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The Effect of Extra Egg White Intake on Nutritional Status of Patients in the Intensive Care Unit (ICU)

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ABSTRACT

Background: Ventilated critically ill patients admitted to the intensive care unit (ICU) often have impaired nutritional status. This is due to the high catabolic process resulting from intense inflammation and will cause the patient to be malnourished. Egg white has a high Digestible Indispensable Amino Acid Score (DIAAS) value, and more than 40% of its protein content is essential amino acids with an essential amino acid profile that resembles the profile of the essential amino acid needs of the human body. This study aims to determine the effect of extra egg white intake in critically ill ventilated patients on the nutritional status of patients treated in the intensive care unit of Prof. Dr IGNG Ngoerah Hospital Denpasar. ***Method:*** A true experimental study with a single-blind randomized controlled trial design divided 46 research subjects into two groups: the group with extra egg white Baxter formula with standard hospital enteral nutrition and the group that was only given standard hospital enteral nutrition. Both groups were examined for DL and clinical degree of pitting edema. The Effect of Extra Egg White Intake on Nutritional Status of Patients in the Intensive Care Unit (ICU)All data were compared to see the value of total lymphocytes, neutrophil-lymphocyte ratio and degree of pitting edema. ***Result:*** The TLC results showed a significant increase with a mean ± SD increase of 0.77 ± 0.14 (103/mm3), Effect size 4.307, and $p < 0.001$. The results of NLR obtained a significant decrease with a mean ± SD of 14.3 ± 5.70, Effect size 2.581, and $p = 0.010$. The results of the degree of pitting edema obtained a decrease in the mean ± SD 1.61 ± 0.28, Effect size 4.498 and $p <0.001$. While in the control group, there was no significant difference in the average change. ***Conclusion:*** Giving extra egg white intake increases total lymphocyte count (TLC), decreases neutrophil-lymphocyte count (NLR) and prevents or reduces pitting edema that already exists in critically ill patients who are treated in the ICU room.

Keywords: critical illness; ventilator; malnutrition; extra egg white; standard enteral nutrition

INTRODUCTION

Patients with critical illnesses on ventilators in the intensive care unit (ICU) often experience disruptions in their nutritional status. This is primarily due to the high catabolic process caused by severe inflammation. The impact of malnutrition increases mortality and morbidity rates, leading to prolonged hospital stays, extended use of ventilators, impaired drug efficacy, delayed wound healing, and increased death rates in the ICU. Although nutritional needs are currently calculated according to the operational standards of RSUP Prof. Dr. I.G.N.G Ngoerah Denpasar, nutritional issues still persist among critically ill ventilated patients, particularly protein deficiency. This deficiency is evident in laboratory results such as hypoalbuminemia, low total lymphocyte count, and an increased neutrophil-to-lymphocyte ratio, indicating malnutrition.

The prevalence of malnutrition in critically ill ventilated patients ranges from 38% to 78%. At hospital admission, at least one-third of patients are malnourished, and two-thirds of them experience further nutritional decline without adequate nutrition. Additionally, two-thirds of patients without initial malnutrition may develop malnutrition during their hospital stay [1]. The incidence of hospital malnutrition remains high both abroad and domestically. An epidemiological study in Latin America reported that 25-50.2% of critically ill patients suffer from malnutrition, while 27% of malnourished patients in 25 hospitals in Brazil experienced complications. Another study showed a 52% prevalence of malnutrition among surgical patients [2]. The malnutrition rate among critically ill patients in Spain was 62%, with 54% of hospitalized patients at risk for malnutrition, and the highest prevalence observed in ICU patients at 96% [3].

Another study indicated that 40% of ICU patients are malnourished. The prevalence of malnutrition in three hospitals in Indonesia—RSUP Dr. Sardjito Yogyakarta, RSUP Jamil Padang, and RSUP Sanglah Bali—was 56.9% (Silvia et al., 2016). Malnutrition affects 40-60% of hospitalized patients with acute illnesses, and those who were not malnourished at admission often show a decline in nutritional status within three weeks [4].

Critically ill patients in the ICU tend to be in a hypermetabolic state, experience higher caloric and protein deficits, undergo rapid protein catabolism, or a combination of these factors. These conditions contribute to malnutrition, which ultimately leads to poor clinical outcomes, including nosocomial infections and prolonged ICU stays. Malnutrition in the ICU is also associated with poor prognosis due to the deterioration of body functions, dependency on life support, and high risk of infections, which can increase hospital stay duration and treatment costs[5]. Nutritional assessment is necessary to evaluate malnutrition risk and help categorize nutritional needs according to the patient's current condition and illness [6].

