Received: 2 June 2021 | Accepted: 21 July 2021

DOI: 10.1111/ijcp.14637

THE INTERNATIONAL JOURNAL OF CLINICAL PRACTICE WILEY

ORIGINAL PAPER

Cardiovascular Medicine

Impact of nutritional assessment on long-term outcomes in patients with carotid artery stenting

Muhammed Demir | **Mehmet Özbek**

Department of Cardiology, Dicle University School of Medicine, Diyarbakir, Turkey

Correspondence
Muhammed Demir, Department of Cardiology, Dicle University School of Medicine, Diyarbakir, Turkey.
Email: drmdemirr@gmail.com

Abstract

Background and Aims: Malnutrition is associated with poor clinical outcomes in many diseases. The Controlling Nutritional Status (CONUT) is an objective index used for evaluating nutritional status of hospitalised patients. The aim of this study was to investigate the relationship between malnutrition assessed by CONUT score and the prognosis in patients undergoing carotid artery stenting (CAS).

Methods and Results: The study included 170 patients who underwent CAS because of symptomatic or asymptomatic severe carotid artery stenosis. Median follow-up period was 50 (interquartile range [IQR], 41-60) months. Patients were divided into two groups according to the CONUT score as normal CONUT (score <2) and mild-severe CONUT (score ≥2). Primary endpoint was accepted as MACE (major adverse cardiac events) including all-cause death and ischaemic stroke. The prevalence of MACE was significantly higher in the mild-severe CONUT score group (P = .001). Kaplan Meier analysis showed lower survival rates in the mild-severe CONUT score group (log rank = 9.36, P = .002; Figure 5). The Cox regression analysis showed that, the CONUT score was associated with increased risk of MACE for both unadjusted model and age- and gender- adjusted model, while in a full adjusted model the best predictor was age.

Conclusion: Higher CONUT scores were associated with adverse outcomes in patients with CAS. Malnutrition assessed by the CONUT score is preferable with regards to the detection of MACE in patients with CAS. Larger studies are warranted to investigate if our preliminary findings translate into clinical outcomes in patients with CAS.

1 | INTRODUCTION

Stroke is a leading cause of disability and death worldwide. Atherosclerotic narrowing of the extracranial carotid arteries is responsible for approximately one-fifth of all strokes.[1] There are two main interventional treatment methods in symptomatic or asymptomatic high-grade carotid artery stenosis: carotid artery stenting (CAS) and carotid endarterectomy.[2,3] Although there is sufficient evidence on the long-term outcomes of patients after CAS, potential risk factors affecting the long-term course of the disease have not yet been studied sufficiently.[4,5]

Comorbid diseases accompanying severe CAS affect the long-term outcomes of the disease. Although risk factors showing long-term consequences such as diffuse proliferative hyperplasia after CAS, low high-density lipoprotein cholesterol level, diabetes mellitus (DM), low body mass index (BMI), and contralateral carotid artery occlusion have so far been identified, a detailed risk assessment has not yet been performed.[6-10]

Malnutrition is associated with adverse outcomes in many diseases.[11,12] The Controlling Nutritional Status (CONUT) score is an objective index widely used for evaluating nutritional status of individuals. The CONUT score is calculated based on serum albumin level, total cholesterol level, and total lymphocyte count and it can assess protein reserves, calorie deficit, and immune response.[13] Clinical significance of malnutrition as assessed by the CONUT score has been demonstrated in patients with hypertension, acute coronary syndrome (ACS), and heart failure.[14-16]

Although the CONUT score is a practical, applicable, scoring system with a prognostic value, its clinical significance has not yet been elucidated in CAS patients. The aim of this study was to investigate the relationship between malnutrition assessed by CONUT score and prognosis in patients undergoing CAS.

What's known

- Malnutrition is associated with adverse outcomes in many diseases.
- Clinical significance of malnutrition as assessed by the CONUT score has been demonstrated in patients with hypertension, acute coronary syndrome, and heart failure.
- Impaired nutrition is associated with poor prognosis in patient with carotid artery stenting.

What's new

- Little known about the periprocedural nutritional evaluation and mortality.
- It is important to calculate nutritional scores before to procedure to estimate long term adverse events.
- Impaired nutrition is associated with poor prognosis in patient with carotid artery stenting.

2 | METHODS

2.1 | Study population

The study was designed as a single-center, retrospective study and included 170 patients who underwent CAS due to symptomatic or asymptomatic severe carotid artery stenosis in Dicle University Medical School Hospital between December 2011 and December 2020. Patients with haematological diseases, systemic inflammatory diseases, malignancies, active infectious diseases, end-stage kidney and liver diseases, and a history of thrombolytic therapy within the last 24 h were excluded from the study. The study was conducted in accordance with the Helsinki Declaration and the study protocol was approved by the local ethics committee. The experimental protocols and the process for obtaining informed consent were approved by the appropriate institutional review committee.

2.2 | Definitions

A detailed medical history was obtained from all patients at the time of admission. Hypertension was defined as a systolic blood pressure (SBP) of ≥140 mmHg or a diastolic blood pressure (DBP) of ≥90 mmHg or using antihypertensive medication. DM was defined as a fasting glucose level of ≥126 mg/dL or use of antidiabetic agents or HbA1c >7%. Dyslipidemia was defined as a total cholesterol level of >200 mg/dL or low-density lipoprotein (LDL) level of >130 mg/dL. Smoking was defined as current cigarette smoking. Coronary artery disease (CAD) was defined as >50% narrowing in at least one coronary artery. Peripheral artery disease (PAD) was defined as >50% stenosis in peripheral arteries. Transient ischaemic attack (TIA) was defined based on the 2009 American Heart Association/American Stroke Association (AHA/ASA) guidelines as a transient episode of neurological dysfunction in the spinal cord, retina, and focal brain without acute infarction. Ischaemic stroke was defined as an infarction causing neurological dysfunction in the focal brain, spinal cord and retina lasting more than 24 h.

