THE MEDICAL BULLETIN OF
SISLI ETFAL HOSPITAL

DOI: 10.14744/SEMB.2025.74050
Med Bull Sisli Etfal Hosp 2025;59(1):64–75

Original Research

# Which Nutritional Scoring System Best Predicts Transplant Outcomes in Allogeneic Stem Cell Recipients? A Comparison of Nutritional Risk Index, Prognostic Nutritional Index, and Controlling Nutritional Status

**Sidika Gulkan Ozkan,[1] Suna Avci,[2] Ada Urusak,[3] Arif Ataberk Buyukyatikci,[4] Ali Kimiaei,[1] Seyedehtina Safaei,[1] Yuksel Altuntas,[5] Yuksel Asli Ozturkmen,[6] Zeynep Asli Durak,[1] Mehmet Serdar Yildiz,[7] Hasan Atilla Ozkan[1]**

[1]Division of Hematology, Department of Internal Medicine, Bahcesehir University Faculty of Medicine, Istanbul, Türkiye
[2]Department of Geriatric Medicine, Istanbul University-Cerrahpasa, Cerrahpasa Faculty of Medicine, Istanbul, Türkiye
[3]University of Health Sciences Türkiye, Sisli Hamidiye Etfal Training and Research Hospital, Istanbul, Türkiye
[4]University of Health Sciences Türkiye, Kanuni Sultan Suleyman Training and Research Hospital, Istanbul, Türkiye
[5]Division of Endocrinology, Department of Internal Medicine, University of Health Sciences Türkiye, Sisli Hamidiye Etfal Training and Research Hospital, Istanbul, Türkiye
[6]Division of Hematology, Department of Internal Medicine, Sivas Numune Hospital, Sivas, Türkiye
[7]Department of Internal Medicine, University of Health Sciences Türkiye, Sisli Hamidiye Etfal Training and Research Hospital, Istanbul, Türkiye

## Abstract

**Objectives:** Nutritional status significantly impacts outcomes in allogeneic hematopoietic stem cell transplantation (allo-HSCT). Among various indices, the Nutritional Risk Index (NRI), Prognostic Nutritional Index (PNI), and Controlling Nutritional Status (CONUT) scores hold potential as prognostic tools. This study compares their predictive utility for transplant outcomes.

**Methods:** A retrospective analysis was conducted on 41 patients who underwent their first allo-HSCT between October 2022 and July 2024. Nutritional scores were calculated using pre-transplant data, and their associations with mortality and non-relapse mortality (NRM) were assessed. Receiver operating characteristic (ROC) curves and multivariable logistic regression were employed to evaluate predictive accuracy.

**Results:** The high CONUT score demonstrated the highest prognostic accuracy for mortality (AUC: 0.771, p=0.026) and NRM (AUC: 0.806, p=0.047). It was the sole independent predictor of mortality (OR: 2.180, p=0.028). Both the NRI (AUC: 0.737, p=0.040) and PNI (AUC: 0.803, p=0.008) were also associated with mortality but lacked independent predictive value. Higher CONUT scores correlated with increased mortality rates.

**Conclusion:** The CONUT score emerged as the most effective nutritional scoring system for predicting mortality in allo-HSCT patients. Its simplicity and integration of key clinical parameters make it a valuable tool for early risk stratification and targeted interventions. Further studies with larger cohorts are warranted to validate these findings and refine nutritional management strategies.

**Keywords:** Allogeneic hematopoietic stem cell transplantation, CONUT score, nutritional assessment, NRI, PNI, transplant outcomes

Please cite this article as "Ozkan SG, Avci S, Urusak A, Buyukyatikci AA, Kimiaei A, Safaei S, et al. Which Nutritional Scoring System Best Predicts Transplant Outcomes in Allogeneic Stem Cell Recipients? A Comparison of Nutritional Risk Index, Prognostic Nutritional Index, and Controlling Nutritional Status. Med Bull Sisli Etfal Hosp 2025;59(1):64–75".

**Address for correspondence:** Sidika Gulkan Ozkan, MD. Division of Hematology, Department of Internal Medicine, Bahcesehir University Faculty of Medicine, Istanbul, Türkiye
**Phone:** +90 505 456 59 32 **E-mail:** drgulkan@gmail.com

**Submitted Date:** December 25, 2024 **Revised Date:** February 06, 2025 **Accepted Date:** February 10, 2025 **Available Online Date:** March 18, 2025

Allogeneic hematopoietic stem cell transplantation (allo-HSCT) is a viable therapeutic intervention that can advantage patients with diverse hematological conditions. In recent years, advancements in conditioning regimens, pre- and post-transplantation therapies, and supportive care have increased the availability of allo-HSCT to a broader range of patients.[1-3]

Despite these advancements, allo-HSCT continues to carry significant risks, including substantial mortality and morbidity.[4,5] Transplant outcomes are affected by several factors, including the type and stage of the disease, donor-recipient human leukocyte antigen (HLA) compatibility, donor-recipient sex, conditioning regimen, graft source, and complications including infections, and graft-versus-host disease (GVHD).[6]

Recent research has highlighted the critical role of nutritional status in transplant outcomes, showing that pre-transplant malnutrition is linked to poorer results in allo-HSCT patients.[7] These patients frequently experience malnutrition owing to underlying medical conditions, prior chemotherapy side effects, and infectious processes.[8-10] Conditioning chemotherapy, either alone or combined with total body irradiation (TBI), often exacerbates this issue by causing digestive symptoms, such as anorexia, vomiting, and diarrhea, which impair oral intake. Post-transplant complications, including GVHD, veno-occlusive disease, and infections, can further worsen the nutritional status, leading to long-term malnutrition.[11]

Various nutritional indices, including the Controlling Nutritional Status (CONUT) score, Prognostic Nutritional Index (PNI), and Nutritional Risk Index (NRI), have demonstrated prognostic significance in diverse hematological malignancies.[12-16] However, few studies have used methods such as body mass index (BMI), CONUT score, C-reactive protein-to-albumin ratio (CAR), subjective global evaluation, bioelectrical impedance analysis, and albumin levels to examine the influence of pre-transplant nutritional status. Malnutrition is linked to a lower overall survival rate in allo-HSCT patients, according to these studies.[7]

Nevertheless, the current methods for nutritional assessment remain inadequate for allo-HSCT patients. Assessing nutritional status is made more complex by factors such as the primary disease, previous treatments, conditioning regimens, treatment-related toxicity, and the phase of transplantation.[17]

The purpose of this study is to use NRI, PNI, and CONUT scores to examine the predictive usefulness of pre-transplant nutritional status on allo-HSCT outcomes. It is the only study that we are aware of that evaluates the effects of all three nutritional strategies on transplant outcomes in the same patient group.

## Methods

We conducted a retrospective analysis of the medical records of 65 patients who received their first allo-HSCT at our Adult Bone Marrow Transplant Unit between October 1, 2022, and July 1, 2024. Forty-one patients whose data were required for the calculation of the CONUT score, PNI, and NRI scores in the pre-transplant phase and who had not used anti-cholesterol medications in the six months prior to allo-HSCT were included in the study. This study was approved by the local Institutional Ethics Committee on August 6, 2024, in compliance with the Declaration of Helsinki (approval number: 4477). Informed consent was given in writing by each participant.

