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The impact of nutritional status and body mass index on lung function, functional capacity, and mortality in lung transplant candidates: A retrospective single-center study

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Abstract:

BACKGROUND AND AIM: Lung transplantation is an important treatment option for patients with end-stage lung diseases, and outcomes may be influenced by nutritional status. This retrospective cohort study of 210 lung transplant candidates aimed to examine the associations of the Nutritional Risk Index (NRI), body mass index (BMI), and biochemical markers with functional capacity, lung function, BODE index, mortality, intensive care unit (ICU) duration, and survival.

METHODS: This retrospective cohort study included 210 lung transplant candidates who were treated at a tertiary-level specialized training and research hospital between 2016–2023. The study collected biochemical measurements, Pulmonary Function Test (PFT), Six-Minute Walk Test (6MWT), bone scans, and nutritional status data. It also assessed post-transplant ICU duration and albumin levels.

RESULTS: Severe malnutrition was prevalent (approximately 46%) across all patient groups, including those listed for transplantation, those who underwent transplantation, and those who died while awaiting. Severe malnutrition was significantly associated with lower values of BMI, FVC%, FEV_1, and FEV_1/FVC ($p<0.01$). NRI was strongly correlated with these parameters and post-transplant survival ($r=0.85$, $p<0.001$). Unlike BMI and albumin when considered alone, NRI remained an independent predictor of survival in multivariable linear regression analysis ($p<0.01$). Patients with hypoalbuminemia showed reduced 6MWT performance and lower NRI scores ($p<0.05$). Post-transplant ICU stay was prolonged in patients with severe malnutrition; however, waiting list mortality was not significantly associated with NRI after adjustment.

CONCLUSIONS: The NRI is a simple and effective nutritional screening tool for lung transplant candidates and predicts lung function and survival better than BMI or albumin alone. Routine pre-transplant nutritional optimization guided by NRI may improve post-transplant outcomes.

Keywords: Lung transplantation, nutrition, nutritional risk index

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Introduction

Lung transplantation is the definitive therapy for various end-stage lung diseases, but it is complicated by high morbidity and mortality.[1] Although significant advances have been made in lung transplantation, the median survival remains approximately 6 years, notably lower than in recipients of other solid-organ transplants. Therefore, identifying risk factors associated with poor prognosis in lung transplantation may help mitigate transplant-related risks.[2,3] Malnutrition exacerbates complications, prolongs hospital stays, and impairs survival, particularly in patients experiencing extended waiting times before transplantation.

Nutrition goals in the pre-transplant phase include optimizing the patient's nutritional status and addressing nutrition-related symptoms arising from organ failure. Relative contraindications to nutritional care include class I obesity (body mass index (BMI) 30–34.9 kg/m²), low BMI (<17 kg/m²), cachexia, malnutrition, uncontrolled diabetes, and osteoporosis. The nutritional needs of lung transplant candidates are diverse, requiring individualized recommendations tailored to best meet each patient's needs.[4–6]

The impact of BMI in predicting lung transplant outcomes was first highlighted by Plöchl's report of increased intensive care unit mortality in lung transplant recipients with BMIs in the lowest quartile.[7] Given risk factors such as advanced age and disease severity, lung transplant candidates are more vulnerable to malnutrition, which predisposes them to imbalances in energy, protein, and other essential nutrients. Malnutrition is a known major risk factor leading to adverse outcomes in chronic diseases and can negatively affect protein/energy balance, physical function, and clinical outcomes.[8,9] Therefore, identifying potentially modifiable risk factors such as malnutrition may help offset some of the morbidity and mortality associated with lung transplantation.

No standardized malnutrition screening tool exists for lung transplant candidates. An ideal screening tool would enable the identification of patients at risk of malnutrition and facilitate the improvement of their nutritional status. The Nutritional Risk Index (NRI)—calculated from easy-to-obtain variables (serum albumin and weight relative to ideal body weight)—provides a practical, objective metric. The NRI has the potential to classify nutritional risk based on an individual's score. Chohan et al.[1] proposed that the NRI could serve as an effective tool for identifying malnutrition in lung transplant candidates, potentially aiding in the prediction of both pre- and post-transplant outcomes.