2.3 | Blood samples and nutritional indexes

Haematological and biochemical tests were conducted on the venous blood samples obtained from each patient immediately before routine carotid angiography. Determination of the counts and types of shaped elements of blood was performed for each patient using an automated haematological analyser (Abbott Cell-Dyn 3700; Abbott Laboratory, Abbott Park, IL, USA). Biochemical measurements were performed using the standard methods. Malnutrition assessed by three nutritional scores; CONUT score, Prognostic nutritional index (PNI) score and Malnutrition Universal Screening Tool (MUST) score. The CONUT score is calculated based on three parameters: serum albumin level, total cholesterol level, and total lymphocyte count (Table 1). Patients were divided into two groups according to the CONUT score as normal CONUT score <2 and mild-severe CONUT score ≥2. PNI was calculated using the following formula: 10 × serum albumin value (g/dL) + 0.005 × total lymphocyte count in the peripheral blood (per mm^3). Patients were divided into two groups based on a PNI cut-off value of 40: (a) low PNI (≤40) and (b) high PNI (>40). MUST score is a three step tool. The first step is to calculate the patient's BMI. The second step include of setting up the patient's unplanned weight loss score. During the third step, the acute disease effect that has provoked nutritional intake for >5 days is assigned to each patient. Each parameter can be scored as 0, 1, or 2. From this data, malnutrition scores can be calculated and risk categories designated as low risk (score 0), medium risk (score 1) and high risk (score 2 or more).

2.4 | MACE and follow-up

Primary endpoint was accepted as MACE (major adverse cardiac events) including all-cause death and ischaemic stroke. The follow-up period was defined as the time from the moment of admission to our clinic for angiography to death due to any cause or to the last

TABLE 1 Severity of malnutrition assessed by CONUT score

	Severity			
Parameter	**Normal**	**Mild**	**Moderate**	**Severe**
Serum albumin (g/dL)	≥3.5	3-3.49	2.5-2.99	<2.5
Score	0	2	4	6
Total lymphocytes (/μL)	≥1600	1200-1599	800-1199	<800
Score	0	1	2	3
Total cholesterol (mg/dL)	≥180	140-179	100-139	<100
Score	0	1	2	3
Total CONUT score	0-1	2-4	5-8	9-12

Abbreviation: CONUT, controlling nutritional status.

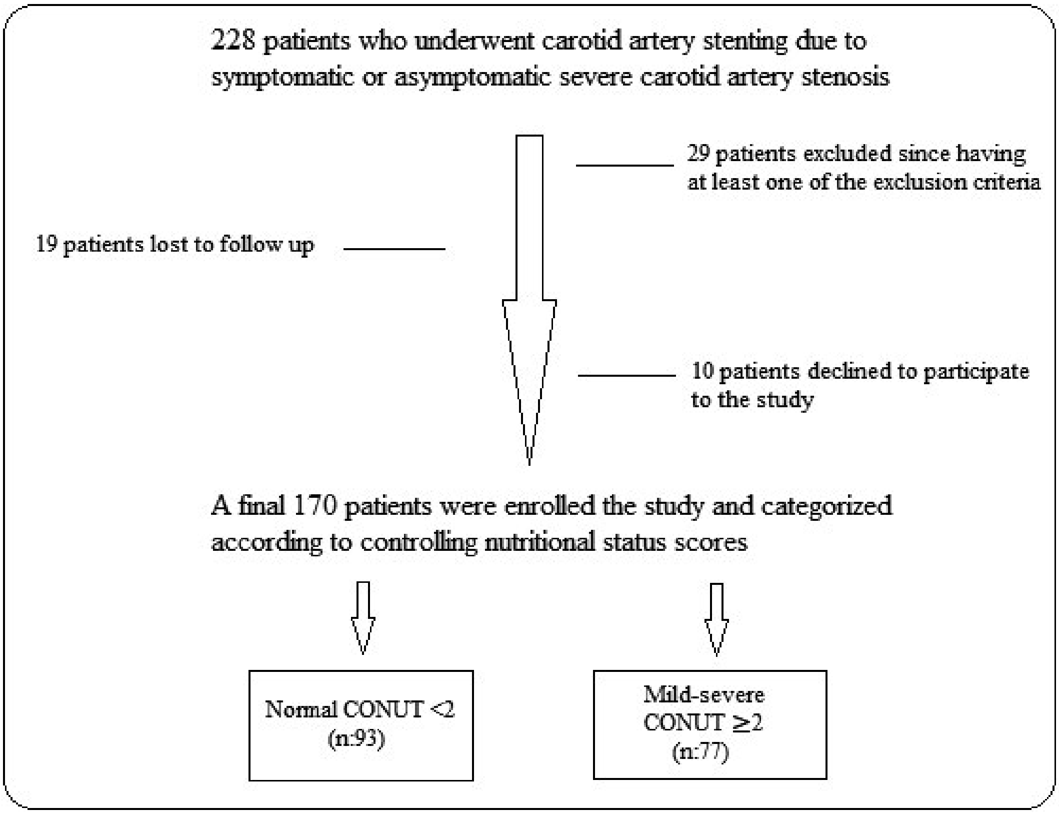


FIGURE 1 Study flow chart

clinical visit. Figure 1 shows flow chart to the study. All follow-up data were accessed from hospital epicrisis, civil registration records or by interviewing (in-person or phone call) patients, their families or their family doctors. The study was terminated after a follow-up period of 94 months.

