REVIEW

The malnourished surgery patient: a silent epidemic in perioperative outcomes?

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Purpose of review
As many as two of every three major surgery patients are malnourished preoperatively – a diagnosis rarely made and treated even less frequently. Unfortunately, perioperative malnutrition is perhaps the least often identified surgical risk factor and is among the most treatable to improve outcomes.

Recent findings
Two important perioperative nutrition guidelines were published recently. Both emphasize nutrition assessment as an essential component of preoperative screening. The recently published perioperative nutrition screen (PONS) readily identifies patients at malnutrition risk, allowing for preoperative nutritional optimization. The use of computerized tomography scan and ultrasound lean body mass (LBM) evaluation to identify sarcopenia associated with surgical risk and guide nutrition intervention is garnering further support. Preoperative nutrition optimization in malnourished patients, use of immunonutrition in all major surgery, avoidance of preoperative fasting, inclusion of postoperative high-protein nutritional supplements, and early postoperative oral intake have all recently been shown to improve outcomes and should be utilized.

Summary
The recent publication of new surgical nutrition guidelines, the PONS score, and use of LBM assessments will allow better identification and earlier intervention on perioperative malnutrition. It is essential that in the future no patient undergoes elective surgery without nutrition screening and nutrition intervention when malnutrition risk is identified.

Keywords
immunonutrition, lean body mass, malnutrition, muscle, nutrition, nutrition screening, oral nutrition supplement, protein, sarcopenia, ultrasound

BACKGROUND

Perioperative malnutrition is a known independent predictor of poor postoperative outcomes. In fact, it has been determined that malnourished surgical patients experience higher postoperative mortality, morbidity, length of stay (LOS), hospital readmission rates, and hospital costs [1,2]. Data from the *National Surgical Quality Improvement Program* demonstrate that malnutrition is among the only major readily modifiable preoperative risk factors associated with poor surgical outcomes, including mortality [2]. Although much attention has been paid to the physiological and pharmacological management of the surgical patient, the importance of perioperative nutrition optimization continues to be poorly appreciated as shown by our recent survey of perioperative nutrition practices [3]. It is estimated that greater than one in every three hospitalized patients is malnourished at hospital admission and the healthcare cost and utilization project indicates that only 3% of these patients are being properly identified and diagnosed during their hospitalization [4]. Consequently, only 1 in 10 malnourished patients are ever diagnosed and even fewer are effectively treated. Also concerning is that a diagnosis of malnutrition rarely leads to adequate intervention. Large dataset analysis of approximately 2 million hospitalized U.S. patients who were diagnosed with malnutrition reveals that less than 7% of these malnutrition-related hospital stays included nutrition intervention aimed at improving nutrition in a meaningful way [4]. Accordingly, only 1 in 100 malnourished patients in U.S. hospitals are treated for

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KEY POINTS

- Perioperative malnutrition is a critically underdiagnosed modifiable surgical risk factor that is associated with preventable adverse surgical outcomes.
- All patients undergo preoperative nutrition screening with the PONS is essential to identify patients in need of perioperative nutrition therapy.
- Measurement of LBM via CT scan and ultrasound demonstrates sarcopenia, shows associations with poor surgical outcome/increased hospital costs, and may be used to guide nutrition intervention.
- Preoperative nutrition optimization in malnourished patients for more than 10 days, use of immunonutrition in all major surgery, and early postoperative oral intake have all recently been shown to improve surgical outcomes.
- All major surgical patients should consume high protein oral nutrition supplements postoperatively to reduce length of stay and continue for at least 1-month posthospital discharge to optimize recovery.

malnutrition. Truly, malnutrition is a silent epidemic occurring daily in our care of patients.