The CONUT score was calculated retrospectively as follows: albumin (mg/dL) ≥3.5 (0), 3.0-3.4 (2), 2.5-2.9 (4), <2.5 (6); total lymphocytes ($mm^3$) ≥1600 (0), 1200-1599 (1), 800-1199 (2), <800 (3); total cholesterol (mg/dL) ≥180 (0), 140-179 (1), 100-139 (2), <100 (3).[18] According to the examination of the receiver operating characteristic (ROC) curve, malnutrition was defined as a CONUT score more than 2.5.

The NRI was calculated using the following formula: 1.519 × serum albumin level (g/L) +41.7 × (present/ideal body weight).[19] The ROC curve analysis indicated that malnutrition was indicated by an NRI ≤107.6.

The PNI was calculated using the following formula: (10× serum albumin [g/dL]) + (0.005× lymphocytes/μL).[20] A PNI ≤48.5 was defined as malnutrition according to ROC curve analysis. PNI scores higher than 48.5 were considered normal; scores between 48.5 and 45 indicated mild malnutrition; scores between 45 and 40 indicated moderate to severe malnutrition; and scores below 40 indicated severe malnutrition.

The first of three days in which the peripheral blood neutrophil count surpassed $500\times10^6$/L was considered neutrophil engraftment. After at least seven days without the need for platelet transfusions, the first of three days in a row with a platelet count of 20,000/μL or greater was considered platelet engraftment.[21]

The Common Terminology Criteria for Adverse Events (CTCAE) version 5.0[22] was used to categorize and evaluate complications. The World Health Organization (WHO) scale, which has grades 0–4, was used to classify the severity of oral mucositis.[23] The Glucksberg criteria[24], were used to grade acute GVHD, while the National Institutes of Health (NIH) consensus standards[25] were used to grade chronic GVHD.

## Statistical Analysis

IBM SPSS Statistics for Windows (version 25.0; IBM Corp., Armonk, NY, USA) was used for all analyses. Q-Q plots and histograms were used to evaluate normalcy. For non-normally distributed continuous data, descriptive statistics were displayed as the median ($25^{th}$–$75^{th}$ percentile), and for categorical variables, as frequency (%). Because of their non-normal distribution, continuous variables were examined using the Mann-Whitney U test. The Fisher-Freeman-Halton test or Fisher's exact test was used to assess categorical variables. ROC curve analysis was used to evaluate the scores' performance in predicting mortality, and Youden's index was used to identify the best cut-off points. Statistical significance was defined as a p-value of less than 0.05.

## Results

Forty-one patients were included in the study: twenty-two had acute myeloid leukemia (AML), seven had acute lymphoblastic leukemia (ALL), four had myelodysplastic syndrome (MDS), three had non-Hodgkin lymphoma (NHL), one had Hodgkin lymphoma (HL), one had Richter syndrome, one had blastic plasmacytoid dendritic cell neoplasm (BPDCN), one had chronic eosinophilic leukemia (CEL), and one had aplastic anemia. The patients' median age was 46 years (range: 24–69; interquartile range: 33–54). Eleven months was the median follow-up period (interquartile range: 8–14; range: 0–25). A total of eight patients (19.51%) died. The causes of death included pulmonary hemorrhage (1 patient), sepsis (4 patients), and disease relapse (3 patients).

The following parameters were significantly lower in the mortality group compared to the other group: veno-occlusive disease (VOD) score (p=0.029), albumin (p=0.041), lymphocyte count (p=0.011), nutritional risk index (NRI) score (p=0.039), and prognostic nutritional index (PNI) score (p=0.008). Conversely, the mortality group exhibited significantly higher values for controlling nutritional status (CONUT) score (p=0.022), serious malnutrition percentage (p=0.017), FluTreo (fludarabine-treosulfan) usage percentage (p=0.005), and relapse percentage (p=0.043). Furthermore, the mortality group's follow-up period was noticeably shorter (p<0.001). No significant differences were observed regarding age at transplantation, sex, height, weight, body mass index (BMI), diagnosis, Karnofsky performance status (KPS) score, hematopoietic cell transplantation-comorbidity index (HCT-CI) score, total cholesterol, disease risk index (DRI), donor-recipient ABO compatibility, complete remission (CR), disease status before transplantation, autologous stem cell transplantation history, patient cytomegalovirus (CMV) status, donor CMV status, donor age, donor sex, donor-recipient relationship, human leukocyte antigen (HLA) compatibility, infused stem cell amount, stem cell source, graft freezing, total body irradiation (TBI), time from diagnosis to transplantation, neutrophil engraftment time, platelet engraftment time, primary or secondary graft failure, eltrombopag use, graft-versus-host disease (GVHD) prophylaxis, mucositis prophylaxis, mucositis grade, acute GVHD, acute GVHD score, chronic GVHD, or complications (Table 1).

### Predictive Scores for Mortality

- CONUT Score: Sensitivity: 100%, specificity: 39.39%, accuracy: 50.00%, positive predictive value: 25.93%, and negative predictive value: 100% for a cut-off point of 2.5 (higher values predict mortality). 0.771 was the area under the receiver operating characteristic (ROC) curve (95% CI: 0.590–0.951, p=0.026).
- NRI Score: Sensitivity: 100%, specificity: 42.42%, accuracy: 53.66%, positive predictive value: 29.63%, and negative predictive value: 100% for a cut-off point of 107.6 (equal to or lower values predict mortality). The 95% CI: 0.567–0.906, p=0.040, was 0.737, which was the area under the ROC curve.
- PNI Score: Sensitivity: 100%, specificity: 51.52%, accuracy: 60.98%, positive predictive value: 33.33%, and negative predictive value: 100% for a cut-off point of 48.5 (equal to or lower values predict mortality). There was a 0.803 (95% CI: 0.651–0.955, p=0.008; Table 2) area under the ROC curve.

### Multivariable Logistic Regression Analysis

The only independent predictor linked to death was the CONUT score (odds ratio [OR]: 2.180, 95% CI: 1.090–4.363, p=0.028) (Table 3). VOD score (p=0.446), albumin (p=0.420), lymphocyte count (p=0.271), NRI score (p=0.447), PNI score (p=0.170), and conditioning regimen (p=0.921) were additional variables that were included in the study but did not show statistical significance.

