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# Test-retest reliability of the Mini Nutritional Assessment– Short Form (MNA-SF) in older patients undergoing cardiac rehabilitation

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Malnutrition is described as a state of insufficient intake of energy, protein and other nutrients leading to changes in body composition (weight loss, reduced fat-free mass) as well as adverse functional and clinical outcomes.[1] Depending on the assessments and definition used, the prevalence in older patients ranges between 12% in community-dwelling adults to 60% of patients in geriatric care facilities.[2–5] Older populations are at high risk of nutritional deficiencies because of risk factors such as multimorbidity, polypharmacy, cognitive and physical decline, poor appetite, depressive syndromes and socioeconomic changes.[4,6]

In particular, malnutrition often affects patients with cardiovascular diseases, e.g., chronic artery disease, aortic stenosis and other valve diseases.[7–9] A recent study reported that 11.3% of older patients (84 ± 1 years of age) with severe aortic stenosis are malnourished and 42.3% are at risk of malnutrition.[9] In addition, it is reported that 44% to 47% of patients over 80 years are at risk of malnutrition or malnourished after transcatheter aortic valve implantation (TAVI), the treatment of choice in the case of aortic stenosis in older people.[10,11] Furthermore, 21.2% to 28.3% of patients over 65 years and 31.7% of older patients (83 ± 6 years) with coronary artery disease undergoing percutaneous coronary intervention (PCI) are malnourished or at risk of malnutrition.[12,13]

Due to reduced muscle protein synthesis and insufficient protein intake, malnourished older patients often suffer from reduced muscle mass and, therefore, have a higher risk of sarcopenia.[14–16] Even if malnutrition can lead to sarcopenia, both syndromes can also co-occur, as they share a similar pathophysiology.[16,17] As a result, these patients experience extensive consequences, e.g., a higher rate of postoperative complications, impaired immune function and wound healing, decreased functional status and higher risk of mortality compared to patients with normal nutritive status.[7,12,18] Accordingly, early and accurate identification of patients who are in need of nutritional care is important to provide prompt nutrition counseling.[1,18]

In Germany, cardiac rehabilitation is highly recommended for patients after PCI or transcatheter heart valve interventions.[19] Currently, no assessments are used in clinical routine to identify patients at risk of malnutrition, which means that malnutrition often remains undiagnosed.[8]

Various assessments have been developed to evaluate patients' nutritional status.[20,21] The Mini Nutritional Assessment (MNA) is one of the most widely used tools especially in older patients.[22,23] Its short form (MNA-SF) with six items has been shown to have a comparable validity to the original version,[24] and high sensitivity and specifity of over 90%.[25] Due to its validity and recommendations from different guidelines,[21,26] the MNA-SF has the potential to become a standard screening tool in cardiac rehabilitation. However, information is lacking on its test-retest reliability.[25,27]

Hence, we aimed to investigate the between-day test-retest reliability of the MNA-SF in older patients in cardiac rehabilitation who underwent catheter-based interventions. A prospective monocentric reliability study was carried out in a rehabilitation center for internal medicine in Rüdersdorf (Germany) between October 2018 and July 2019. Patients in cardiac rehabilitation after transcatheter aortic valve implantation (TAVI), intervention at the mitral or tricuspid valve (AVI) or percutaneous coronary intervention (PCI) with a minimum age of 75 years were enrolled. Exclusion

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criteria were lack of comprehension (e.g., insufficient knowledge of the German language, dementia) or patients' refusal to participate in the study.

The MNA-SF was administered by trained raters within the first three days of cardiac rehabilitation followed by a second investigation one to two days afterwards. The questionnaire consists of six items (A: Decline of food intake over the past three months; B: Weight loss during the last three months; C: Mobility; D: Psychological stress or acute disease during the last three months; E: Neuropsychological problems; and F: Body Mass Index), which are answered by the patient or are evaluated using the data from the patients' records.[24] Patients' neuropsychological decline was detected using the Mini-Mental State Examination with the cut-off ≤ 24 points.[28] Total scores of MNA-SF range from 0 to 14 points, with scores of 12 to 14 points indicating normal nutritional status, scores between 8 and 11 points identifying patients at risk of malnutrition, and scores < 8 points diagnosing malnutrition.[29]

In addition, sociodemographic data (e.g., age, gender, body mass index) and clinical data (e.g., indications for rehabilitation, medication, comorbidities, left ventricular ejection fraction [LVEF], heart rhythm, New York Heart Association [NYHA] Functional Classification, laboratory data) were documented to describe the observed population. Laboratory data included hemoglobin, albumin and protein serum levels, as well as the estimated glomerular filtration rate (eGFR).