Perioperative medicine is an emerging specialty that emphasizes medical care of patients from the time of contemplation of surgery through the operative period to full recovery [5▪▪]. As the role of the anesthesiologist is being redefined, fundamental to perioperative medicine is a coordinated, multidisciplinary care team model aimed at utilizing evidenced-based best practice techniques to optimize patient comorbidities to maximize successful patient outcomes [5▪▪]. Recently published key evidenced-based consensus surgical guidelines indicate that malnutrition is a key modifiable preoperative risk factor associated with poor surgical outcomes that we must address [6▪▪,7▪▪,8]. We must, therefore, improve our ability to preoperatively identify the patient at risk for perioperative malnutrition and utilize evidence-based nutrition optimization techniques if we are to improve surgical outcomes and deliver cost-effective medical care.

HOW CAN WE IMPROVE IDENTIFICATION OF THE MALNOURISHED SURGICAL PATIENT: THE PERIOPERATIVE NUTRITION SCREEN SCORE

Preoperative identification of the malnourished surgical patient is paramount to improving nutrition status during the perioperative period [6▪▪,7▪▪,8]. Screening for malnutrition prior to elective surgery can identify patients at risk for malnutrition who may benefit from preoperative nutritional intervention. The risk of perioperative malnutrition is often most significant for oncologic and gastrointestinal surgeries, where two out every three patients presenting for surgery are malnourished preoperatively [9,10]. These high-risk surgeries are also often targeted by enhanced recovery programs allowing for more meaningful optimization to occur [6▪▪,11▪▪]. Although several screening tools have been validated for use in hospitalized patients, no universally accepted screening tool for preoperative malnutrition risk has been available. A key recent publication from the Perioperative Quality Initiative recommends use of the perioperative nutrition screen (PONS) for preoperative assessment of malnutrition (see Fig. 1) [6▪▪]. PONS was developed as a modified version of the well-validated malnutrition universal screening tool and identifies nutrition risk on the basis of commonly utilized malnutrition questions. Each question, including an albumin level less than 3 is assigned 1 point for a 'positive' response (maximum PONS score of 3). Perioperative malnutrition risk is further assessed on the basis of the patient's preoperative vitamin D and albumin levels (Fig. 1). Any patient with PONS $\geq$1 (any positive response to first three questions) and/or an albumin less than 3 (and/or a vitamin D $<$ 20) is considered high risk for perioperative malnutrition [6▪▪] and should receive preoperative nutrition intervention prior to surgery as described below. If available, referral to a registered dietician for further preoperative nutritional evaluation is also suggested. It has been shown that underweight patients (BMI levels $<$ 18.5 kg/m^2 for adults $<$65 years old) undergoing major surgery have an increase in postoperative complications [12,13]. A

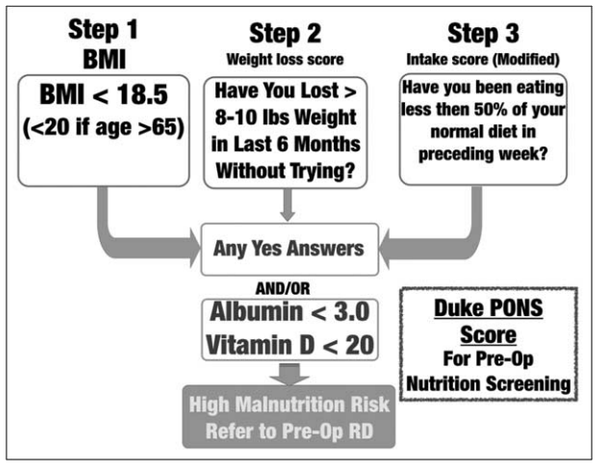

FIGURE 1. PONS assessment tool (PONS; adapted from reference [6▪▪]). *PONS*, Preoperative nutrition score. Any score $\geq$ 1 signifies malnutrition risk, and the patient should receive pre-operative nutrition therapy before undergoing surgery.

longitudinal study by Sergi *et al.* [12] described the nonsurgical risk of malnutrition on the basis of age and found that the risk for all-cause mortality increases starting at a BMI of 24 kg/m^2 for patients more than 65 and doubles when BMI is less than 22 kg/m^2 for men and less than 20 kg/m^2 for women. The PONS, therefore, is based on this association between BMI and all-cause risk and uses a higher BMI (<20 kg/m^2) for adults more than 65 years as it is suggested that higher BMI thresholds should be used for older adults. Irrespective of BMI, unintentional weight loss has been associated with negative postoperative outcomes including morbidity and functional decline [14]. Although limited as a nutritional marker in postoperative setting and states of systemic inflammation, albumin has been long utilized as malnutrition indicator and preoperative albumin levels are a strong predictor of postoperative complications, including mortality [15,16]. Collectively, these components contribute to a thorough preoperative malnutrition screening tool.

