectal resections as part of an ERAS program [316]. Multivariable analysis of this study showed a protective effect against the incidence of postoperative complications (OR 0.2, 95 % CI 0.08 to 0.87, $P = 0.0031$).

While the 2009 ASPEN guideline recommends seven days for preoperative PN [497], it is the opinion of the working group that in patients with severe malnutrition and at high metabolic risk, the expected reduction in the risk of complications justifies a preoperative stay longer than ten days. Whenever possible, e.g., in neoadjuvant therapy, prehabilitation for 4–6 weeks should be aimed for [477,479].

7. Postoperative nutrition

7.1. Which patients benefit most from early postoperative nutrition?

Recommendation 28

Enteral nutrition shall be started within 24 h in patients in whom the caloric requirements cannot be met orally, or an oral diet is not yet possible (A).

This applies in particular to:

- **Patients in whom oral energy and protein intake is expected to be < 50 % in the next seven days (BM) (GPP) (100 % agreement)**
- **Patients after major head and neck surgery and upper gastrointestinal resection for tumor (BM) (B) (82 % agreement)**
- **Patients with severe trauma and/or severe traumatic brain injury (BM) (B) (78 % agreement)**
- **Patients with malnutrition at the time of surgery (BM) (GPP) (94 % agreement).**

Grade of recommendation A/B/GPP – strong consensus 93 % agreement; agreement levels for the individual subgroups are shown at the end of each sentence.

Comment

In a prospective study of 50 patients undergoing major abdominal surgery, protein and energy intakes were recorded in the first week postoperatively. In the majority of patients, energy (82 %) and protein (90 %) intakes were inadequate. In addition, more Clavien-Dindo grade III complications were observed in patients who did not meet the protein target [498].

The rationale of early EN is to achieve caloric needs in high-risk patients in order to avoid any postoperative deterioration of nutritional status. According to a Cochrane meta-analysis, early EN within 24 h may lead to a reduced LOS [125]. Early EN was associated with a decrease in total complications in patients undergoing gastrointestinal resections in another meta-analysis [126].

RCTs and a meta-analysis have shown that early oral feeding can also be safely performed after gastrectomy and esophagectomy and is without risk for anastomotic healing [130,144,147,499]. An RCT in patients undergoing laryngectomy and primary pharyngeal obstruction showed that it was also safe to start oral feeding on POD1 [500]. After gastrectomy, a nasojejunal tube was not required for decompression, which was associated with a shorter LOS [143]. Early EN is also safe in patients with head injury and may suggest a favorable trend in survival rates and disability outcomes [501].

Nevertheless, with special regard to upper gastrointestinal surgery and total laryngectomy, the tolerance to oral feeding may be limited [502]. To achieve tolerance to early oral feeding, the diet should be as low in fiber as possible, especially in the case of colonic anastomoses or ileostomy.

Patients undergoing major surgery for head and neck tumors and esophageal, gastric or pancreatic head carcinoma often have nutritional deficits preoperatively [176–178,187,188,503–505] and are at higher risk for developing septic complications [11,14,177,178,187,188,506]. Postoperatively, the oral intake is mostly prolonged by swelling or delayed gastric emptying until nutrition requirements can be met. Supplemental nutritional therapy reduces morbidity with a protective effect of PN and EN, including immunonutrition [14]. In an analysis of a large US healthcare database, only about 15 % of malnourished patients received postoperative ONS [507].

Patients suffering trauma are at high risk for developing septic complications or multiorgan failure even with normal nutritional status. Early EN has the goal of reducing septic complications [233,252] and has also resulted in a reduced rate of multiorgan failure when started within 24 h [508]. Adding arginine, omega-3 fatty acids, and nucleotides supplements to EN might be beneficial as well in trauma patients [379]. In patients with traumatic brain injury, early EN is associated with significantly fewer infections and a trend toward improved survival and functionality.

However, many of these studies have methodological weaknesses.