All patients gave their written informed consent to participate in the investigation, which was part of the FuNCaRe ("Functional and nutritional status of older patients in cardiac rehabilitation") study and had been approved by the ethics committee of the University of Potsdam (No.39/2018) and was registered in the German Register of Clinical Trials (DRKS00015176).

Continuous variables are displayed as mean ± SD. Categorical variables are expressed as absolute values and percentages. The intra-class correlation coefficient (ICC) with 95% confidence interval (CI) was calculated in order to assess the test-retest reliability of the MNA-SF.[30] The ICC presents values ranging from 0 to 1, with values < 0.5 indicating 'poor' reliability, 0.5 to 0.75 'moderate' reliability, 0.75 to 0.9 'good' reliability and values > 0.9 'excellent' reliability.[31] The ICC is an indicator of relative reliability and is only related to group differences. Therefore, to give an indication of the accuracy of individual scores (absolute reliability), the minimal detectable change in percent (MDC%) was calculated based on the standard error of measurement (SEM).[32,33] MDC% provides an estimate of the random measurement error of the MNA-SF and, hence, determines whether a change in the score of individual patients is real at the 95% confidence level.[34] A MDC% value under 30 is rated as acceptable and under 10 as excellent.[35,36]

An analysis of variance (ANOVA) was used to compare patient characteristics, laboratory and clinical data and nutritional status between patient populations after TAVI, AVI and PCI. Statistical significance was set at $P < 0.05$ (two-sided). Calculations were carried out using SPSS Version 25.0 (IBM) and Microsoft Excel 2013 (Microsoft Corporation).

A total sample of 122 patients (47.6% female, mean age 82.3 ± 3.5 years) was included in the analysis (TAVI: $n = 58$; AVI: $n = 21$; PCI: $n = 43$). Patients' body mass index was 27.0 ± 4.7 kg/m². In total, patients suffered from 5 ± 2 comorbidities and took 9 ± 3 pharmaceuticals, whereby patients after AVI had a significantly higher number of comorbidities compared to patients after TAVI and PCI ($P < 0.001$). In addition, patients after AVI showed significantly lower values in LVEF compared to the other groups ($P < 0.001$). Patient characteristics are presented in Table 1.

At baseline, patients reached a mean MNA-SF score of 11.7 ± 2.3 points, whereby 75 patients (61.5%) showed normal nutritional status, 41 (33.6%) were at risk of malnutrition and 6 patients (4.9%) were malnourished. At the repeat measurement, 1.8 ± 1.2 days after the baseline, the mean MNA-SF was 11.8 ± 2.3 points, with an unchanged number of patients with normal nutritional status and (risk of) malnutrition (Table 2). Patients after AVI showed significantly different MNA-SF scores compared to patients after TAVI and PCI at both measurement points ($P < 0.05$, Table 2). An ICC value of 0.93 (95% CI: 0.90-0.95) and a MDC% of 15 was achieved for the MNA-SF score in the total sample (Table 2).

This study demonstrated 'excellent' test-retest reliability of the MNA-SF in patients after catheter-based interventions undergoing cardiac rehabilitation. According to MNA-SF, more than one-third of the patients investigated were malnourished or at risk of malnutrition, with small variations between the populations after TAVI, AVI or PCI.

In studies with patients after TAVI and of comparable age, similar mean total scores on the MNA-SF but a slightly higher percentage of patients with a risk of malnutrition were identified.[10,11,37] These differences could be due to the heterogeneity of older populations regarding comorbidities, number of pharmaceuticals taken and functional status, which are all factors influencing the nutritional status.[18,38] In addition, a recent study showed that one-fifth of patients