2.5 | Statistical analysis

Data were analysed using SPSS for Windows version 25.0 (Armonk, NY: IBM Corp.). Normal distribution of data was analysed using Kolmogorov-Smirnov test. Categorical variables were expressed as percentages (%) and were compared using Chi-square test. Continuous variables with normal distribution were expressed as mean ± standard deviation (SD) and were compared using Student's *t* test. Continuous variables with nonnormal distribution were expressed as median (25th-75th percentile) and were compared using Mann-Whitney U test. Univariate analysis and multivariate analysis with Cox proportional hazard regression were used to identify predictors of MACE. Three Cox multivariable models were used: model I, unadjusted; model II, age and gender adjusted; and model III, fully adjusted. The variables resulting from the Table 2 with a *P* value <.05, entered as covariated in the model III: age, gender, BMI, current smoker, diabetes,

TABLE 2 Clinical characteristics, medications at discharge and laboratory parameters of the patients

	Total N = 170	Normal CONUT <2 N = 93	Mild-severe CONUT ≥2 N = 77	*P*
Age (y)	68.27 ± 10.23	66.17 ± 10.23	70.81 ± 9.70	.003
Male	105 (61.8%)	55 (59.1%)	50 (64.9%)	.439
Hypertension	126 (74.1%)	67 (72%)	59 (76.6%)	.497
DM	63 (37.1%)	33 (35.5%)	30 (39%)	.640
Dyslipidemia	130 (76.5%)	76 (81.7%)	54 (70.1%)	.076
Current smoker	82 (48.2%)	48 (51.6%)	34 (44.2%)	.333
CAD	104 (61.2%)	61 (65.6%)	43 (55.8%)	.194
PAD	7 (4.1%)	4 (4.3%)	3 (3.9%)	.652
Stroke	66 (38.8%)	31 (33.3%)	35 (45.5%)	.106
TIA	73 (42.9%)	39 (41.9%)	34 (44.2%)	.771
Amaurosis fugax	13 (7.6%)	8 (8.6%)	5 (6.5%)	.607
Rhythm				.459
Sinus rhythm	161 (94.7%)	87 (93.5%)	74 (96.1%)	
Atrium fibrillation	9 (5.3%)	6 (6.5%)	3 (3.9%)	
ASA/clopidogrel	170 (100%)	93 (100%)	77 (100%)	*
ACEI/ARB	112 (65.9%)	61 (65.6%)	51 (66.2%)	.930
Beta-blocker	118 (69.4%)	61 (65.6%)	57 (74%)	.235
Statins	162 (95.3%)	89 (95.7%)	73 (94.8%)	.784
BMI, kg/m^2	25.22 (24.08-27.2)	25 (24.03-26.94)	25.40 (24.21-27.45)	.398
Ejection fraction (%)	60 (60-60)	60 (55-60)	60 (60-60)	.231
SBP mmHg	130 (120-137)	130 (120-136)	130 (120-138)	.539
DBP mmHg	76.5 (70-80)	76 (70-80)	78 (70-80)	.752
PNI	46.35 ± 6.59	50.12 ± 4.57	41.81 ± 5.76	<.001
MUST score	1.15 ± 0.99	0.84 ± 0.83	1.51 ± 1.04	<.001
White blood cell count (×10^6 µL)	8652 ± 2384	8628 ± 2084	8681 ± 2717	.887
Haemoglobin (g/dL)	13.16 ± 1.77	13.61 ± 1.55	12.61 ± 1.88	<.001
Haematocrit (%)	40.58 ± 4.94	42.12 ± 4.48	38.71 ± 4.86	<.001
Lymphocytes (×10^6 µL)	2128 ± 899	2347 ± 738	1863 ± 1005	<.001
Neutrophils (×10^6 µL)	5613 ± 2073	5397 ± 1778	5873 ± 2367	.136
Uric acid	5.72 ± 1.85	5.65 ± 1.8	5.81 ± 1.93	.579
Glucose (mg/dL)	151 ± 86	137 ± 73	168 ± 97	.019
Creatinine (mg/dL)	0.97 ± 0.41	0.9 ± 0.28	1.05 ± 0.52	.021
Total bilirubin (mg/dL)	0.72 ± 0.39	0.75 ± 0.38	0.69 ± 0.41	.302
Serum albumin (g/dL)	3.57 ± 0.45	3.83 ± 0.24	3.24 ± 0.43	<.001
Total cholesterol (mg/dL)	196 ± 46	212 ± 42	177 ± 43	<.001
Triglycerides (mg/dL)	176 ± 92	188 ± 84	161 ± 99	.050
LDL (mg/dL)	120 ± 40	132 ± 38	107 ± 37	<.001
HDL (mg/dL)	41 ± 12	43 ± 12	39 ± 12	.014
INR	1.06 ± 0.34	1.07 ± 0.36	1.05 ± 0.32	.770
TSH (µIU/mL)	1.02 (0.83-1.66)	1.26 (0.92-1.94)	0.97 (0.7-1.25)	<.001
CRP (mg/dL)	0.8 (0.4-1.3)	0.6 (0.3-1)	1 (0.5-2.1)	<.001
Neutrophil to lymphocyte ratio	2.53 (1.93-3.46)	2.25 (1.81-2.83)	2.96 (2.25-4.9)	<.001

Note: Data are expressed as mean ± SD, frequencies (percentages) or as median (interquartile range) as appropriate.

