Narrative review

Perioperative peripheral parenteral nutrition to support major gastrointestinal surgery: Expert opinion on treating the right patients at the right time

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Background & aims: Patients undergoing major gastrointestinal surgery may be in particular need of nutritional therapy due to potential pre-existing disease-related malnutrition and the impact of surgical procedures. Peripheral parenteral nutrition (PPN), delivered via a peripheral catheter, is aligned with the Enhanced Recovery After Surgery (ERAS) concept of minimally invasive interventions where possible. However, uncertainties regarding perioperative PPN for patients undergoing major gastrointestinal surgery arise, in part, due to lack of clinical guidelines. This paper aims to provide practical guidance on perioperative PPN, within the framework of ERAS.

Methods: A panel of surgeons and nurses convened to identify knowledge gaps and share their best practice experience regarding PPN provision for patients undergoing major gastrointestinal surgery. Clinical needs were identified and addressed based on the panel's experience and a narrative review.

Results: Key topics addressed include how PPN can support ERAS nutritional recommendations, identifying gastrointestinal surgery patient subgroups who are likely to benefit from PPN, perioperative timepoints when PPN may be required, and optimizing the delivery of PPN. An algorithm to support the identification and management of patients' perioperative nutritional needs was developed.

Conclusions: This paper aims to assist healthcare providers by addressing best practice questions related to the use of PPN during the critical perioperative period within the ERAS concept. This may facilitate timely nutritional intervention to help improve postoperative clinical outcomes and quality of life for patients undergoing major gastrointestinal surgery.

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1. Introduction and aim

As recommended in the European Society of Clinical Nutrition and Metabolism (ESPEN) guidelines, perioperative nutritional therapy is indicated to address malnutrition and catabolic consequences of surgery, thereby helping to improve or maintain nutritional status and avoid postoperative complications [dataset [1]]. However, identification of surgical

Abbreviations: BMI, body mass index; CVC, central venous catheter; EORTC, European Organisation for Research and Treatment of Cancer; ERAS, Enhanced Recovery After Surgery; ESPEN, European Society of Clinical Nutrition and Metabolism; HCP, healthcare provider; i.v., intravenous; PPN, peripheral parenteral nutrition; PVC, peripheral venous catheter; TPN, total parenteral nutrition.

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patients who will benefit from nutritional intervention is often suboptimal [dataset [2,3]].

Perioperative parenteral nutrition, i.e., delivery of balanced quantities of amino acids, glucose, lipids, and micronutrients intravenously (i.v.), may be required when a patient’s nutritional needs cannot be met by oral or enteral routes [dataset [4]]. However, the topic of parenteral nutrition can present uncertainties as physicians often lack expertise in this field [dataset [5–7]]. Total parenteral nutrition (TPN) is administered via a central catheter to patients requiring complete nutritional support when oral or enteral support is not feasible or is contraindicated. Peripherally inserted central catheters (PICCs) as a low osmolarity solution (usually nutrition (PPN) is administered via a peripheral venous catheter (PVC) as a low osmolarity solution (usually ≤ 850–900 mOsm/L) [dataset [8,9]]. Patients may receive PPN for up to 14 days, either as a bridge to oral or enteral nutrition in order to close nutritional gaps or to provide immediate nutritional support when a central venous catheter is not available [dataset [1,9–11]].

Enhanced Recovery After Surgery (ERAS) pathways are increasingly adopted to optimize the care of patients undergoing major surgery. These pathways are available across a range of surgical settings including gastrointestinal procedures such as colonic surgery, gastrectomy, oesophagectomy, pancreaticoduodenectomy, bariatric surgery and liver surgery [dataset [12–17]]. ERAS recommendations reflect a broad continuum of care including, but not limited to, preoperative counselling and prehabilitation of patients, anaesthetic protocols, surgical procedures, analgesia, wound care, antimicrobial and antithrombotic prophylaxis and patient mobilization [dataset [12–17]]. While minimizing adverse metabolic and catabolic consequences of surgery is a key focus of ERAS recommendations, guidance on parenteral nutrition use to address this aim is limited, and specific guidance on PPN in the perioperative setting is lacking (Table 1).