7.2. Which tube feeds should be used for enteral nutrition?

Recommendation 29

In enteral nutrition, a fully balanced standard polymeric formula should be administered.

Grade of recommendation GPP – strong consensus 100 % agreement

Comment

Most patients can be adequately fed with a fully balanced standard diet. Even if a jejunal tube is available, as in the case of a (fine) needle catheter jejunostomy (NCJ), the administration of a special oligopeptide diet may not be required. Enteral formula diets enriched with fiber are safe and may potentially decrease the rate of diarrhea. However, evidence for a standard recommendation is limited [509]. Individual patient tolerance and patient preference should also be considered when choosing enteral formula diets. To avoid tube occlusion due to clotting and infections, the use of home-made tube feeds is discouraged.

7.3. Which patients benefit from enteral tube feeding?

Recommendation 30

In patients with malnutrition and/or high metabolic risk, intraoperative placement of a nasojejunal tube or feeding jejunostomy should be considered, especially during esophagectomy, total gastrectomy, and pancreatoduodenectomy (BM).

Grade of recommendation B – consensus 89 % agreement

Comment

Numerous studies have demonstrated the low-risk/benefits of intraoperatively placing a feeding tube (nasojejunal tube or

jejunostomy, e.g., needle catheter jejunostomy – NCJ) with the tip located distal to the anastomosis in upper gastrointestinal tract resections [371,510–515]. The open or laparoscopic placement of an NCJ [510,516–518] is considered low-risk when performed by experienced surgeons according to standardized techniques. Reported complication rate in the literature ranges from 1.5 % to 6 % [400,510,514,519–529].

Nevertheless, harm-benefit discussion is inconsistent in the literature. Some authors consider routine placement of a jejunostomy to be redundant and overdone, with a recommendation only for high-risk patients [530–533]. In a recent single-center RCT (n = 48), no difference between nasojejunal tube and feeding jejunostomy was found, while the physical domain of quality of life was improved in nasojejunal patients at the time of discharge and the six-week follow-up [534].

A recent RCT showed the superiority of jejunal feeding maintenance over conventional early oral feeding regarding less body weight loss, higher calorie and protein intake, and less malnutrition state in esophagectomy patients [535]. In an RCT of 58 patients undergoing esophagectomy, those receiving jejunostomy feeding for up to six weeks had significantly less weight loss and higher calorie and protein intake at both 4–5 weeks and four months postoperatively, without increased complications or LOS. These findings suggest potential long-term benefits of jejunostomy feeding.

Meta-analyses comparing jejunostomy with nasojejunal tubes found that jejunostomy reduced postoperative pneumonia, shortened LOS, and prevented tube dislocation, but increased the risk of ileus [536]. Another meta-analysis reported comparable or lower postoperative complication rates in patients without jejunostomy [537]. However, nutritional status and body composition were not assessed in these studies.

In patients after esophagectomy or pancreatoduodenectomy, studies comparing nasojejunal or nasoduodenal tubes with jejunostomy found no major differences in overall complication rates [515,527]. Nasojejunal feeding was associated with fewer bowel complications but more frequent tube dislocation, while jejunostomy had more catheter-related issues [538]. Overall, both methods appear similarly safe, with specific advantages and disadvantages.

In patients undergoing pancreatoduodenectomy, early EN, particularly via percutaneous tubes, was associated with reduced infectious complications and shorter LOS compared with PN, as shown in several meta-analyses [539,540]. A meta-analysis of eight RCTs also showed that routine enteral nutrition supplemented to oral diet especially via a jejunostomy tube may improve postoperative outcomes [472].

Due to the higher dislocation risk of nasojejunal/nasoduodenal tubes, feeding jejunostomy is preferred for patients with malnutrition or high nutritional risk [530,541]. A scoring system may help predict the risk of severe surgical complications. [542]. EN may be continued after discharge.

Tolerance should be closely monitored, especially in patients with impaired gastrointestinal motility [274]. Rapid escalation can lead to intolerance or rare but serious complications such as ischemic bowel; gradual increase over 5-7 days is recommended [287]. Supplemental PN may be necessary.