**Table 1. Patient characteristics.**

| | Total sample (*n* = 122) | TAVI (*n* = 58) | AVI (*n* = 21) | PCI (*n* = 43) | *P*-value |
|---|---|---|---|---|---|
| Age, yrs | 82.3 ± 3.5 | 82.8 ± 3.3 | 82.8 ± 3.9 | 81.4 ± 3.6 | 0.145 |
| Sex, female | 58 (47.5%) | 28 (48.3%) | 10 (47.6%) | 20 (45.5%) | 0.985 |
| BMI, kg/m² | 27.0 ± 4.7 | 27.1 ± 4.9 | 26.6 ± 4.4 | 27.1 ± 4.5 | 0.894 |
| Comorbidities, no. | 4.7 ± 2.0 | 4.7 ± 1.9 | 6.4 ± 2.2 | 3.7 ± 1.4 | < 0.001 |
| Arterial hypertension | 100 (82.0%) | 50 (86.2%) | 16 (76.2%) | 34 (79.1%) | 0.491 |
| Hyperlipidemia | 49 (40.2%) | 20 (34.5%) | 8 (38.1%) | 21 (48.8%) | 0.339 |
| Kidney disease | 42 (34.4%) | 17 (29.3%) | 10 (47.6%) | 15 (34.9%) | 0.317 |
| Diabetes mellitus | 38 (31.1%) | 17 (29.3%) | 7 (33.3%) | 14 (32.6%) | 0.915 |
| Orthopedic diseases | 25 (20.5%) | 8 (13.8%) | 4 (19.0%) | 13 (30.2%) | NA |
| Infections | 15 (12.3%) | 4 (6.9%) | 7 (33.3%) | 4 (9.3%) | NA |
| Cerebrovascular diseases | 11 (9.0%) | 6 (10.3%) | 2 (9.5%) | 3 (7.0%) | NA |
| Cancer | 11 (9.0%) | 4 (6.9%) | 2 (9.5%) | 5 (11.6%) | NA |
| Gastrointestinal diseases | 12 (9.8%) | 4 (6.9%) | 2 (9.5%) | 6 (14.0%) | NA |
| Pharmaceuticals, no. | 8.9 ± 2.7 | 8.7 ± 2.6 | 9.1 ± 2.7 | 9.2 ± 2.9 | 0.734 |
| Beta blockers | 95 (77.9%) | 42 (72.4%) | 19 (90.5%) | 34 (79.1%) | 0.226 |
| Diuretics | 71 (58.2%) | 34 (58.6%) | 18 (85.7%) | 19 (44.2%) | 0.007 |
| ACE inhibitors | 56 (45.9%) | 25 (43.1%) | 8 (38.1%) | 23 (53.5%) | 0.428 |
| Angiotensin II receptor antagonists | 48 (39.3%) | 25 (43.1%) | 7 (33.3%) | 16 (37.2%) | 0.690 |
| Opioid analgesics | 15 (12.3%) | 7 (12.19 | 3 (14.3%) | 5 (11.6%) | NA |
| Anticonvulsants | 7 (5.7%) | 4 (6.9%) | 1 (4.8%) | 2 (4.7%) | NA |
| Antidepressants | 7 (5.7%) | 4 (6.9%) | 2 (9.5%) | 1 (2.3%) | NA |
| MMSE | 25.9 ± 2.9 | 25.6 ± 3.2 | 26.7 ± 2.1 | 25.9 ± 2.7 | 0.298 |
| NYHA | | | | | |
| Class I | 59 (48.4%) | 33 (56.9%) | 8 (38.1%) | 18 (41.9%) | 0.074 |
| Class II + III | 63 (51.6%) | 25 (43.1%) | 13 (61.9%) | 25 (58.1%) | |
| Echocardiography | | | | | |
| Sinus rhythm | 81 (66.4%) | 38 (65.5%) | 5 (23.8%) | 38 (88.4%) | < 0.001 |
| Pacemaker/artrial fibrillation | 41 (33.6%) | 20 (34.5%) | 16 (76.2%) | 5 (11.6%) | |
| LVEF, % | 53.7 ± 8.4 | 56.5 ± 6.2 | 49.3 ± 10.4 | 52.2 ± 8.7 | < 0.001 |
| Laboratory data | | | | | |
| Hemoglobin, mmol/L | 7.5 ± 0.8 | 7.2 ± 0.7 | 7.4 ± 0.7 | 7.9 ± 0.9 | < 0.001 |
| Protein, g/dL | 6.7 ± 0.4 | 6.7 ± 0.5 | 6.6 ± 0.6 | 6.5 ± 0.3 | 0.053 |
| Albumin, g/dL | 4.1 ± 0.2 | 4.1 ± 0.2 | 4.0 ± 0.3 | 4.1 ± 0.2 | 0.156 |
| eGFR, mL/min per 1.73 m² | 65.9 ± 17.0 | 64.3 ± 14.7 | 67.4 ± 25.8 | 67.3 ± 14.5 | 0.612 |

Results are presented as mean ± SD or *n* (%). ACE: angiotensin-converting enzyme; AVI: atrioventricular valve intervention; eGFR: estimated glomerular filtration rate; LVEF: left ventricular ejection fraction; MMSE: Mini-Mental State Examination; NA: not applicable; NYHA: New York Heart Association Functional Classification; PCI: percutaneous coronary intervention; TAVI: transcatheter aortic valve implantation.

after TAVI are referred to geriatric rehabilitation, which is administered for multimorbidity patients, and these patients have a lower mobility and nutritional status compared to patients referred to cardiac rehabilitation.[39] Hence, mainly healthier patients were examined in this study, indicating a positive selection bias. Regarding patients after PCI, our results are in accordance with a recent investigation by Calvo *et al.* with older patients undergoing primary PCI.[13] Remarkably, patients after AVI reached a statistically significant lower score on the MNA-SF and showed a significantly higher number of comorbidities as well as lower LVEF values compared to patients after TAVI or PCI. If patients suffer from a high number of comorbidities, it is more likely that they will have had an acute illness in the last three months, which is related to one item of the MNA-SF.[24] Indeed, the number of comorbidities was negatively correlated to the MNA-SF score in our dataset. Furthermore, Fukui, *et al.*[9] demonstrated that lower LVEF as a measure of heart function is related to malnutrition. However, our data did not confirm this association.