Abbreviations: ACEI, angiotensin-converting enzyme inhibitor; ARB, angiotensin receptor blocker; ASA, acetylsalicylic acid; CAD, coronary artery disease; CRP, C-reactive protein; DBP, diastolic blood pressure; HDL, high-density lipoprotein; INR, international normalised ratio; LDL, low-density lipoprotein; MUST, malnutrition universal screening tool score; PAD, peripheral artery disease; SBP, systolic blood pressure; TSH: thyroid stimulating hormone.

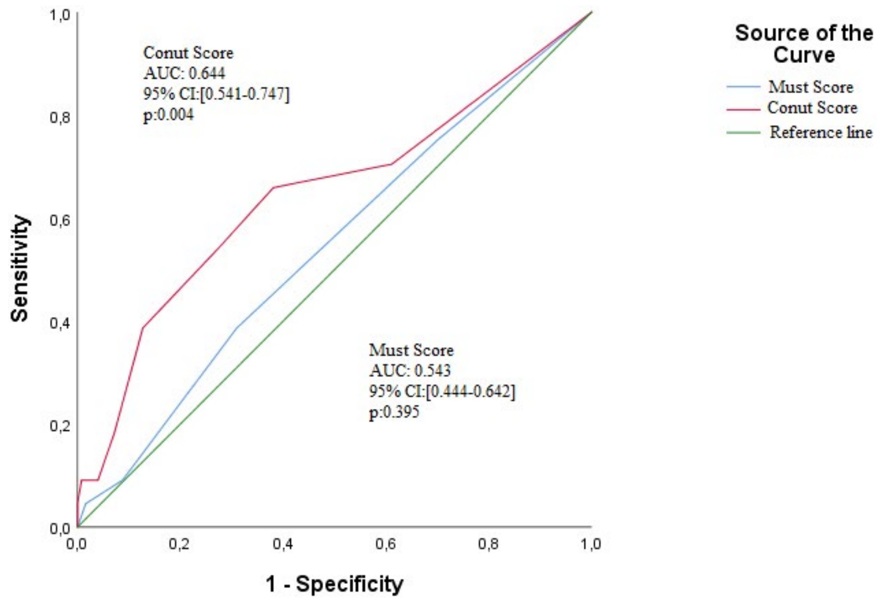
*No statistics were computed because ASA and clopidogrel are constant.

TABLE 3 Severity of carotid artery stenosis and clinical outcomes of patients

	Total N = 170	Normal CONUT <2 N = 93	Mild-severe CONUT ≥2 N = 77	*P*
Left carotid stenosis				
0%-50%	55 (32.4%)	36 (38.7%)	19 (24.7%)	
50%-69%	5 (2.9%)	2 (2.2%)	3 (3.9%)	.218*
70%-89%	43 (25.3%)	23 (24.7%)	20 (26%)	
90%-100%	67 (39.4%)	32 (34.4%)	35 (45.5%)	
Right carotid stenosis				
0%-50%	89 (52.4%)	42 (45.2.7%)	47 (61%)	
50%-69%	3 (1.8%)	3 (3.2%)	0 (0%)	.040*
70%-89%	42 (24.7%)	29 (31.2%)	13 (16.9%)	
90%-100%	36 (21.2%)	19 (20.4%)	17 (22.1%)	
Stented vessel				
Right carotid artery	78 (45.9%)	49 (52.7%)	29 (37.7%)	.050
Left carotid artery	102 (60%)	50 (53.8%)	52 (67.5%)	.068
Follow-up period (mo)	50 (41-60.25)	52 (42.5-59)	48 (37-64.5)	.306
Mortality	40 (23.5%)	13 (14%)	27 (35.1%)	.001
New-onset stroke (follow-up period)	4 (2.4%)	1 (1.1%)	3 (3.9%)	.330*
MACE	44 (25.9%)	15 (16.1%)	29 (37.7%)	.001

Note: Data are expressed as frequencies (percentages) as appropriate.
*Fisher's Exact Test. MACE: Major adverse cardiac events.

FIGURE 2 ROC curve indicating the ability of CONUT and MUST score to predict MACE in patients with carotid artery stenting. AUC, area under the curve; CI, confident interval



dyslipidemia, hypertension, left ventricular ejection fraction, rhythm, CAD, ACEI, ARB, beta blokers and statin use, glucose, CRP, TSH, NLR, albümin, total cholesterol, haemoglobin, haematocrit, lymphocytes, MUST score.

The optimum PNI, MUST and CONUT score cut-off values for the prediction of mortality were determined using receiver operating characteristic (ROC) curve analysis. Correlations were analysed using Spearman's correlation coefficient. Survival analysis was performed using Kaplan-Meier analysis. A *P* value of <.05 was considered significant.

3 | RESULTS

The study included 170 patients, comprising 105 (61.8%) men and 65 women (38.2%) with a mean age of 68.27 ± 10.23 years. Median follow-up period was 50 (interquartile range [IQR]: 41-60.25) months. Patients were divided into two groups according to the CONUT score: CONUT score <2 and CONUT score ≥2. Clinical characteristics, medications at discharge and laboratory parameters of both groups are shown in Table 2. The age, MUST score, glucose, creatinin, CRP and the neutrophil-to-lymphocyte ratio (NLR) were significantly higher and the PNI score, haemoglobin, haematocrit, lymphocytes, serum albumin, total cholesterol, LDL, TSH were significantly lower in the mild-severe CONUT score group compared with the normal CONUT score group. Table 3 presents a comparison of clinical outcomes of patients both groups. Significant differences were found between the two groups with regard to mortality and MACE. No significant differences were found between MUST score and MACE (*P* = .372).