This paper aims to provide concise, practical guidance on PPN during the critical perioperative period within the framework of ERAS. The group shared their best practices regarding the use of PPN before and after surgery, including how PPN can support ERAS nutritional recommendations, identifying surgical patients who may benefit from PPN, and approaches to optimize PPN delivery. This guidance is focused on patients undergoing major gastrointestinal surgery, since malnutrition associated with the underlying disease such as gastrointestinal cancer along with the short-term impact of surgery on patients’ ability to eat and gastrointestinal function may necessitate perioperative nutritional support.

2. Methods

A multidisciplinary panel comprising surgeons and nurse specialists from four hospitals (located in Germany [2 sites], Italy and Spain) convened to discuss best practices regarding the provision of PPN at their institutions, focusing on patients undergoing major gastrointestinal surgery. Together, the panel had extensive clinical experience in clinical nutrition, gastrointestinal surgery and nursing, and included (but not limited to) steering committee members of the German Society for Nutritional Medicine (DGEM) and authors of the DGEM clinical nutrition in surgery guidelines [dataset [18]], director of the foregut research centre and institutional multidisciplinary surgical oncology board, institution department head of general and gastrointestinal surgery, and head of scientific activities and secretary of the Italian Association of Cancer Nurses.

Clinical questions about perioperative PPN are addressed in this narrative review based on European clinical guidelines, clinical experience of the panel members, and published clinical studies which were identified by a non-systematic search of MEDLINE for relevant English-language publications (clinical studies of PPN in gastrointestinal surgery patients). Key topics include how PPN can support ERAS nutritional recommendations, identifying subgroups of gastrointestinal surgery patients who are likely to benefit from PPN, perioperative timepoints when PPN may be required, and approaches to optimize the delivery of PPN. Opportunities and challenges which may be encountered with PPN were also discussed.

ERAS guidelines for major gastrointestinal surgical procedures were identified from the ERAS Society website (http://erassociety.org/guidelines/list-of-guidelines/). Each guideline was reviewed for relevant recommendations regarding PPN, which are summarized in Table 1.

### Table 1

| ERAS recommendations |
|----------------------|
| Colonic surgery [17] |
| • “For malnourished patients, oral nutritional supplementation (or additional PN when indicated) has the best effect if started 7–10 days preoperatively” |
| • “EN or PN will often be necessary if major complications develop” |
| • “PN should not be used routinely” |
| • “PN is indicated only in patients who cannot eat and drink normally, or tolerate EN” |
| • “PN should be reduced as tolerance of EN increases” |
| Pancreaticoduodenectomy [15] |
| Gastroctomy [14] |
| Liver surgery [13] |
| Oesophagectomy [12] |
| Bariatric surgery [16] |

EN, enteral nutrition; ERAS, Enhanced Recovery After surgery; PN, parenteral nutrition.
supporting patient mobilization [dataset [24]]. Surgical trauma also induces an immuno-inflammatory response involving interactions between pro-inflammatory cytokines (e.g., tumour necrosis factor-alpha [TNF-α], interleukin-1 [IL-1], IL-6, IL-8, and IL-10), hormones (e.g., catecholamines, adrenocorticotropic hormone, cortisol, and glucagon), chemokines and other cellular mediators [dataset [25]]. Increased production of proinflammatory cytokines is regularly observed following major surgery and can induce systemic inflammatory responses and/or immunosuppression, resulting in hemodynamic instability, metabolic derangements and muscle wasting [dataset [26]].

