

# Mortality risk assessment using the malnutrition and inflammation scale and hand grip strength in patients with chronic kidney disease undergoing hemodialysis treatment. A single-center observational study

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## Abstract

**Received:** November 3, 2022  
**Accepted:** January 24, 2023  
**Published:** February 28, 2023  
**Editor:** Dr. Franklin Mora Bravo.

### Cite:

Álvarez L, Nafarrate J, Segura F. Mortality risk assessment using the malnutrition and inflammation scale and hand grip strength in patients with chronic kidney disease undergoing hemodialysis treatment. A single-center observational study. REV SEN 2023;11(1):43-50. DOI: <http://doi.org/10.56867/46>

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**Introduction:** Patients with chronic kidney disease on maintenance hemodialysis often struggle with malnutrition and sarcopenia. Different studies have defined the malnutrition and inflammation score (MIS) and the handgrip strength test (HST) as independent risk factors. This study aimed to perform the two tests in a group of patients on a hemodialysis program.

**Methods:** This is a cross-sectional study carried out in the hemodialysis service of UMAE 71, Coahuila, Mexico. The variables were: demographic, clinical, laboratory, MIS, HST, and mortality. The sample was nonprobabilistic.

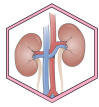
**Results:** 101 patients were analyzed, 50.5% men. Mortality was 25.74%, and the most frequent cause of death was acute myocardial infarction, 34.61%, followed by SARS CoV2 pneumonia, 23.07%. The HST between men and women, for the right hand, was  $17.71 \pm 11.94$  vs.  $11.5 \pm 6.99$ ,  $P=0.0002$ , and for the left hand,  $14.63 \pm 7.06$  vs.  $10.31 \pm 4.98$ ,  $P=0.0001$ . The area under the ROC curve for the MIS was 0.562 and 0.567 for handgrip strength for men and women. A sensitivity of 96% and a specificity of 17% for the HST, and for the MIS, a sensitivity of 92% and a specificity of 20% were found.

**Conclusion:** MIS and HST are indicators with low discriminative capacity. The present study found high sensitivity and low specificity for both tests, which does not guarantee their reliable application to assess the risk of short-term mortality (<12 months) in patients older than 18 years with chronic kidney disease on hemodialysis.

## Keywords:

**MESH:** Renal Dialysis, Weight Loss; Sarcopenia; Renal Insufficiency, Chronic; Hand Strength; Malnutrition.

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**D**ecreased muscle mass and strength are prevalent conditions in dialysis patients; however, these conditions do not co-occur; the decrease in strength is not directly related to the loss of muscle mass. Decreased glomerular filtration < 10 ml/min/1.73 m<sup>2</sup> reduces muscle mass and density by 28 mm<sup>2</sup> and 0.15 mg/cm<sup>3</sup>, respectively, predisposing patients to a progressive loss of muscle strength and quality [1]. It has also been shown to be a simple, noninvasive, and reliable indicator that reflects nutritional status and muscle function in chronic kidney disease (CKD) patients [2, 3]. The predictive power of muscle function, particularly handgrip strength, has been demonstrated in numerous clinical investigations [4-6].

The population on hemodialysis, in particular, has increased mortality during the first year after the start of dialysis due to aging, protein-energy wasting, physical inactivity, and chronic inflammation associated with a higher discharge rate [7].

When using handgrip strength to assess high-risk patients with mortality after starting replacement therapy, a cohort conducted in Brazil in patients with hemodialysis <6 months found a 2-fold higher rate of all-cause mortality in both sexes according to the cutoff points for that population [8].

Patients with CKD have a high risk of developing malnutrition. Therefore, timely diagnosis contributes to improving responses to treatments, delaying comorbidities, and, above all, improving patients' quality of life. Since most of these can be preventable, their investigation is essential.

