

Correlation between inferior vena cava collability index and malnutrition in critical patients: A prospective observational study

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Abstract

Background

We aimed to investigate the correlation between the inferior vena cava collability index (IVC-CI) used in the evaluation of fluid volume and the Nutrition Risk Index (NRI), Prognostic Nutrition Index (PNI), Geriatric Nutrition Risk Index (GNRI) and Controlling Nutritional Status Scoring (CONUT) used in the evaluation of malnutrition.

Methods

This study is a prospective observational study. Demographic data, laboratory data, Body Mass Indexes (BMI), NRI, PNI, GNRI and CONUT in the first 24 hours of admission to the intensive care unit of 96 critically ill patients admitted to the tertiary intensive care unit with assisted invasive mechanical ventilator support and IVC-CI values were recorded. Patients with an IVC-CI $>45\%$ were evaluated as hypovolemia. Of the patients, 61 (63.5%) patients with an IVC-CI value of $45\% \geq$ were group 1, and 35 (36.5%) patients with an IVC-CI value of $>45\%$ were determined as group 2. Correlation between the IVC-CI and malnutrition scores was investigated between the groups.

Results

As a result of the statistical analysis; there was a statistically significant difference between the two groups in terms of BMI, NRI, PNI, GNRI and CONUT ($p < 0.001$). According to the correlation analysis results, NRI ($r_s = -0.716$, $p < 0.001$), PNI ($r_s = -0.743$, $p < 0.001$), GNRI ($r_s = -0.723$, $p < 0.001$), CONUT ($r_s = 0.741$, $p < 0.001$) were significantly correlated with the IVC-CI.

Conclusions

This study shows that there is a correlation between the IVC-CI used in the evaluation of fluid volume and malnutrition.

Key words: Inferior Vena Cava Collability Index, Nutrition Risk Index, Prognostic Nutrition Index, Geriatric Nutrition Risk Index, Controlling Nutritional Status Scoring

Introduction

The respiratory cycle (inspiration/expiration) creates a pressure difference in the intrathoracic space and this pressure difference affects the venous return of blood to the heart. As a result, narrowing and enlargement of the inferior vena cava (IVC) occur¹. Inferior vena cava collability index (IVC-CI) is a dynamic parameter that is calculated by the measurements of the maximum and minimum diameters of the inferior vena cava in spontaneous respiration and is used in the evaluation of the fluid volume of critically ill patients treated in intensive care units^{2,3}. This index is evaluated by echocardiographic subcostal approach. It correlates with other parameters used in the evaluation of fluid volume in patients treated in the intensive care unit^{4,5}.

Malnutrition occurs due to decreased oral nutrition or critical illness⁶. Hypovolemia may accompany malnutrition as a result of decreased oral nutrition in critically ill patients. In addition, serum albumin value is a parameter used in the evaluation of malnutrition⁷. In patients with malnutrition, changes occur in body fluid composition due to low albumin levels and as a result, hypovolemia may be seen accompanying malnutrition⁸.

Malnutrition is seen in critically ill patients treated in the intensive care unit, with a prevalence ranging from 30% to 50%⁹. In these patients, malnutrition may occur during admission to the intensive care unit or may develop during the intensive care treatment process. In the evaluation of malnutrition, Nutrition Risk Index (NRI), Prognostic Nutrition Index (PNI), Geriatric Nutrition Risk Index (GNRI) and Controlling Nutritional Status Scoring (CONUT), which can be calculated with some laboratory data (albumin, lymphocyte, etc.) and body mass index (BMI) values is used¹⁰.

As a result of our literature review, we have seen that the correlation of the IVC-CI, which is used in the evaluation of fluid volume, with the scorings used in the evaluation of malnutrition has not been investigated. Therefore, we aimed to investigate the relationship between NRI, PNI, GNRI and CONUT scores used in malnutrition assessment and IVC-CI.

Materials and Methods

Patients

This study was designed as a prospective observational

study. The study was carried out in accordance with the 1975 Helsinki declaration. The patients included in the study or their relatives were informed about the study and their written consents were obtained. The study was carried out in the tertiary adult intensive care unit with 45 intensive care beds in our hospital.

