Artículo Original

Risk of hospital malnutrition, inflammatory markers, and medical nutrition therapy in digestive surgery patient: a retrospective cohort study from eastern indonesia

Kartika MAROLA[1], Agussalim BUKHARI[2], Nurpudji A. DAUD[2], WARSINGGIH[3], AMINUDDIN[2], MARNIAR[2]

1 Clinical Nutrition Medical Speciality Education Program, Faculty of Medicine, Hasanuddin University, Makassar, South Sulawesi, Indonesia.
2 Department of Nutrition, Faculty of Medicine, Hasanuddin University, Makassar, South Sulawesi, Indonesia.
3 Department of Digestive Surgery, Faculty of Medicine, Hasanuddin University, Makassar, South Sulawesi, Indonesia.

ABSTRACT

Introduction: The prevalence of hospital malnutrition in Indonesian 23.9% - 60.5%. It is important to evaluate nutritional status of patients at admission to prevent malnutrition and to identify the need for nutritional therapy. Nutrition, immunity, and the gastrointestinal tract are closely interrelated. Malnutrition is widely reported in surgical patients, especially those who have undergone major surgery, and is a particular risk in patients undergoing surgery for upper gastrointestinal cancer or colorectal cancer. Studies show a high prevalence of malnutrition or high nutritional risk during hospital admission, but this is rarely assessed in the clinical setting, especially for patients undergoing elective surgery. There has been no study on digestive surgery patients receiving medical nutritional therapy (MNT).

Method: A retrospective cohort study was conducted, including 353 digestive surgery patients who were admitted between January 2022 and January 2024. This study used medical record data with a total sample of digestive surgery patients. Nutritional status was assessed using the Malnutrition Universal Screening Tool (MUST). This study identified the MUST modified scores of digestive surgery patients, with albumin, Neutrophil-to-Lymphocyte Ratio (NLR), and Total Lymphocyte Count (TLC) values. Statistical analyses were performed using chi-square tests for categorical variables and t-tests or Mann-Whitney U tests for continuous variables, with a p-value of <0.05 considered statistically significant.

Result: The most common diagnosis is rectal cancer. Moderate MUST score in 144 patients (40.7%), low MUST score in 140 patients (39.6%) and high MUST scores in 69 patients (19.5%). 96 patients (27%) received medical nutrition therapy, 71% with severe protein energy malnutrition diagnosis, 29% with moderate protein energy malnutrition diagnosis.

Conclusion: Malnutrition is common among digestive surgery patients and is associated with impaired immune function, as evidenced by hypoalbuminemia and higher NLR in malnourished patients. MUST modified score directly correlated with hypoalbuminemia, increased of NLR, and patient mortality in RSUP. Dr. Wahidin Sudirohusodo Makassar, South Sulawesi.

KEYWORDS

Inflammatory status, nutritional assessment, retrospective studies, immune function, surgical complications, clinical recovery.

Correspondencia:
Agussalim Bukhari
agussalimbukhari@yahoo.com

INTRODUCTION

Hospital Malnutrition often under-recognized condition among hospitalized patients in Asia. Poor nutritional status is associated with an increased risk of adverse clinical outcomes, including infectious and non-infectious complications, increased length of stay and increased mortality[1].

The prevalence of malnutrition in Indonesian hospitals varies between 23.9% and 60.5%. This may be due to variability in the patient population as well as the parameters used. Malnutrition in hospitals can be caused by individual and/or institutional factors[2].

The prevalence of malnutrition in hospitals varies according to the patient population, screening and assessment methods, and hospital setting; however, it is generally estimated that 20 to 50% of hospitalized patients are malnourished on admission, and approximately one-third of patients who are not malnourished on admission may become malnourished during hospitalization. Certain patient populations, including surgical patients, critically ill patients, geriatrics and cancer patients are known to be particularly susceptible to malnutrition[3].

Disease-related malnutrition is a common condition but is often underestimated or even unrecognized in chronic diseases. Malnutrition negatively impacts clinical outcomes and increases mortality through impaired wound healing, increased rates of infection and other complications, increased duration and intensity of treatment, and increased length of hospital stay[4].