Within the ERAS multimodal strategies to reduce morbidity and enhance the recovery of patients undergoing major gastrointestinal surgery, several recommendations are directed to modulate perioperative insulin sensitivity and the associated metabolic and catabolic consequences of the surgical stress response. For example, carbohydrate loading is recommended prior to gastrectomy, pancreaticoduodenectomy, oesophagectomy and liver surgery as this has been shown to increase insulin sensitivity and reduce insulin resistance in the postoperative period [dataset [12-15,27,28]]. ERAS pathways also recommend that gastrointestinal surgical patients should be maintained in fluid balance over the perioperative period. For example, ERAS pathways recommend against use of abdominal/chest drainage [dataset [12-17]]. Nevertheless, the multidisciplinary expert panel agreed that PPN can enable adherence to ERAS pathways in several ways. Importantly, ERAS guidelines advocate minimally invasive procedures, for example supporting laparoscopic surgery where possible and minimizing use of abdominal/chest drainage [dataset [12-17]]. Therefore, PPN, which does not require a central line, is aligned with the ERAS strategy of minimizing invasive procedures and can benefit selected patients who are in a catabolic state or at nutritional/metabolic risk. Consequently, patients who experience postoperative complications and who cannot be nourished adequately via oral or enteral routes could benefit from additional nutrition via PPN to bridge the nutritional gap. Furthermore, PPN also contributes to fluid replacement in patients who require nutritional support.

5. Who should be considered for PPN?

Several factors influence each patient’s metabolic/catabolic risk during the perioperative period. Some patients can be at particularly high risk due to their underlying disease. For example, patients with pancreatic cancer frequently experience altered glucose homeostasis, as well as abdominal pain and vomiting which impact oral intake [dataset [36,37]]. Tumour-related bowel obstruction, malabsorption due to gastrointestinal inflammation, and side effects of radiotherapy such as nausea and intestinal damage can also impact physiological reserves [dataset [30]]. Some surgical procedures can also impair a patient’s ability to receive oral nutrition during the early postoperative period, thereby contributing to metabolic risk. For example, patients undergoing oesophageal resection, gastrectomy or pancreaticoduodenectomy and can experience swelling, impaired gastric emptying or paralytic ileus, the latter being associated with an increased risk of aspiration pneumonia [dataset [4,38]]. The risk of metabolic/catabolic complications of surgery may also be heightened in frail patients. Sarcopenia, characterized by loss of muscle mass and muscle strength, was found to be predictive of severe postoperative complications (Clavien-Dindo Grade III or above) in gastric cancer patients undergoing radical gastrectomy [dataset [39-41]]. Sarcopenia is also associated with shorter recurrence-free survival and overall survival in patients undergoing gastrointestinal cancer surgery as well as higher healthcare costs in this setting [dataset [39,42-45]]. Furthermore, elderly patients may have age-comorbidities and/or age-related physiological changes that reduce their capacity to withstand the stress of surgery [dataset [27,30]]

For patients requiring major gastrointestinal surgery who are unable to receive sufficient nutrition orally and/or enterally during the perioperative period, PPN is feasible as complimentary nutrition to meet caloric and nutritional goals and limit the surgical stress response. This notion is supported by study of 53 patients with moderate or severe nutritional shortfalls who received PPN, most frequently following (40%) or prior to (15%) resection of gastrointestinal cancer, or due to small bowel fistulas (15%) [dataset [11]]. PPN enabled nutritional requirements to be achieved in over two-thirds of patients (68%) within 3 days [dataset [11]].
Based on the expert group’s experience, rationale for delivering nutrition via a PVC, considerations regarding patient selection, the timeframe for initiating PPN and how to administer PPN are summarized in Fig. 1. PPN may be administered to supplement limited oral and/or enteral intake at any time during the perioperative period, including postoperative day 1 and prior to surgery for patients at high risk of surgical stress response. As well as avoiding an invasive procedure and time delay establishing a CVC, PPN is also appropriate for patients with CVC complications such as infection or thrombosis. Also, while many cancer patients undergoing surgery have a central venous port or PICC line, oncologists may wish to reserve the central line to administer chemotherapy rather than using it for parenteral nutrition. Furthermore, compared with a nasogastric tube, PPN is considered less invasive and is better tolerated by some patients [dataset 

Thrombophlebitis is the most frequent complication of PVC, although the reported prevalence varies considerably across studies (2–80%), due in part to differences in survey selection, follow-up times and definitions of thrombophlebitis [dataset [10,47–50]]. As well as causing discomfort, thrombophlebitis necessitates rotation of venous access sites which can be painful and clinically challenging in some patients [dataset [10]]. However, several factors can reduce the risk of thrombophlebitis, including the composition of the infused solution. For example, the glucose content of high osmolarity solutions can be reduced by including lipids in the PPN composition as an alternate energy source.