Inclusion criteria were determined as patients admitted to the adult intensive care unit, undergoing spontaneous ventilation under invasive mechanical ventilation (PEEP: 5 cmH₂O/ P-Inspiration: 0 cmH₂O) and informed consent.

Exclusion criteria from the study were heart valve disease, right heart failure, pregnancy status, inability to visualize the inferior vena cava, not in sinus rhythm, without spontaneous breathing and postsurgical patients.

Inferior Vena Cava Collapsibility Index Measurement

The patients were evaluated in the supine neutral position. Positive end expiratory pressure (PEEP) value was set as 5 cmH₂O in mechanical ventilator. With the ECHO probe of the Siemens Acuson P500 device (Siemens, California, USA) Ultrasonography device, IVC, aorta and vertebra were visualized outplane with B-Mode ECHO before the subxiphoid window. IVC was viewed in-plane position by turning the ECHO probe counterclockwise without changing its position. The exit of the IVC from the heart and the hepatic vein were visualized, and the ECHO cursor was placed on the part after approximately 1 cm past the hepatic vein and evaluated with M-Mod ECHO. The diameter of the IVC was monitored for several breath periods and the screen was frozen to measure the diameter of the narrowest and widest IVC diameters (Figure-1). Screen printouts were taken from each patient separately. IVC-CI for each patient was calculated using the formula $IVC-CI = (V_{max} - V_{min}) / V_{max}^{11,12}$. $>45\%$ IVC-CI was interpreted as consistent with hypovolemia^{4,13}. Measurements were made by echocardiography-trained intensive care specialists.

Calculation of malnutrition scores

Calculation of the **Nutritional Risk Index** = $[1.519 \times \text{serum albumin (g/dL)} + (41.7 \times \text{body weight (kg)} / \text{ideal body weight (kg)}]$

{NRI < 83.5; major risk, 83.5–97.5; moderate risk 97.5–100; mild risk, NRI > 100; no risk }¹⁴

Calculation of the **Prognostic Nutrition Index** = $[\text{Serum albumin (g/dL)} \times 10 + \text{total lymphocyte count (mm}^3) \times 0.005]$

{PNI > 38: normal, PNI of 35–38: Moderate, PNI < 35: Severe risk of malnutrition }¹⁵

Calculation of the **Geriatric Nutrition Risk Index** = $[\text{Serum albumin (g/dL)} \times 14.89 + 41.7 \times (\text{body weight (kg)} / \text{ideal body weight (kg)}]$

{GNRI < 82: Major risk, GNRI: 82 to < 92: Moderate risk, GNRI: 92 to ≤ 98: Low risk, GNRI: > 98: No risk }¹⁶

The ideal body weight of the patients was calculated using the Lorentz formula¹⁶

Body Mass Index = $\text{weight (kg)} / \text{height}^2 (\text{m}^2)$ ¹⁷

Calculation of the **Controlling Nutritional Status** = Calculated according to Table 1

{ 0–1: Normal nutritional status, 2–4: Light degree of undernutrition, 5–8: Moderate degree of undernutrition, 9–12: Severe degree of undernutrition }¹⁸

G-Power test

The sample size targeted in the study was 0.4 medium-high effect size in the correlation analysis test (Cohen's effect size 0.10 low, 0.3 medium and 0.5 high for correlation analysis) with the G*Power 3.1 program used in power analysis, With a power of 95% and an alpha value of 0.05, the sample size was calculated as a minimum of 75.

Patient Data Collection

According to the inclusion and exclusion criteria of the study, 96 critically ill patients who were admitted to the tertiary intensive care unit and on assisted invasive mechanical ventilator support were included in the study. Demographic data, laboratory data, BMI, NRI, PNI, GNRI, CONUT scores and IVC-CI values of the patients were recorded in the first 24 hours.

61 (63.5%) patients with IVC-CI values ≤ 45% were Group I, and 35 (36.5%) patients with IVC-CI values > 45% were Group II.