The Cox proportional hazard analysis revealed that the CONUT score but not the MUST score was associated with increased risk of MACE for an unadjusted model [HR (95% CI), 1.31 (1.14-1.51), *P* < .001]. After adjustment for age and gender (model II), the CONUT score [1.26 (1.09-1.46), *P* = .001] in addition to age [1.04 (1.01-1.08), *P* = .005] predicted the MACE. Instead, the prediction of MACE by the CONUT score disappears in the third model, where we adjusted for all parameters mentioned in the statistical section. Indeed, from the full adjusted model, age [1.06 (1.02-1.10), *P* = .003] predicted the MACE (Table 4).

At a cut-off value of 1.5, the CONUT score predicted long-term all-cause death and stroke with a sensitivity of 66% and a specificity of 62% (ROC area under curve [AUC]: 0.644, 95% CI: 0.541-0.747; Figure 2). At a cut-off value of 46, PNI predicted long-term all-cause death and stroke with a sensitivity of 65% and a specificity of 57% (AUC: 0.655, 95% CI: 0.560-0.749; Figure 3). A negative correlation was observed between the CONUT score and PNI (*r* = −.716, *P* < .001; Figure 4). A positive correlation was observed between the CONUT score and MUST score (*r* = .456, *P* < .001; Figure 4). Kaplan Meier analysis showed lower survival rates in the mild-severe CONUT score group (log rank = 9.36, *P* = .002; Figure 5) and in the group with a low PNI score (≤40; log rank = 14.98, *P* < .001; Figure 6).

TABLE 4 Cox proportional hazard regression analysis of risk of MACE in three regression models during 94 months of follow-up in the study population

	HR (95% CI)	*P* values
Model I		
CONUT score	1.31 (1.14-1.51)	<.001
MUST score	1.19 (0.88-1.60)	.238
Model II		
CONUT score	1.26 (1.09-1.46)	.001
Age	1.04 (1.01-1.08)	.005
Model III		
Age	1.06 (1.02-1.10)	.003

Note: Model I: univariate analysis.
Model II: model adjusted for age and gender.
Model III: model adjusted for all clinical variables with a *P* value <.05 from Tables 2.
Both nutritional indices entered into the models as continuous variables.
Abbreviations: 95% CI, 95% confidential interval; CONUT, controlling nutritional status score; HR, hazard ratio; MACE, major adverse cardiac events; MUST, malnutrition universal screening tool score.

4 | DISCUSSION

This study investigated the long-term prognostic value of malnutrition assessed by the CONUT score in CAS patients and the results indicated a higher prevalence of all-cause death and stroke in malnourished patients compared with patients with normal nutrition.

The CONUT score was first described by Ignacio de Ulı´barri et al as an objective parameter reflecting malnutrition in

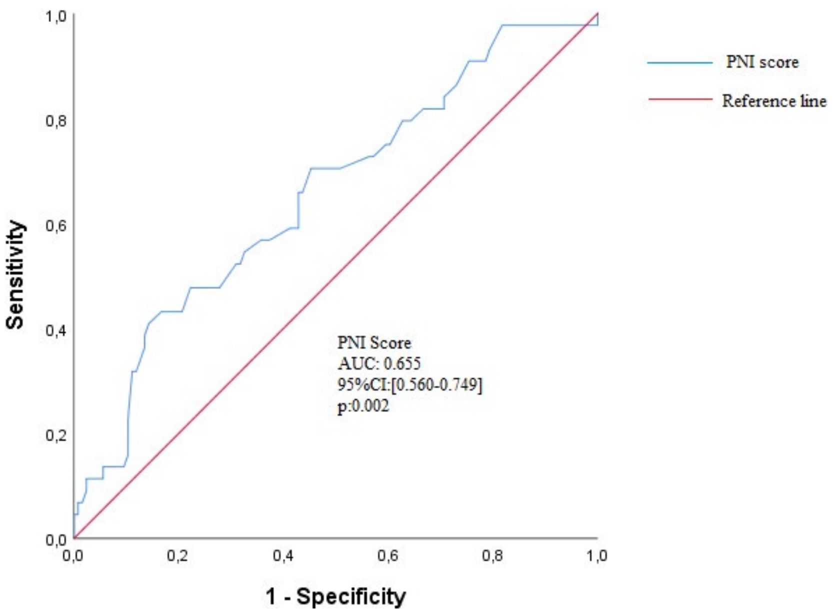


FIGURE 3 ROC curve indicating the ability of prognostic nutritional index (PNI) to predict MACE in patients with carotid artery stenting. AUC, area under the curve; CI, confident interval