Recommendation 31

For nutritional therapy in all perioperative periods, special attention should be given to prevent refeeding syndrome in patients with malnutrition and/or metabolic risk.

For these patients, standard enteral nutrition should be started at a low rate of intake (10–30 mL/h) and carefully increased only if electrolytes are stable, while also monitoring individual intestinal tolerance. Thus, the time to reach the caloric target may vary greatly from individual to individual, increasing from day to day, and may take up to five days.

Grade of recommendation GPP – strong consensus 95 % agreement

Comment

For patients at risk of refeeding syndrome, particularly those with significant nutritional deficiencies or extended periods of fasting, the initiation of nutrition should be increased gradually. Refeeding syndrome is a potentially life-threatening condition resulting from fluid and electrolyte shifts that occur when reintroducing nutrition after a period of starvation or undernutrition. Therefore, for these high-risk patients, EN should begin at a slow rate (e.g., 10–30 mL/h) and be gradually increased over several days, monitoring for signs of intolerance. This cautious approach helps to prevent severe life-threatening conditions induced by rapid electrolyte shifts, such as hypophosphatemia, hypokalemia, hypomagnesemia, and vitamin B1 deficiency, leading to serious cardiac, respiratory, and neurological complications.

The recommendation aligns with recommendations in the NICE guidelines (2006, updated 2017) [543], ASPEN consensus recommendations on refeeding syndrome (2020) [544], and ESPEN guidelines on micronutrient supplementation [545], all of which emphasize the importance of gradual nutrition build-up and close monitoring for the prevention of refeeding syndrome. For detailed protocols to prevent and treat refeeding syndrome, the aforementioned guidelines should be reviewed.

Recommendation 32

If tube feeding is required for more than four weeks in patients with malnutrition and/or metabolic risk, such as in severe traumatic brain injury, percutaneous endoscopic gastrostomy or jejunal tube placement should be performed.

Grade of recommendation GPP – strong consensus 96 % agreement

Comment

A percutaneous endoscopic gastrostomy or jejunostomy (PEG or PEJ) should be performed in patients with an indication for prolonged EN, especially when laparotomy is not indicated, such as in severe traumatic brain injury or after neurosurgical procedures. In patients with stenosing esophageal cancer and planned neoadjuvant therapy, PEG placement should be coordinated with the surgeon beforehand. The guidelines for the placement of a PEG [546,547] recommend the placement for a feeding duration of 4–6 weeks.

7.4. Which patients benefit from enteral nutrition after hospital discharge?

Recommendation 33

Patients who require nutritional therapy perioperatively should have regular assessment of nutritional status during hospitalization with continuation post-hospital discharge, including referral for nutritional counseling and oral/tube supplementation as appropriate. (BM)

Grade of recommendation B – strong consensus 100 % agreement

Comment

After major gastrointestinal surgery or pancreatectomy, with special regard to cancer, oral intake alone may be inadequate for most patients over a prolonged period, indicating a potential risk for postoperative malnutrition [548–551]. In a prospective study of 50 patients undergoing major abdominal surgery, protein and energy intake were recorded in the first week postoperatively. In most patients, energy (82 %) and protein intake (90 %) were insufficient. In addition, more Clavien-Dindo III complications were observed in patients who did not reach the protein target

[498]. After esophagectomy, approximately 30 % of patients are expected to lose more than 15 % of their body weight within six months [551]. A meta-analysis of 18 studies showed a postoperative weight loss of 5–12 % at six months, with more than half of the patients losing over 10 % of their body weight after twelve months [552].

A prospective cohort study showed adequate micronutrient intake following general recommendations in only 10 % of patients undergoing esophagectomy (n = 96) with reconstruction with a gastric pull-up [548].