Malnutrition is widely reported in surgical patients, especially those who have undergone major surgery, and is particularly at risk in patients undergoing surgery for upper gastrointestinal cancer or colorectal cancer. Pre-operative malnutrition has been shown to increase length of hospital stay, higher rates of infection and mortality at the surgical site, and is associated with higher post-operative complications, increased costs, poorer quality of life and lower survival rates. Studies show a high prevalence of malnutrition or high nutritional risk during hospital admission, but this is rarely assessed in the clinical setting, especially for patients who will undergo elective surgery[5].

Malnutrition is common in surgical patients and between 16 - 67% of surgical patients are malnourished before surgery. Estimates vary depending on the population examined and the diagnostic instruments used[6].

Approximately 44% of all patients hospitalized for elective surgical procedures are at risk of malnutrition. However, this prevalence varies depending on the criteria for malnutrition and the screening tools used. In surgical patients, preoperative malnutrition is associated with an increased risk of postoperative complications, increased mortality and medical costs, and longer hospital stays[7].

Patients undergoing gastrointestinal surgery have decreased oral intake, tumor cachexia, impaired absorption due to intestinal obstruction, or reduced intestinal length which affects their nutritional status. Other surgical parameters such as preoperative sepsis, American Society of Anesthesiology (ASA) score of more than 3, emergency surgery, open surgery, long duration of surgery, and massive intraoperative blood loss contribute to poor postoperative outcomes. In addition, low socioeconomic status, Indian customs, restrictions on intake of certain foods pose additional risks[8].

Medical Nutritional Therapy (MNT) involves the use of specific nutritional interventions to manage medical conditions. For instance, Enteral Nutrition (EN) is preferred for patients who can tolerate it, as it maintains gut integrity and function. For patients unable to use their gastrointestinal tract, Parenteral Nutrition (PN) provides essential nutrients intravenously. MNT is tailored to each patient's needs, ensuring they receive the right balance of macronutrients and micronutrients[9].

There has been no study on hospital malnutrition, especially digestive surgery patients at RSUP. Dr. Wahidin Sudirohusodo, so the novel of this study is to identify problems related to hospital malnutrition in digestive surgery patients at RSUP. Dr. Wahidin Sudirohusodo Makassar for the period January 2022 - January 2024.

MATERIAL AND METHODS

Study Design and Participants

This study utilized a retrospective cohort design to assess the prevalence of malnutrition and its association with clinical outcomes in digestive surgery patients.

This study used medical record data with a total sample of digestive surgery patients. The population of this study were inpatients at the RSUP. Dr. Wahidin Sudirohusodo Makassar period January 2022 - January 2024 according to the inclusion criteria. The sample size in this study was determined using the total sampling method.

Inclusion criteria were patients diagnosed with digestive surgery disease, aged > 18 years, hospitalized ³ 7 days. Patients were excluded if they had incomplete medical records or were above the age of 59, and hospitalized < 7 days.

Nutritional Assessment

Malnutrition risk was evaluated using the Malnutrition Universal Screening Tool (MUST). MUST applied at Wahidin Sudirohusodo Hospital:

1. Adult patients with BMI score with standard:
   a. BMI 20 (>30 Obese)   : 0
   b. BMI 18, - 20   : 1
   c. BMI < 18,5   : 2

2. Nutritional status classification for children with graphic standard CDC, weight for height:
   a. >90 − 110%   : 0
   b. 70–90%   : 1
   c. <70%   : 2

3. Score of unplanned weight loss in the last 3-6 months:
   a. Weight loss <5%   : 0
   b. Weight loss 5-10%   : 1
   c. Weight loss>10%   : 2

4. Nutritional intake score for acute patients:
   a. Nutritional intake>5 days   : 0
   b. No nutritional intake>5 days : 2

5. If the patient cannot be weighed, then do upper arm circumference measurement, upper arm circumference classification for adults:

a. >85% : 0
b. 70.1 – 84.9% : 1
c. <70% : 2

TOTAL SCORES =

Interpretation of scores:

- Low risk (0) = Monitoring after 7 days.
- Medium risk (1 – 2) = Monitoring intake for 3 days, continued every 7 days if no change. Treatment plan can be changed as needed.
- High risk (³3) = Collaborate with Nutrition Support Team.