Ethics Approval

Approval for the study was obtained from the clinical research ethics committee of Kastamonu University. (Decision no: 2022-KAEK-47)

Statistical Analysis

The significance in differences between the means of two normally distributed continuous variables was determined by independent t-test. Non-normal distributed continuous variables were tested by Mann-Whitney U test. Pearson's chi-square test was applied to determine the group comparison of categorical variables. Spearman's rank order correlation analysis was performed to determine the relationship of NRI, PNI, GNRI, CONUT and IVC-CI (%). Binary logistic regression with enter method was used to determine the impacts of NRI, PNI, GNRI and CONUT. $p < 0.05$ was indicated statistical significance. All statistical analyses were performed using the SPSS 26.00 (SPSS Inc, Chicago, USA).

Results

A total of 96 patients were included in the study. 52 (54.2%) of the patients included in the study were female and the other participants were male. The patients were grouped as the level of IVC-CI(%). The value of IVC-CI (%) equal and lower 45 represents Group I, higher 45 represents Group II. The mean age of patients in group I was 68.13 ± 11.87 years and the mean age of patients in Group II was 73.94 ± 15.77 years.

There was a statistically significant difference between the two groups in terms of age ($p = 0.008$), BMI ($p < 0.001$), lymphocyte count ($p = 0.017$), neutrophil lymphocyte ratio (N/L) ($p = 0.019$), creatinine ($p = 0.016$), albumin ($p < 0.001$), CRP albumin ratio (C/A) ($p = 0.015$), total cholesterol ($p < 0.001$), triglyceride ($p < 0.001$), urea ($p = 0.012$), total bilirubin ($p = 0.012$), prealbumin ($p < 0.001$), LDH albumin ratio (LDH/A) ($p = 0.004$), potassium ($p = 0.020$), procalcitonin ($p < 0.001$), lactate ($p = 0.006$) as laboratory data. A statistical difference was found between the groups in terms of NRI, PNI, GNRI and CONUT ($p < 0.001$). In Table 2, median of NRI, PNI and GNRI was statistically higher in Group I.

In Table 3, while 26 (74.3%) the patients in Group II had severe malnutrition according to the PNI at admission to the intensive care unit, 9 (14.8%) patients in Group I severe

Table 1: CONUT scores

Parameters	degree of malnutrition			
	Normal	Mild	Moderate	Severe
serum albumin (g/dL)	≥3.5	3.0–3.49	2.5–2.99	<2.5
Point	0	2	4	6
Total lymphocytes (10 ³ /ul)	≥1600	1200–1599	800–1199	<800
Point	0	1	2	3
total cholesterol (mg/dL)	≥180	140–179	100–139	<100
Point	0	1	2	3
Total CONUT scores	0-1	2-4	5-8	9-12

Table 2: Socio-demographics and biochemical characteristics of patients regarding to the level of IVC-CI (%) (n=96)

