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# Body mass index adjusted calf circumference as phenotypic criterion to diagnose malnutrition in cardiac patients admitted in intensive care unit

# Perímetro de la pantorrilla ajustado por el índice de masa corporal, como criterio fenotípico, para el diagnóstico de malnutrición en pacientes cardíacos ingresados en la unidad de cuidados intensivos.

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## ABSTRACT

**Introduction:** Early screening malnutrition risk at hospital admission is crucial. However, the aim of the present study is to assess Body Mass Index (BMI) adjusted calf circumference (CC) as GLIM (Global Leadership Initiative on Malnutrition) phenotypic criterion to diagnose malnutrition in cardiac patients admitted to an intensive care unit due to lack of reports on it.

**Materials and Methods:** Cross-sectional, descriptive study approaching cardiac patients admitted to an intensive care unit (ICU). Age, BMI (kg/m$^2$) and CC (cm) were measured. CC was adjusted based on BMI categories. Nutritional Risk Screening (NRS 2002) and GLIM methods were used to assess malnutrition risk and diagnose, respectively. Statistical analysis included descriptive techniques.

**Results:** Thirty-six patients were assessed, 22 of them belonged to the male sex and 14, to the female sex. Most patients were elderly (n=22, 61.11%), recorded normal BMI weight (n=15, 41.66%), CC below the recommended cut-off point (n=19, 52.77%). BMI-adjusted CC was below the recommended cut-off point - males (n=12, 54.54%) and females (n=9, 64.28%). NRS 2002 ≥ 3 points (n=36, 4.05 ± 1.12). Patients scoring ≥ 3 were assessed based on GLIM criteria. GLIM: n=9 (25%) showed malnutrition, when BMI was used as a phenotypic criterion. Malnutrition was observed in most cases (n=19, 52.77%) when CC was the criterion. BMI-adjusted CC criterion resulted in malnutrition in 21 (58.33%) assessed patients (male, n=12, 54.54%; female, n=9, 64.28%). APACHE II score was ≥ 10 (n=36) and the mortality risk reached 55.50 ± 21.00% in the assessed patients.

**Conclusions:** All patients showed nutritional risk (NRS 2002). Malnutrition prevalence varied when BMI, calf circumference (CC) and BMI-adjusted CC were used as phenotypic criterion through GLIM diagnosing; it was higher in case of BMI-adjusted CC. Similarly, BMI-adjusted CC allowed diagnosing malnutrition through the GLIM method applied in overweight patients.

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**Keywords:** Calf circumference; Body mass index; Intensive care unit; Malnutrition.

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## RESUMEN

**Introducción:** La detección precoz del riesgo de desnutrición en el momento del ingreso hospitalario es fundamental. Debido a la escasez de estudios, el presente trabajo tuvo como objetivo evaluar la circunferencia de la pantorrilla (CP) ajustada por el índice de masa corporal (IMC) como criterio fenotípico para el diagnóstico de malnutrición en pacientes con enfermedades cardiovasculares ingresados en una unidad de cuidados intensivos (UCI).

**Metodología:** estudio transversal en pacientes cardíacos admitidos en una UCI. Se recopilaron datos sobre edad, IMC (kg/m²) y CP (cm). La CP fue ajustada según las categorías de IMC. Para la evaluación del riesgo nutricional y el diagnóstico de desnutrición, se aplicaron los criterios del Nutritional Risk Screening 2002 (NRS-2002) y del Global Leadership Initiative on Malnutrition (GLIM).

**Resultados:** Se evaluaron 22 hombres y 14 mujeres, con una mayoría de adultos mayores (n = 22; 61,1%). La mayor parte presentó IMC dentro de los valores normales (n = 15; 41,7%) y CP por debajo del valor recomendado (n = 19; 52,8%). Al considerar la CP ajustada por IMC, los valores se encontraron por debajo de lo recomendado en 12 hombres (54,5%) y 9 mujeres (64,3%). Todos los pacientes presentaron puntuación ≥ 3 en el NRS-2002. GLIM: IMC como criterio fenotípico, se diagnosticó malnutrición en 9 pacientes (25%). Este porcentaje aumentó al 52,8% (n = 19) cuando se utilizó la CP, y alcanzó el 58,3% (n = 21) al aplicar la CP ajustada por IMC.