According to the consensus by the Academy of Nutrition and Dietetics (AND) and the American Society for Parenteral and Enteral Nutrition (A.S.P.E.N.), malnutrition is defined by the presence of two or more criteria: inadequate energy intake, weight loss, loss of muscle mass, loss of subcutaneous fat, localized or generalized fluid accumulation, or decreased functional status. In a study by Rocha et al., 2015, nutritional status assessment through biochemical measures such as albumin, total lymphocyte count, and Subjective Global Assessment (SGA) classification was correlated as predictors for identifying nutritional status. One biochemical parameter for assessing nutritional status is the Total Lymphocyte Count (TLC) [7]. The cut-off points used for nutritional status classification (immunological decline) based on TLC are>2000 cells/m3 (normal), 1,200 to 2,000 cells/m3 (mild decrease), 800 to 1,199 cells/m3 (moderate decrease), and < 800 cells/m3 (severe decrease) [7]. Malnutrition is associated with decreased body mass, including thymic gland atrophy, which eventually leads to lymphopenia [8]. Besides TLC, the neutrophil-to-lymphocyte ratio (NLR) is a new parameter for determining nutritional status that can be easily calculated from complete blood count results and reflects s/ystemic inflammation [9]. An NLR value of ≥12.6 is associated with a low BMI [10].

Adequate nutritional interventions have been shown to mitigate the metabolic response to stress and effectively modulate the immune response. Nutritional support for critically ill patients can prevent further metabolic damage and loss of lean body mass [11]. Nutritional support is essential to meet the macro and micronutrient needs of these patients. In this study, we aim to provide additional nutritional support by supplementing with extra egg white intake. It is known that egg white has a high Digestible Indispensable Amino Acid Score (DIAAS). DIASS is an assessment by the Food and Agriculture Organization of several aspects: the proportion of essential amino acids to non-essential amino acids in food protein, the profile of essential amino acids according to human needs, and ease of digestion. Based on this assessment, egg white protein has the highest DIASS value, not only because more than 40% of its protein content is essential amino acids but also due to its essential amino acid profile closely matches the human body's essential amino acid needs. Each 100 grams of chicken egg white contains an average of 10.5 grams of protein, 95% of which is albumin (9.83 grams), while each 100 grams of duck egg white contains an average of 11 grams of protein. Due to its protein composition, egg white has good potential as a nutritional source to increase body albumin levels, as seen in cases of hypoalbuminemia often associated with inflammation [12] Severe inflammation can increase capillary permeability and serum albumin release, leading to an expanded interstitial space and increased albumin distribution volume. The protein content in egg whites, especially ovalbumin, makes it a good candidate as an oral supplement to correct hypoalbuminemia[12].

Several studies have found that egg white when given in the form of juice, can enhance patients' protein intake acceptance [13]. Egg white is easily absorbed by the digestive tract and contains a high protein content. Providing egg white intake can also help reduce hospital treatment costs, particularly in the ICU. Thus, supplementing with egg white can reduce or even eliminate the need for synthetic albumin supplements such as plasmanate or 20% albumin to correct nutritional status, especially in hypoalbuminemia patients. In this era of national health insurance (BPJS), efficient and effective management of critically ill ventilated patients in the ICU is crucial for achieving recovery. Additionally, this study is feasible for clinical application in other hospitals, particularly in remote areas.

METHOD

This study is pure experimental research with a single-blind randomized controlled trial design. The study subjects were divided into two groups: Group A, which received standard enteral nutrition with extra egg white, and Group B, which received standard enteral nutrition without the addition of extra egg white juice. The allocation of subjects to each group was done through randomization, ensuring that each subject had an equal chance of receiving the treatment. The subjects gave their consent but were unaware of which group they were assigned to. Measurements of the three outcome variables were conducted twice, before and after the treatment. The study was conducted in the Intensive Care Unit of Prof. Dr. I.G.N.G Ngoerah General Hospital in Denpasar from June to August 2023, or until the sample size was met.

Inclusion Criteria: a. Patients aged 18 to under 65 years old; b. Critically ill-ventilated patients, either medical or post-surgical, who are being treated in the ICU of Prof. Dr. I.G.N.G Ngoerah General Hospital, Denpasar; c. Patients capable of receiving enteral nutrition; d. Patients who are not allergic to chicken eggs. Exclusion Criteria: a. Patients whose families refuse the procedures involved in the study, as evidenced by informed consent; b. Presence of contraindications for administering extra egg white juice (such as egg allergy, non-functioning intestines, severe inflammation, or in specific cases like post-operative intestinal anastomosis and total bowel obstruction); c. Patients receiving parenteral nutrition therapy; d. Patients with malnutrition; e. Patients with AIDS; f. Patients with aplastic anemia; g. Patients with myelodysplasia; h. Patients with leukemia; i. Patients with lymphoma; j. Patients with systemic lupus erythematosus (SLE). Drop-Out Criteria: a. Patients who develop an allergy to egg white; b. Occurrence of stress ulcers during the treatment; c. Patients are unable to receive enteral nutrition; d. Presence of residuals in the nasogastric tube (NGT) greater than 200 ml; e. Patients who die during the study period; The sampling technique used was consecutive admission random sampling, in which subjects were selected based on the order of their arrival, provided they met the inclusion criteria, until the required sample size was achieved.

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RESULT

In this study, 53 patients were initially included, but 7 patients passed away, resulting in a total of 46 subjects. There were 23 respondents in group A and 23 respondents in group B. The deceased patients were immediately categorized under the dropout criteria. The characteristics of the patient data are presented in Table 1.

TABLE 1: Characteristics of the Study Data.