The malnutrition-inflammation score (MIS) is a nutritional scoring system validated in stages III-V of chronic kidney disease, especially in dialysis patients. The MIS combines the components included in the subjective global assessment, such as the body mass index and laboratory values, being a measure that is easy to apply and reproducible. The MIS incorporates ten components: 70% are subjectively evaluated, and 30% are objectively assessed. Nutritional parameters have been shown to correlate better than subjective global assessment since this includes associated comorbidity parameters and is recommended by the latest nutrition clinical practice guideline published by the NKF/KDIGO initiative for the evaluation of nutritional status in patients with stage 5 CKD with and without dialysis [9-11].

The MIS is a mortality risk prediction tool for predialysis and dialysis-dependent CKD patients. Of all the existing ones, it is the one that best predicts mortality in these patients [12]. Initially, in 2001, Kalantar et al. demonstrated that MIS correlated with morbidity and mortality in patients with maintenance HD during the 12-month follow-up and with a risk calculated by Cox regression analysis of an increase of every 10 MIS units of 10.43 [13].

Jagardewaran et al. applied this MIS score in the Indian predialysis population, finding a sensitivity of 56.5% and a specificity of 81% for mortality prediction for 36 months of follow-up [14]. In people with stable maintenance HD, Rambod M et al. reported that for

every 2-unit increase in MIS above 8 points, there was a twofold increased mortality risk during a 5-year follow-up. In the Asian population, Ho et al. observed that MISs of 3, 4, and 5 increased the risk of mortality in this population by 10%, 40%, and 80%, respectively. However, similar cohort studies that use the MIS score to predict the risk of death in hemodialysis patients in Brazil, Argentina, and Korea report higher mortality with scores greater than 7-8 and 5 points, respectively. Although these studies were conducted in ethnically diverse populations, the same trend of increased mortality risk can be observed with increasing MIS [15-19].

This study aimed to evaluate the malnutrition and inflammation scale and hand grip strength with a diagnostic test in patients with CKD undergoing hemodialysis treatment at a hemodialysis center in Coahuila, Mexico.

## Materials and methods

### Study design

The present study is cross-sectional. The source is prospective.

### Scenery

The study was conducted in the hemodialysis service of UMAE No 71 of the Mexican Institute of Social Security in Coahuila, Mexico, from December 1, 2021, to September 30, 2022.

### Participants

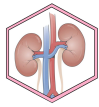
Patients of legal age with stage 5-d chronic kidney disease receiving renal function replacement therapy with >90 days in the hemodialysis program and with stable dry weight who had authorized and signed informed consent were included. Patients with acute or chronic infection, liver cirrhosis, hematological diseases, and active malignancy; patients with upper extremity abnormalities or bilateral arteriovenous fistula; patients hospitalized for surgery in the last month; and patients in critical condition or with extreme fluid overload were excluded. Cases with incomplete data were eliminated from the analysis, with incomplete medical records, or without follow-up after admission.

### Variables

The variables were sex, age, height, weight, body mass index, hemoglobin, albumin, transferrin, cholesterol, triglycerides, urea nitrogen, presence of anuria, manual grip strength, type of vascular access, associated comorbidities, and days of treatment. Per week, mortality, degree of anemia, mortality risk.

### Data sources/measurements

The source was direct; surveys and measurements were carried out on the patients upon admission to the study before the hemodialysis session. Handgrip strength was immediately measured with a Jamar® brand-certified hydraulic dynamometer before connecting to the hemodialysis machine. Clinical and hemodialysis records were reviewed



to evaluate the average dry weight of the last three months and the latest laboratory results necessary to perform the "Inflammation and Malnutrition Score." The resident doctor applied this survey; the evaluation lasted approximately 20 minutes; for one month, all the patients were evaluated, and general data were collected at the beginning of hemodialysis treatment. The information was treated confidentially; no personal data were included to allow the identification of the study subjects.

### Biases

The principal investigator kept the data with a guide and records approved in the research protocol to avoid interviewer, information, and memory biases. Observation and selection bias was avoided by applying the participant selection criteria. All the clinical and paraclinical variables of the period above were recorded. Two researchers independently analyzed each record in duplicate, and the variables were recorded in the database once their concordance was verified.

### Study size

The sample was nonprobabilistic, census type, where all possible cases of the study period were included.

