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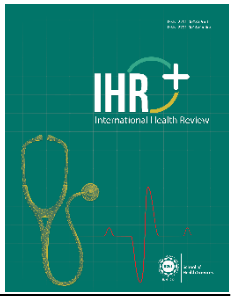


**Title:** **Evaluation of Pre- and Post-operative Nutritional Status of Gastrointestinal Surgery Patients**

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# Evaluation of Pre- and Post-operative Nutritional Status of Gastrointestinal Surgery Patients

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## ABSTRACT

Malnutrition is highly prevalent in patients undergoing gastrointestinal (GI) surgeries, and is associated with adverse health outcomes. Both pre- and post-operative nutritional status assessment of these patients may help timely diagnose and manage health complications. The current study aimed to assess the nutritional status of GI surgery patients both before and after surgery and then determined associations between both values. The study was a prospective observational cohort one that utilized convenience sampling to collect data from 75 GI surgery patients admitted in a local tertiary care settings. Data was collected on socio-demographics, anthropometric and biochemical parameters, as well as clinical signs and symptoms. Paired t-test was used to assess associations after data was analyzed on SPSS version 23. Approximately, 52% of the study sample comprised males and 32.2% patients had undergone cholelithiasis surgery. White blood cells (WBCs) ($p = 0.000$) and lymphocyte count ($p$ = 0.015) were both statistically significant for pre- and post-operative associations. However, Body Mass Index (BMI), hemoglobin, hematocrit, and creatinine levels were not found to be statistically significant. Malnutrition is common among those with GI issues and surgeries. Nutrition assessment prior to surgery and timely nutrition interventions can help prevent and manage complications arising from poor nutritional status in these patients.

**Keywords:** anthropometric and biochemical indicators, gastrointestinal surgery, malnutrition, nutritional assessment, postoperative outcomes

## 1. INTRODUCTION

Gastrointestinal (GI) problems are increasingly becoming a matter of concern among people of all ages worldwide [1]. If identified in the initial

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stages, most GI issues can be managed without any medical interventions [2]. However, in certain GI conditions, medications become inevitable for disease management. Furthermore, problems arising within the gut are often anatomical or functional in nature, requiring surgical intervention [3].

Patients undergoing gastrointestinal surgery often suffer from malnutrition. This puts them at a high risk of infections, increased morbidity and mortality, delayed wound healing and hospital discharge as well as higher healthcare expenditures. It is estimated that 19-50% of gastrointestinal patients are malnourished during the time of surgery, which acts as an independent variable in associated peri-operative complications [4]. It is therefore, imperative to carry out a nutritional assessment to determine an individual's nutritional status, especially those who are at a risk of being malnourished prior to or after surgery. Nutritional assessment involves the systematic procedure of gathering and interpreting nutrition-related parameters [5].

The pre-operative nutritional status of an individual is quite important in predicting post-operative complications [6]. Evidence suggests that patients undergoing surgeries with a better nutritional status have better post-operative outcomes and decreased length of hospital stay than those with a compromised nutritional status [7]. GI problems interfere with gut functions until a full recovery is made. Surgical procedures can disrupt the anatomy and physiology of the GI tract, some of which have severe consequences than others [8]. Resections of the stomach, small intestine, and large intestine significantly influence the absorption of nutrients and drugs. This means that these patients are at a greater risk of experiencing malnutrition after tumor or organ resection. This is why nutritional interventions both before and after surgery hold great importance [9].

Even though the relationship between procedures involving the gut and a person's nutritional status is quite evident, few studies have focused on the nutritional aspects of surgeries. If nutrition-related problems, such as micronutrient deficiencies, muscle wasting or malnourishment are assessed well before the surgery, the risk of post-surgery complications and increased length of hospital stay could be decreased [10]. Thus, the nutritional status of patients prior to surgery can be somewhat predictive of the patient's prognosis post-surgery [11]. The current study aimed to determine the pre-and-post operative nutritional status of patients undergoing major GI surgeries. Additionally, the study predicted that post-operative evaluation of the participants would reflect reduced body weight, BMI, and creatinine levels. This indicates wasting and increased white blood cell (WBC) and lymphocyte count, representing post-operative infections.