### 6. How can the delivery of PPN be optimized?

#### 6.1. Catheter care

Thrombophlebitis is the most frequent complication of PVC, although the reported prevalence varies considerably across studies (2–80%), due in part to differences in survey selection, follow-up times and definitions of thrombophlebitis [dataset [10,47–50]]. As well as causing discomfort, thrombophlebitis necessitates rotation of venous access sites which can be painful and clinically challenging in some patients [dataset [10]]. However, several factors can reduce the risk of thrombophlebitis, including the composition of the infused solution. For example, the glucose content of high osmolarity solutions can be reduced by including lipids in the PPN composition as an alternate energy source.

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### Table 2

Examples of gastrointestinal surgical patients who may benefit from perioperative PPN.

| Patient characteristics | PPN timeframe |
|-------------------------|--------------|
| **Early postsurgical/rehabilitation phase** |  |
| Oncology patient undergoing esophagectomy, pancreatic or gastric resection | Consider PPN for ~7 days post surgery |
| Bariatric patient with anastomotic leakage or staple-line failure requiring remedial surgery including endoscopic repair |  |
| Patient with postoperative complications following gastric resection e.g. septic pneumonia, paralytic ileus or anastomotic complications including postoperative fistula e.g. duodenal stump leakage (‘rescue PPN’ to avoid a jejunostomy tube) | Consider PPN for a bridging period |
| **Late postsurgical/rehabilitation phase** | Consider supplemental PPN to prevent malnutrition in the first month after surgery |
| Patient adjusting to feeding tube following esophagectomy |  |
| Patient intolerant to tube feeding (e.g. severe diarrhea) | Consider PPN up to 10 days before surgery |
| **Presurgical/prehabilitation phase** | Consider inpatient and/or outpatient PPN delivery |
| Patient with pancreatic cancer experiencing anorexia/cachexia/sarcopenia and significant weight loss |  |
| Patient with esophageal stenosis and dysphagia refusing a nasogastric feeding tube during neoadjuvant treatment |  |
| Patient with large, symptomatic hiatus hernia impacting oral/enteral intake |  |
| Patient with severe edema following neoadjuvant radio/chemotherapy for esophageal cancer |  |

EN, enteral nutrition; GI, gastrointestinal; ICU, intensive care unit; ONS, oral nutritional supplements; PPN, peripheral parenteral nutrition.

The clinical scenario captured in this table are examples and do not represent an exhaustive list.

* Oral or enteral intake do not meet caloric/nutrient requirements (PPN administered in conjunction with ONS and/or EN to reach nutritional requirements. If the nutritional goals cannot be achieved, consider administering complete parenteral nutrition via a central venous catheter).

* Administration of parenteral nutrition via central venous line is not feasible/appropriate.
thoroughly lessening the risk of thrombophlebitis as well as a supplying essential fatty acids and omega-3 fatty acids (if fish oil is included in the lipid emulsion)[dataset [9–11,50,51]]. In addition, lipids can exert a protective effect on the vascular epithelium [dataset [11,50]][dataset [10,11]][dataset [10,11]]. Catheter material and catheter placement. Catheters should be flexible and inert (to avoid mechanical trauma and venous irritation), with polyurethane and silicone catheters having lower thrombogenic potential than polyvinyl catheters [dataset [10]]. Locating catheters in large vessels away from flexures may also reduce the incidence of thrombophlebitis [dataset [10]], and use of a small diameter cannula may result in a high velocity of flow and fast dilution of the infusion solution.