**Conclusiones: T**odos los pacientes presentaron riesgo nutricional. La prevalencia de malnutrición varió dependiendo del criterio fenotípico utilizado en el marco del diagnóstico GLIM, siendo más elevada cuando se empleó la CP ajustada por IMC. Estos hallazgos sugieren que este parámetro puede ser especialmente útil para detectar malnutrición en pacientes con sobrepeso, lo que refuerza su aplicabilidad clínica en unidades de cuidados intensivos.

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**Palabras clave:** Circunferencia de la pantorrilla; Índice de masa corporal; Unidad de cuidados intensivos; Malnutrición.

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## KEY MESSAGES

- Older age can be a risk factor for worst prognosis in ICU patients, regardless of nutritional status.
- Malnutrition prevalence reached 25%, 52.77% and 58.33% when BMI, calf circumference (CC) and BMI-adjusted CC were used as phenotypic criteria through GLIM diagnosing, respectively.
- BMI-adjusted CC was the most promising method for overweight cardiac patients diagnostic in ICU.

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## INTRODUCTION

Malnutrition is a risk factor presenting poor clinical outcomes, mainly in patients with cardiovascular disease admitted to the herein assessed hospital.[1] Catabolism is significantly enhanced and anabolism is weakened in critically ill cardiac patients in intensive care unit (ICU), mainly due to inflammatory responses that result in muscle loss and increased nutritional risk.[2,3] Hence, early malnutrition risk screening at hospital admission is crucial.[4]

Although no specific nutritional score has been validated for ICU use, nutritional risk screening (NRS 2002) accounts for the best predictive values when it comes to mortality; therefore its daily application is recommended.[5] NRS 2002 includes three parts: nutritional status, disease severity and age; and the score ranges from 0 to 7 - ≥ 3 points highlight malnutrition risk.[4] Studies carried out with cardiac patients pointed out higher nutritional risk associated with more severe symptoms, according to the NRS 2002, regardless of 1-year re-hospitalization or long-term mortality risk factors.[1,6,7]

NRS 2002 is the first Global Leadership Initiative on Malnutrition (GLIM) step to identify patients who need nutritional support. The second GLIM step can be adopted when NRS 2002 shows nutritional risk (≥ 3 points).[8,9] Secondary assessment and malnutrition diagnoses are recommended; there should be at least 1 etiological (inflammation and disease burden) and phenotypic (low body mass index (BMI) and muscle mass loss) index recorded.[10,11] According to Vico[12], Kootaka and Cols.[13] and Yamaguchi and Cols.[14] prognosis, low physical function and increased all-cause mortality were associated with GLIM criteria in patients with cardiovascular disease.

Muscle mass loss is a phenotypic criterion to GLIM diagnosing. Calf circumference (CC), in its turn, is an alternative low-cost measurement[10] applicable to estimate muscle mass. Evidence has highlighted CC prognostic value as predictor of adverse outcomes such as prolonged hospital stay and mortality risk.[15,16] However, BMI-adjusted CC was recommended to replace raw CC due to subcutaneous adipose tissue depots.[17] Excess adiposity can be associated with false normal CC values and mask muscle mass loss, despite its detrimental effect on CC prognostic value.[16]

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Miyahara and Cols.[18] assessed older adults in a Geriatrics and Gerontology Hospital, and suggested BMI-adjusted CC as good alternative to assess GLIM-based malnutrition. However, the aim of the present study was to determine malnutrition prevalence in cardiac patients admitted to an intensive care unit based on BMI-adjusted CC as phenotypic criterion through GLIM diagnosing due to lack of reports on it.