In patients with a complicated course and intensive care stay, an observational study found that post-extubation spontaneous caloric intake did not exceed 700 kcal/d (2.9 MJ/d) in these patients. This intake level is metabolically inadequate during a period when the recommended energy intake is 1.2–1.5 times the resting energy expenditure, emphasizing the importance of monitoring oral intake during recovery [553].

Therefore, it must be considered that these patients are still at metabolic risk after discharge, and, therefore, need follow-up assessment of nutritional status, including documentation of the amount of oral food intake.

Nutritional counseling is strongly recommended and very readily accepted by most patients. Additionally, postoperative and post-discharge administration of ONS has been studied in several RCTs [242,249,251,253,267,269]. A systematic review of 14 studies with 2480 patients showed a significant reduction in postoperative weight loss in patients receiving ONS after gastrointestinal surgery [554]. This is especially true for patients after major gastrointestinal surgery such as gastrectomy [550], older adult patients with fractures [170,185,248], but also after colorectal resections [555]. When ONS was taken, energy intake was significantly higher in the intervention group than in the control group [185,269]. However, in older patients, compliance with the intake of ONS was low, and this was independent of nutritional status. Nevertheless, energy intake was significantly higher in the intervention group than in the control group [185,269].

Possible causes for limited compliance for the intake of ONS [549,556,557] include taste, loss of appetite, bloating, decreased enteral tolerance with dumping syndrome, meteorism, and diarrhea. However, the number of diet-related complaints was not shown to be an independent risk factor for the presence of suboptimal nutritional intake [548]. In patients undergoing gastrectomy only 26.2 % consumed more than 250 mL of ONS per day in the second and 50.8 % in the fourth week [491].

In an RCT with 113 patients undergoing gastric surgery (73 distal gastrectomy, 40 total gastrectomy), adding ONS for twelve weeks after discharge was compared with a usual postoperative diet. The intake of ONS resulted in significantly less weight and muscle loss only in the patients with total gastrectomy, but was not observed in patients with subtotal resection [558].

Previous analyses demonstrated that the intake of oral elemental nutritional supplements (300 kcal (1.3 MJ)) after gastrectomy significantly reduced weight loss in patients who underwent curative distal or total gastrectomy in the short term [559] and in those who underwent total gastrectomy after one year [560]. This suggests that short-term ONS administration for ≥14 days may have long-term benefits for preventing weight loss. The one-year completion rate of adjuvant chemotherapy in patients who could tolerate ONS surpassed that of previous studies without ONS [561].

In another RCT, a significant reduction in weight loss, along with higher BMI and SMI, was observed in 353 patients with NRS ≥3 who received nutritional counseling combined with ONS after gastrectomy in the intervention group versus a control with nutritional counseling only. While there was no difference in 90-day readmission rates, fatigue and loss of appetite were less common in the intervention group with dietary advice and ONS [562]. In the secondary analysis of this study, including 321 patients with NRS ≥3, long-term mortality and handgrip strength were significantly improved in the intervention group. The adjusted hazard ratio for mortality between the two groups was 0.69 (95 % CI 0.50 to 0.96, $P = 0.026$) [563].

A multicenter RCT of 1003 post-gastrectomy patients compared the effects of a 400 kcal/d (1.7 MJ) ONS on weight loss after one year with that of control patients without supplementation. Overall, weight loss was significantly lower in the intervention group after three months, though this effect leveled off over time, with no significant difference observed after one year. In the ONS group, only 50.4 % of patients consumed more than 200 kcal/d (0.8 MJ/d, mean 301 mL), but these patients had significantly lower body weight loss (8.2 ± 7.2 %) than the control group at one year ($P = 0.0204$) [564]. The advantages regarding weight loss were confirmed in a systematic review and meta-analysis of seven trials [565].

Patients after colorectal resections seem to benefit less. In an RCT after surgery for colorectal cancer, a three-month intervention with ONS led to significantly higher SMI (39.75 ± 5.83 vs. 38.01 ± 6.18 cm^2/m^2, $P = 0.037$) and lower sarcopenia prevalence (28.6 % vs. 42.1 %, $P = 0.040$). No significant differences were observed in weight, weight loss, BMI, serum albumin, or 90-day readmission rate. Delay, dose reduction, or termination of adjuvant chemotherapy were significantly reduced in the ONS group (21.2 % vs. 36.8 %, $P = 0.024$). ONS had no significant effect on QOL [566].