Data Collection

Data on patient demographics, nutritional status, inflammatory markers, length of stay, and mortality were collected from the hospital's medical records. The primary outcomes measured were LOS, inflammatory response (Albumin, NLR, TLC), and mortality. Data were analysed to determine the correlation between malnutrition risk and these outcomes.

Statistical Analysis

Descriptive statistics were used to summarize patient characteristics. Categorical variables were analysed using chi-square tests, while continuous variables were analysed using t-tests or Mann-Whitney U tests, depending on the distribution of the data. A p-value of <0.05 was considered statistically significant.

RESULT

This study involved 353 patients. The study obtaining ethical approval from the Health Research Ethics Committee of the Faculty of Medicine, Hasanuddin University with number: 313/UN4.6.4.5.31/PP36/2024.

This study involved 353 samples with mean age 43.4 ± 11 years old. Gender was dominated by 212 males (60%) and 141 females (40%). The highest MST score was a moderate MST score of 144 patients (40.7%), a low MST score of 140 patients (39.6%) and a high MST score of 69 patients (19.5%). There were 50 patients who died during hospitalization (14%) and 303 patients survived (86%). 27% patients with clinical nutrition collaboration, the most diagnoses 71% with severe protein energy malnutrition, and 29% with moderate protein energy malnutrition.
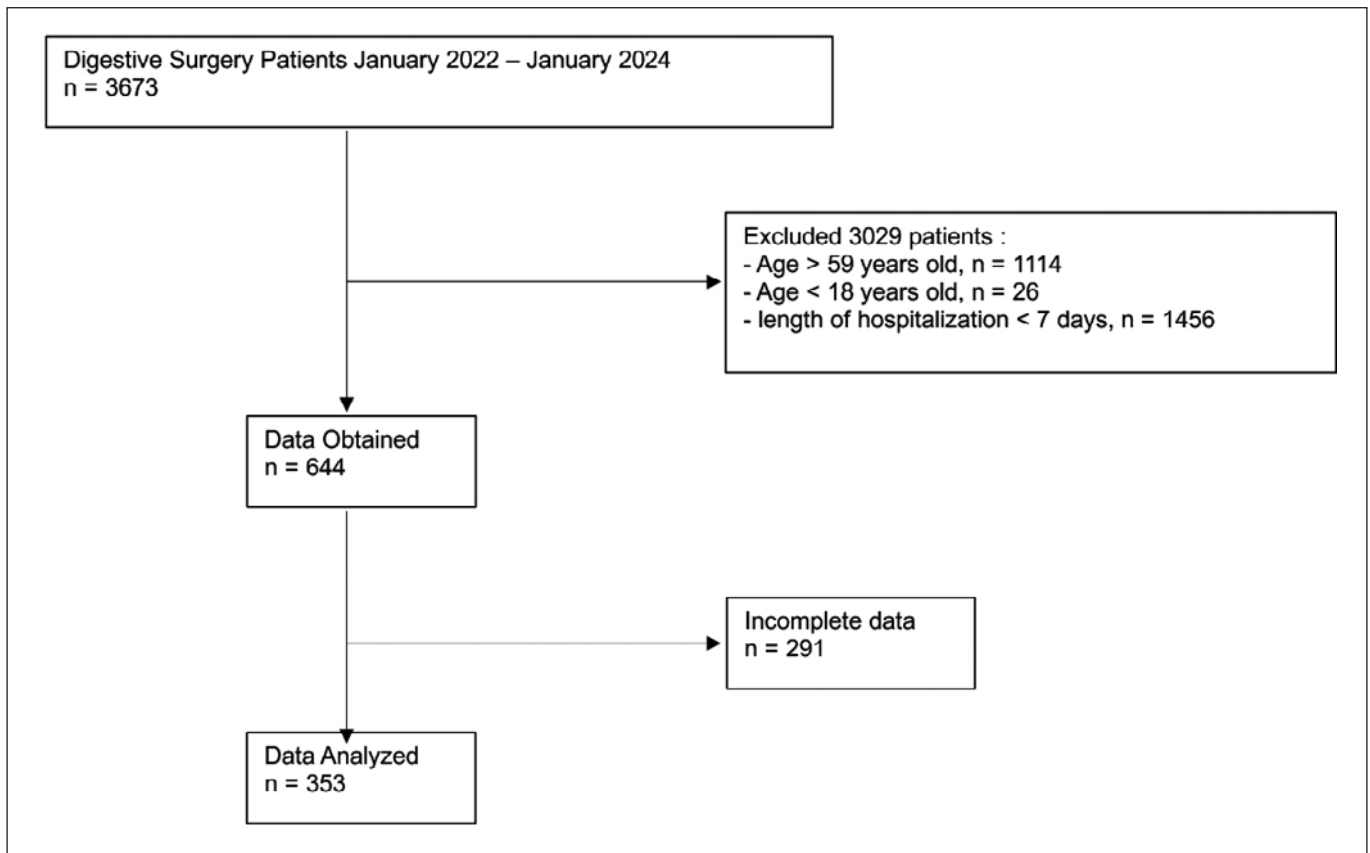