## 2. MATERIALS AND METHODS

A prospective observational (longitudinal) cohort study was conducted at a tertiary care hospital in Rawalpindi, Pakistan, for 12 weeks from October 2019 to December 2019.

### 2.1. Sampling Technique and Sample Size

Convenience sampling was used to collect the data from patients admitted in a local tertiary care hospital over the course of three months. All eligible GI surgery patients admitted to the hospital during this time period were recruited, and a total of 75 patients met the inclusion criteria to be a part of the study.

### 2.2. Inclusion and Exclusion Criteria

**2.2.1. Inclusion Criteria.** All adult patients (> 18 years) who were hospitalized in the tertiary care hospital during the three-month study duration, for a major GI surgery, and had a hospital stay of at least six days were included. The surgeries were of comparable clinical severity, as reflected by a minimum of 6 days hospital stay for all the included study participants, as this allowed for homogenous study sample in terms of surgical complications, recovery, and impact on nutritional status.

**2.2.2. Exclusion Criteria.** Any patients undergoing minor GI surgeries with hospital stay of less than 6 days were not included. Patients receiving artificial nutritional support, either enteral or parenteral, were excluded from the study. This is because this would have drastically affected their nutritional parameters, thereby limiting the study’s ability to assess natural changes in nutritional status due to GI surgery. Additionally, patients who had intra-abdominal sepsis, intra-abdominal bleeding, peritonitis, or ileus were excluded from the study as this would have impacted their biochemical parameters.

### 2.3. Informed Consent

Informed consent was taken from all the participants prior to their inclusion in the study.

### 2.4. Data Collection Method

Data was collected on the topic by a complete nutritional assessment of the patients including information regarding anthropometrics, biochemical lab values, and clinical signs and symptoms. This data was collected before the surgery and then every 3 days post-surgery until the patient was discharged.

**2.4.1. Personal Information.** Sociodemographic data, such as gender, occupation, education, and number of family members, was collected using a self-developed questionnaire.

**2.4.2. Medical History.** Information regarding any acute and chronic health conditions that may influence the outcome of surgery, any previous surgeries, hospital admissions, and medications was collected.

**2.4.3. Anthropometric Data.** Information regarding weight, height, usual weight, ideal weight, and BMI both before and after surgery was collected.

**2.4.4. Biochemical Data.** Lab values of hemoglobin, WBCs, hematocrit, lymphocyte, and creatinine were collected.

**2.4.5. Clinical Signs and Symptoms.** Signs and symptoms, mostly the ones associated with the functioning of the gut, such as appetite, nausea, vomiting, anorexia, and such others were collected.

### 2.5. Statistical Analysis

The data collected was analyzed via paired t-test to check the association between the pre- and post-operative nutritional status of GI surgery patients, as data was collected from the same patients at points of time (pre-and post-surgery). The normality of the data was determined using the Kolmogorov-Smirnov test via the SPSS version 23.0. The cut-off $p$ value for significant results was set at 0.05, with a confidence interval of 95%.

## 3. RESULTS

A total of $n = 77$ patients were assessed at the time of admission for their socio-demographic and nutrition profile. Two were excluded as they developed post-surgical sepsis. Out of the 75 patients, $n = 39$ were males. In terms of age, most patients belonged to the age group of 30-35 years ($n = 18$), followed by the age group 40-45 years ($n = 14$). Regarding marital status, $n = 33$ patients were single, while $n = 34$ were married. The most common diagnosis for which patients were undergoing surgery included Cholelithiasis (32.2%), Sub-acute intestinal obstruction (19.7%), Carcinoma (CA) of the Colon (17.6%), CA Rectum (15.3%), and CA Esophagus (7.7%) among others (7.5%) (Table 1).