Recommendation 34

An intraoperatively placed jejunostomy may be temporarily left in place at the time of discharge, depending on weight progression and/or for the compliance with adjuvant chemotherapy.

Grade of recommendation GPP – strong consensus 100 % agreement

Comment

If a feeding jejunostomy has been placed during surgery, it may be beneficial to make an individualized decision about removal at the time of hospital discharge. If necessary, supplemental EN via the jejunostomy, such as 500–1000 kcal/d (2.1–4.2 MJ/d), administered overnight over an extended period, can be provided. In many cases, training of the patient and family enables care to be managed without the involvement of a home care service [567]. Two RCTs of home enteral feeding for 4–6 weeks demonstrated the safety and acceptance, showing better maintenance of body weight and muscle/fat compartments even after minimally invasive surgery [568,569].

A study randomized 58 patients after esophagectomy to early oral feeding (early group) or late oral feeding with jejunostomy feeding support (late group), with 29 in each group [535]. Jejunostomy feeding was maintained at discharge and continued up to six weeks postoperatively. The late group exhibited significantly less body weight loss at both 4–5 weeks postoperatively (8.3 % vs. 5.6 %; $P = 0.002$) and four months (15.0 % vs. 10.5 %; $P = 0.003$). The total calorie and protein intake were higher in the late group at 4–5 weeks (1800 kcal/d (7.5 MJ/d) vs. 1100 kcal/d (4.6 MJ/d), $P < 0.001$) and four months (1565 kcal/d (6.6 MJ/d) vs. 1200 kcal/d (5.0 MJ/d), $P = 0.010$). No difference was observed for complication rates and LOS [535].

In a prospective observational study, 24 patients underwent supplementing home enteral nutrition (HEN) after total gastrectomy for three months through a jejunostomy during the night: 1200 kcal/d (5.0 MJ/d)). These patients were compared with those not receiving enteral supplementation. After three and six months, patients with nocturnal HEN had significantly less body weight loss (three months HEN 4.0 % vs. control 15.2 %, $P < 0.0001$, six months 7.7 % vs. 17.7 %, $P < 0.0001$). Regarding tolerance to

adjuvant chemotherapy, patients with HEN significantly had a higher completion rate (70 % vs.29 %, $P = 0.042$) and longer duration of chemotherapy (458 vs. 261 d, $P = 0.031$) [570].

Thus, although postoperative weight loss is often inevitable, HEN may help to attenuate deterioration [551,564,571,572]. This may be of special importance in older patients. Compared with a control group, significant benefits of HEN for eight weeks have been demonstrated in older patients after esophagectomy, with improvements in BMI, patient-generated subjective global assessment (PG-SGA) score, serum albumin, and immune parameters [569]. An RCT showed that post-discharge EN after upper gastrointestinal resections improved energy intake without improvement in fatigue, quality of life, or health economics [573]. It should be mentioned that in some patients potential disturbed sleep patterns and stoma-related problems have been observed with long-term living with a jejunostomy tube [574].

In a meta-analysis of nine RCTs involving 757 patients after esophagectomy, an oral diet was compared with HEN. HEN was associated with significantly increased body weight (WMD = 3 kg, 95 % CI 2.36 to 3.63, $P < 0.001$), BMI (WMD = 0.97 kg/m, 95 % CI 0.74 to 1.21, $P < 0.001$), albumin (WMD = 3.43 g/L, 95 % CI 2.35 to 4.52, $P < 0.001$), hemoglobin (WMD 7.23 g/L, 95 % CI 5.87 to 8.59, $P < 0.001$), and total protein concentrations (WMD = 5.13 g/L, 95 % CI 3.7 to 6.56, $P < 0.001$). No significant differences were observed in prealbumin concentrations and gastrointestinal adverse events. Physical and role function were also significantly better in the HEN group. Nausea/vomiting and fatigue symptoms were significantly reduced. Appetite loss, diarrhea, and sleep disturbance in the HEN group were also significantly less than in the control group [572].