NRI, given its simplicity and prior evidence of its predictive capability, was investigated in this study for its prognostic value, alongside BMI and biochemical markers, for functional and survival outcomes in lung transplant candidates.

Materials and Methods

The study population consisted of patients evaluated at a tertiary-level lung transplantation center between 2016 and 2023. The inclusion criteria were as follows. Patients aged 18–65 years with end-stage lung disease who were actively listed for lung transplantation, recevied oral nutrition, and had no severe psychiatric illness were included in the study. Patients who were removed from the waiting list, were pregnant or lactating, had severe psychiatric illness, received enteral nutrition via PEG or JEG, or had missing data were excluded.

Of 228 patients, 210 met the inclusion and exclusion criteria and were included in the retrospective cohort study. Ethics committee approval for this study was obtained from Ethics Committee of Koşuyolu High Specialisation Training and Research Hospital (Approval Number: 2023/04/671, Date: 28.02.2023).

Data collection

Study data were collected by the researcher from the hospital archive and the hospital information management system. After obtaining ethics committee approval, eligible patients were identified from the Lung Transplant Clinic database. 15 November 2023 was designated as the inclusion cut-off date, and patients on the waiting list at that time were followed for an additional 30 days. The study population consisted of patients registered between 08 December 2016 and 09 November 2023. A total of 210 patients entered the transplant list on these dates and met the inclusion and exclusion criteria. 73 patients died while waiting on the list, 86 patients were transplanted, and 51 patients remain on the current waiting list.

Table 1: Patients' age, waiting time for transplantation, and clinical values

Variables	Mean±SD	Median (25p-75p)
Waiting time (day)	264.01±285.61	160 (70–367)
Age (year)	46.42±13.4	50 (37–57)
BMI (kg/m^2)	23.03±4.22	23.5 (20–26)
6MWT (m)	275.39±141.06	297 (190–381)
FVC (%)	44.39±17.62	41.6 (33–52)
FEV_1 (%)	36.83±19.51	32 (21–49.35)
FEV_1/FVC (%)	72.94±24.47	78 (54–90)
NRI	83.06±9.71	83.12 (76.1–90.78)
Post-transplant NRI	70.12±13.96	74.2 (64.38–78.2)
BODE index	5.97±1.93	6 (5–7)
Post-transplant ICU stay (days)	9.68±9.83	6 (3.5–13)
Post-transplant survival (day)	753.2±879.87	151.5 (18–1650)

SD: Standard deviation, BMI: Body mass index, 6MWT: Six-minute walk test, FVC: Forced vital capacity, FEV_1: Forced expiratory volume in one second, NRI: Nutritional risk index, BODE: Body mass index, airflow obstruction, dyspnea, and exercise, ICU: Intensive care unit.

For all patients, biochemical data, pulmonary function test (PFT) results, six-minute walk test (6MWT) data, bone mineral density (BMD) measurements and immunonutrition reporting status, height (cm), and weight (kg) on the date they entered the list were retrospectively reviewed. The duration of post-transplant intensive care unit hospitalisation, albumin values routinely checked at the first-month follow-up of patients who survived the first month after transplantation, and patients' L-glutamine reporting status were retrieved from the hospital information management system. It was ensured that L-glutamine supplementation had been reported at least 30 days prior. Glutamine supplementation between 15-30 g was reported for patients in whom immunonutrition was recommended, as recommended in the literature.[10]

Nutritional assessment

Nutritional status was determined using the Nutritional Risk Index (NRI), calculated as:

$$NRI = (1.519 \times \text{serum albumin [g/L]}) + (41.7 \times \text{current weight / ideal body weight})$$

Patients were classified as severely malnourished (NRI < 82), moderately malnourished (NRI 82–92), mildly malnourished (NRI 92–98), or no risk (>98).[11]