### Non-Relapse Mortality (NRM)

Five patients (12.20%) experienced NRM. In this group, lymphocyte count (p=0.021) and donor age (p=0.046) were significantly lower, while the CONUT score (p=0.041) was significantly higher. Follow-up time was also significantly shorter in the NRM group (p<0.001). There were no significant differences between the NRM group and the other group regarding age at transplantation, sex, height, weight, BMI, diagnosis, KPS score, HCT-CI score, VOD score, albumin, total cholesterol, NRI score, PNI score, DRI, donor-recipient ABO compatibility, CR, disease status before transplantation, transplantation history, patient CMV sta-

**Table 1.** Summary of variables with regard to mortality

| | | Mortality | | |
|---|---|---|---|---|
| | **Total (n=41)** | **Yes (n=8)** | **No (n=33)** | **p** |
| Age at transplantation | 46 (33-54) | 54.5 (40.5-63.5) | 46 (32-52) | 0.152‡ |
| Sex | | | | |
| Female | 12 (29.27%) | 2 (25.00%) | 10 (30.30%) | 1.000# |
| Male | 29 (70.73%) | 6 (75.00%) | 23 (69.70%) | |
| Height, m | 1.72 (1.66-1.80) | 1.70 (1.67-1.75) | 1.75 (1.65-1.80) | 0.307‡ |
| Weight, kg | 79.9 (70-85) | 79.95 (74.15-84.45) | 78 (70-86) | 0.818‡ |
| Body mass index, kg/m2 | 26.12 (22.99-28.65) | 28.20 (24.88-29.33) | 25.52 (22.99-28.01) | 0.205‡ |
| Diagnosis | | | | |
| AML | 22 (53.66%) | 4 (50.00%) | 18 (54.55%) | 0.257¶ |
| ALL | 7 (17.07%) | 0 (0.00%) | 7 (21.21%) | |
| MDS | 4 (9.76%) | 2 (25.00%) | 2 (6.06%) | |
| NHL | 3 (7.32%) | 1 (12.50%) | 2 (6.06%) | |
| Other | 5 (12.20%) | 1 (12.50%) | 4 (12.12%) | |
| Karnofsky performance status score | 90 (90-100) | 90 (85-90) | 90 (90-100) | 0.088‡ |
| HCT CI score | 0 (0-1) | 0.5 (0-1) | 0 (0-1) | 0.535‡ |
| VOD score, % | 2.68 (1.67-4.97) | 1.06 (0.82-2.36) | 3.07 (2.14-4.99) | 0.029‡ |
| Albumin | 4.2 (3.8-4.5) | 3.85 (3.5-4.1) | 4.2 (3.9-4.6) | 0.041‡ |
| Total cholesterol | 166.5 (135.5-190.5) | 134 (128-190) | 167 (143-191) | 0.328‡ |
| Lymphocyte (x103) | 0.83 (0.49-1.27) | 0.33 (0.19-0.70) | 0.99 (0.64-1.51) | 0.011‡ |
| CONUT score | 3 (2-4) | 4 (3-6) | 3 (2-4) | 0.022‡ |
| NRI score | 105.44 (99.42-110.06) | 100.18 (94.87-103.98) | 105.50 (99.69-110.06) | 0.039‡ |
| PNI score | 46.7 (41.25-51.4) | 41.1 (35.7-44.65) | 49.2 (42.7-53.45) | 0.008‡ |
| Normal | 15 (36.59%) | 0 (0.00%) | 15 (45.45%)* | 0.017¶ |
| Malnutrition | 8 (63.41%) | 8 (100.00%) | 18 (18.18%) | |
| Moderate to severe malnutrition | 10 (24.39%) | 2 (25.00%) | 8 (24.24%) | |
| Serious malnutrition | 8 (19.51%) | 4 (50.00%) | 4 (12.12%)* | |
| Disease risk index | | | | |
| Low | 5 (12.50%) | 1 (12.50%) | 4 (12.50%) | 0.794¶ |
| Intermediate | 20 (50.00%) | 3 (37.50%) | 17 (53.13%) | |
| High | 14 (35.00%) | 4 (50.00%) | 10 (31.25%) | |
| Very high | 1 (2.50%) | 0 (0.00%) | 1 (3.13%) | |
| Donor recipient ABO compatibility | | | | |
| Match | 20 (51.28%) | 5 (62.50%) | 15 (48.39%) | 0.885¶ |
| Minor mismatch | 14 (35.90%) | 2 (25.00%) | 12 (38.71%) | |
| Major mismatch | 4 (10.26%) | 1 (12.50%) | 3 (9.68%) | |
| Bidirectional mismatch | 1 (2.56%) | 0 (0.00%) | 1 (3.23%) | |
| CR | | | | |
| CR1 | 28 (77.78%) | 4 (66.67%) | 24 (80.00%) | 0.596# |
| CR2 | 8 (22.22%) | 2 (33.33%) | 6 (20.00%) | |
| Disease status before transplantation | | | | |
| Complete response | 32 (78.05%) | 5 (62.50%) | 27 (81.82%) | 0.225¶ |
| Partial response | 1 (2.44%) | 1 (12.50%) | 0 (0.00%) | |
| Stable disease | 5 (12.20%) | 1 (12.50%) | 4 (12.12%) | |
| Progressive disease | 3 (7.32%) | 1 (12.50%) | 2 (6.06%) | |
| Transplantation history | | | | |
| No | 35 (85.37%) | 7 (87.50%) | 28 (84.85%) | 0.754¶ |
| Autologous | 3 (7.32%) | 1 (12.50%) | 2 (6.06%) | |
| Allogeneic | 3 (7.32%) | 0 (0.00%) | 3 (9.09%) | |