Another meta-analysis of 15 RCTs involving 1059 patients undergoing upper gastrointestinal tract resections additionally compared HEN and ONS [575]. HEN seemed to be superior because significant reduction of weight loss (−3.95 vs. −5.82 kg; SMD = 1.98 kg; 95 % CI 1.24 to 2.73) and reduction of the incidence of malnutrition or latent malnutrition (RR 0.54, $P < 0.01$). Furthermore, improved concentrations of albumin, hemoglobin, pre-albumin, and transferrin were observed. Subgroup analysis revealed that weight loss in the HEN subgroup was significantly lower than that in the control group without any supplementation (WMD = 2.69 kg, $P < 0.01$). No significant difference was found between the ONS subgroup and the control group. The same results were observed for serum albumin, the physical function dimension of QL (WMD = 5.29, 95 % CI 1.86 to 8.73), but the fatigue dimension of QL (WMD = −8.59; 95 % CI −12.61 to −4.58) was significantly better in the HEN group [575].

Further data from controlled trials are urgently needed to assess the long-term benefits of post-hospital nutritional therapy with special regard to the comparison of enteral feeding versus oral supplementation [576].

It is the opinion of the guideline group that shared decision making after upper gastrointestinal cancer surgery should address the potential benefits of postoperative ONS and even HEN if jejunostomy is available.

For patient monitoring, self-evaluation with a validated tool such as the PG-SGA-SF can be helpful [577].

8. Bariatric surgery

Recommendation 35

Early oral diet shall be resumed after bariatric surgery (as part of an Enhanced Recovery After Bariatric Surgery (ERABS) protocol) (BM, IE).

Grade of recommendation A – strong consensus 100 % agreement

Comment

The ERABS protocol recommends reintroducing clear liquids within hours postoperatively, followed by a stepwise progression to full liquids, and then puréed or soft foods, thoroughly chewed, as tolerated [578]. Bariatric surgery guidelines recommend the implementation of ERABS and a similar stepwise reintroduction of liquids/foods [579].

The ERABS protocol reduces postoperative nausea, time to mobilization, length of ICU and hospital stays, without increasing complications or morbidity [580,581]. Observational studies suggest that introducing soft/puréed foods within one week postoperatively is safe, faster than the previous two-to-six-week guideline [582,583]. Dietitian-led counseling on food reintroduction, protein intake, and healthy eating is recommended but supported by limited evidence, with studies reporting no or mixed effects on readmissions and weight loss [578,579,584–586].

Evidence on consuming ≥60 g/d of protein remains inconsistent, with supplementation not consistently preserving fat-free mass and higher protein diets showing no clear impact on weight loss or regain [587,588].

Postoperative thiamine deficiency requires prompt treatment and is linked to factors like preexisting deficiency, rapid weight loss, poor nutrition, vomiting, diarrhea, or non-adherence to supplements [578,579]. Bariatric surgery increases the risk of multiple nutrient deficiencies, necessitating lifelong, procedure-specific supplementation and regular monitoring, although long-term adherence remains low [578,579].

Standard hypocaloric postoperative care does not require PN unless complications arise, avoiding central venous catheterization and its risks [578,579].

Recommendation 36

The use of a nasojejunal tube or jejunostomy may be considered in patients with bariatric surgery and complications with an indication for relaparoscopy/laparotomy.

Grade of recommendation GPP – strong consensus 92 % agreement

Comment

Even in cases of severe complications, the advantages of EN in terms of outcome (mortality) and cost-benefit ratio must be considered [589–591]. For EN, an intraoperatively carefully placed nasojejunal tube, jejunostomy, or even gastrostomy in the residual stomach can be used [589–592]. However, the risk of leakage is increased in the patient with morbid obesity.