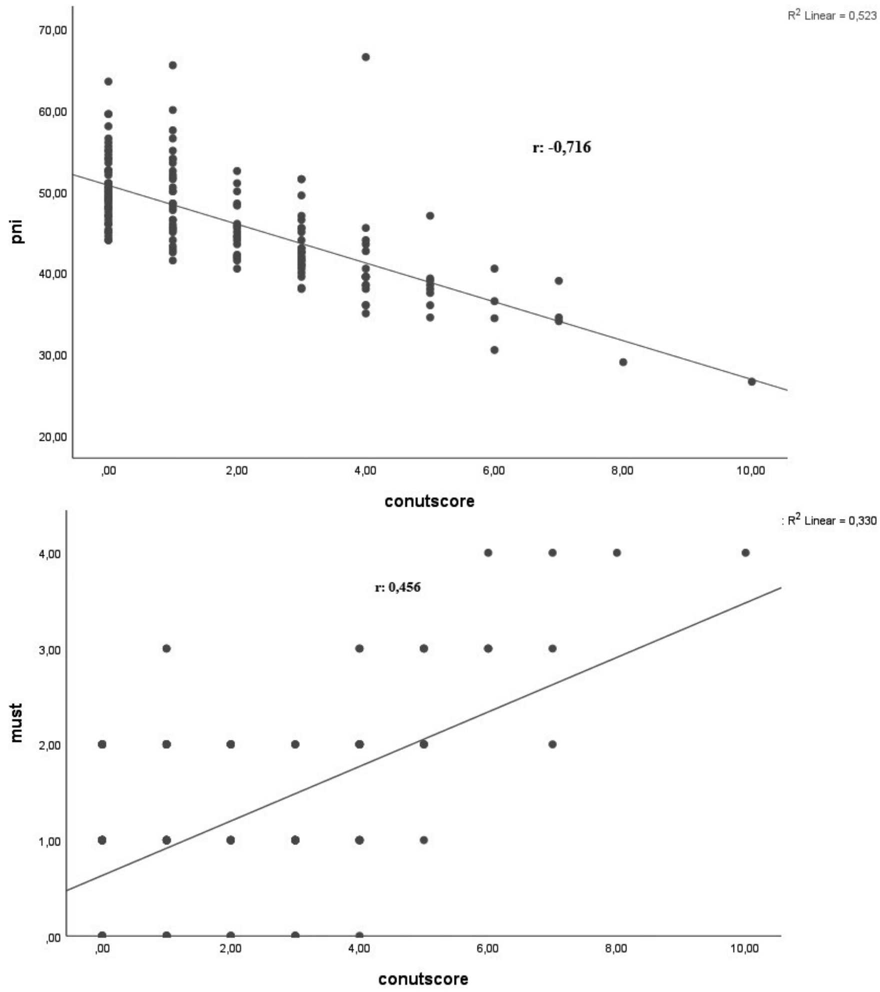


FIGURE 4 Correlation analysis of CONUT score with PNI and MUST scores

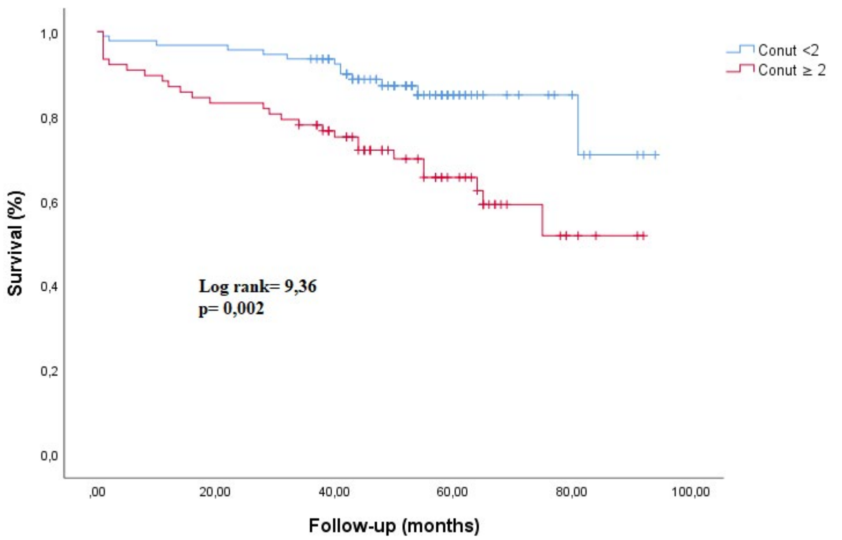


FIGURE 5 Kaplan-Meier survival analysis for CONUT score. During long-term follow-up period (median, 50 months), patients group with CONUT ≥2 had significantly worse survival than patients group with CONUT <2 (P =.002). Mean survival period for CONUT <2 and CONUT ≥2 was 83.001 ± 2.946 and 65.965 ± 4.048 months, respectively; P =.002

hospitalised patients.[13] In recent studies, the association of the CONUT score with clinical poor outcomes has been demonstrated in various cardiovascular diseases. Takahashi et al reported that high CONUT score was associated with adverse outcomes in patients with ACS and also showed its prognostic value in ACS patients.[15] Nochioka et al showed that malnutrition assessed by the CONUT score was associated with adverse cardiac events in patients with chronic heart failure.[17] Kunimura et al demonstrated that the combined use of BMI and CONUT score in stable CAD was associated with MACE.[18] In some other studies, the CONUT score was shown to be an independent strong predictor of adverse cardiovascular events and foot events in PAD patients.[19]