Figure 1. Flow chart of trail

Table 1. Basic characteristics of patients

Basic Characteristics		n	%
Sex	Men	212	60
	Woman	141	40
Age	18 – 59 y.o	43.4 ±11	
Education status	No education	37	10,5
	Elementary	41	11,6
	Secondary	55	15,5
	High School	150	42,4
	Bachelor	70	19,8
Marital Status	Married	301	85,2
	Unmarried	42	11,8
	Widowed	10	2,8
Occupation Status	Employee	213	60,5
	Unemployed	140	39,5
MUST modified Score	Low risk	140	39,6
	Moderate risk	144	40,7
	High risk	69	19,5
Mortality	Yes	50	14
	No	303	86
Medical Nutrition Therapy	Yes	96	27
	No	257	73
Medical Nutrition Diagnosis	Moderate PEM	28	29
	Severe PEM	68	71

Tabla 2. Most common diagnoses in subjects

Digestive surgery patients	n	%
Rectal cancer	38	24
Colon cancer	34	21
Intra-abdominal tumor	15	9.3
Choledocholithiasis	13	8
Cholelithiasis	12	7.4
Hepatoma	12	7.4
Rectal tumor	12	7.4
Colon tumor	11	7.4
Colorectal cancer	8	5
GIST	6	3.7

The table 3 shows a significant MST modified score and albumin level (p = 0.000), MST scores and NLR (P = 0.027).

The table 5 shows a significant MST modified score and mortality rates (P= 0.006).

The table 7 shows a significant MST modified score, MNT and non MNT, p = 0.000.

The table 8 shows a higher mortality rate in patients who received medical nutrition therapy. This may be influenced by the diagnosis, severity of the disease, complications, and the length of time the patient was consulted to clinical nutrition.

DISCUSSION

The aim of this study was to determine the association of the hospital malnutrition risk score, Malnutrition Universal Screening Tools (MUST) modified score, with inflammatory biomarkers, length of hospitalization, mortality, MNT and non MNT.

This study found that 60.4% of digestive surgery patients were at moderate and high risk of malnutrition.

Surgical trauma elicits a series of events that generate an immune response with activation of the cytokine cascade in the postoperative period. Cytokines play an important role in regulating the inflammatory response at the site of injury, thereby facilitating the wound healing process. However, excessive cytokine production can have systemic consequences leading to postoperative complications and death[10].