The PONS allows quick and efficient preoperative malnutritional risk identification and should be routinely performed on all patients coming for major surgery during preoperative assessment. Delaying major elective surgery should be considered in patients with any positive finding on PONS score, which identifies patient as being at risk for malnutrition, to allow for adequate nutrition optimization [6▪▪]. Although the optimal time period for preoperative nutrition optimization is unclear, it appears that a minimum of 7–10 days should occur, and the risk of disease progress from delaying surgery should be weighed against the significant risk of operating on a malnourished patient.

ROLE OF LEAN BODY MASS AND SARCOPENIA IN SURGICAL OUTCOMES

Sustained malnutrition can lead to the reduction in quantity and quality of lean body mass (LBM) – sarcopenia. Within the last 10 years, this syndrome has received increasing attention as a possible predictor of adverse outcomes after surgery [17,18]. In contrast to traditional perioperative nutritional assessments that typically focus on weight loss and serum markers of nutrition (i.e., serum albumin levels), sarcopenia is a potentially much more objective indicator of nutritional and metabolic reserve prior to surgery [19▪▪]. Currently, sarcopenia largely remains undiagnosed [20,21] as it is often difficult to differentiate from overall weight loss, especially in obese patients [22]. Computerized tomography (CT) scan LBM analysis has begun to be utilized and studied around the world to assess preoperative 'metabolic reserve' and 'fitness for surgery' [19▪▪]. This innovative technique may effectively identify patients at higher risk for malnutrition and poor surgical outcomes [19▪▪].

In surgical patients, a rapidly growing body of literature demonstrates that low baseline LBM may be an independent risk factor for complications in patients undergoing hepatic [23] colorectal [24,25], diverticular [26▪], and pancreatic [27] oncological surgery. These findings are supported by a recent metaanalysis evaluating sarcopenia as a predictor of postoperative complication risk postgastrointestinal cancer surgery [28▪▪]. Twenty-nine studies ($n = 7176$) were evaluated utilizing a range of CT scan sarcopenia measures and found that perioperative sarcopenia prevalence ranges from 12 to 78%. Preoperative sarcopenia was associated with increased risk of major complications (risk ratio 1.40; 95% confidence interval (CI) 1.20–1.64; $P < 0.001$) and total complications (risk ratio 1.35; 95% CI 1.12–1.61; $P = 0.001$). Although sarcopenia was associated with an increased risk of complications after gastrointestinal tumor resection, these retrospective studies lack methodological consensus, limiting interpretation and clinical utilization of these findings [28▪▪].

Sarcopenia carries a significant health cost burden. For patients undergoing major general or vascular surgery, decreasing LBM is associated with increased insurer costs. Sarcopenic patients had a mean payer cost of $34,796 versus $21,380.6 in nonsarcopenic patients [29]. Further, CT analysis of LBM in 452 patients (median age 65, 61.5% males) undergoing surgery for colorectal cancer (38.9%), colorectal liver metastases (27.4%), primary liver tumors (23.2%), and pancreatic/periampullary cancer (10.4%) showed that 45.6% had sarcopenia and post-adjustment for confounders; low LBM was associated with a cost increase of €4061 ($P = 0.015$) [30▪▪]. Thus, initial data indicate that in some surgical populations, sarcopenia is independently associated with increased costs. Sarcopenia treatment with nutrition and exercise interventions may reduce hospital costs in an era of escalating healthcare costs and an increasingly ageing population [31▪▪].