## METHODOLOGY

Cross-sectional study carried with a convenience sample comprising cardiac patients admitted to an intensive care unit (ICU) located in the Recôncavo Baiano region. Data collection was carried out between August and December 2019. The study was approved by the Ethics Committee of the Federal University (CAAE: 7118618.2.0000.0056).

All participants signed the informed consent form. Exclusion criteria were age (< 20 years), pregnancy, amputations, advanced terminal illness, patients readmitted to the ICU, patients admitted to the ICU with diagnonis unrelated to heart disease. The following data were collected from the patients within their first 72 ICU-admission hours: age; estimated height [according to the following equations: men = (2.02 x knee height [KH,cm]) – (0.04 x age [years]) + 64.19) and women = (1.83 x KH [cm]) – (0.24 x age [years] + 84.88)]; estimated body mass [according to the following equations: men = (KH [cm] x 1.09) + (arm circumference [AC, cm] x 3.14) – 83.72) and women = (KH [cm] x 1.24) + (AC [cm] x 2.81) – 82.48)].[19] Knee height (KH, cm) was measured with the aid of a non-stretchable measuring tape, based on the distance between the heel and the top of the thigh, with patient in supine position, and knee and ankle bent at 90° angle. Arm circumference (AC, cm) was measured with the aid of a non-stretchable measuring tape at the midpoint between the acromion and the olecranon.[20]

Body mass index (BMI, kg/m$^2$) was calculated based on the estimated height and body mass. The cut-off point used to classify BMI was proposed by the Wold Health Organization for adults and the by the Pan American Health Organization for elderly individuals (≥ 60 years).[21,22] Calf circumference (CC, cm) was measured with the aid

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of a non-stretchable measurement tape at the widest calf point, with patient in supine position. The cut-off point adopted to classify CC was higher than 34 cm in males and 33 cm in females.[23] Subsequently, CC was adjusted based on BMI categories before comparing CC to the suggested sex-specific cut-off point, namely: <18.5 kg/m$^2$ (original CC value), 18.5-24.9 kg/m$^2$ (original CC value), 25-29.9 kg/m$^2$ (-3 cm), 30-39.9 kg/m$^2$ (-7 cm) and ≥40 kg/m$^2$ (-12 cm).[3,23,24,25]

The Nutritional Risk Screening (NRS 2002) method was used to assess malnutrition risk. Total score ranged from 0 to 7 points. Nutritional status, disease severity and age were assessed - ≥ 3 suggested nutritional risk and ≥ 5 pointed towards very high risk.[26] Patients scoring ≥ 3 was assessed based on GLIM (Global Leadership Initiative on Malnutrition) criteria. Inflammation was the etiological criteria applied to all patients.[27] The following phenotypic criteria were used to diagnose malnutrition: BMI reduction or lean mass decrease (assessed through calf circumference).

Glasgow Coma Scale data (GSC. Score range 3 – deep coma to 15 – full consciousness),[28] approximate mortality risk (%), and Acute Physiology and Chronic Health Evolution (APACHE II score > 10 indicates a high risk of nutritional deficiency, in context of the NRS 2002)[26,29] were collected from the medical records.

Data were analyzed in Graph Pad Prism (Version 5.0, 2007, San Diego, CA, USA) and Microsoft Excel software based on column statistics and expressed as means ± standard deviation, minimum and maximum value, absolute frequencies and percentages. Shapiro Wilk test was used to assess numerical data normality. Student's t-Test or Mann Whitney test were adopted to compare numerical data depending on normality results. Paired t-test or Wilcoxon test were used to compare CC vs. BMI adjusted CC. Chi-square or Fisher's exact tests were used to assess the association between numerical variables. All testes followed the 5% significance level.