Variables		Total n=96	Group I n= 61 (63.5%)	Group II n= 35 (36.5%)	test	p
Age(years)		73.0 (62.0-80.0)	69.0 (59.5-76.0)	78.0 (68.0-84.0)	U=717.0	0.008
Gender	Female	52 (54.2%)	36 (59.0%)	16 (45.7%)	X ² =1.585	0.208
	Male	44 (45.8%)	25 (41.0%)	19 (54.3%)		
BMI		19.15 (18.0-23.87)	23.1 (19.8-24.6)	17.6 (17.1-18.6)	U=141.5	<0.001
WBC(10 ³ /ul)		11.25 (8.82-12.37)	10.6 (8.5-12.65)	11.3 (9.3-13.6)	U=925.5	0.279
Neutrophil(10 ³ /ul)		7.2 (5.2-9.47)	6.6 (5.1-8.9)	7.8 (5.4-10.9)	U=840.0	0.083
Lymphocyte(10 ³ /ul)		0.98 (0.81-1.10)	1.0 (0.9-1.1)	0.9 (0.75-1.05)	U=754.0	0.017
Platelets(10 ³ /ul)		255.0 (154.25-305.0)	255.0 (176.0-331.0)	255.0 (154.0-287.0)	U=963.0	0.426
N/L		6.71 (5.32-9.87)	6.28 (4.85-9.15)	7.8 (5.84-14.0)	U=760.0	0.019
P/L		255.46 (172.91-316.84)	235.45 (175.29-326.83)	258.16 (163.33-305.0)	U=1036.0	0.810
Creatinine(mg/dl)		0.59 (0.35-0.92)	0.68 (0.49-0.91)	0.44 (0.24-1.0)	U=752.5	0.016
ALT(U/L)		12.0 (7.0-17.0)	12.0 (8.0-17.0)	9.0 (0.4-18.0)	U=853.0	0.102
AST(U/L)		11.0 (8.0-17.75)	12.0 (8.5-18.5)	10.0 (7.0-15.0)	U=956.5	0.397
CRP(mg/l)		26.4 (13.65-51.72)	23.9 (13.2-40.0)	31.2 (65.3-15.6)	U=889.0	0.174
Albumin(g/dL)		2.9 (2.6-3.51)	3.4 (2.87-3.68)	2.55 (2.4-2.75)	U=202.5	<0.001
C/A		8.38 (4.25-16.04)	7.87 (4.09-13.68)	11.01 (6.0-28.03)	U=749.0	0.015
Total Cholesterol (mg/dL)		155.3 (134.0-178.6)	169.0 (154.5-187.15)	130.0 (105.5-142.5)	U=235.5	<0.001
Triglyceride(mg/dL)		114.5 (100.72-140.02)	129.6 (108.0-145.85)	100.5 (90.6-108.0)	U=381.5	<0.001
Urea(mg/dl)		34.55 (21.35-51.05)	30.2 (20.5-46.6)	45.3 (30.6-55.6)	U=737.5	0.012
Total Bilirubin(mg/dl)		0.58 (0.4-0.8)	0.7 (0.4-0.9)	0.48 (0.3-0.7)	U=738.5	0.012
Prealbumin(mg/dl)		19.5 (17.2-23.05)	22.0 (18.95-23.9)	17.2 (16.5-18.3)	U=254.5	<0.001
LDH(U/L)		284.0 (217.75-339-75)	296.0 (238.5-339.0)	264.0 (209.0-354.0)	U=1017.0	0.701
LDH/A		95.57 (77.84-111.33)	90.4 (75.54-103.0)	105.83 (85.83-136.53)	U=691.0	0.004
Sodium(mEq/L)		142.0 (138.0-146.75)	142.0 (138.0-144.0)	144.0 (138.0-151.0)	U=816.5	0.055
Potassium(mEq/L)		4.25 (3.9-4.77)	4.2 (3.85-4.4)	4.7 (4.0-5.1)	U=761.5	0.020
Procalcitonin		0.07 (0.05-1.2)	0.05 (0.05-0.82)	0.87 (0.05-2.4)	U=675.5	<0.001
Lactate(mmol/L)		2.05 (1.2-3.2)	1.5 (0.98-2.85)	2.9 (1.5-3.3)	U=703.5	0.006
NRI		91.1 (83.6-101.45)	99.0 (93.45-102.6)	82.2 (81.0-85.5)	U=217.0	<0.001
PNI		36.8 (34.2-39.2)	39.0 (37.1-40.2)	34.2 (33.3-35.2)	U=161.0	<0.001
GNRI		90.15 (81.57-98.9)	97.8 (90.25-99.9)	81.3 (80.1-83.5)	U=179.0	<0.001
CONUT		5.0 (1.0-8.0)	2.0 (1.0-4.5)	8.0 (7.0-10.0)	U=220.5	<0.001

Median of variables

BMI:body mass index, WBC: White Blood Cell, N/L: Neutrophil Lymphocyte Ratio , P/L: Platelet Lymphocyte Ratio, CRP: c-reactive protein, C/A: c-reactive protein albumin ratio, LDH: Laktat dehydrogenaz, LDH/A: Laktat dehydrogenaz albumin ratio, PNI:

Prognostic Nutritional Index, GNRI: Geriatric Nutrition Risk Index, NRI: nutrition risk index, CONUT: controlling nutritional status scores,

Table 3: Nutrition index of patients regarding to the level of IVC-CI (%) (n=96)