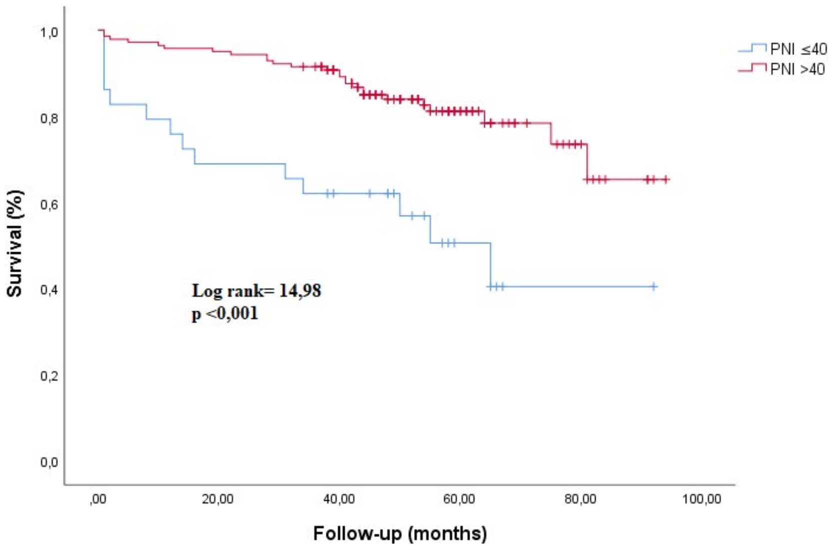


FIGURE 6 Kaplan-Meier survival analysis for PNI. During long-term follow-up period (median, 50 months), patients group with PNI ≤40 had significantly worse survival than patients with PNI >40 (P <.001). Mean survival time for PNI ≤40 and PNI >40 was 54.033 ± 7.277 and 79.521 ± 2.607, respectively; P <.001

Additionally, it was also reported to be associated with increased prevalence of all-cause death in patients with ST elevation myocardial infarction (STEMI).[20]

To date, numerous nutritional indicators such as serum albumin, total cholesterol, Mini Nutritional Assessment (MNA), Subjective Global Assessment (SGA), and Geriatric Nutritional Risk Index (GNRI) have been reported.[21-23] Of these, MNA and SGA are dependent on the physician's subjective observations. Nevertheless, an evaluation performed with only one nutritional indicator may be affected by various factors and may not provide sufficient information. Therefore, in this study, we used both PNI and MUST score in addition to the CONUT score. PNI, which is calculated on serum albumin level and total lymphocyte count, is an objective nutritional indicator reflecting the immune-nutritional status of individuals. Decreased albumin and lymphocyte response in acute diseases reflect poor immune-nutritional status. On the other hand, PNI is mainly used as a parameter reflecting the immune-nutritional status of patients planned for gastrointestinal surgery to assess the risk of perioperative surgery.[24,25] In our study, a PNI score of ≤40 was associated with a shorter survival time. MUST score include three criteria to determine the overall risk of malnutrition and it seems that each of the criteria can independently prognosticate clinical outcome.[26] MUST score predicted clinical outcomes in patients undergoing surgery for colorectal cancer.[27] In contrast with literature, in our study, no statistically significant difference was found between the MUST score and all-cause mortality and stroke.

In the literature, CAS patients have been evaluated with biochemical parameters as well. Of these, NLR has been shown to be associated with in-stent restenosis in CAS patients.[28] Additionally, CRP and B-type natriuretic peptide have been demonstrated to have a prognostic value in CAS patients undergoing carotid surgery.[29]

Both the studies in the literature and our study indicated that malnutrition is associated with mortality. Accordingly, the CONUT score, which is an objective and easily applicable scoring system, can be a useful nutritional indicator in predicting adverse events in CAS patients and, as a novel indicator, can contribute to the prediction of adverse events such as long-term mortality and stroke in the CAS patients, in addition to traditional parameters.

The study had several limitations. First, it was a single-center retrospective study and had a relatively small sample size. Second, the CONUT scores were not assessed after hospital discharge and thus the effect of changes in post-discharge CONUT scores on clinical outcomes could not be evaluated. Third, malnutrition was assessed only by using the CONUT score, PNI and MUST score. Other nutritional indicators such as MNA, SGA and GNRI were not used.

In conclusion, malnutrition assessed by the CONUT score is preferable with regards to the detection of MACE in patients with CAS. The CONUT score is a useful tool for risk stratification of patients with CAS. However, larger studies are warranted to investigate if our preliminary findings translate into clinical outcomes in patients with CAS.

ACKNOWLEDGMENTS

The authors wish to thank Lezgin Dursun, who worked as a researcher at the School of Medicine of Dicle University for his data assistance.

DISCLOSURE

The authors declared no conflict of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

ORCID

Muhammed Demir https://orcid.org/0000-0002-9049-7123
Mehmet Özbek https://orcid.org/0000-0003-2243-6190

REFERENCES

1. Mozaffarian D, Benjamin EJ, Go AS, et al.; American Heart Association Statistics Committee; Stroke Statistics Subcommittee.