### Quantitative variables

Descriptive and inferential statistics were used. The results were expressed on a scale of means and standard deviation. Categorical data such as sex are presented in proportions.

### Statistical analysis

Noninferential and inferential statistics are used. For the descriptive analysis, measures of central tendency and dispersion were calculated according to each variable's measurement scale. Qualitative variables are absolute numbers and percentages; quantitative variables are medians and standard deviations.

Inferential analysis: comparing values on the scale between the groups was carried out with Student's t-test; the importance and proportion were compared with the chi-square test. Associations were tested using the Chi-square or Fisher's exact test, OR, and 95% CI determination. Diagnostic tests with sensitivity and specificity are presented. The statistical significance level was  $P < 0.05$ . The statistical package used was SPSS 28.0 (IBM Corp. Released 2021. IBM SPSS Statistics for Windows, Version 28.0. Armonk, NY: IBM Corp.

## Results

### Participants

A total of 101 analyzable patients entered the study.

### General characteristics of the sample

They were 51/101 men (50.5%) and 50/101 women (49.5%). The mean age was  $57.09 \pm 0.07$  years; the mean weight was  $69.01 \pm 16.94$  kg, and the mean BMI was  $25.25 \pm 5.7$  kg/m<sup>2</sup>. The main comorbidity was systemic arterial hypertension in 60.3% (61/101), followed by diabetes mellitus in 27.7% (28/100). Table 1 shows the population's

demographic characteristics; a statistically significant difference was observed in weight, which was higher for men. Twenty-one patients (42%) had anuria in the female group, and 20 patients (39.22%) had anuria in the female group ( $P = 0.597$ ).

In the most significant proportion of study subjects, the dominant hand was the right in 95.05% (96/101), with no difference between sexes; all patients had anemia, and moderate anemia was more frequent in 37.6% (38/101), with no difference between the sexes.

A total of 66.34% (67/101) had a central venous catheter. A total of 77.23% (78/101) underwent hemodialysis less than three times per week.

### Hand grip strength and mortality

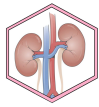
A statistically significant difference was observed in the manual grip strength between men and women:  $17.71 \pm 11.94$  vs.  $11.5 \pm 6.99$ ,  $P = 0.0002$ , and  $14.63 \pm 7.06$  vs.  $10.31 \pm 4.98$ ,  $P = 0.0001$  (Table 2).

Mortality was 25.74% (26/101), and the most frequent cause of death was acute myocardial infarction in 9 cases (34.61%), followed by SARS-CoV2 pneumonia in 6 patients (23.07%).