**Table 1.** CONT.

| | Mortality | | | |
|---|---|---|---|---|
| | **Total (n=41)** | **Yes (n=8)** | **No (n=33)** | **p** |
| Patient CMV | | | | |
| IGG positive | 38 (92.68%) | 7 (87.50%) | 31 (93.94%) | 0.488# |
| IGG negative | 3 (7.32%) | 1 (12.50%) | 2 (6.06%) | |
| Donor CMV | | | | |
| IGG positive | 32 (88.89%) | 5 (71.43%) | 27 (93.10%) | 0.163# |
| IGG negative | 4 (11.11%) | 2 (28.57%) | 2 (6.90%) | |
| Donor age | 29 (24-46) | 27 (21-31) | 34.5 (24.5-47) | 0.216‡ |
| Donor sex | | | | |
| Female | 8 (20.51%) | 3 (37.50%) | 5 (16.13%) | 0.323# |
| Male | 31 (79.49%) | 5 (62.50%) | 26 (83.87%) | |
| Donor recipient relationship | | | | |
| Relative | 25 (64.10%) | 5 (62.50%) | 20 (64.52%) | 1.000# |
| Unrelated | 14 (35.90%) | 3 (37.50%) | 11 (35.48%) | |
| HLA compatibility | | | | |
| Full matched | 26 (65.00%) | 4 (50.00%) | 22 (68.75%) | 0.604¶ |
| Mismatch | 5 (12.50%) | 1 (12.50%) | 4 (12.50%) | |
| Haploidentical | 9 (22.50%) | 3 (37.50%) | 6 (18.75%) | |
| Infused stem cell (x$10^6$/kg) | 6.31 (5.35-7.20) | 7.00 (5.75-7.25) | 6.30 (5.35-7.00) | 0.449‡ |
| Stem cell source | | | | |
| Peripheral blood | 40 (100.00%) | 8 (100.00%) | 32 (100.00%) | N/A |
| Bone marrow | 0 (0.00%) | 0 (0.00%) | 0 (0.00%) | |
| Cord blood | 0 (0.00%) | 0 (0.00%) | 0 (0.00%) | |
| Graft freezing | 1 (2.50%) | 0 (0.00%) | 1 (3.13%) | 1.000# |
| Conditioning regimen | | | | |
| FluBu3 | 18 (43.90%) | 2 (25.00%) | 16 (48.48%) | 0.005¶ |
| FluTBI | 5 (12.20%) | 0 (0.00%) | 5 (15.15%) | |
| FluMel | 5 (12.20%) | 2 (25.00%) | 3 (9.09%) | |
| FluTreo | 4 (9.76%) | 4 (50.00%) | 0 (0.00%)* | |
| FluBu2 | 3 (7.32%) | 0 (0.00%) | 3 (9.09%) | |
| TEC-FluBu2 | 1 (2.44%) | 0 (0.00%) | 1 (3.03%) | |
| TBF | 1 (2.44%) | 0 (0.00%) | 1 (3.03%) | |
| FluCy | 4 (9.76%) | 0 (0.00%) | 4 (12.12%) | |
| TBI | 27 (65.85%) | 6 (75.00%) | 21 (63.64%) | 0.692# |
| Time between diagnosis and transplantation, months | 6 (3-12) | 8.5 (4.5-17.5) | 5 (3-12) | 0.305‡ |
| Time to neutrophil engraftment | 15 (14-17) | 15 (14-16) | 15 (14-17) | 0.642‡ |
| Time to platelet engraftment | 15 (13.5-19.5) | 17 (15-22) | 15 (13-19) | 0.312‡ |
| Primary graft failure | 1 (2.70%) | 0 (0.00%) | 1 (3.13%) | 1.000# |
| Secondary graft failure | 3 (7.32%) | 1 (12.50%) | 2 (6.06%) | 0.488# |
| Eltrombopag use | 12 (29.27%) | 2 (25.00%) | 10 (30.30%) | 1.000# |
| GVHD prophylaxis | | | | |
| T cell depletion | 0 (0.00%) | 0 (0.00%) | 0 (0.00%) | N/A |
| ATG | 5 (12.20%) | 1 (12.50%) | 4 (12.12%) | 1.000# |
| CSA | 41 (100.00%) | 8 (100.00%) | 33 (100.00%) | N/A |
| MTX | 2 (4.88%) | 1 (12.50%) | 1 (3.03%) | 0.356# |
| MMF | 22 (53.66%) | 5 (62.50%) | 17 (51.52%) | 0.703# |
| Post Cy | 38 (92.68%) | 7 (87.50%) | 31 (93.94%) | 0.488# |

**Table 1.** CONT.

| | | Mortality | | |
|---|---|---|---|---|
| | **Total (n=41)** | **Yes (n=8)** | **No (n=33)** | **p** |
| Mucositis prophylaxis | | | | |
| Antifungal + antibacterial mouthwash | 41 (100.00%) | 8 (100.00%) | 33 (100.00%) | N/A |
| Black mulberry | 41 (100.00%) | 8 (100.00%) | 33 (100.00%) | N/A |
| Mucosamin | 15 (36.59%) | 1 (12.50%) | 14 (42.42%) | 0.220# |
| Mucositis | 14 (35.90%) | 2 (28.57%) | 12 (37.50%) | 1.000# |
| Grade of mucositis | | | | |
| None | 25 (64.10%) | 5 (71.43%) | 20 (62.50%) | 0.572¶ |
| Grade 1 | 5 (12.82%) | 0 (0.00%) | 5 (15.63%) | |
| Grade 2 | 3 (7.69%) | 0 (0.00%) | 3 (9.38%) | |
| Grade 3 | 6 (15.38%) | 2 (28.57%) | 4 (12.50%) | |
| Acute GVHD | 5 (12.20%) | 1 (12.50%) | 4 (12.12%) | 1.000# |
| Acute GVHD score | 0 (0-0) | 0 (0-0) | 0 (0-0) | 0.398‡ |
| Chronic GVHD | 3 (7.89%) | 0 (0.00%) | 3 (9.68%) | 1.000# |
| Relapse | 5 (12.20%) | 3 (37.50%) | 2 (6.06%) | 0.043# |
| Complications | | | | |
| Bacterial infections and fever | 35 (85.37%) | 8 (100.00%) | 27 (81.82%) | 0.323# |
| Cardiac complications | 1 (2.44%) | 0 (0.00%) | 1 (3.03%) | 1.000# |
| Hyperbilirubinemia | 2 (4.88%) | 1 (12.50%) | 1 (3.03%) | 0.356# |
| Bleeding complications | 5 (12.20%) | 1 (12.50%) | 4 (12.12%) | 1.000# |
| GI problems | 11 (26.83%) | 3 (37.50%) | 8 (24.24%) | 0.658# |
| Elevated creatinine | 2 (4.88%) | 0 (0.00%) | 2 (6.06%) | 1.000# |
| IPA | 2 (4.88%) | 0 (0.00%) | 2 (6.06%) | 1.000# |
| CMV reactivation | 3 (7.32%) | 1 (12.50%) | 2 (6.06%) | 0.488# |
| TMA | 1 (2.44%) | 0 (0.00%) | 1 (3.03%) | 1.000# |
| Neurological complications | 2 (4.88%) | 0 (0.00%) | 2 (6.06%) | 1.000# |
| Follow-up time, months | 11 (8-14) | 3 (0.5-5) | 12 (10-16) | <0.001‡ |

Descriptive statistics are presented using median (25th percentile - 75th percentile) for non-normally distributed continuous variables and frequency (percentage) for categorical variables. ‡ Mann Whitney U test, # Fisher's exact test, ¶ Fisher-Freeman-Halton test,* Statistically significant category for the variables with three or more categories. Statistically significant p values are shown in bold. AML: Acute Myeloid Leukemia; ALL: Acute Lymphoblastic Leukemia; MDS Myelodysplastic Syndromes; NHL: Non-Hodgkin Lymphoma; VOD: Veno-Occlusive Disease; HCT CI: Hematopoietic Cell Transplantation Comorbidity Index; CONUT: Controlling Nutritional Status; NRI: Nutritional Risk Index; PNI: Prognostic Nutritional Index; CR: Complete Remission; CR1: Complete Remission, first occurrence; CR2: Complete Remission, second occurrence; CMV: Cytomegalovirus; HLA: Human Leukocyte Antigen; FluBu3: Fludarabine and Busulfan, three-day regimen; FluTBI: Fludarabine and Total Body Irradiation; FluMel: Fludarabine and Melphalan; FluTreo: Fludarabine and Treosulfan; FluBu2: Fludarabine and Busulfan, two-day regimen; TEC-FluBu2: Thiotepa, Etoposide, and Fludarabine with Busulfan, two-day regimen); TBF: Thiotepa, Busulfan, and Fludarabine; FluCy: Fludarabine and Cyclophosphamide); TBI: Total Body Irradiation; GVHD: Graft-versus-Host Disease; ATG: Anti-Thymocyte Globulin; CSA: Cyclosporine A; MTX: Methotrexate; MMF: Mycophenolate Mofetil; Post Cy: Post-transplant Cyclophosphamide; IPA: Invasive Pulmonary Aspergillosis; TMA: Thrombotic Microangiopathy; GI: Gastrointestinal; IGG: Immunoglobulin G; N/A: Not Applicable.

tus, donor CMV status, donor sex, donor-recipient relationship, HLA compatibility, infused stem cell amount, stem cell source, graft freezing, conditioning regimen, TBI, time from diagnosis to transplantation, engraftment times, graft failure, eltrombopag use, GVHD prophylaxis, mucositis prophylaxis, mucositis grade, acute GVHD, acute GVHD score, chronic GVHD, or complications (Table 4).