Malnutrition is a major problem in the gastrointestinal perioperative setting, as only 40% of malnourished patients are ultimately treated. Malnutrition can be defined as a condition that occurs when the body does not receive enough essential nutrients to maintain healthy growth and function. This can result from insufficient nutrient intake and/or the inability to absorb nutrients properly, or an unbalanced diet. Malnutrition has been associated with poor clinical outcomes, as it has been shown that malnourished patients have a relative mortality risk of 1.6-1.9 and remain hospitalized for 1.5-1.7 times longer. Thus, up to 80% of patients who present with compromised nutritional status on admission will further deteriorate if no nutritional regimen is provided[11].

It has been observed that patients who are malnourished at the time of admission also appear to be at a higher risk of

Table 3. Correlation of MUST modified score and inflammatory biomarkers

Inflammation biomarkers				Low	Moderate	High	Total	p value
Albumin	Normal		n	51	34	9	94	0.004*
			%	54.3%	36.2%	9.6%	100%	
	Mild hypoalbuminemia		n	44	39	21	104	
			%	42.3%	37.5%	20.2%	100%	
	Moderate hypoalbuminemia		n	22	39	22	83	
			%	26.5%	47%	26.5%	100%	
	Severe hypoalbuminemia		n	23	32	17	72	
			%	31.9%	44.4%	23.6%	100%	
TLC	Normal		n	73	66	27	166	0.464
			%	44%	39.8%	16.3%	100%	
	Mild depletion of immunity		n	20	22	16	58	
			%	34.5%	37.9%	27.6%	100%	
	Moderate depletion of immunity		n	22	24	14	60	
			%	36.7%	40%	23.3%	100%	
	Severe depletion of immunity		n	25	32	12	69	
			%	36.2%	46.4%	17.4%	100%	
NLR	Normal		n	48	44	11	103	0.028*
			%	46.6%	42.7%	10.7%	100%	
	Mild increase of NLR		n	34	31	28	93	
			%	36.6%	33.3%	30.1%	100%	
	Moderate increase of		n	24	28	9	61	
			%	39.3%	45.9%	14.8%	100%	
	Severe increase of		n	34	41	21	96	
			%	35.4%	42.7%	21.9%	100%	

(The "MUST Modification Score" spans the Low, Moderate, High columns.)

Values are n (%). Significant if p<0.05.
Comparison was performed using Chi square test.

poor nutritional intake during hospitalization. Surgery can exacerbate malnutrition through a systemic inflammatory response, which in turn increases metabolic activity, increases energy consumption, impairs organ function, and compromises immunity. In addition, undernourished patients may develop infections at the surgical site; therefore, they have a greater chance of morbidity[11].

The metabolic response to surgery triggers various metabolic and endocrine changes and the perioperative catabolic response is characterized by a period of negative nitrogen balance leading to increased muscle and fat breakdown, sympathetic nervous system stimulation and insulin resistance. Increased metabolic activity leads to an increase in body temperature and respiratory rate: in patients undergoing elective surgery, there can be a 10-15% increase in basal energy expenditure and in the absence of complications, it can take 3-8 days to transition from catabolism to anabolism. Therefore, it is common for patients to experience weight

Table 4. Correlation of MUST modified score and length of stay (LOS) in hospital

LOS			MUST Modification Score			Total	P value
			Low	Moderate	High		
LOS	7-14 days	n	39	36	19	94	0.847
		%	41.5%	38.3%	20.2%	100%	
	> 14 days	n	101	108	50	259	
		%	39%	41.7%	19.3%	100%	

Table 5. Correlation of MUST modified score and mortality

Mortality			MUST Modification Score			Total	P value
			Low	Moderate	High		
Mortality	Yes	n	10	27	14	51	0.006*
		%	19.6%	52.9%	27.5%	100%	
	No	n	130	117	55	302	
		%	43%	38.7%	18.2%	100%	

Table 6. Length of stay (LOS) and length of consulted to clinical nutrition

	Mean	SD	Median	Minimum	Maximum
LOS	20.2	8.9	18	7	53
Length of consulted	7.5	7.8	5	0	30

Table 7. Assosiation of MUST modified score and Medical Nutrition Therapy (MNT), Non Medical Nutrition Therapy (Non - MNT)