Variable	Group A n=23	Group B n=23	p-value
Age (mean±SD)	45.61±16.38	50.22±10.17	0.258
Gender (%)			
Man	15 (65.2)	11 (47.8)	0.234
Woman	8 (34.8)	12 (52.2)	
Basic Diseases			
Cerebrovascular disease	10 (43.5)	10 (43.5)	
Trauma	2 (8.7)	4 (17.4)	
Digestive surgery	3 (13.0)	0 (0)	
Infection	4 (17.4)	7 (30.4)	
Cancer	4 (17.4)	2 (8.7)	
Comorbidities			
There is	11 (47.8)	9 (39.1)	0.552
There isn't any	12 (52.2)	14 (60.9)	
Comorbidities			
Hypertension	8 (34.8)	3 (13.0)	
Heart disease	1 (2.34)	0 (0)	
Hypothyroid	0 (0)	1 (2.34)	
Low back pain	0 (0)	1 (2.34)	
Diabetes mellitus	2 (8.7)	1 (2.34)	
Pneumonia	0 (0)	1 (2.34)	
Obesity degree II	0 (0)	1 (2.34)	
Autoimmune	0 (0)	1 (2.34)	
Albumin level before treatment (g/dl)	2.86 ± 0.22	2.92 ± 0.31	0.665
Body Weight (kg)	54.86±10.42	54.82±7.35	0.987
Egg white (grams)	299.27 ± 146.59	-	

*Independent t-test; **Chi-square; SD: Standard deviation.

An analysis comparing TLC, NLR, and the degree of pitting edema based on the distribution of normality and homogeneity tests showed that not all data were normally distributed and homogeneous. Therefore, the Wilcoxon test was used, as presented in Table 2.

TABLE 2: Comparative Analysis of the Median (min-max) for TLC, NLR, and the Degree of Pitting Edema.

Variable	Group A			Group B		
	Before	**After**	**p-value***	**Before**	**After**	**p-value***
TLC (×103 /μL)	0.98 (0.83-2.57)	1.61 (0.83-2.57)	<0.001**	1.05 (0.35-5.96)	0.86 (0.20-1.89)	0.018**
NLR	15.41 (6.81-44.18)	10,10 (2.22-53.78)	0.004**	11.85 (1.35-41.26)	15.65 (5.39-95.00)	0.007**
Degree of Pitting edema	1 (0-3)	0 (0-3)	0.003**	0 (0-2)	2 (0-3)	<0.001**

*Wilcoxon test; **significant at p<0.05.

The results in Table 2 show that, in group A, there was a significant increase in TLC from before the treatment, with a median (min-max) of 0.98 $\times 10^3$ /μL (0.83-2.57) increasing to 1.61 $\times 10^3$ /μL (0.83-2.57), with a p-value of <0.001. In contrast, in group B, there was a significant decrease from a pre-treatment value of 1.05 $\times 10^3$ /μL (0.35-5.96) to 0.86 $\times 10^3$ /μL (0.20-1.89), with a statistically significant p-value of <0.001 (Figure 1).

For NLR, the results show a significant decrease in group A from a pre-treatment median (min-max) of 15.41 (6.81-44.18) to 10.10 (2.22-53.78), with a p-value of 0.016. Conversely, in group B, there was a significant increase from a pre-treatment value of 11.85 (1.35-41.26) to 15.65 (5.39-95.00), with a statistically significant p-value of 0.007 (Figure 2).

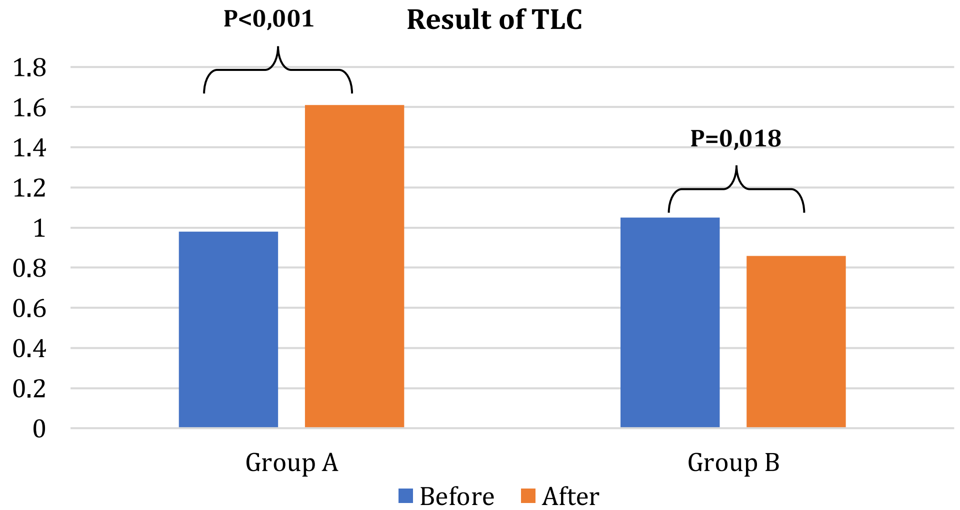

FIGURE 1: Graph of the Differences in TLC Results.