For predicting non-relapse mortality (NRM) at a cut-off point of 3.5, the CONUT score had 75.00% sensitivity, 69.44% specificity, 70.00% accuracy, 21.43% positive predictive value, and 96.15% negative predictive value (higher values predict mortality). Table 5 shows that the ROC curve's area under the curve was 0.806 (95% CI: 0.607–1.000, p=0.047).

## Discussion

For a variety of hematological conditions, allogeneic hematopoietic stem cell transplantation, or allo-HSCT, is a feasible therapeutic option. Previous studies have evaluated malnutrition as a prognostic factor in allo-HSCT patients by using single scoring systems. To the best of our knowledge, this study is the first to assess malnutrition prognostically in this patient population using three distinct scoring sys-

**Table 2.** Performance of scores to predict mortality, ROC curve analysis

| | CONUT | NRI | PNI |
|---|---|---|---|
| Cut-off | >2.5 | ≤107.6 | ≤48.5 |
| Sensitivity | 100.00% | 100.00% | 100.00% |
| Specificity | 39.39% | 42.42% | 51.52% |
| Accuracy | 50.00% | 53.66% | 60.98% |
| PPV | 25.93% | 29.63% | 33.33% |
| NPV | 100.00% | 100.00% | 100.00% |
| AUC (95% CI) | 0.771 (0.590-0.951) | 0.737 (0.567-0.906) | 0.803 (0.651-0.955) |
| p | 0.026 | 0.040 | 0.008 |

CONUT: Controlling Nutritional Status; NRI: Nutritional Risk Index; PNI: Prognostic Nutritional Index; PPV: Positive Predictive Value; NPV: Negative Predictive Value; AUC: Area Under ROC Curve; CI: Confidence Interval; ROC: Receiver Operating Characteristic.

tems. In univariate analysis, a low PNI and NRI, as well as high CONUT scores, were found to be significantly associated with mortality. However, in the multivariate analysis, only a high CONUT score (with a cut-off point of 2.5) was independently associated with an increased mortality risk.

The NRI has been used since the late 1980s as a tool to predict disease progression across various medical conditions.[26,27] Orvain et al.[10] demonstrated that in acute myeloid leukemia (AML) patients undergoing allo-HCT, the predictive capacity of NRI was comparable to that of pre-transplant serum albumin levels, suggesting a reliance on serum albumin for its prognostic value. Consistent with this, our study identified low NRI (p=0.039) and low serum albumin level (p=0.041) as independent predictors of mortality in univariate analyses. However, body weight, a component of the NRI, may inadequately reflect nutritional status compared to albumin levels, especially in populations with stable weight profiles. Notably, our cohort exhibited minimal weight fluctuations and maintained a normal pre-transplant weight, possibly due to its high socioeconomic status and access to quality healthcare and nutrition. In multivariate analyses, neither NRI (p=0.447) nor serum albumin (p=0.420) were significant predictors of mortality, and NRI was similarly non-significant for non-relapse mortality (NRM). These findings may reflect the limitations related to the relatively small sample size.

The PNI, as reviewed by He et al.[28] has been widely validated as a prognostic marker for hematologic malignancies. In our cohort, PNI scores were significantly lower in the mortality group (p=0.008) in univariate analysis. However, contrary to prior research, multivariate analysis revealed no statistically significant independent association between PNI and overall mortality (p=0.170) or NRM (p=0.067). Notably, a significant association was observed in the subgroup with severe malnutrition (PNI < 40, p=0.017), although the small sample size (n=8) limited broader applicability. This discrepancy underscores the inherent limitations of our retrospective study design and sample size constraints, which may have reduced the power to detect robust associations.

The CONUT score emerged as a particularly effective tool in our study, with significantly higher scores in the mortality group (p=0.022). Among the nutritional indices evaluated, only the CONUT score was an independent predictor of mortality in the multivariate analysis (p=0.028). For NRM prediction, the CONUT score demonstrated commendable diagnostic metrics: 75.00% sensitivity, 69.44% specificity, 70.00% accuracy, 21.43% positive predictive value, and 96.15% negative predictive value (NPV). However, in multivariate analysis, it showed that the CONUT score was not a predictor of NRM. According to Araie et al.[17], in 200 patients receiving allo-HCT for myeloid malignancies, high CONUT scores independently predicted early NRM, 1-year survival, and median survival time. Although the CONUT score was predictive for NRM in univariate analysis, multivariate analysis did not find it to be statistically significant. We thought that this was related to the sample size of our study.

To our knowledge, this study is the first to conduct a comparative evaluation of the NRI, PNI, and CONUT scores within a single patient population. While all three indices demonstrated predictive utility for mortality, the CONUT score proved particularly robust. Unlike the NRI and PNI, which rely primarily on numerical calculations, the CONUT score incorporates threshold-based categorizations informed by cumulative clinical insights. This facilitates the precise identification of malnutrition among patients who fall below

**Table 3.** Significant factors independently associated with mortality, multivariable logistic regression analysis

| | β coefficient | Standard error | p | Exp(β) | 95% CI for Exp(β) | |
|---|---|---|---|---|---|---|
| CONUT score | 0.780 | 0.354 | 0.028 | 2.180 | 1.090 | 4.363 |
| Constant | -4.349 | 1.434 | 0.002 | 0.013 | | |

Nagelkerke $R^2$=0.290; CONUT: Controlling Nutritional Status; CI: Confidence Interval; Nagelkerke $R^2$: Nagelkerke R-squared.