**Table 1.** Variables were compared between the study groups.

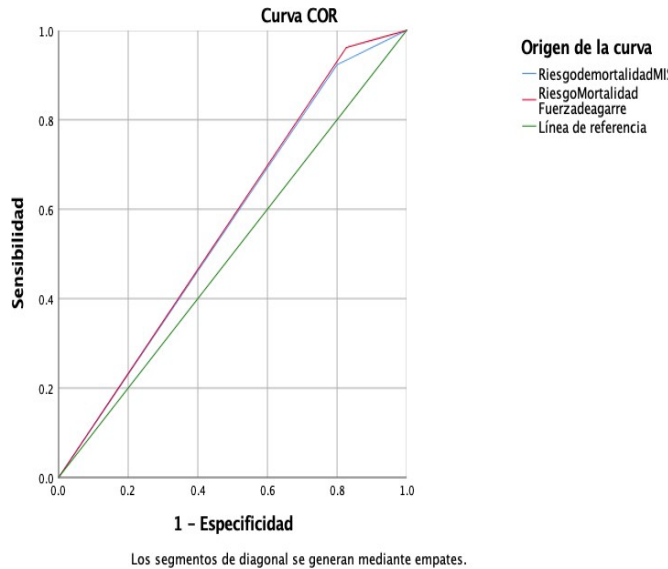
|   | Women<br>n=50 | Men<br>n=51  | P        |
|---|---------------|--------------|----------|
| <b>Anthropometric and laboratory data</b> |               |              |          |
| Age (Years)                               | 57.72±13.1    | 56.47±14.0   | 0.644    |
| Weight (kg)                               | 63.1± 15.0    | 74.8 ± 16.9  | <0.00001 |
| Size (M)                                  | 1.60 ± 0.07   | 1.69 ±0.04   | <0.00001 |
| BMI (kg/m <sup>2</sup> )                  | 24.59 ± 5.86  | 25.89 ± 5.51 | 0.253    |
| Albumin (g/dl)                            | 3.71± 0.76    | 3.65 ± 0.78  | 0.692    |
| Transferrin (mg/dl)                       | 162.3 ± 56.6  | 142.6 ± 45.5 | 0.057    |
| Cholesterol (mg/dL)                       | 153.5 ± 37.0  | 146.2 ± 35.4 | 0.316    |
| Triglycerides (mg/dl)                     | 129.5 ± 56.9  | 134.6 ± 78.4 | 0.710    |
| BUN (mg/dl)                               | 41.3 ± 12.4   | 48.2 ± 19.4  | 0.037    |
| <b>Comorbidities</b>                      |               |              |          |
| Arterial hypertension                     | 33 (66%)      | 28 (54.9%)   | 0.254    |
| Diabetes mellitus 2                       | 14 (28%)      | 14 (27.45%)  | 0.254    |
| Heart failure                             | 5 (10%)       | 6 (11.76%)   | 0.999    |
| Ischemic heart disease                    | 4 (8%)        | 3 (5.88%)    | 0.715    |
| Previous kidney transplant                | 2 (4%)        | 6 (11.76%)   | 0.269    |
| <b>Dominant hand</b>                      |               |              |          |
| Right                                     | 48 (96%)      | 48 (94.12%)  | 0.999    |
| Left                                      | 2 (4%)        | 3 (5.88%)    | 0.999    |
| <b>Anemia</b>                             |               |              |          |
| Mild                                      | 19 (30%)      | 16 (31.37%)  | 0.443    |
| moderate                                  | 20 (40%)      | 18 (35.29%)  | 0.443    |
| severe                                    | 8 (16%)       | 15 (29.41%)  | 0.443    |
| <b>Vascular access</b>                    |               |              |          |
| Arteriovenous fistula                     | 17 (34%)      | 17 (33.33%)  | 0.990    |
| Nontunneled catheter                      | 16 (32%)      | 17 (33.33%)  | 0.990    |
| tunneled catheter                         | 17 (34%)      | 17 (33.33%)  | 0.990    |
| <b>Number of treatments per week</b>      |               |              |          |
| <3  | 37 (74%)      | 41 (80.4%)   | 0.444    |
| 3 or more                                 | 13 (26%)      | 10 (19.6%)   | 0.444    |

BMI: body mass index. BUN: blood urea nitrogen.



Regarding the risk of mortality, we observed that with hand grip strength, 81 patients (80.2%) were classified as having a higher risk of mortality. In contrast, with the MIS classification, 83.17% (84/101) of the cases had an increased risk of death, with no significant differences by sex (Table 2).

**Figure 1.** ROC curve of the mortality risk with the scale of malnutrition and inflammation and manual grip strength.



Neither the grip strength of the hand nor the MIS classification are discriminant for predicting mortality risk in patients with chronic kidney disease undergoing hemodialysis replacement therapy. The area under the ROC curve for the MIS score was 0.562 and 0.567 for hand grip strength for men and women, respectively. The sensitivity of handgrip strength was 96%, and the specificity was 17%, while the MIS was 92% and 20%, respectively, as observed in Table 4 and Figure 1.