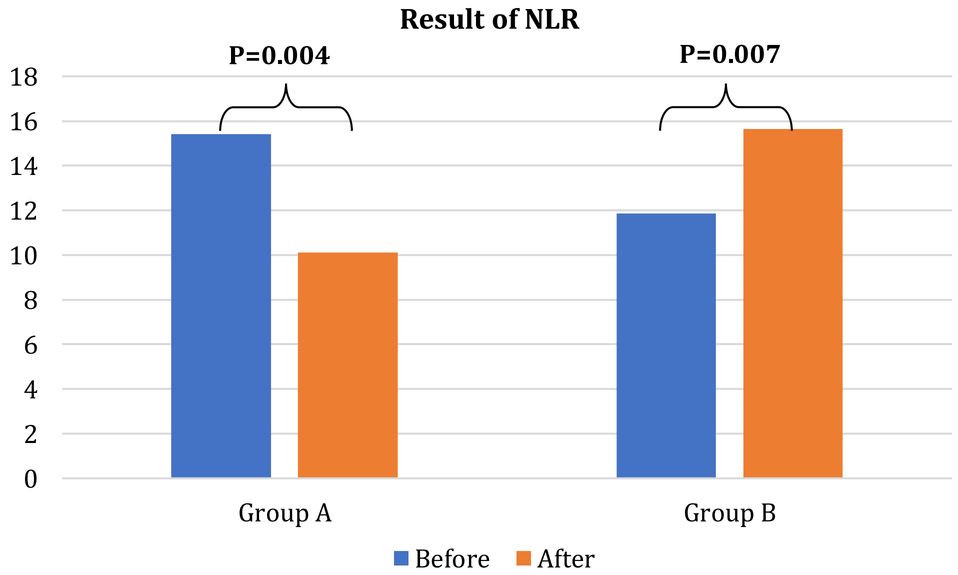

FIGURE 2: Graph of the Differences in NLR Results.

The results for the degree of pitting edema showed a significant decrease in group A, with a pre-treatment median (min-max) of 1 (0-3) decreasing to 0 (0-3), with a p-value of <0.001.

In contrast, in group B, the degree of pitting edema increased significantly from a pre-treatment value of 0 (0-2) to 2 (0-3), with a statistically significant p-value of <0.001 (Figure 3).

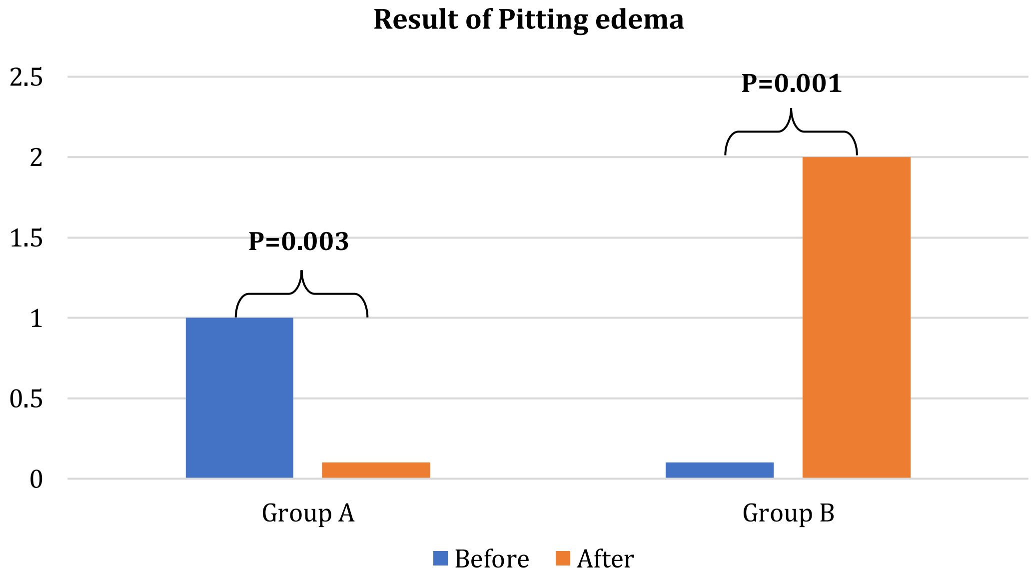

FIGURE 3: Graph of the Differences in Pitting Edema Results.

To compare the mean differences in TLC, NLR, and the degree of pitting edema between the groups, the Mann-Whitney test was used because the data were not normally distributed. The results are presented in Table 3.

TABLE 3: Analysis of the Mean Differences (Delta) for TLC, NLR, and the Degree of Pitting Edema.

Variable	**Group A**			**Group B**		
	Mean ± SD	**Effect size**	**p-value***	**Mean ± SD**	**Effect size**	**p-value**
ΔTLC (×103 /μL)	0.77 ±0.14	4,307	<0.001**	-0.42±0.27	-0.590	0.555
Δ NLR	-14.3±5.70	-2,581	0.010**	0.22±2.7	1,791	0.073
Δ Pitting edema	-1.61±0.28	-4,498	<0.001**	0.39±0.21	1,556	0.120
Variable	**Kelompok A**			**Kelompok B**		
	Rerata ± SD	**Effect size**	**Nilai p***	**Rerata ± SD**	**Effect size**	**Nilai p**
Δ TLC (×10^3 /μL)	0,77 ±0,14	4,307	<0,001**	-0,42±0,27	-0,590	0,555
Δ NLR	-14,3±5,70	-2,581	0,010**	0,22±2,7	1,791	0,073
Δ Pitting edema	-1,61±0,28	-4,498	<0,001**	0,39±0,21	1,556	0,120

*Mann-Whitney test; **significant at p<0.05.