**Table 4.** Summary of variables with regard to non-relapse mortality

| | Non-relapse mortality | | |
|---|---|---|---|
| | **Yes (n=5)** | **No (n=36)** | **p** |
| Age at transplantation | 49 (43-60) | 46 (32.5-53.5) | 0.523‡ |
| Sex | | | |
| Female | 1 (20.00%) | 11 (30.56%) | 1.000# |
| Male | 4 (80.00%) | 25 (69.44%) | |
| Height, m | 1.70 (1.70-1.71) | 1.74 (1.65-1.80) | 0.380‡ |
| Weight, kg | 84 (80-84.9) | 78.15 (70-85.5) | 0.461‡ |
| Body mass index, kg/m2 | 28.73 (27.68-29.93) | 25.82 (22.92-28.24) | 0.163‡ |
| Diagnosis | | | |
| AML | 2 (40.00%) | 20 (55.56%) | 0.080¶ |
| ALL | 0 (0.00%) | 7 (19.44%) | |
| MDS | 2 (40.00%) | 2 (5.56%) | |
| NHL | 1 (20.00%) | 2 (5.56%) | |
| Other | 0 (0.00%) | 5 (13.89%) | |
| Karnofsky performance status score | 90 (90-90) | 90 (90-100) | 0.842‡ |
| HCT CI score | 0 (0-1) | 0 (0-1) | 0.981‡ |
| VOD score, % | 2.34 (0.94-2.38) | 2.86 (1.73-4.98) | 0.461‡ |
| Albumin | 4 (3.7-4) | 4.2 (3.8-4.55) | 0.255‡ |
| Total cholesterol | 151.5 (113-199.5) | 166.5 (139.5-190.5) | 0.620‡ |
| Lymphocyte (x103) | 0.38 (0.12-0.66) | 0.99 (0.57-1.41) | 0.021‡ |
| CONUT score | 4.5 (3.5-5.5) | 3 (2-4) | 0.041‡ |
| NRI score | 102.46 (97.90-102.46) | 105.50 (99.42-110.06) | 0.231‡ |
| PNI score | 43.3 (38.9-43.7) | 48.2 (41.9-52.98) | 0.067‡ |
| Normal | 0 (0.00%) | 15 (41.67%) | 0.155¶ |
| Mild malnutrition | 1 (20.00%) | 7 (19.44%) | |
| Moderate to severe malnutrition | 2 (40.00%) | 8 (22.22%) | |
| Serious malnutrition | 2 (40.00%) | 6 (16.67%) | |
| Disease risk index | | | |
| Low | 0 (0.00%) | 5 (14.29%) | 0.249¶ |
| Intermediate | 1 (20.00%) | 19 (54.29%) | |
| High | 4 (80.00%) | 10 (28.57%) | |
| Very high | 0 (0.00%) | 1 (2.86%) | |
| Donor recipient ABO compatibility | | | |
| Match | 3 (60.00%) | 17 (50.00%) | 0.462¶ |
| Minor mismatch | 1 (20.00%) | 13 (38.24%) | |
| Major mismatch | 1 (20.00%) | 3 (8.82%) | |
| Bidirectional mismatch | 0 (0.00%) | 1 (2.94%) | |
| CR | | | |
| CR1 | 3 (75.00%) | 25 (78.13%) | 1.000# |
| CR2 | 1 (25.00%) | 7 (21.88%) | |
| Disease status before transplantation | | | |
| Complete response | 3 (60.00%) | 29 (80.56%) | 0.134¶ |
| Partial response | 1 (20.00%) | 0 (0.00%) | |
| Stable disease | 1 (20.00%) | 4 (11.11%) | |
| Progressive disease | 0 (0.00%) | 3 (8.33%) | |
| Transplantation history | | | |
| No | 4 (80.00%) | 31 (86.11%) | 0.567¶ |
| Autologous | 1 (20.00%) | 2 (5.56%) | |
| Allogeneic | 0 (0.00%) | 3 (8.33%) | |

**Table 4.** CONT.

| | Non-relapse mortality | | |
|---|---|---|---|
| | **Yes (n=5)** | **No (n=36)** | **p** |
| Patient CMV | | | |
| IGG positive | 4 (80.00%) | 34 (94.44%) | 0.330# |
| IGG negative | 1 (20.00%) | 2 (5.56%) | |
| Donor CMV | | | |
| IGG positive | 3 (75.00%) | 29 (90.63%) | 0.390# |
| IGG negative | 1 (25.00%) | 3 (9.38%) | |
| Donor age | 23.5 (19-26.5) | 34 (25-46) | 0.046‡ |
| Donor sex | | | |
| Female | 1 (20.00%) | 7 (20.59%) | 1.000# |
| Male | 4 (80.00%) | 27 (79.41%) | |
| Donor recipient relationship | | | |
| Relative | 3 (60.00%) | 22 (64.71%) | 1.000# |
| Unrelated | 2 (40.00%) | 12 (35.29%) | |
| HLA compatibility | | | |
| Full matched | 2 (40.00%) | 24 (68.57%) | 0.262¶ |
| Mismatch | 1 (20.00%) | 4 (11.43%) | |
| Haploidentical | 2 (40.00%) | 7 (20.00%) | |
| Infused stem cell (x106/kg) | 7.20 (6.50-7.20) | 6.30 (5.32-7.08) | 0.498‡ |
| Stem cell source | | | |
| Peripheral blood | 5 (100.00%) | 35 (100.00%) | N/A |
| Bone marrow | 0 (0.00%) | 0 (0.00%) | |
| Cord blood | 0 (0.00%) | 0 (0.00%) | |
| Graft freezing | 0 (0.00%) | 1 (2.86%) | 1.000# |
| Conditioning regimen | | | |
| FluBu3 | 2 (40.00%) | 16 (44.44%) | 0.453¶ |
| FluTBI | 0 (0.00%) | 5 (13.89%) | |
| FluMel | 1 (20.00%) | 4 (11.11%) | |
| FluTreo | 2 (40.00%) | 2 (5.56%) | |
| FluBu2 | 0 (0.00%) | 3 (8.33%) | |
| TEC-FluBu2 | 0 (0.00%) | 1 (2.78%) | |
| TBF | 0 (0.00%) | 1 (2.78%) | |
| FluCy | 0 (0.00%) | 4 (11.11%) | |
| TBI | 3 (60.00%) | 24 (66.67%) | 1.000# |
| Time between diagnosis and transplantation, months | 9 (3-19) | 6 (3.5-12) | 0.764‡ |
| Time to neutrophil engraftment | 15.5 (15-16) | 15 (14-17) | 0.841‡ |
| Time to platelet engraftment | 25 (17-33) | 15 (13-19) | 0.103‡ |
| Primary graft failure | 0 (0.00%) | 1 (2.86%) | 1.000# |
| Secondary graft failure | 1 (20.00%) | 2 (5.56%) | 0.330# |
| Eltrombopag use | 1 (20.00%) | 11 (30.56%) | 1.000# |
| GVHD prophylaxis | | | |
| T cell depletion | 0 (0.00%) | 0 (0.00%) | N/A |
| ATG | 1 (20.00%) | 4 (11.11%) | 0.497# |
| CSA | 5 (100.00%) | 36 (100.00%) | N/A |
| MTX | 1 (20.00%) | 1 (2.78%) | 0.232# |
| MMF | 3 (60.00%) | 19 (52.78%) | 1.000# |
| Post Cy | 4 (80.00%) | 34 (94.44%) | 0.330# |
| Mucositis prophylaxis | | | |
| Antifungal + antibacterial mouthwash | 5 (100.00%) | 36 (100.00%) | N/A |