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## RESULTS

Thirty-six (n=36) cardiac patients admitted to the ICU were herein assessed: twenty-two (n=22) male and fourteen (n=14) female patients. Most patients were elderly (n=22) presenting normal BMI weight (n=15) and they were followed by underweight elderly (n=12). Mean CC recorded for most patients (n=19) showed CC below the recommended cut-off point. Mean CC was below the recommended cut-off point in most assessed male (n=12) and female (n=9) patients when CC was adjusted based on BMI categories. GCS score was associated with full consciousness. APACHE II score was ≥ 10 (n=36) and mean mortality risk reached 55.50 ± 21.00 % in the assessed patients. Furthermore, the comparison between CC and BMI-adjusted CC showed significant difference; BMI-adjusted CC was lower than CC (p-value < 0.0001, paired t-test) (Table 1).

Table 2 shows data of patients admitted to an intensive care unit based on CC or BMI-adjusted CC classification. There was no significant difference in the assessed parameters, except for BMI in CC – patients presenting the aforementioned classification recorded higher BMI (p = 0.030). This difference was not observed when this parameter was assessed in BMI-adjusted CC (p-value = 0.317).

Disease severity (APACHE ≥ 10), age (cut-off 70 years) and nutritional risk were assessed through the NRS 2002 questionnaire supported by nutritional status (BMI) data. Patients showed NRS 2002 ≥ 3 points (n=36), nutritional risk ranging from 3 to 4 points in most male (n=15) and female (n=8) patients. Very high risk (5 – 7 points) was observed in 13 of the assessed patients. According to the GLIM questionnaire, most patients (n=27) did not show malnutrition when BMI was used as a phenotypic criterion. However, the CC criterion was associated with malnutrition in most patients (n=19). CC adjusted based on BMI categories resulted in malnutrition in 21 patients: in 12 male and in 9 female participants (Table 3).

Nutrition Risk Screening (NRS), Global Leadership Initiative on Malnutrition (GLIM) score based on CC or on BMI-adjusted CC classification, are shown in Table 4. There was significant association between GLIM (vs. BMI-adjusted CC, criterion), and CC and BMI-adjusted CC, in other words, there were more malnutrition cases, based on both classifications, when CC was above the limit.

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**Table 1. Data of the patients admitted to an intensive care unit.**

| Parameters | Patients (n=36) | Male (n=22) | Female (n=14) | p-valor |
|---|---|---|---|---|
| Age (years): | 60.86 ± 11.16 (33 – 82) | 59.73 ± 11.71 (33 – 79) | 62.64 ± 10.39 (47 – 82) | 0.453 |
| Adult | 14 (38.88%) | 8 (36.36%) | 6 (42.85%) | 0.482 |
| Elderly | 22 (61.11%) | 14 (63.63%) | 8 (57.14%) | |
| BMI (kg/m$^2$): | 23.81 ± 5.58 (11.87 – 36.96) | 23.58 ± 5.46 (11.87 – 36.96) | 23.74 ± 5.97 (13.26 – 33.89) | 0.942 |
| Underweight | 12 (33.33%) | 7 (31.81%) | 5 (35,71%) | 0.636 |
| Normal weight | 15 (41.66%) | 9 (40.90%) | 6 (42.85%) | |
| Overweight | 6 (16.66%) | 5 (22.72%) | 1 (7.14%) | |
| Obesity | 3 (8.33%) | 1 (4.54%) | 2 (14.28%) | |
| CC (cm): | 34.22 ± 4.76 (27 – 45) | 34.81 ± 5.21 (27 – 45) | 33.30 ± 3.96 (27.9 – 40) | 0.364 |
| Below | 19 (52.77%) | 12 (54.54%) | 7 (50%) | 0.530 |
| Above | 17 (47.22%) | 10 (45.45%) | 7 (50%) | |
| BMI-Adjusted CC: | 32.56 ± 3.68 (25.66 – 40) | 33.17 ± 3.74 (27 – 40) | 31.59 ± 3.50 (25.6 – 36.9) | 0.191 |
| Below | 21 (58.33%) | 12 (54.54%) | 9 (64.28%) | 0.411 |
| Above | 15 (41.66%) | 10 (45.45%) | 5 (35.71%) | |
| GCS score | 14.83 ± 0.61 (12 – 15) | 14.71 ± 0.78 (12 – 15) | 15.00 ± 0.00 (15) | 0.110 |
| APACHE II | 23.75 ± 6.82 (13 – 40) | 22.86 ± 6.85 (13 – 40) | 25.14 ± 6.79 (17 – 39) | 0.336 |
| RM (%) | 55.50 ± 21.00 (18.51 – 91.33) | 54.00 ± 20.40 (18.51 – 91.33) | 57.85 ± 22.49 (23.24 – 88.73) | 0.602 |