The results in Table 3 show that the Δ TLC indicates a significant difference in group A, with an effect size increase of 4.307 and a mean ± SD increase of 0.77 ± 0.14 (10^3/mm^3), which is statistically significant with a p-value of <0.001. In contrast, group B did not show a significant mean difference, with a p-value of 0.555 (Figure 4).

The results for Δ NLR indicate a significant difference in group A, with an effect size decrease of 2.581 and a mean ± SD decrease of 14.3 ± 5.70, which is statistically significant with a p-value of 0.010. In contrast, group B did not show a significant mean difference, with a p-value of 0.070 (Figure 5).

The results for Δ pitting edema indicate a significant difference in group A, with an effect size decrease of 4.498 and a mean ± SD decrease of 1.61 ± 0.28, which is statistically significant with a p-value of <0.001. In contrast, group B did not show a significant mean difference, with a p-value of 0.120 (Figure 6).

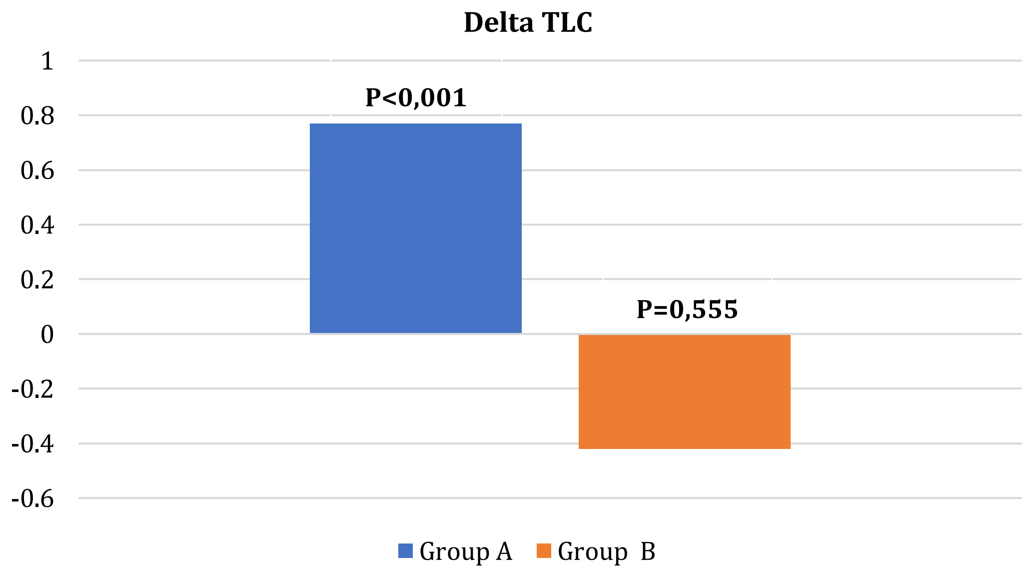

FIGURE 4: Graph of the Difference in TLC Results Between Groups A and B.

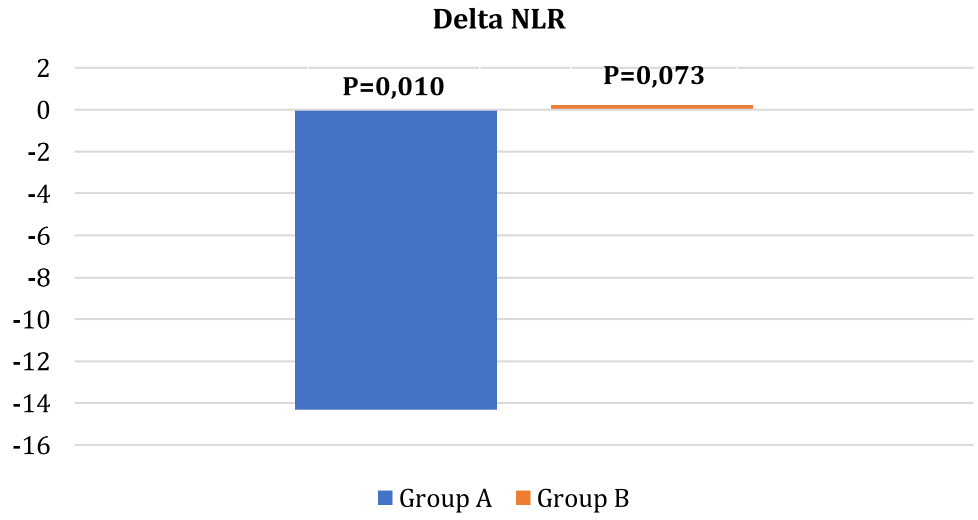

FIGURE 5: Graph of the Difference in NLR Results Between Groups A and B.