Variables	Group I, n= 61 (63.5%) n (%)	Group II, n= 35 (36.5%) n (%)	X ² test	p
NRI				
1 Absent	27 (44.3)	0 (0.0)	45.432	<0.001
2 Mild	17 (27.9)	1 (2.9)		
3 Moderate	12 (19.7)	16 (45.7)		
4 Severe	5 (8.2)	18 (51.4)		
PNI				
1 Absent	38 (62.3)	0 (0.0)	43.493	<0.001
2 Moderate	14 (23.0)	9 (25.7)		
3 Severe	9 (14.8)	26 (74.3)		
GNRI				
1 Absent	28 (45.9)	0 (0.0)	54.454	<0.001
2 Mild	17 (27.9)	0 (0.0)		
3 Moderate	12 (19.7)	13 (37.1)		
4 Severe	4 (6.6)	22 (62.9)		
CONUT				
1 Absent	26 (42.6)	0 (0.0)	51.035	<0.001
2 Mild	20 (32.8)	0 (0.0)		
3 Moderate	10 (16.4)	20 (57.1)		
4 Severe	5 (8.2)	15 (42.9)		

NRI: nutrition risk index, PNI: prognostik nutrition index, GNRI: geriatrik nutrition risk index, CONUT: controlling nutritional status scores

Table 4: Correlations among variables

	NRI	PNI	GNRI	CONUT
NRI				
PNI	0.937**			
GNRI	0.940**	0.930**		
CONUT	-0.901**	-0.894**	-0.903**	
IVC-CI (%)	-0.716**	-0.743**	-0.723**	0.741**

***p* < 0.01. NRI: nutrition risk index, PNI: prognostik nutrition index, GNRI: geriatrik nutrition risk index, CONUT: controlling nutritional status scores

Table 5: Logistic regression for prognostic factors

Variables	β	SE	p	OR	95% CI for OR	
					Lower	Upper
Constant	32.456	14.781	0.028	1.246E+14		
NRI	0.243	0.167	0.145	1.276	0.919	1.770
PNI	-0.417	0.369	0.259	0.659	0.320	1.360
GNRI	-0.458	0.217	0.035	0.632	0.413	0.968
CONUT	0.014	0.260	0.958	1.014	0.609	1.688

NRI: nutrition risk index, PNI: prognostik nutrition index, GNRI: geriatrik nutrition risk index, CONUT: controlling nutritional status scores

malnutrition. Statistically significant association were found in NRI, PNI, GNRI, CONUT in terms of IVC-CI (%) level. The percentage of patients was decreasing by the severity of NRI, PNI, GNRI and CONUT in Group I. On the other hand, patients in Group II were more likely to have high severity of NRI, PNI, GNRI and CONUT.

A Spearman's rank-order correlation was run to detect the relationship between the values of NRI, PNI, GNRI, CONUT and IVC-CI (%) in Table 4. In correlation matrix, there was a strong and negative correlation between IVC-CI (%), and NRI (rs=-0.716, p<0.001), PNI (rs=-0.743, p<0.001), GNRI (rs=-0.723, p<0.001) which was statistically significant. However, IVC-CI(%) and CONUT had strong and positive correlation (rs=0.741, p<0.001), which was

statistically significant.

In Table 5, binary logistic regression analysis with enter method was performed to determine the risk factors of IVC-CI (%) in patients. GNRI (OR 0.632, CI 0.413-0.968, p=0.035) was a independent predictor for IVC-CI (%).

Discussion

In our prospective observational study, there was a statistically significant difference in admission to ICU between hypovolemic (IVC-CI; >45%) and non-hypovolemic (IVC-CI; ≤45%) critical intensive care patients according to all four nutritional scores(NRI,PNI,GNRI and CONUT). More severe malnutrition was detected in the hypovolemic patient group. In addition; there was a statistically significant difference between hypovolemic and non-hypovolemic