**Table 1**. Demographic Profile of Patients undergoing Gastrointestinal (GI) Surgery (*n*=75)

| Variable | Category | Percentage |
|---|---|---|
| Gender | Male | 52 |
| | Female | 48 |
| Age (years) | 30-35 | 24 |
| | 35-40 | 16 |
| | 40-45 | 18.7 |
| | 45-50 | 12 |
| | 50-55 | 16 |
| | 55-60 | 13.3 |
| Marital Status | Single | 44 |
| | Married | 45.3 |
| | Divorced | 6.66 |
| | Widowed | 4 |
| Educational Status | No formal education | 2.6 |
| | Primary | 8 |
| | Secondary | 18.6 |
| | Bachelor's | 48 |
| | Master's or higher | 22.6 |
| Current Diagnosis | Cholelithiasis | 32.2 |
| | Sub-acute intestinal obstruction | 19.7 |
| | *CA Colon | 17.6 |
| | *CA Rectum | 15.3 |
| | *CA Esophagus | 7.7 |
| | Others | 7.5 |
| Co-morbidities | Diabetes Mellitus | 16 |
| | Hypertension | 18.6 |
| | Ischemic Heart Disease | 5.3 |

| Variable | Category | Percentage |
|---|---|---|
| | Diabetes + Hypertension | 24 |
| | Diabetes + ischemic heart disease | 25.3 |
| | Hypertension + ischemic heart disease | 6.6 |
| | Others | 4 |

At the time of admission, $n$ = 27 patients were underweight according to the BMI, while 32 were in the normal BMI category. The results showed that 10 patients were in the overweight category, while 6 patients were obese. Post-surgery, $n$ = 41 patients were underweight, 28 had a normal weight, 4 were overweight, and 2 were obese (Figure 1).

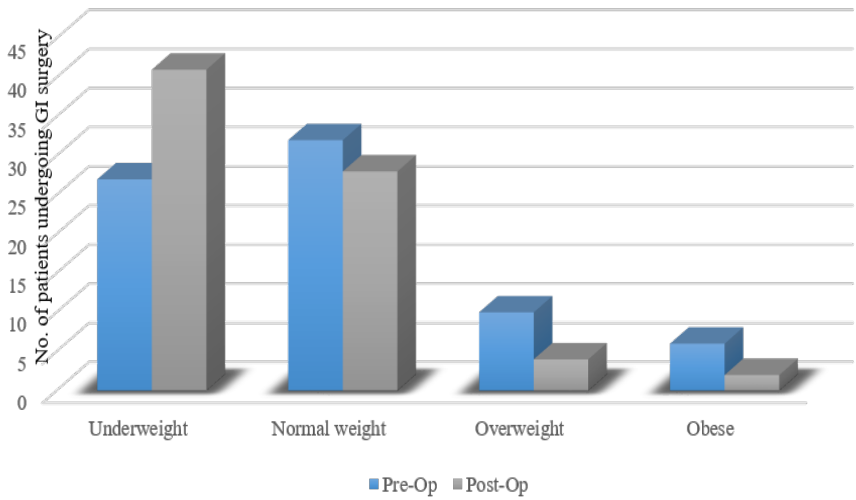


**Figure 1**. Comparison of Pre- and Post-operative Body Mass Index (BMI) of the Study Population

In terms of weight loss, $n$ = 19 patients underwent 1 to 4.9% weight loss, while 25 patients had a weight loss of 5 to 9.9%. Around 14 patients had a weight loss of 10 to 19.9%, while 17 patients had a weight loss of 20% or greater, which is one of the highest risk factors for malnutrition among surgery patients (Figure 2).