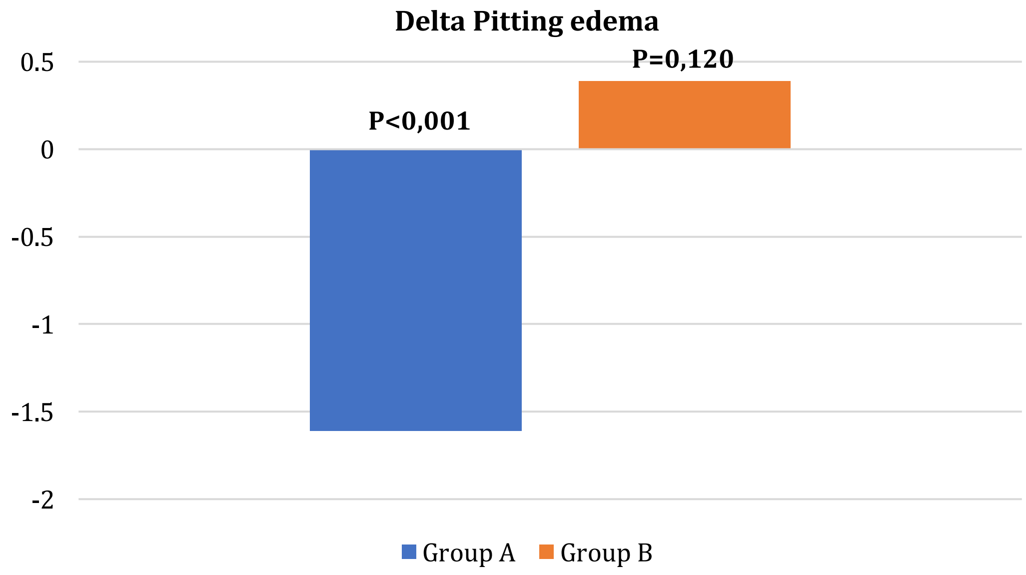

FIGURE 6: Graph of the Difference in Pitting Edema Results Between Groups A and B.

DISCUSSION

The results show that the average age between the two groups is not significantly different, with group A having a mean age of 45.61 ± 16.38 years and group B having a mean age of 50.22 ± 10.17 years. These findings are similar to those of Syamsiatun & Siswati (2015), who reported a mean age of 48.78 ± 11.23, with the most common age range being 45–55 years [13]. Patients under the age of 65 represent the highest age group among those receiving care in the ICU, with the most common age range being 45–55 years [14]. Zilberberg et al. (2020) conducted a study comparing the duration of ventilator use in patients with a mean age ± SD of 62.0 ± 15.8 for long-term ventilator use and 61.7 ± 17.2 for patients with short-term ventilator use (<4 days). The study found that age is not associated with the duration of ventilator use. The factors contributing to prolonged ventilator use in ICU patients include complications such as severe sepsis, septic shock, heart failure, and renal failure [15]. Advancing age causes a slight decrease in plasma albumin levels. The administration of extra egg whites in the ICU showed no difference in effectiveness based on the patient's age [13].

There was no significant difference in gender between the two groups, with the majority being male compared to female (p = 0.234). In group A, there were 15 male respondents (65.2%) and 8 female respondents (34.8%). In group B, there were 11 male respondents (47.8%) and 12 female respondents (52.2%). These results are not significantly different from those observed Syamsiatun & Siswati, (2015), In the treatment group receiving additional egg whites, there were 8 male respondents (30%) and 19 female respondents (70%), whereas, in the control group, the majority were male, with 14 respondents (56%) and 11 female respondents (44%); p = 0.054. The metabolism of albumin in males and females does not differ, resulting in a similar prevalence of hypoalbuminemia in both genders [13,16].

"In this study, the average administration of egg whites was 299.27 grams (300 grams), equivalent to 300 ml of egg whites per day, which was effective in increasing TLC, reducing NLR, and decreasing pitting edema. The study by Zhuang et al. (2021) showed that adding at least half an egg to each meal can help boost immunity and reduce mortality rates in patients with cardiovascular disease (CVD) by 1.07 times (95% CI 1.06-1.09) and cancer by 1.07 times (95% CI 1.06-1.08) [17]. Extra egg whites can be used as an adjunct to antihypertensive medication to help lower blood pressure [18]. The administration of extra egg whites, prepared by blending 40 g of cooked egg whites with 70 g of fresh fruit and 15 g of sugar, given to patients with hypoalbuminemia three times a day for seven consecutive days, resulted in a higher mean increase in albumin levels in the treatment group (0.522 ± 1.685) compared to the control group (0.007 ± 0.4522) (p = 0.001)[13].

Eggs are rich in complete proteins that enhance muscle protein synthesis and help maintain skeletal muscle mass. On average, a large egg provides approximately 6.3 grams of protein rich in essential amino acids. Eggs are an affordable, nutritious food with significant health benefits. These nutrients include vitamins, essential proteins, minerals, fats, and various bioactive compounds.