In a series of 126 patients undergoing revisional bariatric surgery, most feeding tubes were placed in the excluded stomach (89.7 %), and the median tube size was 18 F. Feeding tubes were used for feeding in 68.2 % of patients, with feeding initiated at a median of two days. Leakage around the tube (32.5 %) and pain (26.8 %) were common complaints. Significant tube-related complications included infection (9.1 %), dislodgement (5.9 %), reintervention (5.8 %), and reoperation (2.8 %); 16.7 % experienced at least one significant complication. Feeding tubes were removed at a median of 36 days [593].

Another series included 73 patients with leaks after sleeve gastrectomy. Feeding jejunostomy was performed in nine patients (12.3 %) without complications. Patients were followed up for 12 months. All leaks healed within 8.8 ± 0.72 weeks. Patients receiving jejunal feeding had shorter recovery time (HR 2.7, $P = 0.018$) [594].

9. Organ transplantation

9.1. When is nutritional therapy necessary before organ transplantation?

Recommendation 37

Recommendations for the living donor and recipient are no different from those for patients undergoing major abdominal surgery.

Grade of recommendation GPP – strong consensus 100 % agreement

Recommendation 38

In cases of malnutrition, nutritional status shall be optimized before organ transplantation (BM).

Grade of recommendation A – strong consensus 100 % agreement

Recommendation 39

In cases of malnutrition, a structured nutrition plan should be implemented first, followed by supplementation with ONS or enteral nutrition (BM).

Grade of recommendation B – strong consensus 100 % agreement

Recommendation 40

Follow-up visits of patients on the transplant waiting list should also include assessment of nutritional status.

Grade of recommendation GPP – strong consensus 100 % agreement

Comment on recommendations 37–40

Malnutrition determines the course of chronic organ failure and its prevalence in patients on the liver transplant waiting list can range from 17.2 % to 57.7 % [595]. This is particularly true for functional status (see the relevant organ-specific guidelines [596–598]). Nutritional parameters correlate with outcome after transplantation [599–603]. The often long preoperative waiting period should be used for (medical) nutritional therapy. In four interventional studies (two RCTs) on preoperative nutrition in patients on the waiting list for organ transplantation [604–607] improvement in nutritional parameters has been shown in all four studies. In the case of nutritional intervention, no relationship between mortality and nutritional status was found [595]. However, in one RCT, the improved nutritional status parameters before transplantation had no effect on outcome and mortality [605].

Initial results on the use of preoperative immunomodulating diets in patients on the liver transplant waiting list and for five days after transplantation showed favorable effects on total body protein and a possible reduction in the rate of infectious complications [607], however, this could not be confirmed in a large RCT [608].

In a recent RCT, supplementation of 3 g HMB compared with 3 g supplementation of maltodextrin (active control) with nutritional counselling for twelve weeks in 47 patients awaiting liver transplantation was investigated. Nutritional counseling with supplementation with HMB or active control improved arm circumference, dynamometry, and the frailty index in both groups. Other parameters like BMI or phase angle were without difference [609]. The secondary analysis of this RCT revealed that nutritional goals at the end of the twelve-week follow-up were only met in twelve (25.5 %) of 47 patients [610]. Another RCT including 55 patients with severe malnutrition and cirrhosis awaiting liver transplantation investigated in addition to a high-energy high protein diet nocturnal nasogastric feeding for a median duration of 63 days. The 2-fold increased energy and protein intake led to significant increase in handgrip strength, mid-upper arm circumference, triceps skin fold and immune function in the intervention group [611]. These studies demonstrate the benefits of nutritional counselling and monitoring for patients on the waiting list for organ transplantation.

No data are available on the metabolic conditioning of the living donor and recipient. Experimental results [612] showing an influence of nutritional status on liver ischemia-perfusion injury may confirm the concept of metabolic conditioning by additional preoperative glucose drinks.