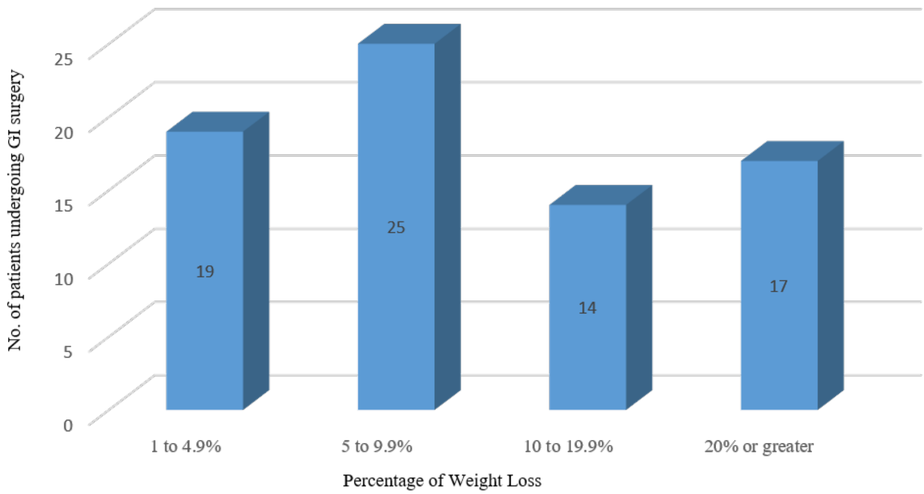


**Figure 2.** Percentage of Weight Loss in Study Population before and after Surgery

The results revealed that there existed a statistically significant association between pre- and post-operative levels of WBCs ($p = 0.000$) and lymphocyte count ($p = 0.015$). However, no statistically significant association was present between the pre- and post-operative BMI of the study population, hemoglobin, hematocrit, and creatinine levels (Table 2).

**Table 2.** Paired Differences in Pre- and Post-surgery Levels of Different Variables among Patients undergoing Major Gastrointestinal Surgeries

| Variable | *SD* | Mean Difference | *SE* | 95% CI | | *t* (74) | *p* |
|---|---|---|---|---|---|---|---|
| | | | | LL | UL | | |
| Pre-operative Weight – Post-operative Weight | 1.10 | -0.24 | 0.12 | -0.49 | 0.01 | -1.88 | 0.06 |
| Pre-operative BMI – Post-operative BMI | 0.81 | -0.10 | 0.09 | -0.29 | 0.08 | -1.13 | 0.26 |
| Pre-operative WBC Count – Post-operative WBC Count | 1.08 | 0.46 | 0.12 | 0.21 | 0.71 | 3.73 | 0.00* |
| Pre-operative Hemoglobin – Post-Operative | 1.43 | 0.14 | 0.16 | -0.18 | 0.47 | 0.88 | 0.37 |

| Variable | *SD* | Mean Difference | *SE* | 95% CI | | *t* (74) | *p* |
|---|---|---|---|---|---|---|---|
| | | | | LL | UL | | |
| Hemoglobin | | | | | | | |
| Pre-operative Hematocrit – Post-operative Hematocrit | 1.37 | 0.09 | 0.15 | -0.22 | 0.41 | 0.58 | 0.55 |
| Pre-operative Lymphocyte Count – Post-operative Lymphocyte Count | 1.49 | 0.42 | 0.17 | 0.08 | 0.76 | 2.47 | 0.01* |
| Pre-operative Creatinine – Post-operative Creatinine | 1.24 | 0.20 | 0.14 | -0.08 | 0.48 | 1.39 | 0.16 |

## 4. DISCUSSION

The results of the study showed that the body weights, WBC, and lymphocyte count levels were significantly different before and after surgery. In contrast, other biochemical parameters and BMI were insignificantly affected before and after surgery. It has been estimated that malnutrition affects around 20% of patients undergoing surgery [12]. It has also been documented that physiological stress leads towards a weakened immune system, reduced food intake, and negative energy balance, all of which are directly or indirectly linked to malnutrition [13]. Patients undergoing major GI surgery are always at a risk of certain other complications. These include leakage of esophago-jejunal and esophago-gastral anastomosis, bile leakage after pancreatic surgery, organ dysfunction, organ failure after severe sepsis and septic shock, peritonitis, mediastinitis, or pleural empyema. It is, therefore, vital to screen the patient before a surgical procedure [14]. Surgery imposes great metabolic and physiological stress on the body, leading to a spiked basal metabolic rate, depletion of nitrogen stores, and a negative nitrogen balance. However, these and many other complications can be prevented post-surgery with the correct nutritional interventions. Additionally, keeping a patient in a fasting state for more than 12 hours prior to surgery is seen to be of no great significance and only adds to the discomfort and a potential risk of increasing blood sugar levels after surgery. It is now considered an outdated practice that only results in complications and reduced quality of life in general [15].

The results of this study are supported by similar studies conducted in the past. A narrative review focusing on pre-operative nutritional status and interventions on post-operative surgical and nutrition outcomes concluded that nutrition support prior to surgery may only benefit those who are at risk of being undernourished, while no significant changes were seen in those with a normal nutritional status [16]. Another study found a positive association between poor pre-operative nutritional status and longer post-operative hospital stays. This is subsequently associated with higher healthcare expenditures and poor quality of life for GI surgery patients. It is thereby recommended that patients who have experienced a more than 10% weight loss in 6 months prior to surgery should be given nutrition intervention for at least 1 to 2 weeks and have their surgery postponed if needed [17].