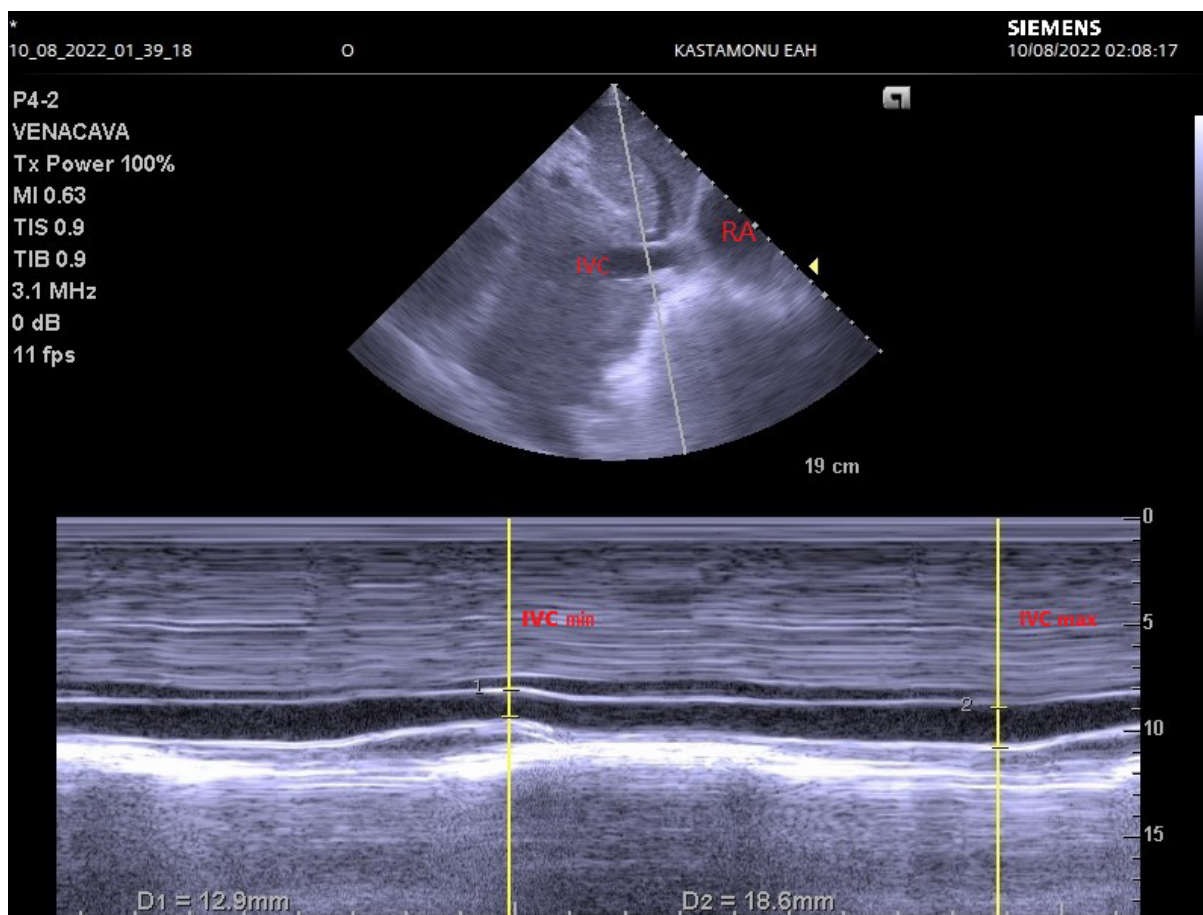


Figure 1: Inferior Vena Cava Collapsibility Index Measurement

groups according to IVC-CI(%) in the laboratuvar values[BMI, Lymphocyte count (103/ul), neutrophil-lymphocyte ratio, Creatinine (mg/dl), albumin (g/dL), CRP albumin ratio, Total Cholesterol (mg/dL),Triglyceride(mg/dL), Urea(mg/dl), Total Bilirubin(mg/dl), Prealbumin(mg/dl), LDH albumin ratio, Potassium(mEq/L), Procalcitonin, Lactate(mmol/L)]. According to the correlation analysis, we found a statistically significant correlation between IVC-CI (%) and NRI, PNI, GNRI and CONUT scores.