**Table 2. Nutritional status and test-retest reliability.**

| MNA-SF results | Total sample (*n* = 122) | TAVI (*n* = 58) | AVI (*n* = 21) | PCI (*n* = 43) | *P*-value |
|---|---|---|---|---|---|
| First measurement | | | | | |
| MNA-SF score | 11.7 ± 2.3 | 12.0 ± 1.8 | 10.3 ± 3.0 | 12.1 ± 2.2 | 0.006 |
| Normal nutritional status | 75 (61.5%) | 36 (62.1%) | 9 (42.9%) | 30 (69.8%) | 0.115 |
| Risk of malnutrition | 47 (38.5%) | 22 (37.9%) | 12 (47.1%) | 13 (30.2%) | |
| Second measurement | | | | | |
| MNA-SF score | 11.8 ± 2.3 | 12.0 ± 1.8 | 10.4 ± 3.1 | 12.0 ± 2.2 | 0.014 |
| Normal nutritional status | 75 (61.5%) | 34 (58.6%) | 11 (52.4%) | 30 (69.8%) | 0.336 |
| Risk of malnutrition | 47 (38.5%) | 24 (41.4%) | 10 (47.6%) | 13 (30.2%) | |
| Test-retest reliability | | | | | |
| ICC (95% CI) | 0.93 (0.90–0.95) | 0.89 (0.83–0.94) | 0.95 (0.89–0.98) | 0.92 (0.86–0.96) | |
| MDC | 15% | 13% | 15% | 15% | |

Results are presented as mean ± SD or *n* (%). CI: confidence interval; ICC: intraclass correlation coefficient with < 0.5 "poor", 0.5–0.75 "moderate", 0.75–0.9 "good", > 0.9 "excellent"; MDC: minimal detectable change; MNA-SF: Mini Nutritional Assessment-Short Form with < 12 points "(risk of) malnutrition".

Laboratory parameters such as albumin, hemoglobin or protein are commonly used as markers to assess patients' nutritional status. These parameters are influenced by various factors, such as inflammatory processes, hydration status or renal impairment and therefore their eligibility in identifying malnutrition is controversial.[11,40–42] More than one-third of the patients in this study had a kidney disease and suffered on average from five comorbidities, which might have had an impact on these parameters. Furthermore, these parameters can only detect patients who are already malnourished, which could be too late for optimal treatment strategies as malnutrition is reversible if detected early.[38]

In contrast, the MNA-SF has the advantage of identifying patients at risk of malnutrition and is a reliable assessment according to ICC and MDC%.

These results are comparable to previous research by Bleda *et al*. and Lin *et al*., who examined the test-retest reliability of the original version (MNA) in institutionalized elderly people and patients with stroke, respectively.[32,43] The high reliability of both assessment tools can be explained by the way they are carried out. Firstly, the questionnaires are interviewer-administered, so questions can be clarified immediately in the case of misunderstanding by the older patients, which is an advantage over other methods (e.g., self-reporting).[32,44] On the other hand, the data do not only rely on the patient's statement, but can partly be obtained from the patient's record, resulting in a high degree of objectivity.

Our study has some limitations. The targeted interval of one to two days between the first and second measurements of the nutritional status with the MNA-SF could not always be achieved because of patients' individual therapeutic plans during the rehabilitation process. Due to the short interval between the measurements of 1.8 days, it is possible that patients remembered their answers from the baseline investigation. Even if no interval between measurements is recommended, in comparable studies seven or more days are common.[32,43] However, similar results were found between the cited studies and our results. Furthermore, differences between the defined patient groups should be interpreted with caution due to the small sample size.

In conclusion, the MNA-SF established good to excellent test-retest reliability for assessing nutritional status in older patients after catheter-based interventions. A high number of patients after AVI were affected by probable malnutrition, highlighting the importance of the assessment of malnutrition in older populations for timely implementation of preventive treatment. The MNA-SF can be highly recommended as a reliable screening tool for identifying patients at risk of malnutrition in cardiac rehabilitation.

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