In this study, the WBC count after surgery showed an increase as compared to initial values. The reason for this rise is the incidence of infection, stress, trauma or inflammation, which are very likely to occur after a patient undergoes surgery. Post-operative WBCs are often indicative of surgical stress and the body's natural post-operative inflammatory response. Therefore, these WBC changes are a better reflection of the body's stress response rather than direct pathological changes [18]. Furthermore, studies have reported positive associations between post-operative WBC count and surgery duration and complexity, rather than infection, and have found elevated WBCs to be a normal recovery component [19]. The current study also reported increased lymphocyte count post-surgery. This is comparable to other studies which reported surgeries to be associated with temporal modifications in lymphocyte counts, as part of immune activation and subsequent recovery phases [20]. Another study also reported that post-operative recovery is characterized by a temporary elevation of lymphocytes followed by their return to baseline levels as the patient's immune system adapts and homeostasis is restored [21].

In contrast, the hemoglobin levels showed a slightly declining trend after surgery. A possible explanation is the blood loss during and after surgery. However, the declining trend for hemoglobin was minimal and did not affect the post-surgery nutritional status of patients. Jiang et al. also highlighted no significant change in the post-operative hemoglobin levels, which is in accordance with the results of the current study [22]. Hematocrit levels were also not significantly affected in the post-operative study population. This can be linked to pro-inflammatory cytokines in the adipose tissues reducing hemoglobin and hematocrit levels in pre-operative patients. GI surgeries then improve the hematological profile of such patients after surgery [23]. The lymphocyte count of the study participants showed a significant difference before and after surgery. Surgery puts the body under physiological and endocrine stress and triggers inflammatory reactions, which alters the body's lymphocyte levels [24]. However, the lymphocyte count before and after surgery remained lower than normal for multiple reasons, including stress from illness, cancer, malnutrition, and GI conditions. Majority of the biochemical indicators did not report statistically significant results due to a number of factors. These include the study's short perioperative observation period, the biomarkers being physiologically stable, clinical management of the patients' pre- and post-surgery leading to stabilized biomarkers, and ineffectiveness of the study to capture statistically significant changes in these indicators as they require a longer time period to show evident changes.

The difference in results in this study compared to the previous studies may be attributed to smaller sample size, different study settings (including age group and population sub-group), types of major GI surgeries, diagnosis of patients, and disease histories. The current study only measured the body weights of patients and calculated their body mass indices on the basis of their weights and heights for anthropometry. No other anthropometric measurements could be performed, such as waist circumference, mid-upper arm circumference, skinfold thickness or triceps skinfold thickness, due to their limited feasibility and practicality in the clinical setting. This is because patient mobility in the peri-operative state was limited and clinical workflow further restrained resources and time. Similarly, only those biochemical parameters were included in the study, which the surgeons routinely ordered before and after major GI surgeries. This was another limitation of this study. Furthermore, the study also did not include patients with severe GI surgery complications. This may limit generalizability of the findings as such patients exhibit higher levels of metabolic stress and nutritional deterioration. Additionally, the study used convenience sampling to recruit patients due to the clinical nature of the study. Sample recruitment depended upon GI surgery patient admittance to the hospital within the three months the study was being conducted. Therefore, convenience sampling allowed accessibility to all eligible patients within the study's timeframe. Furthermore, data was collected from a single tertiary care setting, which when combined with convenience sampling, may limit the generalizability of results. The included study sample may not be an accurate representation of all GI surgery patients admitted in different healthcare settings. Moreover, the study did not record post-operative infection rates or clinical complications. Therefore, changes in inflammatory markers were interpreted as a post-operative physiological response. Lastly, the study did not adjust for potential confounders, such as age, comorbidities, or type of GI surgery, which may influence the nutritional outcomes reported in the study.