Eggs have a high nutrient-to-energy density ratio per egg. A standard boiled egg weighing about 50 grams can provide 78 kcal of energy, 0.56 grams of carbohydrates, 6.29 grams of protein, and 5.3 grams of total fat. The total fat in an egg contains up to 160 mg of saturated fat, 72 mg of polyunsaturated fat, 80 mg of monounsaturated fat, and 186 mg of cholesterol. The micronutrients in eggs include iron, calcium, phosphorus, zinc, potassium, magnesium, sodium, and most vitamins, except for vitamin C. These vitamins include riboflavin, niacin, thiamine, folate, and vitamins A, B6, B12, D, E, and K. In addition to providing high-quality protein comparable to breast milk, eggs are also a source of antioxidants [19,20].

Important antioxidants in eggs include phosvitin, which is rich in phosphoserine, ovotransferrin, which binds Fe3+, and ovalbumin, which enhances the antioxidant activity of polysaccharides through covalent binding. These antioxidants work by binding metal ions and scavenging free radicals, thereby inhibiting lipid oxidation. Therefore, eggs are a potential natural source of antioxidants that can be used in cosmetics and the food industry. The antioxidant activity of eggs can improve many degenerative conditions, cerebrovascular disorders, and cardiovascular diseases in humans [21,22].

The underlying diseases in both groups were the same, with cerebrovascular diseases being the most common, each with 10 respondents (43.5%). The most common comorbid condition was hypertension, indicating that the administration of eggs can be recommended for patients, given its benefits in supporting body function improvement during the recovery process. These findings are similar to those of Jeong et al. (2021), who found that the most common patients requiring ventilator support and ICU admission were those with cerebrovascular diseases, accounting for 49 cases (20.9%) [23]. Eggs are not only rich in bioactive components and essential nutrients but also contain high levels of cholesterol. This has led to controversy and differing opinions on dietary recommendations across populations. Nonetheless, due to their nutritional quality, eggs and their derivatives are known to reduce inflammation and modulate the immune system [22]. The study by Batiha et al. (2021) revealed that egg whites are recommended for COVID-19 patients due to their significant immunomodulatory and anti-inflammatory properties, which are attributed to several of their chemical constituents. Eggs are a complex food component containing many essential nutrients, bioactive compounds, and high-quality proteins [16].

The pre-treatment albumin levels showed no significant difference between the two groups (p = 0.665), with group A having albumin levels of 2.86 ± 0.22 g/dl and group B having 2.92 ± 0.31 g/dl.

These results are similar to the findings of Jeong et al. (2021), which reported that among 234 ICU patients on ventilators, the median albumin level was 2.8 (2–3.2) g/dl [23]. The results of this study are also similar to those of Syamsiatun & Siswati (2015), which found that albumin levels in patients at Dr. Sardjito Hospital Yogyakarta and Panembahan Senopati Hospital Bantul were 2.70 ± 0.48 g/dl in the treatment group and 2.82 ± 0.41 g/dl in the control group; p = 0.207 [13].

Albumin plays an important role in transporting certain chemicals, including drugs, through the circulatory system. It carries various water-insoluble substances (such as bilirubin, fatty acids, and certain hormones), maintains plasma oncotic pressure, serves as a defense mechanism (through its control and antioxidant functions), aids in nutrient metabolism, and accelerates cellular tissue recovery. Additionally, albumin functions as a water reserve for the body prevents the constriction and blockage of blood vessels, helps maintain osmotic pressure, serves as a transport medium for drugs, and provides protection against foreign substances (such as viruses, bacteria, fungi, and cancer cells). Enhanced drug transport capacity can accelerate the recovery process. Albumin also protects the body by binding toxins together with bilirubin, transporting them to the liver for neutralization. Bilirubin bound to albumin acts as an antioxidant by preventing damage to vitamin E caused by free radicals [24].

The results for body weight also showed no significant difference between the two groups (p = 0.987), with the treatment group having a mean weight of 54.86 ± 10.42 kg and the control group 54.82 ± 7.35 kg. A study conducted in 10 hospitals with 2,845 patients admitted to the ICU found that the average body weight of the patients was similar to this study, at 62.67 ± 11.8 kg, with the most common weight range being 60–70 kg [25].

The results for TLC in the group receiving extra egg whites showed a median (min-max) increase from 0.98 (0.83-2.57) to 1.61 (0.83-2.57), with a p-value of <0.001. In contrast, in the control group, the pre-treatment value of 1.05 (0.35-5.96) decreased to 0.86 (0.20-1.89), which was statistically significant with a p-value of <0.001. The Δ TLC showed a significant difference in the treatment group, with an effect size increase of 4.307 and a mean ± SD increase of 0.77 ± 0.14, which was statistically significant with a p-value of <0.001. Meanwhile, in the control group, no significant difference in the mean was found, with a p-value of 0.555. These findings are consistent with the study by Konwar et al. (2015), which found that administering at least 30 ml of egg whites per intake significantly increased TLC, with a p-value of <0.01 [26].