Adult (< 60 years), Elderly (≥ 60 years); BMI, Body Mass Index; CC, Calf Circumference; GCS, Glasgow Coma Scale; APACHE, Acute Physiology and Chronic Health Evaluation; RM, Risk of mortality. Numerical variables: Student's t-test; categorical variables: Chi-square test or Fisher's exact test.

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**Table 2. Data of the patients admitted to an intensive care unit based on CC or BMI-adjusted CC classification.**

| Parameters | CC | | p-value | BMI-adjusted CC | | p-value |
|---|---|---|---|---|---|---|
| | Below (n=19) | Above (n=17) | | Below (n=21) | Above (n=15) | |
| Age (years): | 61.72 ± 2.25 (45-79) | 59.06 ± 3.04 (33-82) | 0.367 | 61.70 ± 2.06 (42-79) | 58.73 ± 3.41 (33-82) | 0.341 |
| Adult | 6 (31.58%) | 8 (47.06) | 0.272 | 7 (33.33%) | 7 (46.67%) | 0.321 |
| Elderly | 13 (68.42%) | 9 (52.94) | | 14 (66.77%) | 8 (53.33%) | |
| BMI (kg/m$^2$): | 22.06 ± 1.15 (12-32) | 26.06 ± 1.42 (18-37) | 0.030* | 23.20 ± 1.30 (12-34) | 25.07 ± 1.42 (18-37) | 0.317 |
| Underweight | 7 (36.84%) | 5 (29.41%) | 0.639 | 7 (33.33%) | 5 (33.33%) | 1.000 |
| Normal weight | 9 (47.37%) | 6 (35.29%) | | 9 (42.86%) | 6 (40.00%) | |
| Overweight | 2 (10.53%) | 4 (23.53%) | | 3 (14.29%) | 3 (20.00%) | |
| Obesity | 1 (5.26%) | 2 (11.77%) | | 2 (9.52%) | 1 (6.67%) | |
| GCS score | 14.83 ± 0.17 (12-15) | 14.82 ± 0.13 (13-15) | 0.963 | 14.75 ± 0.15 (12-15) | 14.80 ± 0.15 (13-15) | 0.817 |
| APACHE II | 26.06 ± 1.75 (15-40) | 21.65 ± 1.34 (13-35) | 0.080 | 25.55 ± 1.64 (15-40) | 21.73 ± 1.47 (13-35) | 0.136 |
| RM (%) | 59.78 ± 5.29 (23-91) | 50.47 ± 4.69 (19-89) | 0.175 | 58.85 ± 4.91 (23-91) | 50.47 ± 5.15 (19-89) | 0.226 |

Adult (< 60 years), Elderly (≥ 60 years); BMI, Body Mass Index; CC, Calf Circumference; GCS, Glasgow Coma Scale; APACHE, Acute Physiology and Chronic Health Evaluation; RM, Risk of mortality. Numerical variables: Student's t-test; categorical variables: Chi-square test or Fisher's exact test; *p<0.05.