**Table 2.** Hand grip strength and MIS.

|  | Women<br>n=50 | Men<br>n=51  | P      |
|--|---------------|--------------|--------|
| <b>Hand grip strength</b>                        |               |              |        |
| Right hand                                       | 11.5 ± 6.99   | 17.71 ± 11.9 | 0.0002 |
| Left hand  | 10.3 ± 4.98   | 14.63 ± 7.1  | 0.0001 |
| <b>Malnutrition and Inflammation Score (MIS)</b> |               |              |        |
| MIS  | 10.62 ± 5.02  | 10.47 ± 4.19 | 0.871  |
| <b>Mortality risk from manual grip strength</b>  |               |              |        |
| Lower risk                                       | 4 (8%)        | 10 (19.61%)  | 0.091  |
| Higher risk                                      | 46 (92%)      | 41 (80.39%)  | 0.091  |
| <b>MIS Mortality Risk</b>                        |               |              |        |
| Lower risk                                       | 10 (20%)      | 4 (7.84%)    | 0.399  |
| Higher risk                                      | 40 (80%)      | 44 (86.27%)  | 0.399  |
| <b>Deaths</b>                                    |               |              |        |
| Deaths   | 14 (28%)      | 12 (23.53%)  | 0.607  |

MIS: malnutrition and inflammation score.

**Table 3.** Association between risk of mortality by manual grip strength, mortality and malnutrition scale.

|   | survivors<br>n=75 | Deceased<br>n=26 | P     |
|---|-------------------|------------------|-------|
| <b>Mortality risk from manual grip strength</b> |                   |                  |       |
| Lower risk                                      | 13 (17.33%)       | 1 (3.85%)        | 0.108 |
| Higher risk                                     | 62 (82.66%)       | 25 (96.15%)      | 0.108 |
| <b>MIS Mortality Risk</b>                       |                   |                  |       |
| Lower risk                                      | 15 (20%)          | 2 (7.92%)        | 0.148 |
| Higher risk                                     | 60 (80%)          | 24 (92.31%)      | 0.148 |

MIS: malnutrition scale in inflammation.

**Table 4.** Diagnostic tests of hand grip strength and the scale of malnutrition and inflammation.

| Proof | V+ | F+ | V- | F- | S   | AND | PPV | VPN | abc   |
|-------|----|----|----|----|-----|-----|-----|-----|-------|
| MIS   | 24 | 60 | 15 | 2  | 92% | 20% | 29  | 88  | 0.562 |
| HGS   | 25 | 62 | 13 | 1  | 96% | 17% | 29  | 93  | 0.567 |

MIS: malnutrition and inflammation score. HGS: Hand grip strength. v: true F: false. S: Sensitivity. E: Specificity. PPV: positive predictive value. NPV: negative predictive value. ABD: Area under the curve.

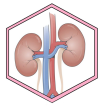
## Discussion

Dialysis patients have an increased mortality rate, and associated comorbidities and malnutrition-inflammation syndrome are related factors. During hemodialysis treatment, multiple associated factors perpetuate the inflammatory process and promote a negative protein-energy balance, resulting in a higher rate of malnutrition and sarcopenia and, consequently, a reduction in muscle mass and strength [20]. Both malnutrition and loss of muscle mass and strength are conditions validated as independent risk factors and predictors of mortality in CKD patients on hemodialysis [1, 21].

Different investigations have demonstrated the predictive power of handgrip strength and MIS score; both are predictive tools for mortality risk used in CKD patients on hemodialysis [11]. The present study evaluated mortality risk using HGS and MIS scores. The results show 101 patients with a similar distribution by sex and age, only highlighting the presence of greater weight, height, and BUN levels in the male group.

Regarding handgrip strength measurement, the present study found that 95.05% of the patients in both groups had right-hand dominance. A statistically significant difference was observed in manual grip strength between men and women in both hands, regardless of manual dominance.

Regarding the association of mortality risk with HGS, the present study classified 82.66% (62/75 patients) for HGS and 80% (60/75 patients) for MIS of the surviving group with higher risk, while of the group deceased, 96.15% (25/26 patients) by HGS and 92.31% (24/26 patients) by MIS and a small proportion of the dead was classified with lower risk in both tests.