Statistical analysis

Statistical analyses were performed using IBM SPSS Statistics for Windows, version 25.0 (IBM Corp., Armonk, NY, USA). Continuous variables were presented as mean ± standard deviation or median (25th–75th percentile), and categorical variables as number and percentage. Normality was assessed using the Kolmogorov–Smirnov test. Categorical variables were analyzed using the chi-square or Fisher's exact test, as appropriate. For continuous variables, one-way ANOVA with Tukey post-hoc test or non-parametric tests (Kruskal–Wallis and Mann–Whitney U tests) were applied, depending on the data distribution. Associations between continuous variables were evaluated using Spearman's rank correlation analysis. Variables included in regression analyses were determined a priori based on clinical evidence from previous studies demonstrating associations between nutritional status and clinical outcomes. Survival time was treated as a continuous variable, and correlation and linear regression analyses were performed only for exploratory and associative purposes. A p-value of <0.05 was considered statistically significant.

Results

A total of 210 patients listed as candidates for lung transplantation were included in the study. The cohort comprised 72.9% male patients, with a mean age of 46.4 ± 13.4 years. The mean waiting time on the transplant list was 264.0±285.6 days. Baseline anthropometric, nutritional, respiratory, and clinical characteristics—including body mass index (BMI), NRI, BODE index, pulmonary function parameters, six-minute walk test (6MWT) performance, and post-transplant outcomes—are summarized in Table 1.

Patients were categorized into three groups according to current status: transplanted, deceased while on the waiting list, and still awaiting transplantation. Comparative analyses of demographic, clinical, and laboratory characteristics are presented in Tables 2–5.

Table 2: Distribution of patients according to their current status

Variables	On the list (n=51)	Transplanted (n=86)	Ex-listed (n=73)	p
Gender, n (%)				0.578†
Female	13 (25.5)	21 (24.4)	23 (31.5)	
Male	38 (74.5)	65 (75.6)	50 (68.5)	
Diagnosis, n (%)				0.001†
Obstructive lung disease	6 (11.8)	25 (29.1)	7 (9.9)	
Interstitial lung disease	24 (47.1)	36 (41.9)	49 (69.0)	
Suppurative lung disease	20 (39.2)	23 (26.7)	11 (15.5)	
Vascular lung disease	1 (2.0)	2 (2.3)	1 (1.4)	
Diabetes, n (%)				0.121†
Yes	9 (17.6)	9 (11.1)	4 (5.8)	
No	42 (82.4)	72 (88.9)	69 (94.2)	
Bone status, n (%)				0.655†
Normal	16 (57.1)	37 (47.4)	34 (51.5)	
Osteopenia/Osteoporosis	12 (42.9)	41 (52.6)	32 (48.5)	
Use of enteral nutritional supplements, n (%)				<0.001†
Yes	8 (28.6)	24 (30.8)	15 (22.7)	
No	20 (71.4)	54 (69.2)	51 (77.3)	
NRI category, n (%)				0.711¶
Severe malnutrition	23 (46.0)	40 (47.1)	30 (41.7)	
Moderate malnutrition	18 (35.3)	17 (20.2)	33 (46.5)	
Mild malnutrition	10 (19.6)	28 (32.9)	10 (13.7)	
No risk of malnutrition	<5%	<5%	<5%	

†: Chi-square test; ¶: Fisher's exact test was applied. NRI: Nutritional risk index.

Table 3: Clinical and demographic characteristics of patients according to NRI status