9.2. When is medical nutrition therapy indicated after organ transplantation?

Recommendation 41

After organ transplantation, an early oral or enteral nutrition should be provided within 24 h according to individual tolerance (BM).

Grade of recommendation B – strong consensus 100 % agreement

Recommendation 42

After small bowel transplantation, oral or enteral nutrition can be started early, with cautious increases within the first week, and then gradually increased as tolerated (BM).

Grade of recommendation 0 – strong consensus 100 % agreement

Comment on recommendations 41 and 42

It is generally agreed that early oral nutrition or EN is feasible and should be administered to patients undergoing organ transplantation [308,596,613]. ERAS protocols after liver transplantation, including early intake, have demonstrated benefits in reducing complications, ICU stays, hospital LOS, and mortality. However, these protocols lack standardization and relevance for long-term nutritional follow-up [614].

EN is also viable after small bowel transplantation, even with high intestinal secretions, when started at low rates in the first postoperative week [615].

Recommendation 43

If enteral nutrition is inadequate before or after organ transplantation, supplemental parenteral nutrition should be provided (BM).

Grade of recommendation B – strong consensus 96 % agreement

Comment

A meta-analysis of nine RCTs and ten cohort studies (1300 patients) reported significant benefits of EN, alone or combined with PN, over PN alone, in the form of reduced postoperative infections, ICU hours, LOS, improved nutritional status, better liver function, and fewer biliary complications after liver transplantation. The EN + PN group also had lower infection rates and higher prealbumin concentrations [616]. Early EN with PN is particularly recommended for malnourished patients [616,617]. Notably, tacrolimus absorption is unaffected by EN [618], and feeding jejunostomy is safe post-transplant [619]. If oral and tube intake are not feasible or remain inadequate, home PN is indicated [620]. Evidence for synbiotics, prebiotics, or probiotics in solid organ transplant recipients is still insufficient [621]. The use of an immunomodulating enteral diet has not shown consistent benefits [622]. For PN lipid delivery, no particular recommendations exist for patients undergoing organ transplantation.

Recommendation 44

As part of the follow-up after organ transplantation, the nutritional status should be regularly monitored. Nutritional counseling should be offered for these patients.

Grade of recommendation GPP – strong consensus 96 % agreement

Comment

Malnutrition, sarcopenia, frailty, obesity, and sarcopenic obesity are prevalent and predict poor outcomes after organ transplantation [623–626]. Energy and protein requirements are often unmet in the first month post-transplant, although energy intake increases thereafter [627]. Consequently, early post-transplant, patients lose both fat and lean body mass, with long-

term fat mass recovery but incomplete lean mass restoration [628–631]. Sarcopenia and obesity increase over time [628,631]. Long-term nutritional follow-up and dietary counselling are, therefore, reasonable, although evidence for interventions is largely lacking. In selected cases, bariatric surgery is effective for weight loss and can be considered pre-, peri-, or post-transplantation [632,633].

10. Research questions

1. Clinical benefit of medical nutritional therapy within ERAS protocols
2. Clinical benefit of supplementation with single or combined immunomodulatory substrates, including synbiotics, in different surgical subgroups
3. Effects of modulation of the intestinal microbiota
4. Timing of initiation of supplemental parenteral nutrition
5. Importance of nutritional therapy in the post-discharge outpatient phase
6. Long-term outcomes of perioperative nutritional therapy
7. Development of new patient-centered, clinically relevant outcome parameters to evaluate the success of nutritional therapy – PROMS

Declarations

Disclaimer

This guideline has been developed with reasonable care and with the best of knowledge available to the authors at the time of preparation. They are intended to assist healthcare professionals and allied healthcare professionals as an educational tool to provide information that may support them in providing care to patients. Patients or other community members using this guideline shall do so only after consultation with a health professional and shall not mistake this guideline as professional medical advice. This guideline must not substitute seeking professional medical and health advice from a health professional.

Author contributions

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Appendix A. Supplementary data

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