In recent years, there has been an increase in the use of ultrasonography (USG) in intensive care practice. With USG, cardiac preload can be evaluated and whether venous return to the heart is adequate or not can be determined. The inferior vena cava, as the closest vein to the heart, is a vascular structure that can be easily visualized by USG and is used to evaluate cardiac preload^{19,20}. As a dynamic variable in predicting fluid response, IVC-CI, which is calculated as a result of changes in the respiratory cycle and diameter of the inferior vena cava, was recommended to be used in the consensus of circulatory shock and hemodynamic monitoring published in 2014 by the European Society of Intensive Care Medicine².

In the systematic review and metaanalysis published by Huang et al.²¹, they stated that IVC-CI showed moderate performance in predicting fluid response in patients on mechanical ventilator. Si et al.²² also stated in their meta-analysis that IVC-CI performed moderately in terms of sensitivity and specificity in predicting fluid response. Unlike the literature, our study is a study that investigates IVC-CI together with malnutrition scores and evaluates IVC-CI in terms of malnutrition. Malnutrition is a very common clinical problem in critically ill patients treated in intensive care. The cause of malnutrition in critically ill patients can

be listed as patient-dependent and independent factors, including hypercatabolism and related loss of muscle mass, malnutrition, age, chewing/swallowing problems²³. In their study, Giner et al.²⁴ found malnutrition in 42% of the patients in the intensive care unit. Yi-Chia Huang et al.²⁵ detected malnutrition in all intensive care patients receiving mechanical ventilator support. NRI, PNI, GNRI and CONUT are the scorings used in the evaluation of malnutrition, which are derivatives of each other and calculated by using similar parameters^{14-16,18}. In our study, there was significant malnutrition in the group with IVC-CI > 45% (Group II) according to 4 nutrition scores, which was consistent with the literature.

We think that the reason why we detected malnutrition according to 4 nutrition scores is that similar parameters are used in the calculation of these scores and that they are derivatives of each other. The more significant malnutrition observed in Group II suggests that the factors causing hypovolemia cause more severe malnutrition. In addition, it is a known fact that the prevalence of malnutrition increases with the physiological changes brought about by aging²⁶. According to a study, it was stated that the elderly patient group applied with malnutrition between 20% and 50% before admission to the hospital²⁷. In our study, the mean age of the patients in Group II (78 years) was higher than the patients in Group I (69 years) and the parameters used in the calculation of nutrition scores (albumin, lymphocyte, etc.) may have created a statistical difference between the groups. At the same time, we think that the effect of hypovolemia among the groups compared to IVC-CI is the reason for the more significant malnutrition observed in the patients in Group II.

Serum albumin is involved in the regulation of colloid

oncotic pressure, the transport and binding of substances such as drugs and hormones. Low serum albumin levels are common in critically ill patients²⁸. Due to low serum albumin in critically ill patients, transcapillary leakage of intravascular fluid increases and this causes hypovolemia clinically by causing a decrease in intravascular volume²⁹. In our study, the serum albumin level was 3.4 g/dl on average in Group I patients, and 2.55 g/dl in Group II patients, and our Group II patients had more pronounced hypovolemia compared to IVC-CI. In our study, albumin value is used as the basis of NRI, PNI, GNRI and CONUT scoring, which we consider as malnutrition scoring. We think that the lower albumin level in our group II patients is the reason for the more severe malnutrition in this group. In line with this information, we think that one of the underlying causes of the correlation between IVC-CI and malnutrition may be related to the serum albumin level.

Conclusion

As a result of our study, we found that there is a significant correlation between IVC-CI, which is a radiological imaging method and used as a dynamic parameter in the evaluation of fluid volume, and NRI, PNI, GNRI, and CONUT scores used in the evaluation of malnutrition. This is the first study to investigate the correlation of a dynamic imaging method used in the evaluation of fluid volume with malnutrition, and we think that this study may serve as an example for other studies on this subject.

Limitation

It is a single-center study and the IVC-CI measurement was made by different intensive care specialists with echocardiography training.

Conflict of Interest

The authors have no conflicts of interest to declare.

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Author Contributions

Study design: VGS, AY

Acquisition of data: VGS, AY, ÖT, UD

Analysis and interpretation of data: VGS, FÇİ

Drafting of manuscript: VGS, AY, ZD

Critical revision: VGS

Statistical analysis: VGS, FÇİ

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