MUST Modified Score			Nutrion therapy		Total	p value
			MNT	Non MNT		
MUST	Low	n	20	120	140	0.000*
		%	21.1%	46.5%	39.7%	
	Moderate	n	46	98	144	
		%	48.4%	38%	40.8%	
	High	n	29	40	69	
		%	30.5%	15.5%	19.5%	

Table 8. Analysis of MUST modified score, mortality rates, and MNT

			MNT		Jumlah	Nilai p
			With MNT	Non MNT		
Outcome	Death	n	27	23	50	0.000*
		%	28.4%	8.9%	14.2%	
	Survive	n	68	235	303	
		%	71.6%	91.1%	85.8%	

loss after gastrointestinal surgery. It has been found that 50% of patients lose more than 10% of their body weight a year after upper gastrointestinal surgery and half of patients undergoing colorectal surgery fail to reach their calorie intake targets, and almost no patients reach their protein intake targets after hospital discharge[12].

This study found that 73.4% of digestive surgery patients were admitted with hypoalbuminemia. 44.4% of patients with moderate MUST modified score had severe hypoalbuminemia.

Hypoalbuminemia is prevalent in hospitalized and critically ill patients. Critical illness is associated with hypoalbuminemia through various mechanisms. It can alter the distribution of albumin between the intravascular and extravascular compartments resulting in decreased albumin synthesis and increased albumin degradation and clearance. The reduction in albumin synthesis results from increased transcription of genes for positive acute phase proteins (such as C-reactive protein) and decreased transcription rate of albumin messenger RNA. However, the increased degradation and clearance of albumin is due to an increase in capillary leakage, which is influenced by several cytokines in the inflammatory process such as TNF-alpha, interleukin-6, and prostaglandins[8].

Plasma albumin has three main functions: osmotic, transport, and nutritional, and accounts for more than 75-80% of the total plasma osmotic pressure (25 mmHg). During physiological stress, a decrease in serum albumin levels to hypoalbuminemia levels leads to a decrease in oncotic pressure, which in turn causes interstitial oedema[6].

Albumin, a very important protein, transports hormones, fatty acids and exogenous drugs and regulates plasma oncotic pressure. As albumin levels decrease during injury and infection, albumin is referred to as a negative active phase protein. The maintenance protein called serum albumin is rapidly upregulated by inflammatory signals. Low serum albumin levels are mostly caused by inflammatory conditions, by high levels of the cytokine's interleukin-6 (IL-6) and tumor necrosis factor-alpha (TNF-alpha). A common finding in both acute and chronic diseases is hypoalbuminemia. Although

new data suggest that increased catabolism is the more frequent reason, hypoalbuminemia in chronic diseases, is associated with decreased albumin synthesis due to wasting and cachexia. The mechanism that causes hypoalbuminemia in acute conditions differs from that in chronic diseases because capillary leakage into the interstitial space due to inflammatory processes is the main source of hypoalbuminemia in acute conditions. In addition, reduced synthesis, dilution of blood due to fluid administration, renal and intestinal losses due to congestion, and increased catabolism also play a role[6].

Historically, serum albumin concentration was considered a marker of nutritional status and clinicians monitored albumin concentration in patients during hospital stays. It was based on the pathophysiological rationale that albumin concentrations reflect circulating proteins in plasma, with lower concentrations indicating nutritional deficiencies[13].

In this study, 71% of digestive surgery patients were admitted to the hospital with increased NLR. 46% of patients with a moderate MUST modified score had a moderate increase in NLR.

Neutrophils are one of the first responders at sites of infection and injury and as such are powerful mediators of acute inflammation[14].

The neutrophil to lymphocyte ratio, calculated as a simple ratio between neutrophil and lymphocyte counts measured in peripheral blood, is a biomarker that reflects the balance between two aspects of the immune system: acute and chronic inflammation (as indicated by neutrophil counts) and adaptive immunity (lymphocyte counts). In cancer patients, higher NLR has been associated with poor prognosis. Nutrition, immunity, inflammation, and cancer are closely linked, which in turn can affect the survival prognosis of cancer patients. Gastric cancer patients often experience symptoms such as weight loss, hypoproteinemia, anemia and malabsorption, which are associated with inhibition of humoral and cellular immune function, altered inflammatory response and wound healing. In radical distal gastrectomy, a large part of the stomach, including tumor and normal tissue, is removed, resulting in malnutrition,

which greatly increases the risk of tumor recurrence. Surgical trauma can inhibit the body's fluid and cellular immune function and stimulate the body to produce inflammation and traumatic changes, resulting in poor nutrition[6].