**Table 4.** CONT.

| | Non-relapse mortality | | |
|---|---|---|---|
| | **Yes (n=5)** | **No (n=36)** | **p** |
| Black mulberry | 5 (100.00%) | 36 (100.00%) | N/A |
| Mucosamin | 1 (20.00%) | 14 (38.89%) | 0.636# |
| Mucositis | 1 (25.00%) | 13 (37.14%) | 1.000# |
| Grade of mucositis | | | |
| None | 3 (75.00%) | 22 (62.86%) | 1.000¶ |
| Grade 1 | 0 (0.00%) | 5 (14.29%) | |
| Grade 2 | 0 (0.00%) | 3 (8.57%) | |
| Grade 3 | 1 (25.00%) | 5 (14.29%) | |
| Acute GVHD | 1 (20.00%) | 4 (11.11%) | 0.497# |
| Acute GVHD score | 0 (0-0) | 0 (0-0) | 0.542‡ |
| Chronic GVHD | 0 (0.00%) | 3 (8.82%) | 1.000# |
| Complications | | | |
| Bacterial infections and fever | 5 (100.00%) | 30 (83.33%) | 1.000# |
| Cardiac complications | 0 (0.00%) | 1 (2.78%) | 1.000# |
| Hyperbilirubinemia | 1 (20.00%) | 1 (2.78%) | 0.232# |
| Bleeding complications | 1 (20.00%) | 4 (11.11%) | 0.497# |
| GI problems | 1 (20.00%) | 10 (27.78%) | 1.000# |
| Elevated creatinine | 0 (0.00%) | 2 (5.56%) | 1.000# |
| IPA | 0 (0.00%) | 2 (5.56%) | 1.000# |
| CMV reactivation | 1 (20.00%) | 2 (5.56%) | 0.330# |
| TMA | 0 (0.00%) | 1 (2.78%) | 1.000# |
| Neurological complications | 0 (0.00%) | 2 (5.56%) | 1.000# |
| Follow-up time, months | 1 (0-2) | 11.5 (8-15.5) | <0.001‡ |

Descriptive statistics are presented using median (25th percentile - 75th percentile) for non-normally distributed continuous variables and frequency (percentage) for categorical variables; ‡ Mann Whitney U test, # Fisher's exact test, ¶ Fisher-Freeman-Halton test. Statistically significant p values are shown in bold; AML: Acute Myeloid Leukemia; ALL: Acute Lymphoblastic Leukemia; MDS: Myelodysplastic Syndromes; NHL: Non-Hodgkin Lymphoma; KPS: Karnofsky Performance Status; HCT CI: Hematopoietic Cell Transplantation Comorbidity Index; VOD: Veno-Occlusive Disease; NRI: Nutritional Risk Index; PNI: Prognostic Nutritional Index; CR: Complete Remission; CMV: Cytomegalovirus; HLA: Human Leukocyte Antigen; GVHD: Graft-versus-Host Disease; TBI: Total Body Irradiation; ATG: Anti-Thymocyte Globulin; CSA: Cyclosporine A; MTX: Methotrexate; MMF: Mycophenolate Mofetil; Post Cy: Post-transplant Cyclophosphamide; IPA: Invasive Pulmonary Aspergillosis; TMA: Thrombotic Microangiopathy.

**Table 5.** Performance of CONUT score to predict nonrelapse mortality, ROC curve analysis

| | **CONUT** |
|---|---|
| Cut-off | >3.5 |
| Sensitivity | 75.00% |
| Specificity | 69.44% |
| Accuracy | 70.00% |
| PPV | 21.43% |
| NPV | 96.15% |
| AUC (95% CI) | 0.806 (0.607-1.000) |
| p | 0.047 |

CONUT: Controlling Nutritional Status; ROC: Receiver Operating Characteristic; PPV: Positive Predictive Value; NPV: Negative Predictive Value; AUC: Area Under the Curve; CI: Confidence Interval.

the critical thresholds. Additionally, the CONUT score integrates serum albumin level, a well-established marker of mortality risk, with total lymphocyte count, further enhancing its predictive capacity. Despite the comparable area under the receiver operating characteristic (ROC) curve values for CONUT and NRI, the threshold-based design of CONUT may account for its superior prognostic performance.

## Limitations

This retrospective, single-center study has several inherent limitations. The small sample size of 41 patients reduced the statistical power and generalizability of the results. The heterogeneous patient population, which included various diseases and treatment methods, further complicates the interpretation of the findings. In addition, the relatively

short follow-up period of 11 months may have limited the comprehensive assessment of transplant outcomes. The retrospective calculation of nutritional indices and potential selection bias also constrain the broader applicability of the study. These limitations underscore the need for larger, prospective, and multicenter investigations to validate and expand upon these findings.

## Conclusion

In conclusion, nutritional assessment plays a crucial role in predicting the outcome of allo-HSCT recipients. Among the three scoring systems evaluated, NRI, PNI, and CONUT, the high CONUT score demonstrated the highest prognostic utility for mortality and non-relapse mortality (NRM). Its integration of clinically significant parameters, including serum albumin and lymphocyte count, combined with a threshold-based approach, likely accounts for its superior predictive performance. To provide a thorough evaluation of patient risk, the CONUT score can be used in combination with other risk models, such as the Hematopoietic Cell Transplantation Comorbidity Index (HCT-CI). Despite being a helpful tool, the CONUT score's role in allo-HSCT is still being investigated; further research is required to standardize its application and identify the best cutoff values for various patient populations. Further studies with larger sample sizes are needed to confirm these results and to optimize nutritional risk management in this population.

### Disclosures

**Ethics Committee Approval:** The study was approved by the Sisli Hamidiye Etfal Training and Research Hospital Clinical Research Ethics Committee (date: 06.08.2024, no: 4477).

**Peer-review:** Externally peer-reviewed.

**Conflict of Interest:** The authors declared no conflicts of interest related to the publication of this study.

**Funding Statement:** The authors declared no external funding was received for this research.

**Authorship Contributions:** Concept – S.G.O., S.A.; Design – Y.A., H.A.O.; Supervision – S.G.O., H.A.O., S.A.; Fundings – A.U., A.A.B.; Materials – A.K., S.S.; Data Collection and/or Processing – A.U., A.A.B.; Analysis and/or Interpretation – M.S.Y., A.Y.O.; Literature Review – Z.A.D., A.U.; Writing – S.G.O., S.A., A.U., A.K.; Critical Review – S.G.O., H.A.O.

**Use of AI for Writing Assistance:** The authors declared that this article was written by the authors, with ChatGPT-4 (OpenAI, 2024) used exclusively for grammar correction and enhancing clarity. The final manuscript was thoroughly reviewed and approved by the authors to ensure its accuracy and originality, with all analyses, conclusions, and interpretations made independently of AI assistance.