Variables	Severe malnutrition <82	Moderate malnutrition 82–92	Mild malnutrition 92–98	No risk >98	p
Gender, n (%)					
Female	23 (24.7)	15 (20.5)	11 (33.3)	1 (12.5)	0.682†
Male	40 (43.0)	28 (38.4)	13 (39.4)	4 (50.0)	
Current status, n (%)					
On list	24 (25.8)	16 (21.9)	10 (30.3)	6 (75.0)	
Transplant/Ex, n (%)	69 (74.2)	57 (78.1)	23 (69.7)	2 (25.0)	0.014†
Diagnosis					–
Obstructive lung disease	15 (16.1)	9 (12.3)	3 (9.1)	1 (12.5)	
Interstitial lung disease	30 (32.3)	30 (41.1)	9 (27.3)	3 (37.5)	
Vascular lung disease	18 (19.4)	11 (15.3)	7 (21.2)	2 (25.0)	
Indications for retransplantation	34 (36.6)	47 (65.3)	20 (60.6)	6 (75.0)	
Diabetes, n (%)					–
No	35 (37.6)	13 (18.1)	6 (18.2)	0 (0.0)	
Yes	4 (4.3)	0 (0.0)	0 (0.0)	0 (0.0)	
Bone status, n (%)					
Normal	83 (92.2)	62 (87.3)	26 (83.9)	7 (87.5)	
Osteopenia/Osteoporosis	7 (7.8)	9 (12.7)	5 (16.1)	1 (12.5)	0.570†
Enteral product reporting, n (%)					
Reported	42 (53.8)	28 (45.9)	14 (56.0)	3 (37.5)	0.029†
Not reported	27 (34.6)	11 (18.0)	6 (24.0)	3 (37.5)	

†: Chi-square test. NRI: Nutritional risk index.

The proportion of male patients did not differ significantly among the three groups (p>0.05). However, primary diagnoses varied significantly (p<0.05). Suppurative lung disease was more prevalent among patients who remained on the waiting list, whereas interstitial lung disease was less frequent in this group than in the transplanted and

Table 4: Comparison of laboratory and clinical characteristics of patients according to NRI status

Variables	Severe malnutrition <82	Moderate malnutrition 82–92	Mild malnutrition 92–98	No risk >98	p
Age (years)	43.0 (27–55)	54.0 (44–59)	51.0 (48–56)	55.0 (45.5–57)	<0.001¥
Body weight (kg)	54 (46–64)	71 (65–78)	76 (66–83)	73 (65–75.5)	<0.001Ω
BMI (kg/m²)	19.6 (17–22)	25.0 (23.1–26.2)	27.0 (25–29)	29.0 (26.6–30.5)	<0.001¥
Albumin (g/l)	38 (34–41)	40 (38–43)	43 (40–45)	41 (38–44)	<0.001¥
Prealbumin (μg/mL)	17 (15–21)	21 (18–24)	22 (16.5–27)	20.5 (18–25)	0.014¥
Creatinine (mg/dL)	0.62 (0.47–0.71)	0.73 (0.63–0.82)	0.76 (0.56–0.86)	0.68 (0.56–0.94)	<0.001¥
Hemoglobin (g/dL)	13.1 (11.2–14)	14.2 (12.6–15.3)	14.9 (13.4–15.9)	14.25 (11.9–15.1)	<0.001¥
Total cholesterol (mg/dL)	150 (127–195)	200 (167–221)	199 (166–227.5)	226 (196.5–270.5)	<0.001Ω
Triglyceride (mg/dL)	86.5 (70–127)	120.5 (88–151)	122 (89–164)	137 (102–161)	0.001¥
FVC (%)	37 (28–45)	43 (34–54)	47 (41–54)	50.5 (40–55.5)	0.003¥
FEV_1 (L)	0.81 (0.64–1.12)	1.17 (0.72–1.73)	1.25 (0.83–1.54)	1.15 (0.84–1.35)	0.003¥
FEV_1 (%)	24 (19–40)	38 (23–53)	42 (30–54)	45.5 (36–57)	<0.001¥
FEV_1/FVC (%)	67.1 (47–86.3)	83.0 (56.1–95.5)	76.6 (53–86.4)	82.8 (77.5–88.5)	0.028¥
6MWT (m)	270 (138–380)	312.5 (220–402)	295 (190–345)	262.5 (139–295)	0.163¥
Post-transplant ICU stay (days)	322.5 (16.5–1675.5)	228.5 (34.5–1505.5)	132 (13–1846)	28 (8.5–1185)	0.850¥

¥: Kruskal-Wallis Test; Ω: One-way analysis of variance applied. NRI: Nutritional risk index, BMI: Body mass index, FVC: Forced vital capacity, FEV_1: Forced expiratory volume in one second, 6MWT: Six-minute walk test, ICU: Intensive care unit.