Executive summary: heart disease and stroke statistics-2016 update: a report from the American Heart Association. *Circulation*. 2016;133:447-454.
2. Sacco RL, Adams R, Albers G, et al. Guidelines for prevention of stroke in patients with ischemic stroke or transient ischemic attack: a statement for healthcare professionals from the American Heart Association/American Stroke Association Council on Stroke: co-sponsored by the Council on Cardiovascular Radiology and Intervention: the American Academy of Neurology affirms the value of this guideline. *Circulation*. 2006;113:e409-e449.
3. Barnett HJM, Taylor DW, Haynes RB, et al. Beneficial effect of carotid endarterectomy in symptomatic patients with high-grade carotid stenosis. *N Engl J Med*. 1991;325:445-453.
4. Gurm HS, Yadav JS, Fayad P, et al. Long-term results of carotid stenting versus endarterectomy in high-risk patients. *N Engl J Med*. 2008;358:1572-1579.
5. Yadav JS, Wholey MH, Kuntz RE, et al.; Stenting and Angioplasty with Protection in Patients at High Risk for Endarterectomy Investigators. Protected carotid-artery stenting versus endarterectomy in high-risk patients. *N Engl J Med*. 2004;351:1493-1501.
6. Yuo TH, Goodney PP, Powell RJ, Cronenwett JL. "Medical high risk" designation is not associated with survival after carotid artery stenting. *J Vasc Surg*. 2008;47:356-362.
7. Lal BK, Kaperonis EA, Cuadra S, Kapadia I, Hobson RW Jr. Patterns of in-stent restenosis after carotid artery stenting: classification and implications for long-term outcome. *J Vasc Surg*. 2007;46:833-840.
8. Niessner A, Hofmann R, Kypta A, et al. Low high-density lipoprotein cholesterol predicts cardiovascular events after carotid stenting: a long-term survey. *J Thromb Haemost*. 2007;5:950-954.
9. Gurm HS, Fathi R, Kapadia SR, et al. Impact of body mass index on outcome in patients undergoing carotid stenting. *Am J Cardiol*. 2005;96:1743-1745.
10. Keldahl ML, Park MS, Garcia-Toca M, et al. Does a contralateral carotid occlusion adversely impact carotid artery stenting outcomes? *Ann Vasc Surg*. 2012;26:40-45.
11. Datema FR, Ferrier MB, Baatenburg de Jong RJ. Impact of severe malnutrition on short-term mortality and overall survival in head and neck cancer. *Oral Oncol*. 2011;47:910-914.
12. Horwich TB, Kalantar-Zadeh K, MacLellan RW, Fonarow GC. Albumin levels predict survival in patients with systolic heart failure. *Am Heart J*. 2008;155:883-889.
13. Ignacio de Ulibarri J, Gonzalez-Madrono A, de Villar NG, et al. CONUT: a tool for controlling nutritional status. First validation in a hospital population. *Nutr Hosp*. 2005;20:38-45.
14. Sun X, Luo L, Zhao X, Ye P. Controlling Nutritional Status (CONUT) score as a predictor of all-cause mortality in elderly hypertensive patients: a prospective follow-up study. *BMJ Open*. 2017;7:e015649.
15. Takahashi T, Watanabe T, Otaki Y, et al. Prognostic significance of the controlling nutritional (CONUT) score in patients with acute coronary syndrome. *Heart Vessels*. 2021;36:1109-1116.
16. Nishi I, Seo Y, Hamada-Harimura Y, et al. Nutritional screening based on the controlling nutritional status (CONUT) score at the time of admission is useful for long-term prognostic prediction in patients with heart failure requiring hospitalization. *Heart Vessels*. 2017;32:1337-1349.
17. Nochioka K, Sakata Y, Takahashi J, et al. Prognostic impact of nutritional status in asymptomatic patients with cardiac diseases: a report from the CHART-2 Study. *Circ J*. 2013;77:2318-2326.
18. Kunimura A, Ishii H, Uetani T, et al. Impact of nutritional assessment and body mass index on cardiovascular outcomes in patients with stable coronary artery disease. *Int J Cardiol*. 2017;230:653-658.
19. Yokoyama M, Watanabe T, Otaki Y, et al. Impact of Objective malnutrition status on the clinical outcomes in patients with peripheral artery disease following endovascular therapy. *Circ J*. 2018;82:847-856.
20. Basta G, Chatzianagnostou K, Paradossi U, et al. The prognostic impact of objective nutritional indices in elderly patients with ST-elevation myocardial infarction undergoing primary coronary intervention. *Int J Cardiol*. 2016;221:987-992.
21. Guigoz Y, Vellas B, Garry PJ. Assessing the nutritional status of the elderly: the mini nutritional assessment as part of the geriatric evaluation. *Nutr Rev*. 1996;54:59-65.
22. Detsky AS, McLaughlin JR, Baker JP, et al. What is subjective global assessment of nutritional status? *J Parenter Enteral Nutr*. 1987;11:8-13.
23. Bouillanne O, Morineau G, Dupont C, et al. Geriatric Nutritional Risk Index: a new index for evaluating at-risk elderly medical patients. *Am J Clin Nutr*. 2005;82:777-783.
24. Gupta D, Lis CG. Pretreatment serum albumin as a predictor of cancer survival: a systematic review of the epidemiological literature. *Nutr J*. 2010;9:69.
25. Yang L, Xia L, Wang Y, et al. Low prognostic nutritional index (PNI) predicts unfavorable distant metastasis-free survival in nasopharyngeal carcinoma: a propensity score-matched analysis. *PLoS One*. 2016;11:e0158853.
26. Elia M. *Screening for Malnutrition: A Multidisciplinary Responsibility. Development and Use of the 'Malnutrition Universal Screening Tool' ('MUST') for Adults*. BAPEN; 2003.
27. Almasaudi AS, McSorley ST, Dolan RD, Edwards CA, McMillan DC. The relation between Malnutrition Universal Screening Tool (MUST), computed tomography-derived body composition, systemic inflammation, and clinical outcomes in patients undergoing surgery for colorectal cancer. *Am J Clin Nutr*. 2019;110:1327-1334.
28. Shen H, Dai Z, Wang M. Preprocedural neutrophil to albumin ratio predicts in-stent restenosis following carotid angioplasty and stenting. *J Stroke Cerebrovasc Dis*. 2019;28:2442-2447.
29. Stone PA, Thompson SN, Khan M, et al. The impact of biochemical markers on major adverse cardiovascular events and contralateral carotid artery stenosis progression following carotid interventions. *Ann Vasc Surg*. 2017;38:144-150.

How to cite this article: Demir M, Özbek M. Impact of nutritional assessment on long-term outcomes in patients with carotid artery stenting. *Int J Clin Pract*. 2021;00:e14637. https://doi.org/10.1111/ijcp.14637