## References

1. Blaise D, Fürst S, Crocchiolo R, El-Cheikh J, Granata A, Harbi S, et al. Haploidentical T cell-replete transplantation with post-transplantation cyclophosphamide for patients in or above the sixth decade of age compared with allogeneic hematopoietic stem cell transplantation from an human leukocyte antigen-matched related or unrelated donor. Biol Blood Marrow Transplant 2016;22:119–24. [CrossRef]
2. Sophie S, Yves B, Frédéric B. Current status and perspectives of allogeneic hematopoietic stem cell transplantation in elderly patients with acute myeloid leukemia. Stem Cells Transl Med 2022;11:461–77. [CrossRef]
3. Estran S, Loschi M, Benachour S, Soldati A, Chiche E, Sammut R, et al. Improving nutritional status after allogeneic stem cell transplantation: results of phase 2 ALLONUT clinical trial. Bone Marrow Transplant 2024;59:957–64. [CrossRef]
4. Gooley TA, Chien JW, Pergam SA, Hingorani S, Sorror ML, Boeckh M, et al. Reduced mortality after allogeneic hematopoietic-cell transplantation. N Engl J Med 2010;363:2091–101. [CrossRef]
5. McDonald GB, Sandmaier BM, Mielcarek M, Sorror M, Pergam SA, Cheng GS, et al. Survival, nonrelapse mortality, and relapse-related mortality after allogeneic hematopoietic cell transplantation: comparing 2003-2007 versus 2013-2017 cohorts. Ann Intern Med 2020;172:229–39. [CrossRef]
6. Finke J, Schmoor C, Bethge WA, Ottinger HD, Stelljes M, Zander AR, et al. Prognostic factors affecting outcome after allogeneic transplantation for hematological malignancies from unrelated donors: results from a randomized trial. Biol Blood Marrow Transplant 2012;18:1716–26. [CrossRef]
7. Hirose EY, de Molla VC, Gonçalves MV, Pereira AD, Szor RS, da Fonseca A, et al. The impact of pretransplant malnutrition on allogeneic hematopoietic stem cell transplantation outcomes. Clin Nutr ESPEN 2019;33:213–9. [CrossRef]
8. El-Ghammaz AMS, Ben Matoug R, Elzimaity M, Mostafa N. Nutritional status of allogeneic hematopoietic stem cell transplantation recipients: influencing risk factors and impact on survival. Support Care Cancer 2017;25:3085–93. [CrossRef]
9. Miyashita E, Konuma T, Kataoka J, Oiwa-Monna M, Mizusawa M, Isobe M, et al. The prognostic impact of pretransplantation inflammatory and nutritional status in adult patients after myeloablative single cord blood transplantation. Biol Blood Marrow Transplant 2019;25:981–8. [CrossRef]
10. Orvain C, Byelykh M, Othus M, Sandmaier BM, Schoch G, Davis C, et al. Relationship between pretransplantation nutritional status and outcome in adults with acute myelogenous leukemia undergoing allogeneic hematopoietic cell transplantation. Transplant Cell Ther 2022;28:846. [CrossRef]
11. Brotelle T, Lemal R, Cabrespine A, Combal C, Hermet E, Ravinet A, et al. Prevalence of malnutrition in adult patients previously treated with allogeneic hematopoietic stem-cell transplantation.

Clin Nutr 2018;37:739–45. [CrossRef]
12. Yilmaz M, Atilla FD, Sahin F, Saydam G. The effect of malnutrition on mortality in hospitalized patients with hematologic malignancy. Support Care Cancer 2020;28:1441–8. [CrossRef]
13. Matsukawa T, Suto K, Kanaya M, Izumiyama K, Minauchi K, Yoshida S, et al. Validation and comparison of prognostic values of GNRI, PNI, and CONUT in newly diagnosed diffuse large B cell lymphoma. Ann Hematol 2020;99:2859–68. [CrossRef]
14. Yan D, Shen Z, Zhang S, Hu L, Sun Q, Xu K, et al. Prognostic values of geriatric nutritional risk index (GNRI) and prognostic nutritional index (PNI) in elderly patients with Diffuse Large B-Cell Lymphoma. J Cancer 2021;12:7010–7. [CrossRef]
15. Mancuso S, Mattana M, Santoro M, Carlisi M, Buscemi S, Siragusa S. Host-related factors and cancer: malnutrition and non-Hodgkin lymphoma. Hematol Oncol 2022;40:320–31. [CrossRef]
16. Erdogan O, Erdogan T, Panc C, Tasbulak O, Altunova M, Yalcin AA, et al. Prognostic nutritional index as a new prediction tool for all-cause mortality in patients with chronic limb-threatening ischemia undergoing endovascular therapy. Sisli Etfal Hastan Tip Bul 2024;58:346–53. [CrossRef]
17. Araie H, Kawaguchi Y, Okabe M, Lee Y, Ohbiki M, Osaki M, et al. Prediction of clinical outcome by controlling nutritional status (CONUT) before allogeneic hematopoietic stem cell transplantation in myeloid malignancies. Int J Hematol 2019;110:599–605. [CrossRef]
18. Ignacio de Ulíbarri J, González-Madroño A, de Villar NG, González P, González B, Mancha A, et al. CONUT: a tool for controlling nutritional status. First validation in a hospital population. Nutr Hosp 2005;20:38–45.
19. Group VATPNCS. Perioperative total parenteral nutrition in surgical patients. N Engl J Med 1991;325:525–32. [CrossRef]
20. Onodera T, Goseki N, Kosaki G. Prognostic nutritional index in gastrointestinal surgery of malnourished cancer patients. Nihon Geka Gakkai Zasshi [Article in Japanese] 1984;85:1001–5.
21. Kharfan-Dabaja MA, Kumar A, Ayala E, Aljurf M, Nishihori T, Marsh R, et al. Standardizing definitions of hematopoietic recovery, graft rejection, graft failure, poor graft function, and donor chimerism in allogeneic hematopoietic cell transplantation: a report on behalf of the American Society for Transplantation and Cellular Therapy. Transplant Cell Ther 2021;27:642–9.
22. National Cancer Institue. Common Terminology Criteria for Adverse Events (CTCAE) version 5.0. 2017.
23. Miller AB, Hoogstraten B, Staquet M, Winkler A. Reporting results of cancer treatment. Cancer 1981;47:207–14. [CrossRef]
24. Glucksberg H, Storb R, Fefer A, Buckner CD, Neiman PE, Clift RA, et al. Clinical manifestations of graft-versus-host disease in human recipients of marrow from HL-A-matched sibling donors. Transplantation 1974;18:295–304. [CrossRef]
25. Jagasia MH, Greinix HT, Arora M, Williams KM, Wolff D, Cowen EW, et al. National Institutes of Health consensus development project on criteria for clinical trials in chronic graft-versus-host disease: i. the 2014 diagnosis and staging working group report. Biol Blood Marrow Transplant 2015;21:389–401. [CrossRef]
26. Iseri A, Arslan N. Obesity in adults in Turkey: age and regional effects. Eur J Public Health 2009;19:91–4. [CrossRef]
27. Kundu R, Seeger R, Elfassy MD, Rozenberg D, Ahluwalia N, Detsky ME, et al. The association between nutritional risk index and ICU outcomes across hematologic malignancy patients with acute respiratory failure. Ann Hematol 2023;102:439–45. [CrossRef]
28. He J, Wang L, Xu W. The Prognostic Value of Prognostic Nutritional Index in Patients with Lymphoma--Review. Zhongguo Shi Yan Xue Ye Xue Za Zhi [Article in Chinese] 2022;30:641–4.