Given observational evidence for role of LBM is perioperative outcome, we currently require prospective trials examining LBM and surgical outcomes. We urgently need objective methods to preoperatively measure sarcopenia and define objective risk cutoffs for sarcopenia-based measures on the basis of magnitude and type of surgical intervention. Further, as CT scan is not practical for all patients to undergo for LBM assessment alone and not realistic for longitudinal measures, the use of bedside ultrasound for LBM measurement has become an ideal option. To address the potential role of low LBM in perioperative optimization, a highly innovative and novel muscle-

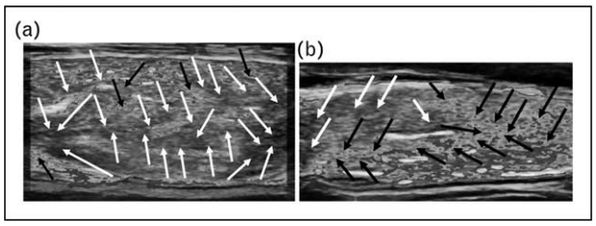

FIGURE 2. Example of muscle sound lean body mass loss over hospital stay is ICU Patient: (A) ICU admit and (B) ICU Day10. Note loss of muscle mass/size and lower muscle glycogen content and high intramuscular adipose tissue (IMAT) at Day 10. Rectus femoris muscle shown In short-axis: Black arrows = low muscle glycogen content, high IMAT; white arrows = high muscle glycogen content, low IMAT.

specific ultrasound device has been developed (Musclesound, Denver, CO). This new ultrasound technology provides bedside measures of LBM, intramuscular glycogen, and intramuscular adipose tissue (IMAT) (e.g., see Fig. 2). IMAT has recently been correlated to muscle strength [32▪]. Intramuscular glycogen ultrasound measures have been validated via muscle biopsy [33] and we showed acutely ill patients have significant intramuscular glycogen deficits [34▪▪]. Intramuscular glycogen is known to change daily on the basis of adequacy of nutrition intake and 'physical stress' and could prove useful in monitoring nutrition delivery and utilization in perioperative patients [35▪▪]. This promising technology requires investigation in the perioperative setting. In closing, LBM could serve as a key predictor of preoperative risk and aid in identifying patients in need for preoperative optimization.

PREOPERATIVE NUTRITION OPTIMIZATION IMPROVES SURGICAL OUTCOMES

A summary of our structured perioperative nutrition protocol is shown in Fig. 3. Undergoing surgery elicits a state of metabolic and physiologic stress on the human body and there is an increase in production of hepatic acute phase protein synthesis, proteins involved in immune function, and proteins required for wound healing [6▪▪,7▪▪,8]. Perioperative fasting can exacerbate the surgical stress response and intensify protein loss; so, preoperative fasting should be avoided.

Protein intake requirements are therefore increased and when protein intake is insufficient to meet increased demands of protein synthesis, LBM breakdown becomes the source of amino acid. Although optimal protein intake for surgical patients has yet to be definitively determined, current nutrition guidelines suggest intake of a minimum of 1.2–2.0 g of protein/kg/day for stressed patients [6▪▪]. Several studies show that consuming 25–35 g of protein in a single meal maximally stimulates muscle protein synthesis; therefore, daily