Based on the authors’ clinical experience, thrombophlebitis and catheter-related infections can be minimized by implementing protocols addressing catheter care. Key aspects of the catheter care protocols used at the authors’ institutions are summarized in Table 3. This includes close monitoring of patients, with daily inspection of the infusion site and clinically driven catheter replacement. A recent Cochrane review also supports this approach, with removing and re-siting of catheters only if signs of inflammation, infiltration or blockage are present [dataset [52]]. Indeed, clinically driven catheter replacement can avoid pain associated with routine catheter re-siting and reduce time pressures on healthcare providers (HCPs) [dataset [52]]. Infection prevention is also critical, including hand hygiene, preparation of the insertion site with chlorhexidine solution, needle-free connectors and other sterile catheter management approaches (Table 3). Insertion, inspection, care and replacement of PVCs should also be undertaken by an experienced i.v. therapy team who are trained on catheter care and PPN delivery. It is noteworthy that studies across a range of inpatient settings support the use of multimodal peripheral catheter care protocols to reduce the prevalence of PVC-associated complications, including infection and thrombophlebitis[dataset [47,53]].

6.2. Avoidance of overfeeding

Rapid reintroduction of nutrition to severely malnourished patients under metabolic/catabolic stress can result in adverse metabolic changes, termed refeeding syndrome, which result from a rapid decline in gluconeogenesis and anaerobic metabolism, mediated by rising serum insulin levels [dataset [54]]. This can elicit a range of symptoms from nausea, vomiting and lethargy to respiratory insufficiency, cardiac failure, hypotension and delirium, and clinical deterioration can be rapid [dataset [54]]. Consequently, awareness of refeeding syndrome is important among HCPs caring for vulnerable patients who require nutritional support. Overfeeding patients during the perioperative period should therefore be avoided. Indeed, ESPEN guidelines on clinical nutrition in surgery recommend parenteral nutrition to be increased step-wise in severely malnourished patients alongside laboratory and cardiac monitoring to avoid refeeding syndrome [dataset [1]]. The expert panel recommend that for severely malnourished patients the caloric load delivered by PPN should be gradually increased over a period of approximately 3 days according to the individual’s needs. When providing PPN to these vulnerable patients, HCPs should consider any additional nutrition they may be receiving orally or enterally as well as non-nutritive sources including lipids such as propofol.

6.3. Multidisciplinary care

Although not widespread practice in many countries, a multidisciplinary HCP team caring for patients’ during the perioperative period (e.g., surgeon, radiologist, clinician, nurse specialist, pharmacist and dietician) is best placed to optimize the provision of nutritional therapy [dataset [55]]. Overall responsibility for coordinating this care is often provided by the lead physician or surgeon, with nurses playing a pivotal role in the placement and care of PVCs, inspection of the infusion site and PPN administration. The expert group supports the practice of the lead physician/surgeon and nurse specialist working as a pair to facilitate close collaboration among the nutritional support team members. The practice of lead physician/surgeon–nurse specialist tandem can help to ensure each patient’s nutritional needs are quickly identified and addressed both before and after surgery using the most appropriate intervention.

7. What evidence from clinical trials and observational studies supports perioperative use of PPN?

There are limited studies directly investigating the impact of PPN in gastrointestinal surgical settings. However, available data

| Table 3 | Suggestions for catheter care based on experts’ clinical practice. |
| --- | --- |
| PVC sitting and selection [8,50] | • Forearm peripheral vein preferred  
  – Replacement PVC inserted into contralateral forearm  
  – Avoid using lower extremity peripheral veins, femoral vein and jugular vein (associated with increased risk of catheter contamination)  
  • Appropriate catheter selection  
  – 20–22 gauge polyurethane may facilitate flow and lower the risk of clotting |
| Clinically driven catheter replacement [52] | • Daily inspection of the infusion site  
  – Catheter replaced if infection, blockage or infiltration is suspected  
  • Maximum time PVC catheter in situ: 2–7 days  
  • Hand hygiene and sterile gloves  
  • Sterile catheter management including 2% chlorhexidine skin preparation  
  – Wait 60 s before dressing  
  • Catheter flushed with saline before and after each use  
  – Disused catheters are flushed every 24 h or locked  
  • Regular change of administration sets, disinfection of hubs, stopcocks and needle-free connectors before access  
  • Use of cannular valves  
  • Clinical case discussions  
  • Refer to local hygiene and infection protocols |