Table 5: The relationship between NRI, nutritional status, functional capacity, and lung capacity

Variables	All group (N=210)	Patients on the waiting list (N=50)	Transplant patients (N=85)	Patients who died while on the waiting list (N=72)
BMI (kg/m²)	0.810** (<0.001)	0.850** (<0.001)	0.856** (<0.001)	0.730** (<0.001)
Total protein (g/dL)	0.119 (0.100)	-0.158 (0.307)	0.113 (0.316)	0.294* (0.015)
Albumin (g/dL)	0.490** (<0.001)	0.453** (0.001)	0.489** (<0.001)	0.542** (<0.001)
Transplant albumin (g/dL)	-0.070 (0.593)	NA	-0.070 (0.593)	NA
Prealbumin (μg/mL)	0.272** (0.003)	0.132 (0.365)	0.442* (0.021)	0.456** (0.003)
6MWT (m)	0.052 (0.463)	0.159 (0.270)	-0.048 (0.668)	0.097 (0.433)
FVC (%)	0.269** (<0.001)	0.255 (0.074)	0.464** (<0.001)	0.065 (0.603)
FEV_1 (L)	0.246** (0.001)	0.188 (0.196)	0.322** (0.004)	0.222 (0.072)
FEV_1 (%)	0.391** (<0.001)	0.309* (0.029)	0.446** (<0.001)	0.425** (<0.001)
FEV_1/FVC (%)	0.176* (0.014)	0.070 (0.631)	0.136 (0.225)	0.228 (0.068)
Post-transplant NRI	0.520** (<0.001)	NA	0.520** (<0.001)	NA
BODE index	-0.317** (<0.001)	-0.472** (0.001)	-0.308** (0.005)	-0.263* (0.039)
Post-transplant ICU stay (days)	0.217* (0.048)	NA	0.217* (0.048)	NA
Post-transplant survival (days)	-0.099 (0.365)	NA	-0.099 (0.365)	NA

*:p<0.05, **:p<0.01. Values are presented as Spearman correlation coefficient (r) and p value. NRI: Nutritional risk index, BMI: Body mass index, 6MWT: Six-minute walk test, FVC: Forced vital capacity, FEV_1: Forced expiratory volume in one second, NA: Not available due to insufficient sample size, ICU: Intensive care unit.

deceased groups. The prevalences of diabetes mellitus and osteoporosis were similar across groups. Use of enteral nutritional products was significantly less frequent in transplanted patients than in the other groups (p<0.001). No statistically significant differences were observed in the distribution of malnutrition risk. Severe malnutrition was common across all groups, and fewer than 5% of patients were classified as well nourished (Table 3).

BMI demonstrated weak correlations with several nutritional and respiratory parameters — including prealbumin, forced vital capacity percentage (FVC%), forced expiratory volume in one second (FEV_1, L), and the FEV_1/FVC ratio — and a moderate correlation with FEV_1 (%). A very strong positive correlation was observed between BMI and NRI, whereas BMI showed a weak inverse correlation with the BODE index. BMI showed a weak association with post-transplant intensive care unit (ICU) length of stay but was not significantly correlated with post-transplant survival duration, white blood cell count, or albumin levels. In contrast, post-transplant survival time showed a moderate positive correlation with total cholesterol levels and a strong positive correlation with NRI (Table 4).

NRI-based analyses revealed that patients with severe malnutrition had significantly lower BMI and worse pulmonary function parameters than those with mild or no malnutrition. Albumin concentrations decreased progressively with increasing malnutrition severity. Patients with severe malnutrition also had significantly lower creatinine levels than those with moderate or mild malnutrition. However, no significant differences were observed among malnutrition severity groups with respect to waiting time, post-transplant ICU stay, functional capacity, biochemical parameters other than albumin and creatinine, or post-transplant survival duration (Table 4).

Across the entire cohort, NRI was strongly positively correlated with BMI (r=0.81, p<0.001) and moderately correlated with albumin levels and with post-transplant NRI values. NRI also demonstrated positive associations with pulmonary function parameters and an inverse association with the BODE index. Detailed subgroup correlation analyses are presented in Table 5.