The neutrophil to lymphocyte ratio (NLR) has been extensively evaluated and shown to be associated with outcomes and predict disease course among patients with various medical conditions including ischemic stroke, cerebral hemorrhage, major cardiac events, as well as sepsis and infectious diseases. Moreover, in cancer patients, higher NLR has been associated with poor prognosis. This adverse association may reflect the contribution of severe inflammation and poor immune function to the development of these diseases[15].

Recent studies have demonstrated the usefulness of NLR in assessing the extent of the systemic inflammatory response. Lee et al. reported that elevated NLR can predict length of hospital stay in patients undergoing surgery for severe cholecystitis, while Xie et al. applied NLR to predict gastrointestinal resection in inguinal hernia caused by ischemia[16].

This study revealed that 53% of digestive surgery patients were admitted with immune depletion. At moderate MUST modified scores, 46.4% of patients had severe immune depletion. Indicating that nutrition affects immunity.

Both of nutritional status and systemic inflammatory response have been shown to play an important role in the development and progression of various diseases and the survival rate of hospitalized patients. Inflammatory processes can lead to energy wastage and increased daily requirements for calories and protein. Total lymphocyte count (TLC) is recognized as a biomarker of a patient's nutritional status, as well as a prognostic factor in several clinical conditions[15].

Lower TLC increases the frequency and severity of infections. Nutritional or immune status not only affects the patient's prognosis, but also affects the effectiveness of chemotherapy and the risk of surgery[14].

This study found that 73.3% of digestive surgery patients were hospitalized for more than 14 days. No significant difference was found between MUST modified score and length of hospitalization.

A significant association between MUST modified score and mortality was found. Mortality rate was 39% in patients with moderate MUST modified score, 20% with high MUST modified score. Low MUST scores had a mortality rate of 7%. For digestive surgery patients, clinical nutrition cooperation had a mortality rate of 29.2% compared to didn't received medical nutrition therapy patients, with a mortality rate of 8.9%.

The strength of this study is using a specific total sample of digestive surgery patients who are vulnerable to malnutrition, before and after surgery and or chemotherapy. This study also used Malnutrition Universal Screening Tool (MUST) to assess the risk of malnutrition and was applied at the RSUP. Dr. Wahidin Sudirohusodo Makassar.

This study has limitations that need to be considered. This study used an observational design, which means that the findings are correlational and cannot be used to determine direct correlation. Other factors may influence the results so interventional studies are needed for further confirmation.

CONCLUSSION

In conclusion, this study underscores the high prevalence of hospital malnutrition among digestive surgery patients and its association with weakened immune function. MUST modified score directly correlated with hypoalbuminemia, increased of NLR, and patient mortality in RSUP. Dr. Wahidin Sudirohusodo Makassar, South Sulawesi. The findings highlight the importance of early nutritional screening and intervention in this population. Addressing malnutrition through timely and targeted nutritional therapy may improve immune function and reduce the risk of complications, ultimately contributing to better outcomes for digestive surgery patients.

ACKNOWLEDGEMENTS

REFERENCES

1. Inciong JFB, Chaudhary A, Hsu HS, Joshi R, Seo JM, Trung LV, et al. Hospital malnutrition in northeast and southeast Asia: A systematic literature review. Clin Nutr ESPEN [Internet]. 2020;39:30–45. Available from: https://doi.org/10.1016/j.clnesp.2020.06.001

2. Czapla M, Uchmanowicz I, Juárez-Vela R, Durante A, Kałużna-Oleksy M, Łokieć K, et al. Relationship between nutritional status and length of hospital stay among patients with atrial fibrillation – a result of the nutritional status heart study. Front Nutr. 2022; 9(December):1–17.