PVC, peripheral venous catheter.
Table 4
Clinical trials and observational studies supporting perioperative PPN for major gastrointestinal surgery.

| Study design | Patients | Key outcomes |
|--------------|----------|--------------|
| **Studies of preoperative PPN** | | |
| Haffejee et al., 1985 [dataset [56]] | • Single-arm, observational study; • PPN (amino acids, glucose, lipid, vitamins and trace elements [-1800 kcal of non-protein energy]) administered for 14 days prior to oesophageagastrostomy or gastric bypass surgery | • Oesophageal squamous carcinoma (N = 15) • Serum albumin <3.5 g/dL • Weight loss >10 kg • Decreased food intake >2 weeks • PPN prevented further weight loss and depletion of lean body mass • Lower than anticipated incidence of postoperative complications, including no major infections or anastomotic leakage despite patients considered at high risk of complications |
| Liu et al., 2013 [dataset [57]] | • Rectal cancer (N = 40) ○ Received PPN: n = 25 ○ No PPN: n = 10 • Malnutrition Screening Tool Score ≥2 | • PPN vs no PPN patients experienced: − higher postoperative albumin levels (2.5 vs 1.9 g/dL, p < 0.001) − earlier ambulation (3.0 vs 4.9 days, p < 0.05) − shorter postoperative hospital stay (18.2 vs 33.7 days, p < 0.05) • No patients who received PPN experienced sepsis vs >25% in no PPN group |
| Kruger et al., 2016 [dataset [58]] | • Biligencratic lesions (N = 82) ○ PPN: n = 42 ○ IES: n = 40 | • Despite comparable oral intakes on non-fasted hospital days, body weight increased in PPN group only (mean [95% CI] gain: 1.7 kg [0.204, 3.210] vs IES, p = 0.027) • Impact of PPN on body weight was particularly marked in cancer patients (mean [95% CI] gain: 2.7 kg [0.71, 4.76] vs IES, p < 0.01) • One case of thrombophlebitis was observed with PPN |
| Hsieh et al., 2015 [dataset [26]] | • Right lobe liver donors (N = 84) ○ PPN: n = 44 ○ No PPN: n = 40 • Residual liver volume <50% | • PPN vs no PPN patients experienced: − more rapid recovery from hyperbilirubinemia (p < 0.001) − lower incidence of pleural effusion (4.5% vs 25%, p = 0.01) − lower incidence of anastomotic leakage (27.5% vs 23%, p = 0.001) − shorter hospital stay (18.2 vs 33.7 days, p < 0.05) |
| Jin et al., 2018 [dataset [59]] | • Gastric cancer (N = 80) ○ PPN: n = 44 ○ No PPN: n = 40 | • PPN vs no PPN patients experienced: − higher levels of albumin, prealbumin and haemoglobin (each, p < 0.05) − higher quality of life scores (EORTC QLQ-C30, p < 0.05) − higher psychological wellbeing scores (HADS-Anxiety, p < 0.05; HADS-Depression, p < 0.01; PHQ-9, p < 0.01) − improved immune function (CD3+, CD4+ and CD4+/CD8+ peripheral blood mononuclear cell counts, all p < 0.05) |
| Cys et al., 1990 [dataset [60]] | • Colorectal surgery (N = 20) ○ PPN: n = 10 ○ IV fluids: n = 10 | • PPN vs IV fluid patients experienced improved nitrogen balance over days 1–5 (p < 0.001), indicating a positive impact on protein loss • Greater incidence of phlebitis leading to catheter change with PPN vs IV fluid (day 3: 100% vs 50%) |
| Cooper et al., 2006 [dataset [61]] | • Esophago-gastric cancer (N = 27) ○ PPN: n = 16 ○ IV fluids: n = 11 | • PPN vs IV fluids patients experienced − lower 30-day (0% vs 18%) and 90-day (0% vs 36%: p < 0.05) mortality − comparable duration of hospital stay (median 10 days) • Two cases of thrombophlebitis were observed in PPN patients |

CL confidence interval; EORTC QLQ-C30, European Organization for Research and Treatment of Cancer Quality of Life Questionnaire; HADS, Hospital Anxiety and Depression Scale; IES, isotonic electrolyte solution; IV, intravenous; PHQ, Patient Health Questionnaire; PPN, peripheral parenteral nutrition.