## 4.1. Conclusion

The study results demonstrated the presence of an increased burden of malnutrition-related indicators, including both anthropometric and biochemical variables, within GI surgery patients. Moreover, parameters, such as body weight, WBC, and lymphocyte count were found to be statistically significantly associated in terms of their pre- and post-surgery levels. Efforts to improve the nutritional status of individuals undergoing GI surgery are thus recommended.

### Author Contribution

**Zoha Imtiaz Malik:** conceptualization, methodology, data curation, writing – original draft. **Syed Hassan Bin Usman Shah:** methodology, formal analysis, writing – review & editing. **Aisha Ijaz Ul Haq:** methodology, writing – review & editing. **Abdul Momin Rizwan Ahmad:** conceptualization, methodology, supervision, writing – review & editing.

### Conflict of Interest

The authors of the manuscript have no financial or non-financial conflict of interest in the subject matter or materials discussed in this manuscript.

### Data Availability Statement

Data supporting the findings of this study will be made available by the corresponding author upon request.

### Funding Details

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### Generative AI Disclosure Statement

The authors did not use any type of generative artificial intelligence software for this research.

### Ethics Approval and Consent

Informed consent was taken from all study participants and they approved of the study data being published. They acknowledged that they cannot be identified via the paper; and that the authors have fully anonymized them. Ethical approval was taken from ethical review committee of University Institute of Diet and Nutritional Sciences (UIDNS), University of Lahore, Islamabad Campus vide letter no. 041/UoL/2019-07/REC. Informed consent of patients was also taken prior to collecting their data.

## REFERENCES

1. Emerenini FC, Nwolisa EC, Iregbu FU, Eke CB, Ikefuna AN. Prevalence and risk factors for Helicobacter pylori infection among children in Owerri, Nigeria. *Niger J Clin Pract*. 2021;24(8):1188-1193. https://doi.org/10.4103/njcp.njcp_687_20
2. Fikree A, Byrne P. Management of functional gastrointestinal disorders. *Clin Med (Lond)*. 2021;21(1):44-52. https://doi.org/10.7861/clinmed.2020-0980
3. Vaou N, Zavras N, Saldari C, et al. Post-surgical gut microbiota alterations in pediatric patients with intestinal disorders. *J Clin Med*. 2026;15(2):e789. https://doi.org/10.3390/jcm15020789
4. Kenny E, Samavat H, Touger-Decker R, Parrott JS, Byham-Gray L, August DA. Adverse perioperative outcomes among patients undergoing gastrointestinal cancer surgery: quantifying attributable risk from malnutrition. *JPEN J Parenter Enteral Nutr*. 2022;46(3):517-525. https://doi.org/10.1002/jpen.2200
5. Serón-Arbeloa C, Labarta-Monzón L, Puzo-Foncillas J, et al. Malnutrition screening and assessment. *Nutrients*. 2022;14(12):e2392. https://doi.org/10.3390/nu14122392
6. Eminovic S, Vincze G, Eglseer D, et al. Malnutrition as predictor of poor outcome after total hip arthroplasty. *Int Orthop*. 2021;45(1):51-56. https://doi.org/10.1007/s00264-020-04892-4
7. Keerio RB, Ali M, Shah KA, Iqbal A, Mehmood A, Iqbal S. Evaluating the impact of preoperative nutritional status on surgical outcomes and public health implications in general surgery patients. *Cureus*. 2024;16(12):e76633. https://doi.org/10.7759/cureus.76633
8. Vinarov Z, Abdallah M, Agundez JA, et al. Impact of gastrointestinal tract variability on oral drug absorption and pharmacokinetics: an UNGAP review. *Eur J Pharm Sci*. 2021;162:105812. https://doi.org/10.1016/j.ejps.2021.105812
9. Noorian S, Kwaan MR, Jaffe N, Yaceczko SD, Chau LW. Perioperative nutrition for gastrointestinal surgery: on the cutting edge. *Nutr Clin*