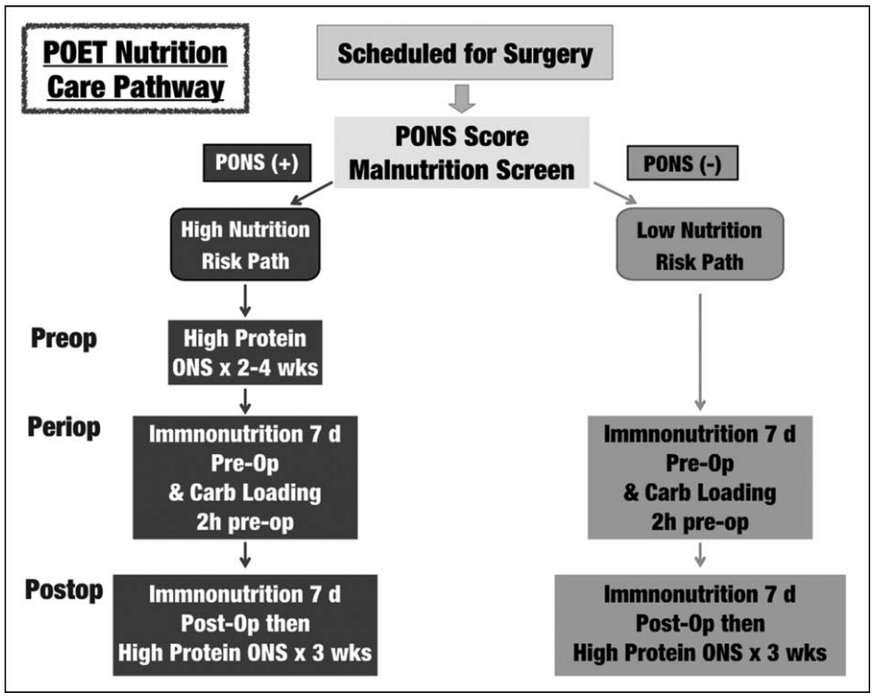

FIGURE 3. Perioperative nutritional care pathways used in Duke Perioperative Enhancement Team Nutrition Program.

protein requirements for patients at malnutrition risk should be addressed by consumption of 25–35 g of protein – particularly whey protein and casein – at every meal to provide high-quality amino acids required to stimulate LBM synthesis [36,37].

The time required for adequate preoperative nutrition optimization and a gold standard marker to quantify optimization progress has not yet been identified. Recent consensus recommendations from the North American Surgical Nutrition Summit emphasize that nutritional care should be established preoperatively for both malnourished and normal nourished patients to foster optimal nutritional status throughout perioperative period [38].

In patients with low risk of perioperative malnutrition [i.e., PONS < 1 and albumin (ALB) > 3.0], high-protein, complex carbohydrate-rich diets should be consumed preoperatively [6▪▪]. Many patients will not be able to meet the suggested perioperative energy goals of 25 kcal/kg/day and 1.5–2 g/kg/day of protein solely from food intake. Thus, it is recommended to encourage patients to take high-protein oral nutritional supplements (HP-ONSs). Immunonutrition (IMN, containing arginine/fish oil) has numerous trials over many years supporting its use in all patients having major gastrointestinal, cardiac, and ear, nose, and throat surgery. This benefit is independent of malnutrition risk and should be utilized in all major surgery patients, where it has been shown to reduce infections and complications by approximately 40% and significantly shorten length of stay [39]. This association has shown to be true not only when IMN is used in enhanced recovery after surgery (ERAS) pathways [40] but also in a large scale prospective cohort study with a propensity score-matched comparative effectiveness evaluation [41▪].

Patients determined to be at risk of malnutrition (i.e., PONS > 1 or ALB < 3.0) should be prescribed HP-ONS prior to any elective surgery for 2–6 weeks [6▪▪,42▪▪]. These patients should consume a minimum of 1.2 g/kg/day total of protein and the HP-ONS should contain more than 18 g/protein/serving given at least twice a day [6▪▪]. Follow-up of patient compliance with oral nutritional supplement (ONS) intake is essential for benefit [6▪▪].

As the role of the anesthesiologist expands to include perioperative nutrition optimization, dieticians are integral to the perioperative care team. For malnourished patients who cannot meet protein/calorie requirements via oral nutrition, a dietician should be consulted and home enteral nutrition initiated for a period of at least 7 days preoperatively. Preoperative parenteral nutrition should be utilized in patients with malnutrition when more than 50% of recommended kcal/protein requirement cannot be adequately met by ON or enteral nutrition [6▪▪].