As a mortality prediction tool, the present study found that HGS had 96% sensitivity and 17% specificity for both groups (AUC 0.567, 95% CI 0.446-0.689). In contrast to the results reported by other authors, the present results differ, with Tian M et al. reporting a sensitivity of 72% and a specificity of 57% (AUC 0.674; 95% CI 0.621 – 0.727;  $P < 0.0001$ ) for the male group and sensitivity 54% specificity 72% (AUC 0.673; 95% CI: 0.607 – 0.739;  $P < 0.001$ ) for the female group [21]. Perez B et al. reported a sensitivity of 61% and a specificity of 76% (AUC 0.689; 95% CI 0.575-0.803;  $P < 0.003$ ) for the male group and women, with 83% sensitivity and 35.7% specificity (AUC 0.615; 95% CI 0.493-0.737;  $P = 0.06$ ).

Both Tian M. and Perez B. cite the use of the ROC curve to evaluate the discrimination of diagnostic tests about the risk of mortality; both studies report AUC higher than ours as well as having a slightly better performance than the results of our research, although far from having a good or excellent effect as a predictor test of increased risk of mortality. On the other hand, a vast difference is also observed between the sensitivity and specificity results reported by different studies compared to the present study; this difference can be explained by the high number of false positive results we obtained in our study. In addition, the similarities between populations concerning the mean age and BMI between the present study and those carried out on Brazilian people are worth noting. At the same time, BMI was lower in the studies with the Chinese population. On the other hand, two important points should be highlighted: the sample size and the follow-up time were much shorter in our study than in the rest.

Regarding using MIS as a mortality predictor tool, our study reported the following results: 92% sensitivity and 20% specificity for both groups (AUC 0.562, 95% CI 0.439-0.684). The studies reported in the literature that use MIS to assess mortality risk report results that are different from ours; Clementoni et al. say a sensitivity of 52.6% and specificity of 77.4% (AUC 0.696, 95% CI 0.604-0.789,  $P < 0.001$ ) at 18 months while follow-up at 24 months or more found 53.5% sensitivity and 82%. Specificity (AUC 0.707; 95% CI 0.615-0.799,  $P < 0.001$ ). Another Brazilian study reported by Cunha B et al. [19] using MIS as a mortality prediction tool with a follow-up of 29 months found a sensitivity of 84.62% and specificity of 61.76% (AUC 0.766, 95% CI, 0.62-0.877,  $P < 0.005$ ). Jagardeswaran et al. used MIS in the Indian population reporting dialysis, finding a sensitivity of 56.5% and a specificity of 81% for mortality prediction for 36 months of follow-up (AUC 0.709; 95% CI 0.604 – 0.815,  $P < 0.001$ ). Finally, Rambod [15] et al. only reported an AUC of 0.67 (95% CI: 1.76–2.33,  $P < 0.001$ ) using the MIS score.

Finally, in contrast to the present study, we highlight that according to the data reported in the literature, the other studies were not carried out in ethnically similar populations; the results write AUC much higher than that reported by our research, with regular to good performances according to the AUC; It is worth noting something vital that we can observe in the results reported by Clementoni et al., it is the modification of the specificity and the AUC while the follow-up time is increased, which may indicate that the increase in

follow-up improves the discriminatory capacity of MIS to determine the risk of mortality.

## Conclusion

The MIS and handgrip strength are indicators with low discriminative capacity. The present study found high sensitivity and low specificity for both tests, which does not guarantee their reliable application to assess mortality risk in the short term (<12 months) in patients older than 18 years with chronic kidney disease on hemodialysis.

## Abbreviations

MIS: malnutrition scale in inflammation.  
FAM: Hand grip strength.  
v: true  
F: false.  
S: Sensitivity.  
E: Specificity.  
PPV: positive predictive value.  
NPV: negative predictive value.  
ABD: Area under the curve.

## Supplementary information

Supplementary materials have not been declared.

## Acknowledgments

Does not apply.

## Author contributions

Luis Rafael Álvarez Velázquez: Data curation, Formal analysis, Fundraising, Research, Methodology, Project management, Resources, Software, Writing – original draft.  
Jesús Iván Nafarrate Rivera: Conceptualization, Supervision, Validation, Visualization, Writing: review and edition.  
Fany Karina Segura López: Conceptualization, Supervision, Validation, Visualization, Writing: review and edition.  
All authors read and approved the final version of the manuscript.