Comparison of nutritional status based on laboratory parameters

When nutritional status was evaluated by albumin levels, no significant differences were observed between the normal-albumin and low-albumin groups for BMI or pulmonary function parameters. However, patients with hypoalbuminemia exhibited significantly lower 6MWT performance and NRI values (p<0.05).

In analyses stratified by cholesterol levels, patients with moderate or severe hypocholesterolemia had significantly lower BMI and poorer pulmonary function compared with those with normal cholesterol levels. NRI values were significantly higher among patients with normal cholesterol concentrations (p<0.001).

Patients with low hemoglobin levels had significantly lower BMI and NRI values, as well as reduced functional capacity and impaired pulmonary function, compared with patients with normal hemoglobin levels.

Mortality was not significantly associated with either NRI or BMI. However, the observed post-transplant survival duration was significantly associated with albumin and urea levels, while its association with white blood cell count did not reach statistical significance. Overall, regression analysis indicated a modest but statistically significant relationship between selected biochemical parameters and observed survival time.

Discussion

In the present study, the general characteristics, anthropometric measurements, biochemical findings, PFT, 6MWT, and bone density measurements of lung transplant candidates were compared according to their current clinical condition. The relationships among patients' NRI, post-transplant NRI, BMI, biochemical findings, post-transplant survival, ICU stay, PFT and 6MWT were investigated. In our study, 34.8% of the 210 patients listed for lung transplantation died while on the list. Similarly, in a study conducted in Japan, 37.7% of the patients listed for transplant died while awaiting transplantation. The main reason for the long waiting times and high mortality rates among patients on the waiting list is insufficient organ donation.[12] In this study, the average waiting time for transplantation was 264.01 days. In the United States, the waiting time for patients listed in 2019 was reported to be an average of 90 days[12] This difference can be attributed to an insufficient number of donors in our country. According to the data published by the Turkish Organ Transplantation Foundation on December 31, 2023, the number of patients waiting for organ transplantation is 32,018, while the total number of deceased donors is only 305.[13]

End-stage respiratory failure is associated with impaired bone health, and osteoporosis and osteopenia are frequently observed in lung transplant candidates, with estimated prevalences reaching 60% and 50%, respectively.[14] In our study, based on bone mineral density results, osteoporosis was detected in 27.3% of the patients and osteopenia in 50.6%. Osteoporosis is one of the significant causes of morbidity following lung transplantation, and the fractures resulting from it can significantly affect patients' life expectancy.[15]

The 6MWT is widely used to assess the functional status of lung transplant patients and is part of the evaluation criteria for transplantation. Most evidence in the literature has examined the relationship between 6MWT and waiting-list mortality. Studies have shown that the functional exercise capacity measured by 6MWT is inversely related to mortality on the waiting list in lung transplant candidates.[16–18] In our study, the median 6MWT for those on the list was 368.00, while for those who died while on the list, it was 257.50. Consistent with the literature, the 6MWT was lower in patients who died while on the list($p<0.001$).

In lung transplantation, the nutritional status of the recipient is considered an indicator of post-transplant outcomes. The BMI of the recipient is one of the most practical and commonly used measurements in medical centers worldwide.[19] The impact of BMI on lung transplant outcomes has been an active area of research; however, due to conflicting evidence in the literature, its effect on lung recipient survival remains controversial.[19–21] The first study to report the relationship between BMI and survival in transplant recipients using a large national database was published by Lederer and colleagues in 2009.[4] In a study screening over 5,900 patients from the database, being obese or underweight was associated with an increased risk of post-transplant mortality. Schwebel et al.[22] used BMI and creatinine height index to assess nutritional status and reported that 72% of the lung transplant patient cohort was undernourished, which led to prolonged ICU stays. In this study, the average BMI of transplant candidates at the time of listing was 23.03 kg/m^2. BMI was associated with post-transplant ICU stay, but not with post-transplant survival. An inverse relationship with the BODE index was identified. In our study, BMI was found to have a moderate correlation with FEV_1 and a weak correlation with FVC and FEV_1/FVC. Waiting times for patients whose BMI is outside the desired range provide an opportunity to improve their overall health. These findings suggest that the waiting period may constitute a critical window for optimizing patients' nutritional status, which may, in turn, have implications for clinical outcomes, including post-transplant intensive care unit (ICU) length of stay.