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**Table 3. Nutrition Risk Screening (NRS), Global Leadership Initiative on Malnutrition (GLIM) score.**

| Parameters | Patients (n=36) | Male (n=22) | Female (n=14) | p-valor |
|---|---|---|---|---|
| NRS 2002: | 4.05 ± 1.12 (3 – 6) | 3.95 ± 1.04 (3 – 6) | 4.21 ± 1.25 (3 – 6) | 0.389 |
| 3 - 4 points | 23 (63.88%) | 15 (68,18%) | 8 (57.14%) | 0.374 |
| 5 -7 points | 13 (36.11%) | 7 (31.81%) | 6 (42.85%) | |
| GLIM (BMI criterion): | | | | |
| No malnutrition | 27 (75%) | 16 (72.72%) | 11 (78.57%) | 0.506 |
| Malnutrition | 9 (25%) | 6 (27.27%) | 3 (21.42%) | |
| GLIM (CC criterion): | | | | |
| No malnutrition | 17 (47.22%) | 10 (45.45%) | 7 (50%) | 0.530 |
| Malnutrition | 19 (52.77%) | 12 (54.54%) | 7 (50%) | |
| GLIM (vs. BMI-adjusted CC, criterion): | | | | |
| No malnutrition | 15 (41.66%) | 10 (45.45%) | 5 (35.71%) | 0.411 |
| Malnutrition | 21 (58.33%) | 12 (54.54%) | 9 (64.28%) | |

NRS, Nutritional Risk Screening; GLIM, The Global Leadership Initiative on Malnutrition; BMI, Body Mass Index; CC, Calf Circumference. Numerical variables: Student's t-test; categorical variables: Fisher's exact test.

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**Table 4. Nutrition Risk Screening (NRS), Global Leadership Initiative on Malnutrition (GLIM) score based on CC or on BMI-adjusted CC classification.**

| Parameters | CC | | p-value | BMI-adjusted CC | | p-value |
|---|---|---|---|---|---|---|
| | Below (n=19) | Above (n=17) | | Below (n=21) | Above (n=15) | |
| NRS 2002: | 4.17 ± 0.26 (3 – 6) | 3.94 ± 0.28 (3 – 6) | 0.473 | 4.05 ± 0.25 (3 – 6) | 4.07 ± 0.30 (3 – 6) | 0.940 |
| 3 - 4 points | 12 (63.16%) | 11 (64.70%) | 0.599 | 14 (66.7%) | 9 (60.00%) | |
| 5 -7 points | 7 (36.84%) | 6 (35.30%) | | 7 (33.3%) | 6 (40.00%) | 0.474 |
| GLIM (BMI criterion): | | | | | | |
| No malnutrition | 13 (68.42%) | 14 (82.35%) | | 15 (71.4%) | 12 (80.0%) | |
| Malnutrition | 6 (31.68%) | 3 (17.65%) | 0.283 | 6 (28.6%) | 3 (20.0%) | 0.427 |
| GLIM (vs. BMI-adjusted CC,criterion): | | | | | | |
| No malnutrition | 0 (0.00%) | 15 (88.24%) | <0.0001 *** | 2 (9.5%) | 15 (100.00%) | <0.0001 *** |
| Malnutrition | 19 (100.0%) | 2 (11.76%) | | 19 (90.5%) | 0 (0.00%) | |

NRS, Nutritional Risk Screening; GLIM, The Global Leadership Initiative on Malnutrition; BMI, Body Mass Index; CC, Calf Circumference. Numerical variables: Student's t-test; categorical variables: Fisher's exact test; ***p<0.0001.

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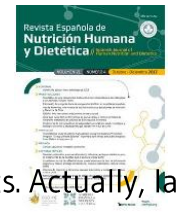

## DISCUSSION

The NRS 2002 and GLIM should not be limited to Scientific Research projects. Actually, lager numbers of trained health professionals are needed to implement protocols aimed at assessing malnutrition risk and diagnosing in patients admitted to ICUs. According to the study, all the assessed patients recorded score ≥ 3 points based on the NRS 2002 for nutritional risk. The BMI-adjusted CC allowed diagnosing malnutrition through the GLIM method in overweight patients. NRS 2002 and GLIM are low-cost questionnaires that help reducing in-hospital malnutrition and muscle loss, and worsening prognosis risk in ICU patients.