*Pract*. 2023;38(3):539-556. https://doi.org/10.1002/ncp.10970

10. Deftereos I, Yeung JMC, Arslan J, et al. Assessment of nutritional status and nutrition impact symptoms in patients undergoing resection for upper gastrointestinal cancer: Results from the multicentre NOURISH point prevalence study. *Nutrients*. 2021;13(10):e3349. https://doi.org/10.3390/nu13103349
11. Karanikki E, Frountzas M, Lidoriki I, et al. The predictive role of preoperative malnutrition assessment in postoperative outcomes of patients undergoing surgery due to gastrointestinal cancer: a cross-sectional observational study. *J Clin Med*. 2024;13(23):e7479. https://doi.org/10.3390/jcm13237479
12. Jones D, Knight SR, Sremanakova J, et al. Malnutrition and nutritional screening in patients undergoing surgery in low- and middle-income countries: a systematic review. *JCSM Clin Rep*. 2022;7(4):79-92. https://doi.org/10.1002/crt2.55
13. Morales F, Montserrat-de la Paz S, Leon MJ, Rivero-Pino F. Effects of malnutrition on the immune system and infection and the role of nutritional strategies regarding improvements in children's health status: a literature review. *Nutrients*. 2023;16(1):e1. https://doi.org/10.3390/nu16010001
14. Liu J, Hu J, Fang J, et al. Risk factors of esophagojejunal anastomotic leakage after total gastrectomy for gastric and Siewert type II/III esophagogastric cancer: A retrospective analysis from a tertiary hospital. *Front Oncol*. 2024;14:e1481278. https://doi.org/10.3389/fonc.2024.1481278
15. Lobo DN, Gianotti L, Adiamah A, et al. Perioperative nutrition: recommendations from the ESPEN expert group. *Clin Nutr*. 2020;39(11):3211-3227. https://doi.org/10.1016/j.clnu.2020.03.038
16. Simancas-Racines D, Frias-Toral E, Campuzano-Donoso M, et al. Preoperative nutrition in bariatric surgery: a narrative review on enhancing surgical success and patient outcomes. *Nutrients*. 2025;17(3):e566. https://doi.org/10.3390/nu17030566
17. Jaxa-Kwiatkowski A, Jaxa-Kwiatkowski M, Jaxa-Kwiatkowska K, Gerber H, Kubiak M, Łysenko L. Perioperative nutritional and metabolic factors affecting surgical outcomes in head and neck cancer

free flap reconstruction: a comprehensive review. *J Clin Med*. 2025;14(11):e3679. https://doi.org/10.3390/jcm14113679

18. Liu S, Huang H, Zhang C, et al. Postoperative leukocyte counts as a surrogate for surgical stress response in matched robot- and video-assisted thoracoscopic surgery cohorts of patients: a preliminary report. *J Robot Surg*. 2024;18(1):e176. https://doi.org/10.1007/s11701-024-01939-1
19. Elbromboly Y, Esawy MA. Post-operative C-reactive protein and white blood cells changes pattern following spinal deformity surgery and its clinical correlation. *J Orthop Surg Res*. 2023;18(1):e790. https://doi.org/10.1186/s13018-023-04288-1
20. Hildenborg M, Kåhlin J, Granath F, et al. The neuroimmune response to surgery: an exploratory study of trauma-induced changes in innate immunity and heart rate variability. *Front Immunol*. 2022;13:e911744. https://doi.org/10.3389/fimmu.2022.911744
21. Schoenberg MB, Han Y, Li X, et al. Dynamics of peripheral blood immune cells during the perioperative period after digestive system resections: a systematic analysis of the literature. *J Clin Med*. 2023;12(2):e718. https://doi.org/10.3390/jcm12020718
22. Jiang Y, Zhao Z, Lu H, Zhou L. Association between bariatric surgery and anemia. *Nutr Clin Métab*. 2022;36(3):217-224. https://doi.org/10.1016/j.nupar.2022.07.004
23. Jungwirth-Weinberger A, Bendich I, Westrich GH, Su EP, Della Valle AG, Boettner F. Preoperative ferritin and hemoglobin levels are lower in patients with a history of COVID-19 but blood loss and transfusion requirements are not increased. *Arch Orthop Trauma Surg*. 2023;143(1):311-315. https://doi.org/10.1007/s00402-021-04082-w
24. Acharya K, Rout DK, Kapadia NA, et al. Surgical stress response: a physiological review of the endocrine, immune, and metabolic changes. *Cureus*. 2025;17(12):e100101. https://doi.org/10.7759/cureus.100101