## Financing

The studies, hemodialysis treatments, laboratory tests, and body composition measurements constituted the regular activity of the hemodialysis units and did not constitute an additional cost for the patients. The authors of the article funded the study.

## Availability of data or materials

The data sets generated and analyzed during the current study are not publicly available due to the confidentiality of the participants.

## Statements

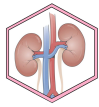
### Ethics committee approval and consent to participate

The local health research committee No. 501 approved the study protocol with the code CEI 001 2018041 (CONBIOETHICS).

### Consent for publication

Not required for studies that do not publish patient photographs, CT scans, or X-ray studies.





## Conflicts of interest

Authors 2 and 3 are Mexican Social Security Institute of Mexico employees.

## References

1. Roshanravan B, Patel KV, Robinson-Cohen C, de Boer IH, O'Hare AM, Ferrucci L, Himmelfarb J, Kestenbaum B. Creatinine clearance, walking speed, and muscle atrophy: a cohort study. *Am J Kidney Dis*. 2015 May;65(5):737-47. doi: 10.1053/j.ajkd.2014.10.016. Epub 2014 Dec 24. PMID: 25542415; PMCID: PMC4414665\_5...  
<https://doi.org/10.1053/j.ajkd.2014.10.016>
2. Schlüssel MM, dos Anjos LA, de Vasconcellos MT, Kac G. Reference values of handgrip dynamometry of healthy adults: a population-based study. *Clin Nutr*. 2008 Aug;27(4):601-7. doi: 10.1016/j.clnu.2008.04.004. Epub 2008 Jun 10. PMID: 18547686. <https://doi.org/10.1016/j.clnu.2008.04.004>
3. Matos CM, Silva LF, Santana LD, Santos LS, et al. Handgrip strength at baseline and mortality risk in a cohort of women and men on hemodialysis: A 4-year study. *J Ren Nutr*. 2014;24(3):157-62. <https://doi.org/10.1053/j.jrn.2013.12.005> PMID: 24598143
4. Norman K, Stobaus N, González MC, Schulzke JD, Pirlich M. Hand grip strength: outcome predictor and marker of nutritional status. *Clin Nutr*. 2011; 30:135-142. <https://doi.org/10.1016/j.clnu.2010.09.010> PMID: 21035927
5. Vecchiarino P, Bohannon RW, Ferullo J, Maljanian R. Short-term outcomes and their predictors for patients hospitalized with community-acquired pneumonia. *Heart Lung* 2004;33:301e7. <https://doi.org/10.1016/j.hrtlng.2004.03.007> PMID: 15454909
6. Humphreys J, de la MP, Hirsch S, Barrera G, Gattas V, Bunout D. Muscle strength as a predictor of loss of functional status in hospitalized patients. *Nutrition* 2002;18:616e20. [https://doi.org/10.1016/S0899-9007\(02\)00756-6](https://doi.org/10.1016/S0899-9007(02)00756-6) PMID: 12093441
7. Klidjian AM, Foster KJ, Kammerling RM, Cooper A, Karran SJ. Relation of anthropometric and dynamometric variables to serious postoperative complications. *Br Med J* 1980;281: 899e901. <https://doi.org/10.1136/bmj.281.6245.899> PMID: 7427501 PMCID: PMC1714169
8. Isoyam N, Quireshi A, Avesani C et al Comparative Associations of Muscle Mass and Muscle Strength with Mortality in Dialysis Patients *Clin J Am Soc Nephrol*. 2014 Oct 7; 9(10): 1720-1728 <https://doi.org/10.2215/CJN.10261013> PMID: 25074839 PMCID: PMC 4186520
9. Lopes M, Silva L, Dantas M et al Sex-age-specific handgrip strength and mortality in an incident hemodialysis cohort: The risk explained by nutrition and comorbidities *Int J Artif Organs* 2018 Dec;41(12):825-832. <https://doi.org/10.1177/0391398818793088> PMID: 30200792