3. Weimann A, Braga M, Carli F, Higashiguchi T, Hübner M, Klek S, et al. ESPEN practical guideline: Clinical nutrition in surgery [Internet]. Vol. 40, Clinical Nutrition. Elsevier Ltd; 2021. 4745–4761 p. Available from: https://doi.org/10.1016/j.clnu.2021.03.031

4. Bannert K, Sautter LF, Wiese ML, Meyer F, Ehlers L, Fromhold-Treu S, et al. Analysis of ESPEN and GLIM algorithms reveals specific drivers for the diagnosis of malnutrition in patients with chronic gastrointestinal diseases. Nutrition. 2023;106:1–9.

5. A'zim AZA, Zaid ZA, Yusof BNM, Jabar MF, Shahar ASM. Effectiveness of intensive perioperative nutrition therapy among adults undergoing gastrointestinal and oncological surgery in a public hospital: study protocol for a pragmatic randomized control trial. Trials [Internet]. 2022;23(1):1–11. Available from: https://doi.org/10.1186/s13063-022-06898-2

6. Issangya CE, Msuya D, Chilonga K, Herman A, Shao E, Shirima F, et al. Perioperative serum albumin as a predictor of adverse out-

comes in abdominal surgery: Prospective cohort hospital based study in Northern Tanzania. BMC Surg. 2020;20(1):4–10.

7. Kutnik P, Wichowska O, Sysiak-sławecka J, Szczukocka M, Rypulak E, Piwowarczyk P, et al. Malnutrition risk in elective surgery patients and effectiveness of preoperative nutritional interventions at a pre-anaesthetic clinic: a 4-year apart, single-centre, observational study. 2023;1–7.

8. Akula B, Doctor N. A Prospective Review of Preoperative Nutritional Status and Its Influence on the Outcome of Abdominal Surgery. Cureus. 2021;13(11).

9. Kotani S. Advanced clinical nutrition: Integrative approaches for hospitalized patients. 2024;44(1):1–2.

10. Mohsen G, Stroemer A, Mayr A, Kunsorg A, Stoppe C, Wittmann M, et al. Effects of Omega-3 Fatty Acids on Postoperative Inflammatory Response: A Systematic Review and Meta-Analysis. Nutrients. 2023;15(15):1–13.

11. Gazouli A, Georgiou K, Frountzas M, Tsourouflis G, Boyanov N, Nikiteas N, et al. Perioperative nutritional assessment and management of patients undergoing gastrointestinal surgery. Ann Gastroenterol. 2024;37(2):142–54.

12. Rowley A, Adiamah A, Kushairi A, Lewis SJ, Lobo DN. The effect of post-discharge oral nutritional supplements on outcomes after gastrointestinal surgery: A systematic review and meta-analysis. Clin Nutr [Internet]. 2023;42(7):1189–201. Available from: https://doi.org/10.1016/j.clnu.2023.04.028

13. Boesiger F, Poggioli A, Netzhammer C, Bretscher C, Kaegi-Braun N, Tribolet P, et al. Changes in serum albumin concentrations over 7 days in medical inpatients with and without nutritional support. A secondary post-hoc analysis of a randomized clinical trial. Eur J Clin Nutr. 2023;(January).

14. Kristian YY, Cahyanur R, Wulandari Y, Sinaga W, Lukito W, Prasetyawaty F, et al. Correlation between branched-chain amino acids intake and total lymphocyte count in head and neck cancer patients: a cross-sectional study. BMC Nutr. 2023;9(1):1–8.

15. Song M, Graubard BI, Rabkin CS, Engels EA. Neutrophil-to-lymphocyte ratio and mortality in the United States general population. Sci Rep [Internet]. 2021;11(1):1–9. Available from: https://doi.org/10.1038/s41598-020-79431-7

16. Putranto AS. Neutrophil-Lymphocyte-Ratio as Predictor of Morbidity and Mortality in Adults with Gastrointestinal Obstruction. New Ropanasury J Surg. 2023;8(3).