One of the screening tools used to identify malnutrition is the NRI. A retrospective cohort study that screened 13,392 lung transplant patients assessed the effect of NRI on post-transplant mortality. FEV_1, FVC, and BMI were lower in patients with a low NRI. The five-year mortality rate was higher in patients with severe malnutrition than in those who were not malnourished. It was also reported that patients with severe malnutrition had longer hospital stays post-transplant.[23] Similarly, patients with severe malnutrition had lower BMIs than the other three groups. The medians of FVC%, FEV_1 (lt), and FEV_1/FVC were significantly lower in those with severe malnutrition than in those with mild malnutrition, and all these values correlated with NRI. In our study, we observed a very strong correlation between post-transplant survival and NRI ($r=0.850$; $p<0.001$). This finding suggests that malnutrition may be associated with post-transplant survival duration and influence post-transplant clinical outcomes.

A study investigating the independent relationship between pre-transplant hypoalbuminemia and higher post-transplant mortality found that hypoalbuminemia at the time of listing was associated with early post-transplant mortality (<1 year)[24] Hypoalbuminemia may directly contribute to poor outcomes post-transplant by promoting oxidative damage or platelet aggregation[25] In this study, albumin levels were recorded at the time of listing. The median albumin value among patients who died while on the list was 38.70 (35–42), whereas that among patients still on the list was 41.00 (38–44); this difference was significant ($p=0.035$). This difference may be due to hypoalbuminemia predisposing patients to infections and lung inflammation, thereby increasing mortality risk.

In coronary artery disease (CAD), cholesterol levels have been shown to be inversely related to all-cause mortality, and a U-shaped relationship has been observed between inflammation, malnutrition, and CAD-related deaths.[26,27] In CAD and dialysis patients, the idea that malnutrition leads to lower cholesterol levels and higher mortality rates is being explored.[26,28] In our study, those with moderate-to-severe low cholesterol had significantly lower BMI, FVC%, and FEV_1% compared with those with normal cholesterol levels. In patients with normal cholesterol levels, NRI was significantly higher than in those with mild or moderate-to-severe low cholesterol. The study concluded that low cholesterol, resulting from malnutrition, negatively affected lung capacity and NRI.

Glutamine is considered a conditionally essential amino acid due to its role in stress response and immune regulation.[28,29] In the present study, 42.7% of patients reported using glutamine as an enteral nutritional supplement; however, no statistically significant association was observed between glutamine use and malnutrition risk.

This study has several limitations that should be considered when interpreting the findings. Its retrospective and single-center design may limit the generalizability of the results. In addition, the use of registry data may not accurately capture patients' nutritional status at the time of transplantation, and the lack of detailed dietary intake records limits a comprehensive assessment of nutritional habits. Furthermore, immunonutrition use could not be objectively confirmed. Nevertheless, the study also has important strengths. The use of the NRI allowed for an objective evaluation of malnutrition, and the inclusion of multiple biochemical parameters enhanced the robustness of the findings. Moreover, anthropometric measurements were performed in a standardized manner by a dietitian, increasing the reliability of the data.

Conclusion

In conclusion, malnutrition is highly prevalent among lung transplant candidates and is closely associated with pulmonary function, biochemical parameters, and post-transplant outcomes. The NRI appears to be a practical and informative tool for identifying nutritional risk beyond BMI alone. Routine nutritional assessment during the waiting period may provide an opportunity to optimize patient status and potentially improve transplant-related outcomes.

Ethics Committee Approval

The study was approved by the Koşuyolu High Specialisation Training and Research Hospital Ethics Committee (No: 2023/04/671, Date: 28/02/2023).

Informed Consent

Informed consent was waived due to the retrospective nature of the study.

Conflicts of Interest

The authors have no conflicts of interest to declare.

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Author Contributions

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