Most cardiac patients in the present study were over 60 years old. According to Herberger and Cols.[1] cardiac cachexia is closely associated with old age in chronic heart failure patients, and it can have nutritional risk implications. It is mainly true in patients in the age group ≥ 70 years, since it represents additional score (in NRS 2002) for higher susceptibility to malnutrition and lean body mass loss.[4] Older age can be a risk factor for worst prognosis in ICU patients regardless of nutritional status, because all the assessed cardiac patients recorded APACHE > 10 (score = 3 points in the NRS 2002).

Milanez and Cols. [30] and Athayde and Cols.[27] observed malnutrition prevalence equals 68.9% and 57.6%, respectively, in Brazilian studies carried out with critical patients that have taken inflammation as criterion for all ICU patients at admission time. The same etiological criterion was used. However, weight loss was not taken into consideration to assess malnutrition prevalence based on phenotypic criteria due technical limitations linked to information collection in ICUs.

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Malnutrition prevalence reached 25% in the present study when BMI was taken as phenotypic criterion. However, according to ESPEN nutrition guidelines for ICU[5] patients, BMI does not accurately reflect malnutrition. Overweight patients have lower malnutrition diagnostic and BMI, alone, is contraindicated to assess nutritional status.[5,26,27] Therefore, calf circumference (CC) was used as phenotypic criterion to reduce muscle loss: malnutrition prevalence reached 52.77%. CC (vs. BMI) enabled more cardiac patients to get a malnutrition diagnosis. Overweight and malnutrition can coexist, and BMI-adjusted CC can work as complementary exam.[5,27] Miyahara and Cols.[18] suggest BMI-adjusted CC as alternative when technical measurements such as dual-energy X-ray absorptiometry are not available. Jensen and Cols.[10] recorded 60% malnutrition prevalence, and it is considered an independent predictor for longer hospital stay and for mortality in older patients presenting high BMI.[10,16] In total, 58.33% of cardiac patients admitted in the herein assessed ICU showed malnutrition when BMI-adjusted CC was adopted. This finding corroborated what Alves and Cols.[3] had previously mentioned, namely: BMI-adjusted CC was the most promising method to for overweight cardiac patients' diagnostic in the herein assessed ICU.

It was almost accurately impossible measuring height and body mass in the intensive care unit, and these were limitations of the present study. There is no consensus about the best method to measure height and body mass in critically ill patients, and it may lead to likely bias for BMI and, consequently, for BMI-adjusted CC and malnutrition diagnosis through the GLIM method. Lack of robust methods for muscle loss analysis like dual-energy absorptiometry, bioelectrical impendance, computed tomography or magnetic resonance imaging is another study limitation. However, these methods are not available in most nutritional assessment and research settings.

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## CONCLUSIONS

The use of low-cost questionnaire should be routine to assess and diagnose malnutrition risk in cardiac patients admitted to the assessed ICU since it help reducing in-hospital malnutrition, muscle loss and worst prognosis risk in ICU patients. Malnutrition prevalence varied when BMI, calf circumference (CC) and BMI-adjusted CC were used as phenotypic criterion for GLIM diagnosing, and it was higher when BMI-adjusted CC was adopted. Similarly, BMI-adjusted CC allowed diagnosing malnutrition through the GLIM method applied in overweight patients.

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## AUTHORS' CONTRIBUTIONS

J.S-B, A.J-S, P.C-R, D.B-A, V.G-S, T.B-S, B.S-B and M.F-M were responsible for extracting and interpreting the results. A.D-P, A.P-B and C.A-C were responsible for designing and writing the final version of manuscript.

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## CONFLICTS OF INTEREST

The authors state declare no conflicts of interest.

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