* Studies captured in this table are based on a non-systematic literature search.

** Patients considered at high risk of complications.

** 16 of 20 patients underwent surgery due to colorectal cancer.

8. Algorithm to deliver PPN in the context of ERAS

Based on European clinical guidelines and experience of the expert panel, an algorithm was developed to assist HCPs to deliver nutritional support to selected patients undergoing gastrointestinal surgery, within the context of the ERAS pathway (Fig. 2). Firstly, in accordance with ERAS pathways and ESPEN guidance on clinical nutrition in surgery, all patients should be screened for metabolic/catabolic stress and nutritional risk prior to surgery [dataset [1,12,13,17]]. The impact of both the underlying disease and surgical procedure on nutritional requirements should be considered. Screening should be conducted
using an appropriate tool such as Global Leadership Initiative on Malnutrition (GLIM) criteria which require one or more phenotypic criterion (involuntary weight loss, low body mass index [BMI], or reduced muscle mass) and at least one aetiologic criterion (reduced food intake/assimilation, or inflammation or disease burden). Alternatively, ESPEN recommend two diagnostic criteria: low BMI, or unintentional weight loss combined with either reduced BMI or low fat free mass index. Nutritional support should be provided promptly to all patients identified at nutritional risk to prevent or correct undernutrition, even if this necessitates delaying surgery for a short period. Screening for nutritional risk should be repeated in all patients after surgery to ensure that the nutritional status can be maintained when prolonged fasting and/or catabolism is anticipated.

Nutritional support should be managed by a specialist team with regular follow-up. In line with the ERAS approach of minimally invasive treatment where possible, perioperative parenteral nutrition should be provided if the patient’s nutritional goals cannot be met by oral or enteral routes alone, and administered peripherally if a CVC is not available (Fig. 2).

**9. Summary and outlook: Improving nutritional support for patients undergoing major gastrointestinal surgery**

Improved awareness of the adverse impact of poor nutritional status as well as metabolic stress on patients undergoing major gastrointestinal surgery and the benefits of timely and appropriate nutritional support, which include shorter hospital stay, fewer complications and improved patient wellbeing, is warranted. Implementation of ERAS recommendations for perioperative nutritional support can help to optimize patient outcomes. However, in line with ESPEN guidelines in clinical nutrition in surgery, ERAS evidence-based nutrition recommendations for gastrointestinal surgery are focused on oral and enteral intake. Indeed, ERAS evidence-based guidance on nutritional support for patients whose needs cannot be met by oral or enteral routes is limited, likely due to limited clinical studies on PPN in this setting. For patients undergoing major gastrointestinal surgery, PPN can facilitate the provision of timely nutritional support during the perioperative period by avoiding the need for invasive CVC insertion, in line with ERAS concept of minimizing invasive procedures where possible.

PPN is generally well tolerated, and side effects such as thrombophlebitis can be largely avoided when venous access and care are carried out in accordance with catheter care protocols by appropriately trained HCPs. With this in mind, the expert panel developed an algorithm to support the identification and management of patients’ perioperative nutritional needs (Fig. 2). Use of perioperative PPN in selected patients can help to maintain the nutritional status and reduce the surgically induced stress response, thereby preventing adverse metabolic consequences following the demands of major gastrointestinal surgery. The practical guidance summarized by this expert panel may facilitate HCPs to provide timely nutritional interventions to gastrointestinal surgery patients, thereby helping to improve postoperative clinical outcomes and patients’ quality of life.

**Statement of authorship**

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All authors agree to be fully accountable for ensuring the integrity and accuracy of the work, and read and approved the final manuscript.

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**Declaration of competing interest**

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