MANAGEMENT OF POSTOPERATIVE NUTRITION

Early oral feeding immediately postmajor surgery, including gastrointestinal surgery, is associated with a decrease in postoperative complications, LOS, and hospital costs [6▪▪,7▪▪,42▪▪]. Specifically, convincing evidence shows that feeding within 24 h of gastrointestinal surgery decreases mortality and major morbidities [43]. High-protein diets are essential to assist in maintaining lean muscle mass in the postoperative period [6▪▪]. Therefore, except for patients with bowel discontinuity, ischemia, or obstruction, a high-protein diet should be initiated within 24 h postsurgery and overall protein intake goals are more important than total calorie intake in the postoperative period [6▪▪]. Patients tolerating 50–100% of nutrition goals should receive HP-ONS (2× day) to meet protein needs. A high-impact recent trial conducted in colorectal surgery patients within an ERAS/enhanced recovery program pathway demonstrated that in patients receiving HP-ONS postoperatively, to achieve consumption of more than 60% of protein needs over first three postoperative days was associated with a 4.4-day reduction in length of stay ($P < 0.001$) [44▪]. For patients consuming less than 50% via the oral route, a dietician should be consulted and enteral nutrition should be administered. Any patient who cannot achieve more than 50% of protein/calories requirement by ONS or enteral nutrition should receive parenteral nutrition for more than 7 days, in combination with enteral nutrition where feasible [6▪▪].

POSTOPERATIVE NUTRITION IS ESSENTIAL TO CONTINUED RECOVERY AFTER HOSPITAL DISCHARGE

Perioperative nutrition optimization does not end at hospital discharge. Recovering postoperative patients, particular the elderly, often experience decreased appetites, persistent nausea, constipation from opiate use, and lack of education about diet optimization [6▪▪,45▪]. An observational study of patients after ICU discharge showed an average spontaneous calorie intake of 700 kcal/day, which is far insufficient to support anabolism as a caloric intake of 1.2–1.5× resting energy expenditure is recommended and thought to be required [6▪▪,45▪,46]. To facilitate continued recovery from the physiological stress of surgery, it is important to continue nutrition optimization therapy postdischarge [45▪]. This is supported by metaanalysis data

demonstrating that ONS use reduces mortality, hospital complications, hospital readmissions, LOS, and hospital costs [47,48]. In a retrospective analysis of a large hospital dataset, Philipson *et al.* [49] matched 724,000 patients who received ONS with controls not receiving ONS and demonstrated a 21% reduction in hospital LOS. In fact, for every $1 spent on ONS, $52.63 was saved in hospital costs [49]. Similar findings are echoed in major randomized trial of 652 patients in 78 centers studying effect of HP-ONS with β-hydroxy β-methylbutyrate versus placebo ONS [50]. Results demonstrate that elderly hospitalized patients at risk for malnutrition benefitted from HP-ONS, with reduced 90-day mortality by approximately 50% relative to placebo (4.8% versus 9.7%; relative risk, 0.49; 95% CI 0.27–0.90; $P = 0.018$) [49]. Therefore, strong societal guideline recommendations indicate that HP-ONS should be consumed in all patients having major surgery for at least 4–8 weeks postoperatively [6▪▪] and should be continued for up to 3–6 months postoperatively in more severely malnourished patients or patients with prolonged postoperative or ICU courses.

CONCLUSION

The malnourished surgical patient is underdiagnosed and undertreated – truly a silent epidemic in perioperative outcomes. HP-ONS and immunonutrition can mitigate the surgically induced metabolic response, immune-suppression, and support optimal postoperative recovery. We need further key prospective Randomized Controlled Trials to determine the optimal method to identify the surgical patient at nutrition risk using tools like the PONS score (Fig. 1) and LBM sarcopenia analysis. We also need study of ideal length of time required for preoperative nutrition optimization and large trials of the structured POET nutrition care pathways (Fig. 3). *In total, it is now abundantly clear that we have a call to action to ensure that in the future no patient undergoes elective surgery without nutrition screening and structured nutrition intervention.*

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Conflicts of interest

There are no conflicts of interest.

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- ▪ of special interest
- ▪▪ of outstanding interest

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