10. Li-Chun H, Hsi -Hao W, Chih -Kang C Et al Malnutrition-inflammation score independently determined cardiovascular and infection risk in peritoneal dialysis patients *Blood Purification*. 2010;29(3):308-16 <https://doi.org/10.1159/000280641> PMID: 20134162
11. Sohrabi Z, Eftekhari M, Eskandari M et al. Malnutrition-inflammation score and quality of life in hemodialysis patients: is there any correlation? , *Nephrourol Mon*. 2015 May 23;7(3):e 27445. [https://doi.org/10.5812/numonthly.7\(3\)2015.27445](https://doi.org/10.5812/numonthly.7(3)2015.27445) PMID: 26034747
12. Avesani C, Sabatino A, Guerra A et al A Comparative Analysis of Nutritional Assessment Using Global Leadership Initiative on Malnutrition Versus Subjective Global Assessment and Malnutrition Inflammation Score in Maintenance Hemodialysis Patients *J Ren Nutr*. 2021 Jul 27;S 1051-2276(21)00172-2.
13. De Roij van Zuidewijn CL, Ter Wee PM, Chapdelaine I., Bots ML, Blankestijn PJ, van den Dorpel MA, Nube MJ, Grooteman MP A comparison of 8 nutrition-related tests to predict mortality in hemodialysis patients. *J. Ren. Nour*. 2015; 25:412-419. <https://doi.org/10.1053/j.jrn.2015.02.005> PMID: 25820178
14. Kalantar -Zadeh K, Kopple J, Block G, et al A malnutrition-inflammation score is correlated with morbidity and mortality in maintenance hemodialysis patients *Am J Kidney Dis*. 2001 Dec;38(6):1251-63. <https://doi.org/10.1053/ajkd.2001.29222> PMID: 11728958
15. Jagadeswaran D, Indhumathi E, Hemamalini AJ, Sivakumar V, Soundararajan P, Jayakumar M. Inflammation and nutritional status assessment by malnutrition inflammation score and its outcome in predialysis chronic kidney disease patients. *Clin Nutr*. 2019;38:341-347. <https://doi.org/10.1016/j.clnu.2018.01.001> PMID: 29398341
16. Rambod M, Bross R, Zitterkoph J et al Association of Malnutrition-Inflammation Score with quality of life and mortality in hemodialysis patients: a 5-year prospective cohort study *Am J Kidney Dis*. 2009 Feb;53(2):298-309. <https://doi.org/10.1053/j.ajkd.2008.09.018> PMID: 19070949 PMCID: PMC 5500250
17. Ho LC, Wang HH, Peng YS, Chiang CK, Huang JW, Hung KY, Hu FC, Wu KD Clinical utility of malnutrition-inflammation score in maintenance Hemodialysis patients: focus on identifying the best cutoff point. *Am J Nephrol*. 2008; 28(5):840-6. <https://doi.org/10.1159/000137684> PMID: 18535370
18. Carreras R, Mengarelli M, Najun Zarazaga The malnutrition and inflammation score as a predictor of mortality in hemodialysis patients *Dial Traspl*. 2008;29(2):55-61 [https://doi.org/10.1016/S1886-2845\(08\)70623-4](https://doi.org/10.1016/S1886-2845(08)70623-4)
19. Clementoni M, Perez B Cuadrado M, Costa J Malnutrition Inflammation Score cutoff predicting mortality in maintenance hemodialysis patient *Clinical Nutrition ESPEN xxx* (2016) 1e5
20. da Cunha S, Cansanção K, Pereira T, Ferreira W Evaluation of the prognostic significance of the malnutrition inflammation score in hemodialysis patients *Clinical Nutrition ESPEN Vol 35*, P 109-115 Feb 2020



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<https://doi.org/10.1016/j.clnesp.2019.10.019>

PMid: 31987102

disease. *Kidney Int* 73(4):391-398.

<https://doi.org/10.1038/sj.ki.5002585>

PMid: 1809468

21. Fouque D, Kalantar-Zadeh K, Kopple J, et al A proposed nomenclature and diagnostic criteria for protein energy wasting in acute and chronic kidney

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