The results for NLR in the treatment group showed a significant decrease from the pre-treatment median (min-max) of 15.41 (6.81-44.18) to 10.10 (2.22-53.78), with a p-value of 0.016. In contrast, the control group showed an increase from the pre-treatment value of 11.85 (1.35-41.26) to 15.65 (5.39-95.00), which was statistically significant with a p-value of 0.007. The Δ NLR showed a significant difference in the treatment group, with an effect size decrease of 2.581 and a mean ± SD decrease of 14.3 ± 5.70, which was statistically significant with a p-value of 0.010. In contrast, no significant difference in the mean was found in the control group, with a p-value of 0.070. These findings are consistent with the study by Song et al. (2014), which found a decrease in NLR levels with the administration of 30 grams, 50 grams, and 100 grams of egg whites over 4 weeks compared to those who received 0 grams and 10 grams, with a p-value of <0.01 [27]. The study results show that critically ill patients have an NLR value greater than 5, which predicts the occurrence of malnutrition [10].

The results for the degree of pitting edema in group A showed a significant decrease from a pre-treatment median (min-max) of grade 1 (0-3) to 0 (0-3), with a p-value of <0.001. In contrast, in group B, the pre-treatment value of 0 (0-2) increased to 2 (0-3), which was statistically significant with a p-value of <0.001. The Δ pitting edema showed a significant difference in group A, with an effect size decrease of 4.498 and a mean ± SD decrease of 1.61 ± 0.28, which was statistically significant with a p-value of <0.001. In group B, no significant mean difference was found, with a p-value of 0.120. The administration of egg whites significantly reduced pitting edema in cases of adult malnutrition with the intake of at least one egg per day (30 grams) for one month. In studies on children suffering from kwashiorkor, a reduction in pitting edema was observed with the administration of 15 grams per day [28].

The statistically significant results of the study are due to the fact that the majority of the population studied had cases of post-cerebrovascular surgery with comorbid hypertension. The absence of other organ damage facilitated easier absorption of the extra egg whites. Egg whites themselves are high in essential amino acids. The main proteins in egg whites are ovalbumin, ovotransferrin, and ovomucoid. Other proteins include ovomacroglobulin (ovostatin), cystatin, lysozyme, avidin, ovoinhibitor, and ovomucoid, which give albumin its characteristic viscosity [16]. The administration of additional protein in the form of extra egg whites for 7 days corresponds to the phases of critically ill patients. During the late acute phase (the flow phase), full EN or PN should be gradually achieved within three to seven days. The protein target should gradually reach 1.3 g/kg or 1.2 to 2.0 g/kg of protein per day.

In this study, the initial number of patients was larger, with 53 subjects; however, 7 of them died during the study, leading to their immediate drop-out. The causes of death were sepsis and organ failure due to complications. These findings are consistent with a meta-analysis conducted in several ICUs in America, Europe, and Asia, involving a total of 785 hospitals, which found the highest mortality rate due to sepsis at 52%, followed by organ failure at 23% (Barreto et al., 2019). This result is also similar to the highest mortality rate in Germany, where 61% of deaths were caused by sepsis [29].

In addition to using egg whites, another study that has been published involved the use of VIP albumin (Ophiocephalus striatus extract, 500 mg) at a dosage of one tablet every 8 hours for 16 days, which was found to increase albumin levels by up to 2.04 ± 1.47 g/dl in ICU patients on mechanical ventilation. Meanwhile, the use of Channa striata extract, 500 mg every 12 hours for 21 days, resulted in an albumin increase of up to 3.6 ± 0.8 g/dl in patients with hypoalbuminemia [30] The results of this study are also similar to those of Farouk Musa et al. (2018), who used Channa striata extract, 500 mg every 8 hours for 18 days, resulting in an increase of 3.5 ± 1.8 g/dl. Another use is 'Supromin,' an enteral-modified food based on tempeh, skim milk, and egg whites, which increased albumin levels by 0.17 ± 0.29 mg/dl after being administered for 7 days to stroke patients with hypoalbuminemia [31].

In the study conducted by Arisa Izzaty (2014), it was found that administering 100% pure Channa striata extract could reduce lymphocytes during the acute phase to 3.8 ± 2.54 g/dl. Low albumin levels can lead to low blood osmotic pressure, resulting in fluid leakage from blood vessels. Therefore, administering snakehead fish extract is quite effective in treating hypoalbuminemia in patients with conditions such as inflammation, sepsis, and several other diseases, thereby reducing the number of lymphocytes in the body [32].

Mustafa et al (2022) study found a reduction in neutrophil levels with the use of snakehead fish extract at a 100% concentration, with a decrease of 0.7 ± 0.98 g/dl [33]. Fadhila found a decrease in neutrophil levels with a 100% concentration of 32.50 ± 0.85 g/dl [34]. Meanwhile, Taslim's study reported that using 81 mg/day Pujimin capsules containing Channa striata extract resulted in a reduction in neutrophil levels by the 10th day (23.33%) [35].

A limitation of this study was that most of the data collected was from neurological cases. Therefore, further research is needed to obtain a more diverse range of data on critically ill ICU patients. The relatively small number of subjects in this study suggests the need for a larger sample size in future research

CONCLUSION

(1) Administration of extra egg whites increases total lymphocyte count (TLC) in critically ill patients treated in the ICU at Prof. Ngoerah General Hospital, Denpasar.
(2) Administration of extra egg whites reduces the neutrophil-lymphocyte ratio (NLR) in critically ill patients treated in the ICU at Prof. Ngoerah General Hospital, Denpasar.
(3) Administration of extra egg whites prevents or reduces existing pitting edema in patients.

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